

Shell Todd Oil Services Limited (STOS)  
Kapuni Wellsites Hydraulic Fracturing  
Monitoring Programme Report  
2012-2014

Technical Report 2014-95

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## Executive summary

Shell Todd Oil Services Limited (STOS) operate the KA1/7/19/20 wellsite, located at 360 Palmer Road, the KA4/14 wellsite, located at 598 Palmer Road and the KA6/11/17 wellsite, located at 849 Ahipaipa Road. The wellsites lie within Kapuni, Waiokura and the Inaha catchments, respectively. Each wellsite contains a number of hydrocarbon producing wells and associated infrastructure.

STOS hold resource consents 7995-1, 7996-1 and 7998-1, authorising the discharge of contaminants into land at the KA1/7/19/20, KA4/14 and KA6/11/17 wellsites, respectively. The consents were issued by the Council on 28 March 2012 (7995-1 and 7996-1) and 5 April 2012 (7998-1). Each consent contains a total of 14 special conditions which set out the requirements that STOS must satisfy.

The following report for the period July 2012 to June 2014 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 Shell Todd Oil Services Limited (STOS), within their Kapuni gas field over the period June 2013 to December 2013. The reports also assess STOS's level of environmental performance and compliance with the resource consents held in relation to the activity.

### **During the monitoring period being reported, STOS demonstrated a high level of environmental performance.**

The programme of hydraulic fracturing undertaken by STOS included the fracturing of three wells, at three separate Kapuni wellsites. The wells targeted for stimulation included KA-14, located at the KA4/14 wellsite; KA-17, located at the KA6/11/17 wellsite; and KA-19, located at the KA1/7/19/20 wellsite. The hydraulic fracturing of these wells took place between June and December 2013.

The programme of monitoring implemented by the Council in relation to these activities spanned both the 2012-2013 and 2013-2014 monitoring periods. The programme included the analysis of samples taken from nine existing groundwater supplies surrounding the wellsites. Samples of groundwater were obtained prior to hydraulic fracturing being undertaken to provide a baseline reference of groundwater composition, with a further round of sampling carried out post hydraulic fracturing for comparison with baseline results.

In addition, samples of the both the hydraulic fracturing fluid and the formation fluids produced back to the wellhead immediately following each fracturing event were obtained for analysis.

The monitoring programme also incorporated a surface water component, whereby biomonitoring surveys were undertaken in surface water bodies surrounding each wellsite where hydraulic fracturing took place. In order to provide a baseline reference for stream health, surveys were undertaken prior to hydraulic fracturing. Additional surveys were then carried out post hydraulic fracturing to determine whether the activity had resulted in any adverse effects on stream health.

The monitoring carried out by the Council indicates that the hydraulic fracturing activities undertaken by STOS had no adverse effects on local groundwater or surface water resources.

There were no Unauthorised Incidents recording non-compliance in respect of the resource consents, or provisions in regional plans, during the period under review.

STOS demonstrated a high level of both environmental and 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 2014-2015 year.

Note: This report relates specifically to the Council's monitoring of hydraulic fracturing activities at the KA1/7/19/20, KA4/14 and KA6/11/17 wellsites over the 2012-2014 period. A separate monitoring report has been prepared by the Council in relation to the monitoring of general activities at the KA1/7/19/20 wellsite. Additional reports for the KA4/14 and KA6/11/17 wellsites will be published in due course.

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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 Shell Todd Oil Services Limited (STOS), within their Kapuni gas field over the period June 2013 to December 2013. The reports also assess STOS's level of environmental performance and compliance with the resource consents held in relation to the activity.

The programme of hydraulic fracturing undertaken by STOS included the fracturing of three wells, at three separate Kapuni wellsites. The wells targeted for stimulation were KA-14, located at the KA4/14 wellsite, 598 Palmer Road; KA-17, located at the KA6/11/17 wellsite, 849 Ahipaipa Road; and KA-19, located at the KA1/7/19/20 wellsite, 360 Palmer Road. The wellsites are located in the Waiokura, Inaha and Kapuni catchments, respectively.

The programme of monitoring implemented by the Council in relation to these activities spanned both the 2012-2013 and 2013-2014 monitoring periods and included groundwater, surface water and discharge monitoring components. This is the first monitoring report produced by the Council in relation to the hydraulic fracturing of the KA-14, KA-17 and KA-19 wells.

### **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 through annual programmes, the resource consents held by STOS for discharges into land associated with hydraulic fracturing in the Waiokura, Inaha and Kapuni catchments, 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 2014-2015 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 items 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 was addressed promptly and co-operatively.
- **Good** Perhaps some administrative requirements of the resource consents were not met at a particular time, however this was addressed without repeated interventions from the Council staff. Alternatively adequate reason was provided

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

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

For reference, in the 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 Kapuni ‘Tight Gas’ Programme

STOS’s Kapuni field has been in production since 1969 and is the oldest producing gas and condensate field in New Zealand. The objective of the Kapuni ‘Tight Gas’ Programme is to improve hydrocarbon production rates from the field, thus extending its economic life. The programme includes the workovers of existing production wells, the drilling of new wells and well stimulation by hydraulic fracturing.

The initial phase of the programme included the hydraulic fracturing of the existing KA-14 and KA-17 wells, and the drilling and hydraulic fracturing of the KA-19 well. The wells are located at the KA4/14, KA6/11/17 and KA1/7/19/20 wellsites, respectively. The location of each wellsite is illustrated in Figure 1. Well construction and geological stratigraphy schematics for each well are included in Appendix I.

A summary of all hydraulic fracturing activities carried out by STOS during the period being reported is provided below in Table 1.

**Table 1** Summary of hydraulic fracturing activity (2012-2014)

Well	Wellsite	Consent	Date		Injection zone (m TVDss)	Formation
			Start	End		
KA-14	KA4/14	7996-1	12/06/13	22/06/13	3,073 to 3,450	Kapuni Group
KA-17	KA6/11/17	7998-1	28/07/13	06/08/13	3,036 to 3,360	Kapuni Group
KA-19	KA1/7/19/20	7995-1	14/11/13	10/12/13	3,065 to 3,419	Kapuni Group

## 1.3 Resource consents

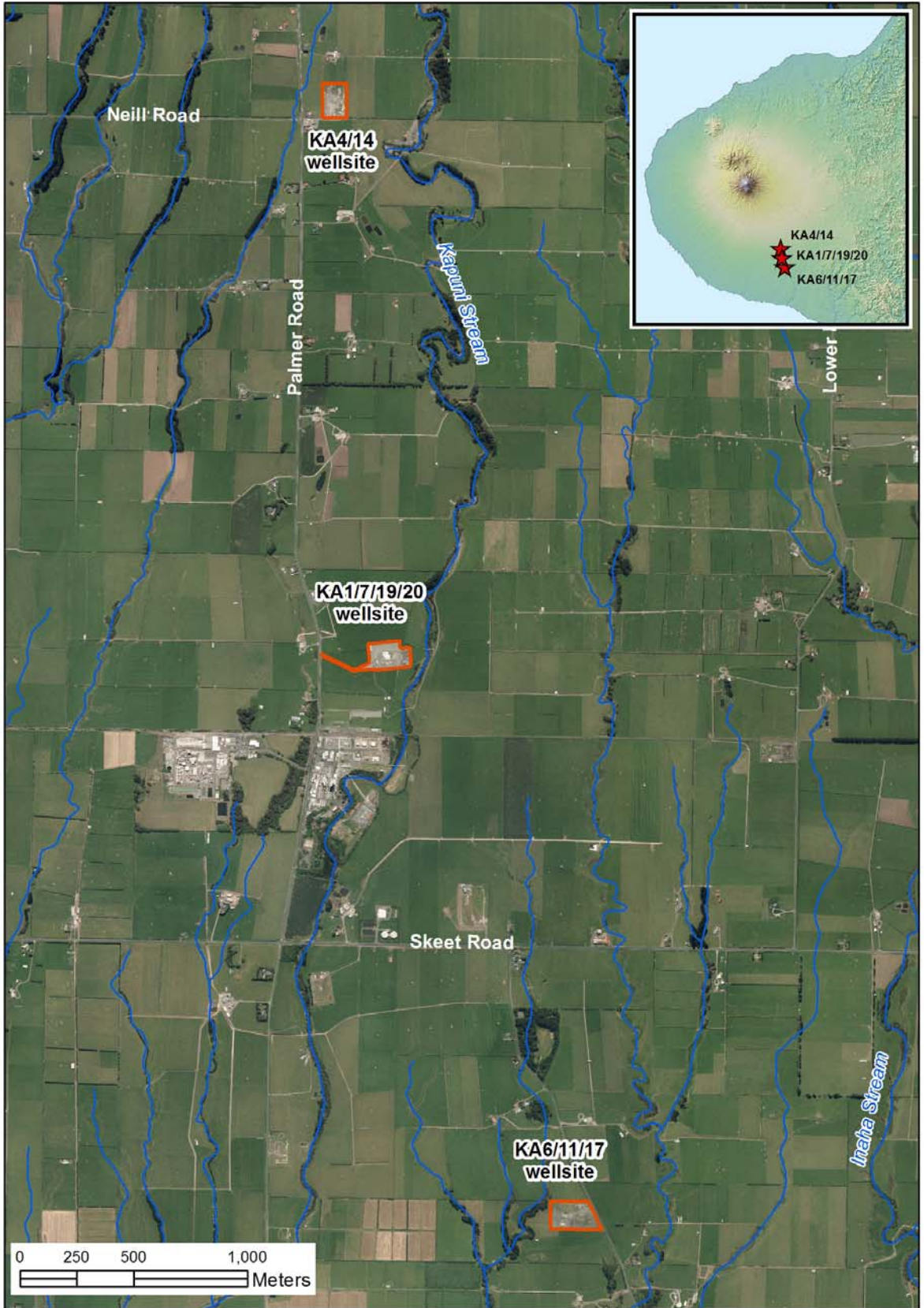
### 1.3.1 Discharges onto and into land

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.

STOS hold resource consents **7995-1**, **7996-1** and **7998-1**, authorising the discharge of contaminants into land at the KA1/7/19/20, KA4/14 and KA6/11/17 wellsites, respectively. The consents were issued by the Council on 28 March 2012 (7995-1 and 7996-1) and 5 April 2012 (7998-1), under Section 87(e) of the RMA. Each consent contains a total of 14 special conditions which set out the requirements that STOS must satisfy.

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

Condition 2 requires the consent holder to ensure that the exercising of the consent does not result in any contaminants reaching any useable freshwater (ground or surface water).



**Figure 1** Locations of Kapuni wellsites where hydraulic fracturing occurred during the period under review

Conditions 3, 4 and 5 relate to fresh water monitoring requirements, to allow compliance with condition 2 to be assessed.

Condition 6 requires the consent holder to carry out pressure testing of equipment prior to discharging.

Condition 7 requires the consent holder to submit a pre-fracturing discharge report prior to any discharge occurring.

Condition 8 is a notification requirement.

Condition 9 requires the consent holder to submit a post-fracturing discharge report after the completion of the hydraulic fracturing programme for each well.

Condition 10 stipulates how the reports required by conditions 7 and 9 are to be submitted.

Condition 11 requires the consent holder to allow the Council access to a location where samples of hydraulic fracturing and return fluids can be obtained.

Condition 12 requires the consent holder to adopt use best practicable options.

Condition 13 relates to the composition of the fracturing fluid.

Condition 14 is a review provision.

Copies of each permit are included in Appendix II.

## **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 KA-14, KA-17 and KA-19 wells 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;
- 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 consents 7995-1, 7996-1 and 7998-1, STOS submitted pre and post-fracturing discharge reports to the Council for each well fractured during the period under review. Pre-fracturing discharge reports provide an outline of the proposed fracturing operations in relation to each well, while post-fracturing reports confirm details of what actually occurred. The specific range of information required in each report is stipulated in the conditions of the resource consents.

### 1.4.4 Chemical sampling

The primary component of the monitoring programme implemented by the Council was the sampling of existing groundwater supplies in the vicinity of each wellsite at which hydraulic fracturing took place, and the analysis of the results.

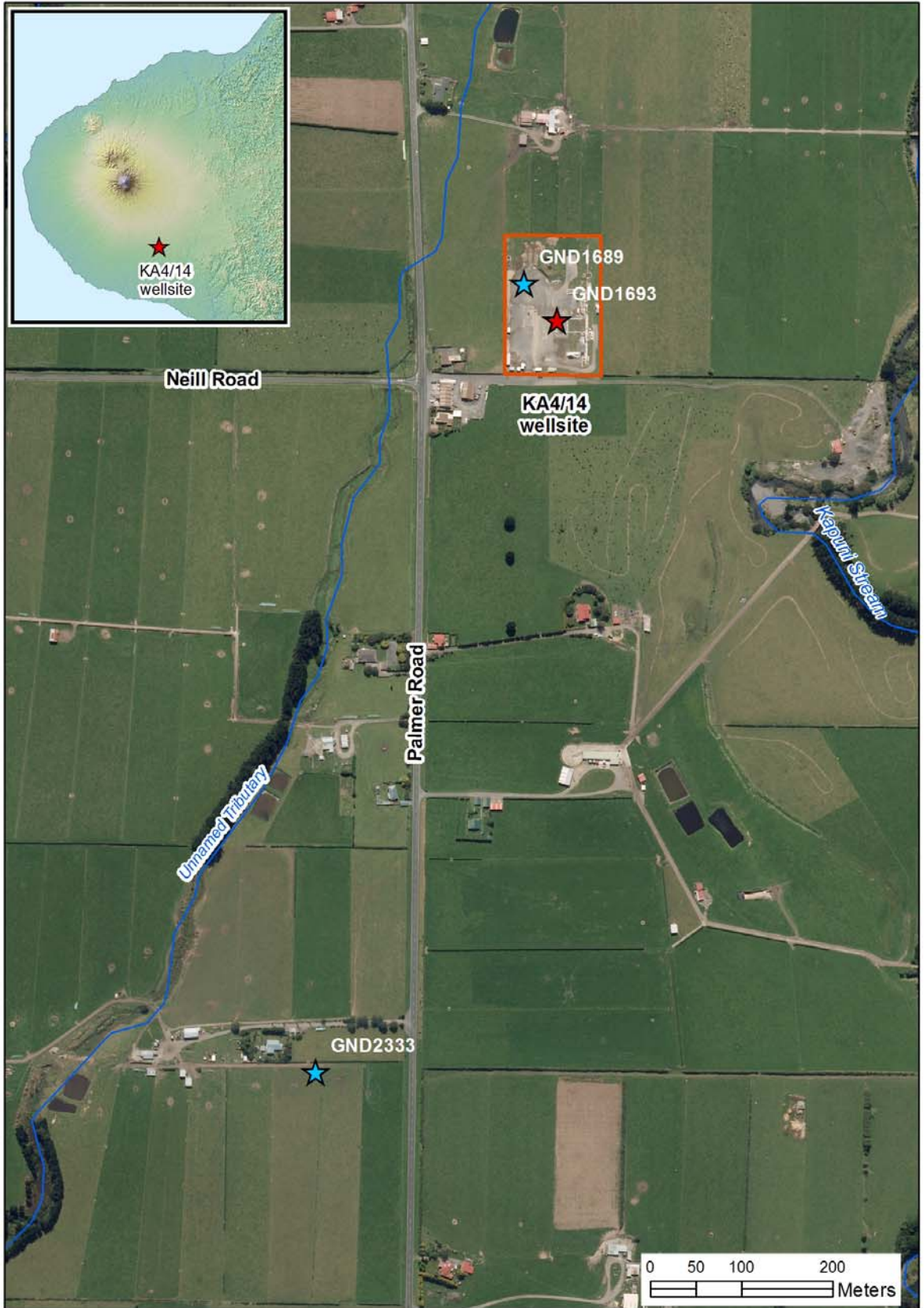
In order to select suitable sites for sampling, the Council carried out surveys in the vicinity of each site to identify existing groundwater abstractions. The surveys were undertaken within defined 'areas of review' which extended 1 km radially from the bottom hole locations of each of the KA-14, KA-17 and KA-19 wells. In total, nine existing water supplies were identified for inclusion in the monitoring programme. The details of each site are included in Table 2 and their proximity to the relevant hydraulically fractured well is illustrated in Figures 2, 3 and 4.

**Table 2** Details of groundwater sites included in the monitoring programme

Hydraulically fractured well	Wellsite	Monitoring site	Distance from bottom hole location (m)	Total depth (m)	Screened interval (m)	Aquifer
KA-14 (GND1693)	KA4/14	GND1689	1,320*	31	19.5 to 31	Volcanics
		GND2333	1,000	10	0 to 10	Volcanics
KA-17 (GND2366)	KA6/11/17	GND0093	753	55	25 to 55	Volcanics
		GND2011	960	430	386 to 430	Matemateonga
		GND2348	911	49	24 to 49	Volcanics
		GND2357	986	35	24 to 35	Volcanics
KA-19 (GND2431)	KA1/7/19/20	GND2342	958	18	NR**	Volcanics
		GND2349	768	40	23 to 40	Volcanics
		GND2352	978	27	24 to 27	Volcanics

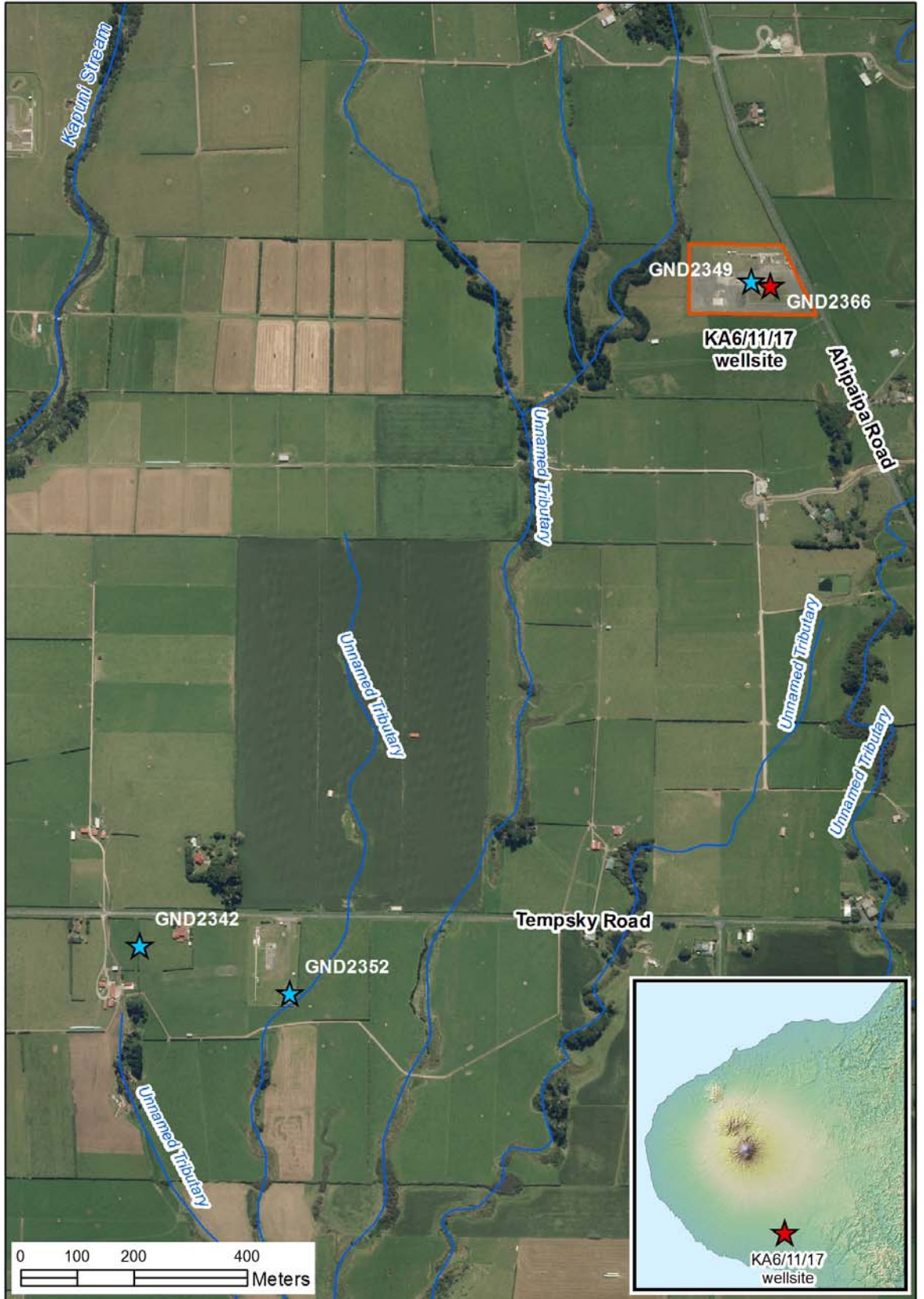
\* Outside of defined area of review but included in assessment due to lack of suitable alternative monitoring sites.

\*\* Bore not accessible to obtain measurements.



**Figure 2** Location of groundwater sampling sites in relation to KA-14 well (GND1693)





**Figure 3** Location of groundwater sampling sites in relation to KA-17 well (GND2366)

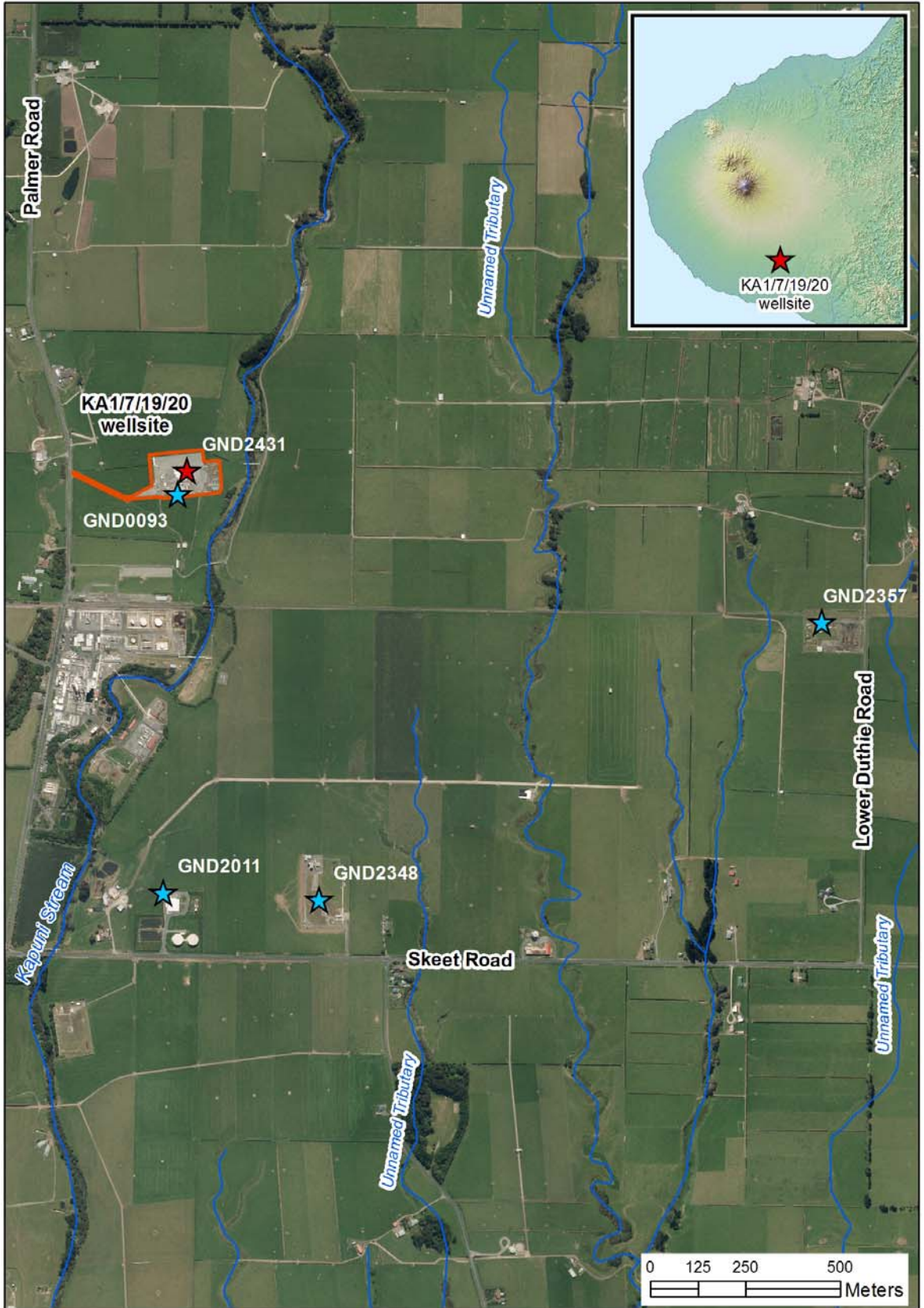


Figure 4 Location of groundwater sampling sites in relation to KA-19 well (GND2431)

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

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

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

### 1.4.5 Biomonitoring surveys

Biological surveys were performed pre and post-fracturing in the vicinity of each wellsite. Surveys were carried out in the rivers/streams which receive stormwater discharges from the respective wellsites. The surveys were undertaken to assess whether stormwater discharges from the sites had resulted in any detrimental effects upon the biological communities within the receiving waters.

The details of each biomonitoring site included in the surveys are presented in Table 3 and their proximity to the relevant hydraulically fractured well is illustrated in Figures 5, 6 and 7.

**Table 3** Details of biomonitoring sites included in the monitoring programme

Hydraulically fractured well	Wellsite	Site code	GPS reference (NZTM)	Location	Sampling method used pre-fracturing	Sampling method used post- fracturing
KA-14	KA4/14	WKR000653	E 1700717 N 5632521	Immediately u/s of Neil Rd, d/s of stormwater discharge	Vegetation sweep	Streambed kick
KA-17	KA6/11/17	INH000428	E 1701824 N 5627781	50m upstream of the stormwater discharge point	Vegetation sweep	Kick-sweep
		INH000429	E 1701796 N 5627722	20m downstream of the stormwater discharge point	Kick-sweep	Kick-sweep
KA-19	KA1/7/19/20	KPN000279	E 1701343 N 5630194	Immediately upstream of pipeline bridge (upstream of KA-1/7/19/20 wellsite)	Streambed kick	Streambed kick
		KPN000281	E 1701216 N 5629958	150m u/s water treatment plant	Streambed kick	Streambed kick



Figure 5 Location of biomonitors in relation to KA-14 well (GND1693)



Figure 6 Location of biomonitors in relation to KA-17 well (GND2366)

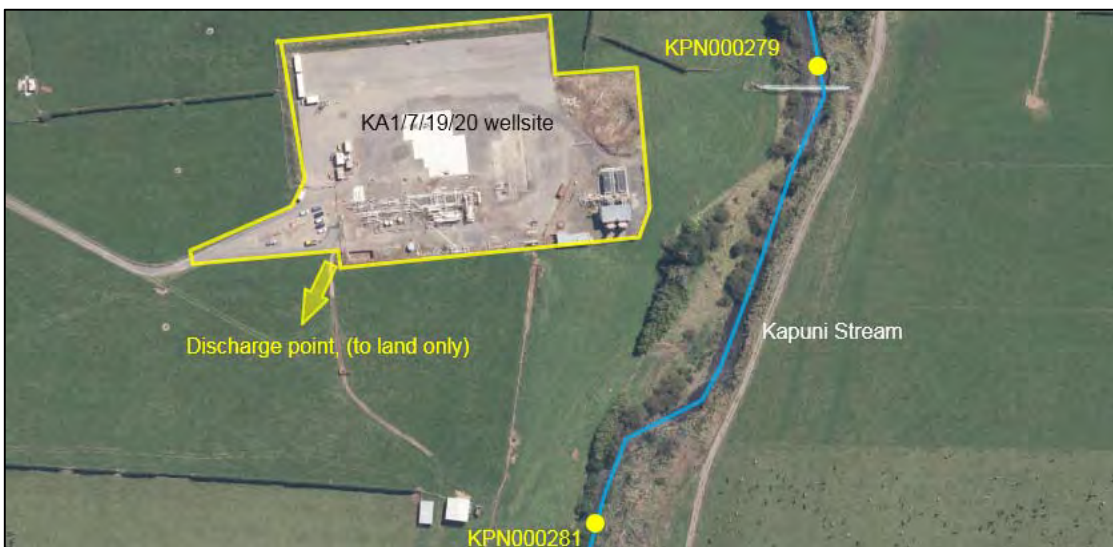


Figure 7 Location of biomonitors in relation to KA-19 well (GND2431)

## 2. Results

### 2.1 Consent holder submitted data

#### 2.1.1 KA-14 post-fracturing discharge report

The conclusions from the KA-14 post-fracturing discharge report are summarised as follows:

- A total of nine discrete zones were fractured over the period 12 June to 22 June 2013, at depths between 3,073 to 3,450 m TVDss.
- A total of 17,021 barrels (bbls) (2,706 m<sup>3</sup>) of liquid was discharged across the nine fractured zones. The total proppant weight was 591 tonnes.
- By volume, 93.1% of the fluid injected was water, 5.3% was proppant, with the remaining 1.6% (43 m<sup>3</sup>) comprised of chemical additives.
- Pressure testing of the tubing and well head equipment was carried out prior to fracturing commencing. The maximum pressure exerted during the fracturing programme remained below the successfully tested levels at all times.
- Low activity tracers were used to directly measure the height of fracture network created during injection into each of the nine zones. The height of fracture networks created ranged from 0 to 20 m. The average width and length of fractures created in each zone were calculated using proprietary software, and ranged from 0 to 9.7 mm and 0 to 385 m, respectively.
- The KA-14 well was opened for flowback for three days following the completion of fracturing operations. At the completion of the flow-back operation, approximately 1,870 bbls (297 m<sup>3</sup>) of fluids injected during fracturing operations was returned to the surface, leaving approximately 15,151 bbls (2,409 m<sup>3</sup>) of the fluids injected (89%) remaining in the formation. Additional fluid is likely to be returned back to the surface as the well produces. It is estimated that between 30 to 50% of the remaining fluid may be recovered as production water over a period of three months to one year.
- The majority of waste fluid from the KA-14 well was disposed of by deep well injection, via the KW-02 injection well, as authorised by consent 1336-3. Approximately 2,298 bbls (365 m<sup>3</sup>) of fluid was discharged via the KW-02 well, comprised of both hydraulic fracturing return fluids and fluids circulated in the well during subsequent works associated with the fracturing process. An additional 667 bbls (106 m<sup>3</sup>) was discharged via the Transpacific handling facility and separator to the New Plymouth Trade Waste system.
- All fracturing treatments were placed successfully. It is considered that the mitigation measures implemented by STOS were effective in ensuring there were no adverse environmental effects associated with fracturing operations.

### 2.1.2 KA-17 post-fracturing discharge report

The conclusions from the KA-17 post-fracturing discharge report are summarised as follows:

- A total of eight discrete zones were fractured over the period 28 July to 6 August 2013, at depths between 3,036 to 3,360 m TVDss.
- A total of 15,181 bbls (2,414 m<sup>3</sup>) of liquid was discharged across the nine fractured zones. The total proppant weight was 373 tonnes.
- By volume, 93.5% of the fluid injected was water, 4.8% was proppant, with the remaining 1.7% (41 m<sup>3</sup>) comprised of chemical additives.
- Pressure testing of the tubing and well head equipment was carried out prior to fracturing commencing. The maximum pressure exerted during the fracturing programme remained below the successfully tested levels at all times.
- Low activity tracers were used to directly measure the height of fracture network created during injection into each of the nine zones. The height of fracture networks created ranged from 2 to 31 m. The average width and length of fractures created in each zone were calculated using proprietary software, and ranged from 2.5 to 4.5 mm and 130 to 730 m, respectively.
- The KA-14 well was opened for flowback for four days following the completion of fracturing operations. At the completion of the flow-back operation, approximately 664 bbls (106 m<sup>3</sup>) of fluids injected during fracturing operations was returned to the surface, leaving approximately 14,517 bbls (2,308 m<sup>3</sup>) of the fluids injected (96%) remaining in the formation. Additional fluid is likely to be returned back to the surface as the well produces. It is estimated that between 30 to 50% of the remaining fluid may be recovered as production water over a period of three months to one year.
- Approximately 80% (85 m<sup>3</sup>) of return fluid from the KA-17 fracturing operations was disposed of by deep well injection, via the KW-02 injection well, as authorised by consent 1336-3. The remaining 20% of fluid (21 m<sup>3</sup>) was discharged via the Transpacific handling facility and separator to the New Plymouth Trade Waste system.
- All fracturing treatments were placed successfully, with the exception of the Zone 8, during which a screen-out occurred. The screen-out resulted in sub-optimal fracture development across Zone 8 and limited placement of proppant in the formation. The stage was interrupted safely and the unplaced proppant was removed from surface pipes and well tubing. Logging results indicate that there was no risk of proppant placement outside the consented discharge interval as a result of the screen-out.
- It is considered that the mitigation measures implemented by STOS were effective in ensuring there were no adverse environmental effects associated with fracturing operations.

### 2.1.3 KA-19 post-fracturing discharge report

The conclusions from the KA-19 post-fracturing discharge report are summarised as follows:

- A total of eight discrete zones were fractured over the period 14 November to 10 December 2014, at depths between 3,065 to 3,419 m TVDs.
- A total of 12,249 bbls (1,948 m<sup>3</sup>) of liquid was discharged across the nine fractured zones. The total proppant weight was 281 tonnes.
- By volume, 93.8% of the fluid injected was water, 4.6% was proppant, with the remaining 1.6% (32 m<sup>3</sup>) comprised of chemical additives.
- Pressure testing of the tubing and well head equipment was carried out prior to fracturing commencing. The maximum pressure exerted during the fracturing programme remained below the successfully tested levels at all times.
- Low activity tracers were used to directly measure the height of fracture network created during injection into each of the nine zones. The height of fracture networks created ranged from 0 to 32 m. The average width and length of fractures created in each zone were calculated using proprietary software, and ranged from 0 to 7.3 mm and 0 to 485 m, respectively.
- In contrast to previously completed hydraulic fracturing operations, the KA-19 was flowed for a period of three days after each zone was fractured, rather than a single flow-back event at the conclusion of all fracturing events. In total, 7,517 bbls (1,195 m<sup>3</sup>) of fluid was returned from the well over the period 16 November 2013 to 8 February 2014, leaving approximately 4,732 bbls (752 m<sup>3</sup>) of the fluids injected (39%) remaining in the formation. Additional fluid is likely to be returned back to the surface as the well produces.
- All return fluid from the KA-19 fracturing operations was disposed of by deep well injection, via the KW-02 injection well, as authorised by consent 1336-3.
- Screen-outs occurred during the stimulation of Zone 2 and Zone 6. The screen-outs resulted in sub-optimal fracture development across each zone and limited placement of proppant in the formation. Each stage was interrupted safely and the unplaced proppant was removed from surface pipes and well tubing. Logging results indicate that there was no risk of proppant placement outside the consented discharge interval as a result of either screen-outs. All other fracturing treatments were placed successfully.
- It is considered that the mitigation measures implemented by STOS were effective in ensuring there were no adverse environmental effects associated with fracturing operations.

## 2.2 Chemical sampling

### 2.2.1 KA-14 groundwater sampling survey

A total of four sites were sampled to monitor the effects of the hydraulic fracturing of the KA-14 well on local groundwater resources.

The results from site GND1689 indicate a minor increase in the concentrations of calcium, iron, magnesium and manganese in the post-fracturing sample, resulting in an increase in water hardness. The changes in the concentrations of these analytes are a result of natural variations in water composition and are unrelated to fracturing activities. Dissolved methane gas concentrations were lower in the post-fracturing sample than were measured pre-fracturing.

The post-fracturing results from site GND2333 showed only very minor variations across all analyses carried out in relation to baseline concentrations.

There were no traces of substances associated with hydraulic fracturing fluids, nor were any hydrocarbons detected at either site. The measured concentrations of all analytes were within the ranges expected for shallow Taranaki groundwater.

A full summary of results for all groundwater samples taken in relation to hydraulic fracturing of the KA-14 well is included below in Table 4. The certificates of analysis are included in Appendix III.

**Table 4** Results of groundwater sampling carried out in vicinity of the KA-14 well

Parameter	Unit	GND1689		GND2333	
		Pre-frac	Post-frac	Pre-frac	Post-frac
Sample date	-	29/04/2013	16/08/2013	23/04/2013	16/08/2013
Lab number	-	1129270.1	1168498.2	1127519.3	1168498.1
Sum of Anions	meq/L	6	6.5	2	2.1
Sum of Cations	meq/L	7.1	7.8	1.98	2.1
pH	pH Units	7.3	6.8	7	6.5
Total alkalinity	g/m <sup>3</sup> (CaCO <sub>3</sub> )	220	230	47	46
Bicarbonate	g/m <sup>3</sup> at 25°C	270	280	57	57
Total hardness	g/m <sup>3</sup> (CaCO <sub>3</sub> )	42	84	58	63
Electrical conductivity	mS/m	58.9	64.9	21.9	22.8
Total dissolved solids	g/m <sup>3</sup>	350	380	164	163
Dissolved barium	g/m <sup>3</sup>	0.091	0.125	0.0099	0.0138
Dissolved bromine	g/m <sup>3</sup>	-	0.29	-	0.086
Dissolved calcium	g/m <sup>3</sup>	7.3	14.2	13.6	14.2
Dissolved copper	g/m <sup>3</sup>	<0.0005	< 0.0005	0.0017	0.0017
Dissolved iron	g/m <sup>3</sup>	10.7	38	< 0.02	< 0.02
Dissolved magnesium	g/m <sup>3</sup>	5.6	11.7	5.9	6.6
Dissolved manganese	g/m <sup>3</sup>	0.73	2.2	0.0012	< 0.0005
Dissolved mercury	g/m <sup>3</sup>	< 0.00008	< 0.00008	< 0.00008	< 0.00008
Dissolved nickel	g/m <sup>3</sup>	0.0006	< 0.0005	< 0.0005	< 0.0005
Dissolved potassium	g/m <sup>3</sup>	22	24	4.4	4.3
Dissolved sodium	g/m <sup>3</sup>	122	92	16.1	16.5



Parameter	Unit	GND1689		GND2333	
		Pre-frac	Post-frac	Pre-frac	Post-frac
Dissolved zinc	g/m <sup>3</sup>	0.0036	0.068	0.0088	0.0016
Bromide	g/m <sup>3</sup>	0.14	-	0.09	-
Chloride	g/m <sup>3</sup>	59	65	17.9	18.9
Nitrite-N	g/m <sup>3</sup>	< 0.002	< 0.002	< 0.002	< 0.002
Nitrate-N	g/m <sup>3</sup>	0.004	0.006	3.5	3.4
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	0.005	0.008	3.5	3.4
Sulphate	g/m <sup>3</sup>	0.6	<0.5	16.7	18.2
Ethylene glycol	g/m <sup>3</sup>	< 4	< 4	< 4	6
Propylene glycol	g/m <sup>3</sup>	< 4	< 4	< 4	< 4
Methanol	g/m <sup>3</sup>	< 2	< 2	< 2	< 2
Benzene	g/m <sup>3</sup>	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Toluene	g/m <sup>3</sup>	0.0032	0.0019	< 0.0010	< 0.0010
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	< 0.0010	< 0.0010	< 0.0010
m&p-Xylene	g/m <sup>3</sup>	< 0.002	< 0.002	< 0.002	< 0.002
o-Xylene	g/m <sup>3</sup>	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Formaldehyde	g/m <sup>3</sup>	< 0.02	< 0.02	< 0.02	< 0.02
Dissolved ethane	g/m <sup>3</sup>	< 0.003	< 0.003	< 0.003	< 0.003
Dissolved ethylene	g/m <sup>3</sup>	< 0.004	< 0.004	< 0.004	< 0.004
Dissolved methane	g/m <sup>3</sup>	4.4	1.37	< 0.002	< 0.002
C7 - C9 hydrocarbons	g/m <sup>3</sup>	< 0.10	< 0.10	< 0.10	< 0.10
C10 - C14 hydrocarbons	g/m <sup>3</sup>	< 0.2	< 0.2	< 0.2	< 0.2
C15 - C36 hydrocarbons	g/m <sup>3</sup>	< 0.4	< 0.4	< 0.4	< 0.4
Total hydrocarbons	g/m <sup>3</sup>	< 0.7	< 0.7	< 0.7	< 0.7

## 2.2.2 KA-17 groundwater sampling survey

A total of three sites were sampled to monitor the effects of the hydraulic fracturing of the KA-17 well on local groundwater resources, however comparative analyses are only available for two of the sites due to a sampling error associated with GND2342. Site GND2342 is located on a local dairy farm which sources water from an on-site well (GND2342) and from the Waimate West water scheme. Separate hoses are used to provide water supply to the dairy shed from each source. Unfortunately, the pre-fracturing sample was taken from the hose supplying Waimate West water, not groundwater from GND2342. This error was not discovered until post-fracturing sampling was carried out December 2013. Data from the post-fracturing sample are within ranges typical of shallow Taranaki groundwater.

The results of the laboratory analysis of samples from site GND2349 indicate a slight increase in potassium concentrations in the post-fracturing sample. Post-fracturing samples from both GND2349 and GND2352 had lower sulphate concentrations than in pre-fracturing samples.

Toluene was detected at concentrations marginally greater than the laboratory detection limit in the pre-fracturing sample taken from GND2349. The exceedance above the limit of detection is within the margin of error for the test method. The

toluene concentration in the post-fracturing sample from this site was below detection limits.

No dissolved methane was detected in the sample taken from GND2342 (post-fracturing). Dissolved methane concentrations in samples obtained from GND2349 and GND2352 were within the expected ranges for shallow groundwater across Taranaki. The methane/ethane ratios indicate that the gas is biogenic in origin and not derived from deep gas reservoirs.

There were no traces of substances associated with hydraulic fracturing fluids, or hydrocarbons relating to fracturing activities in any of the post-fracturing samples obtained.

A full summary of results for all groundwater samples taken in relation to hydraulic fracturing of the KA-17 well is included below in Table 5. The certificates of analysis are included in Appendix III.

**Table 5** Results of groundwater sampling carried out in vicinity of the KA-17 well

Parameter	Unit	GND2342	GND2349		GND2352	
		Post-frac	Pre-frac	Post-frac	Pre-frac	Post-frac
Sample date	-	06/12/2013	01/05/2013	09/12/2013	30/04/2013	05/12/2013
Lab number	-	1212979.2	1130620.2	1213570.1	1130074.1	1212436.2
Sum of Anions	meq/L	3.4	3.3	3	3.3	3.2
Sum of Cations	meq/L	3.4	3.3	3.9 #1	3.8	3.2
pH	pH Units	6.7	6.4	6.8	6.2	6.6
Total alkalinity	g/m <sup>3</sup> (CaCO <sub>3</sub> )	75	85	94	41	68
Bicarbonate	g/m <sup>3</sup> at 25°C	91	104	115	50	82
Total hardness	g/m <sup>3</sup> (CaCO <sub>3</sub> )	70	61	65	87	82
Electrical conductivity	mS/m	35.9	34	31.1	37.9	35.6
Total dissolved solids	g/m <sup>3</sup>	240	240	230	260	220
Dissolved barium	g/m <sup>3</sup>	0.021	0.052	0.048	0.023	0.0196
Dissolved bromine	g/m <sup>3</sup>	0.168	-	0.16	-	0.178
Dissolved calcium	g/m <sup>3</sup>	14.3	13.6	14	18.1	18.2
Dissolved copper	g/m <sup>3</sup>	0.0028	< 0.0005	< 0.0005	< 0.0005	< 0.0005
Dissolved iron	g/m <sup>3</sup>	< 0.02	16.2	18.5	3.6	1.85
Dissolved magnesium	g/m <sup>3</sup>	8.3	6.7	7.3	10.1	8.8
Dissolved manganese	g/m <sup>3</sup>	0.0009	0.38	0.44	0.197	0.12
Dissolved mercury	g/m <sup>3</sup>	< 0.00008	< 0.00008	< 0.00008	< 0.00008	< 0.00008
Dissolved nickel	g/m <sup>3</sup>	< 0.0005	< 0.0005	< 0.0005	0.005	0.0041
Dissolved potassium	g/m <sup>3</sup>	12.3	7.7	18.1	6	5.6
Dissolved sodium	g/m <sup>3</sup>	38	26	32	40	32
Dissolved zinc	g/m <sup>3</sup>	0.013	2.9	1.92	0.023	0.0155
Bromide	g/m <sup>3</sup>	-	-	-	0.12	-
Chloride	g/m <sup>3</sup>	35	40	38	37	38
Nitrite-N	g/m <sup>3</sup>	< 0.002	0.003*	0.012	0.151	0.018
Nitrate-N	g/m <sup>3</sup>	1.42	< 0.002	< 0.002	2.9	4.2
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	1.42	< 0.002*	0.012	3	4.2

Parameter	Unit	GND2342	GND2349		GND2352	
		Post-frac	Pre-frac	Post-frac	Pre-frac	Post-frac
Sulphate	g/m <sup>3</sup>	37	22	< 0.5	61	25
Ethylene glycol	g/m <sup>3</sup>	< 4	< 4	< 4	< 4	< 4
Propylene glycol	g/m <sup>3</sup>	< 4	< 4	< 4	< 4	< 4
Methanol	g/m <sup>3</sup>	< 2	< 2	< 2	< 2	< 2
Benzene	g/m <sup>3</sup>	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Toluene	g/m <sup>3</sup>	< 0.0010	0.0012	< 0.0010	< 0.0010	< 0.0010
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
m&p-Xylene	g/m <sup>3</sup>	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
o-Xylene	g/m <sup>3</sup>	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Formaldehyde	g/m <sup>3</sup>	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Dissolved ethane	g/m <sup>3</sup>	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Dissolved ethylene	g/m <sup>3</sup>	< 0.003	< 0.004	< 0.003	< 0.004	< 0.003
Dissolved methane	g/m <sup>3</sup>	< 0.002	1.36	2.1	0.007	0.068
C7 - C9 hydrocarbons	g/m <sup>3</sup>	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
C10 - C14 hydrocarbons	g/m <sup>3</sup>	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2
C15 - C36 hydrocarbons	g/m <sup>3</sup>	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4
Total hydrocarbons	g/m <sup>3</sup>	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7

\* Matrix interferences required sample dilution prior to analysis, resulting in a higher detection limit than usually achieved

### 2.2.3 KA-19 groundwater sampling survey

A total of four sites were sampled to monitor the effects of the hydraulic fracturing of the KA-19 well on local groundwater resources.

The results of the laboratory analysis of samples from sites GND0093 and GND2357 indicate an increase in pH between pre and post-fracturing samples; however field measurements of pH show much closer agreement. The field notes from the post-fracturing sampling of GND2357 indicate the sample collected for the analysis of metals concentration could not be field filtered. This is the likely cause of the increased iron concentration measured in this sample in comparison to the baseline sample. The post-fracturing results from sites GND0093, GND2348 and GND2357 all show a reduction in sulphate in comparison to baseline concentrations.

Benzene was detected at concentrations marginally above the laboratory detection limit in the pre-fracturing sample taken from GND2348. The exceedance above the limit of detection is within the margin of error for the test method. The benzene concentration in the post-fracturing sample from this site was below detection limits.

Hydrocarbons (C10 to C36 range) were detected in the pre-fracturing sample taken from GND2357, the emergency water supply bore located on the KA9 wellsite. The total hydrocarbon concentration in the sample was 11.8 mg/L. The post-fracturing sample, taken approximately eight months following the pre-fracturing sample, returned hydrocarbon concentrations below laboratory detection limits. Further investigation revealed that during the period between pre and post-fracturing sampling taking place, STOS carried out some remedial works at the KA9 wellsite as part of their overall Kapuni wellsite remediation programme. The works involved the excavation and removal of impacted soils from the wellsite. The remedial works are



Parameter	Unit	GND0093		GND2011		GND2348		GND2357	
		Pre-frac	Post-frac	Pre-frac	Post-frac	Pre-frac	Post-frac	Pre-frac	Post-frac
Propylene glycol	g/m <sup>3</sup>	< 4	< 4	< 4	< 4	< 4	< 4	< 4	< 4
Methanol	g/m <sup>3</sup>	< 2	< 2	< 2	< 2	< 2	2	< 2	< 2
Benzene	g/m <sup>3</sup>	< 0.0010	< 0.0010	< 0.0010	< 0.0010	0.0019	< 0.0010	< 0.0010	< 0.0010
Toluene	g/m <sup>3</sup>	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
m&p-Xylene	g/m <sup>3</sup>	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002	< 0.002
o-Xylene	g/m <sup>3</sup>	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010	< 0.0010
Formaldehyde	g/m <sup>3</sup>	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02	< 0.02
Dissolved ethane	g/m <sup>3</sup>	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003	< 0.003
Dissolved ethylene	g/m <sup>3</sup>	< 0.004	< 0.003	< 0.003	< 0.003	< 0.004	< 0.003	< 0.004	< 0.003
Dissolved methane	g/m <sup>3</sup>	3.1	2.1	1.54	3.6	0.65	1.02	3.7	8
C7 - C9 hydrocarbons	g/m <sup>3</sup>	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10	< 0.10
C10 - C14 hydrocarbons	g/m <sup>3</sup>	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	< 0.2	5.2	< 0.2
C15 - C36 hydrocarbons	g/m <sup>3</sup>	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	< 0.4	6.6	< 0.4
Total hydrocarbons	g/m <sup>3</sup>	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	< 0.7	11.8	< 0.7

\* Matrix interferences required sample dilution prior to analysis, resulting in a higher detection limit than usually achieved

## 2.2.4 Hydraulic fracturing and return fluids

The results of the analyses carried out on samples of the hydraulic fracturing fluid used in the treatment of the each of the KA-14, KA-17 and KA-19 wells are summarised below in Table 7. The certificates of analysis are included in Appendix IV.

Due to the viscosity of the sample of the fluid samples obtained, the range of analyses that were able to be performed on each sample were limited. The sample taken was gel like in composition, as opposed to a liquid. While the fracturing fluid is predominantly comprised of water, specialised additives are used to increase the viscosity of the fluid in order to suspend the proppant prior to injection.

Due to the volume of water used in the fracturing fluid mixture, all additives included in the mixture are highly dilute.

**Table 7** Results of hydraulic fracturing fluid sampling

Parameter	Unit	KA-14	KA-17	KA-19
Sample Date	-	13/06/2013	28/07/2013	14/11/2013
Lab Number	-	1145869.1	1163287.1	1212957.1
Ethylene glycol	g/m <sup>3</sup>	143	250	127
Propylene glycol	g/m <sup>3</sup>	< 4	< 4	< 4
Methanol	g/m <sup>3</sup>	< 2	4	3
Benzene	g/m <sup>3</sup>	< 0.0010	0.053	0.001
Toluene	g/m <sup>3</sup>	0.0025	0.039	0.0091
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	0.0021	0.0045
m&p-Xylene	g/m <sup>3</sup>	< 0.002	0.006	0.025
o-Xylene	g/m <sup>3</sup>	0.0019	0.0032	0.0129

Parameter	Unit	KA-14	KA-17	KA-19
C7 - C9 hydrocarbons	g/m <sup>3</sup>	< 0.4	0.79	5.2
C10 - C14 hydrocarbons	g/m <sup>3</sup>	48	37	530
C15 - C36 hydrocarbons	g/m <sup>3</sup>	102	92	1,220
Total hydrocarbons	g/m <sup>3</sup>	150	130	1,750

A composite sample of return fluids from each well was submitted for analysis. Return fluids are comprised of a mixture of hydraulic fracturing fluids and formation fluids produced from the target reservoir, following the completion of the hydraulic fracturing process. The relative concentrations of each contributing fluid type change as the volume of fluid produced from the well increases. Immediately following the opening of the well post-fracturing, a high proportion of the fluid returning to the wellhead is the fluid injected during the hydraulic fracturing process. As the volume of fluid produced from the well increases, the proportion of hydraulic fracturing fluid reduces in relation to formation fluids.

The results of the analyses carried out on the return fluid samples obtained following the hydraulic fracturing of each of the KA-14, KA-17 and KA-19 wells are summarised below in Table 8 and certificates of analysis are included in Appendix IV. The relatively low levels of salinity (sodium and chloride) in each sample indicate that the composite samples prepared contained a greater proportion of fluids introduced during fracturing activities (comprised predominantly of freshwater) than saline reservoir fluids. The elevated glycol concentrations also indicate a high proportion of fracturing fluid in the return fluid samples submitted for analysis. The presence of elevated levels of hydrocarbon and BTEX compounds are indicative of fluids being drawn from a hydrocarbon bearing reservoir.

**Table 8** Results of hydraulic fracturing return fluid sampling

Parameter	Unit	KA-14	KA-17	KA-19
Sample Date	-	27/06/2013	10/08/2013	24/11/2013
Lab Number	-	1150723.1	1168231.1	1212980.1
pH	pH Units	7.7	7	7.1
Total Alkalinity	g/m <sup>3</sup> (CaCO <sub>3</sub> )	540	930	3,000
Bicarbonate	g/m <sup>3</sup>	-		3,020
Total Hardness	g/m <sup>3</sup> (CaCO <sub>3</sub> )	41	42	125
Electrical Conductivity	mS/m	137.6	224	851
Total Dissolved Solids	g/m <sup>3</sup>	-		9,300
Dissolved Barium	g/m <sup>3</sup>	0.087	0.151	2
Dissolved Bromine	g/m <sup>3</sup>	< 0.5	0.6	5.2***
Dissolved Calcium	g/m <sup>3</sup>	13	11	40
Dissolved Copper	g/m <sup>3</sup>	0.099	0.007	0.057
Dissolved Iron	g/m <sup>3</sup>	10	12	4.4
Dissolved Magnesium	g/m <sup>3</sup>	2	4	6
Dissolved Manganese	g/m <sup>3</sup>	0.172	0.73	2.3
Dissolved Mercury	g/m <sup>3</sup>	< 0.011	< 0.011	< 0.011
Dissolved Nickel	g/m <sup>3</sup>	0.07	0.09	0.36

Parameter	Unit	KA-14	KA-17	KA-19
Dissolved Potassium	g/m <sup>3</sup>	6	11	40
Dissolved Sodium	g/m <sup>3</sup>	210	540	2,100
Dissolved Sulphur	g/m <sup>3</sup>	< 5	9	30
Dissolved Zinc	g/m <sup>3</sup>	0.17	0.05	0.11
Chloride	g/m <sup>3</sup>	250	176	1,180
Nitrite-N	g/m <sup>3</sup>	0.11*	< 0.002	29
Nitrate-N	g/m <sup>3</sup>	< 0.02	0.003	23
Nitrate	g/m <sup>3</sup>	< 0.09	0.011	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	0.10**	0.003	53
Sulphate	g/m <sup>3</sup>	< 15	26	90
Ethylene glycol	g/m <sup>3</sup>	280	1,910	111
Propylene glycol	g/m <sup>3</sup>	115	< 20	< 4
Methanol	g/m <sup>3</sup>	< 20	< 20	< 2
Benzene	g/m <sup>3</sup>	0.003	0.93	2
Toluene	g/m <sup>3</sup>	0.053	3.8	3.1
Ethylbenzene	g/m <sup>3</sup>	0.012	0.32	0.21
m&p-Xylene	g/m <sup>3</sup>	0.041	4.8	1.48
o-Xylene	g/m <sup>3</sup>	0.023	0.7	0.52
Formaldehyde	g/m <sup>3</sup>	2.7	< 0.15	< 0.02
Dissolved Ethane	g/m <sup>3</sup>	< 0.003	0.116	0.3
Dissolved Ethylene	g/m <sup>3</sup>	< 0.004	< 0.004	< 0.003
Dissolved Methane	g/m <sup>3</sup>	< 0.002	0.27	1.38
C7 - C9 hydrocarbons	g/m <sup>3</sup>	3.7	66	15.7
C10 - C14 hydrocarbons	g/m <sup>3</sup>	430	380	140
C15 - C36 hydrocarbons	g/m <sup>3</sup>	750	820	270
Total hydrocarbons	g/m <sup>3</sup>	1,190	1,270	420

\* Due to sample type Methanol analysis was performed on a smaller amount of sample, resulting in a higher detection limit.

\*\* It is noted that the result for Nitrite-N was greater than that for Nitrate-N + Nitrite-N, but is within the analytical variation of these methods.

\*\*\* It should be noted that the replicate analyses performed on this sample as part of Quality Assurance procedures showed greater variation than would normally be expected. This may reflect the heterogeneity of the sample.

## 2.3 Biomonitoring surveys

The Council's standard 'kick-sampling' and 'vegetation sweep' sampling techniques were used to collect streambed macroinvertebrates from the Kapuni Stream and tributaries of the Inaha stream and Waiokura Stream in relation to fracturing at the KA1/7/19/20, KA4/14 and KA6/11/17 wellsites. The intention of these surveys was to determine the health of the macroinvertebrate communities prior to fracturing, which then allowed a comparison with the health of the macroinvertebrate communities once fracturing had been completed at each wellsite. Samples were processed to provide number of taxa (richness), MCI and SQMCI<sub>s</sub> scores for each site.

The MCI is a measure of the overall sensitivity of the macroinvertebrate community to the effects of organic pollution in stony streams. It is based on the presence/absence of taxa with varying degrees of sensitivity to environmental conditions. The SQMCI<sub>s</sub> takes into account taxa abundances as well as sensitivity to pollution. It may indicate

subtle changes in communities, and therefore be the more relevant index if non-organic impacts are occurring. Significant differences in either the MCI or the SQMCI<sub>s</sub> between sites indicate the degree of adverse effects (if any) of the discharges being monitored.

### **2.3.1 KA-14 well (KA4/14 wellsite)**

The pre-fracturing survey of the KA4/14 wellsite, undertaken in May 2012 in the unnamed tributary of the Waiokura Stream, found that the macroinvertebrate community contained moderately high community richnesses. The MCI score was similar to that recorded at 'control' sites in similar streams at comparable altitudes whereas the SQMCI<sub>s</sub> score was significantly higher.

The post-fracturing survey of KA4/14 wellsite, undertaken in July 2013, found that the taxa richness and MCI score recorded in the unnamed tributary of the Waiokura Stream had decreased slightly from the pre-fracturing survey; however it was still similar to scores recorded in 'control' sites in similar streams at comparable altitudes. A significant decrease in SQMCI<sub>s</sub> score was recorded between the pre-fracturing and post-fracturing surveys, however the score was still significantly higher than the median score of 'control' sites in similar streams at comparable altitudes (Stark, 1998). The significant decrease in SQMCI<sub>s</sub> score can be attributed to the change in substrate recorded and to a change in sampling method used between the two surveys, rather than due to any discharges caused by fracturing.

### **2.3.2 KA-17 well (KA6/11/17 wellsite)**

The results of the biomonitoring surveys carried out in the tributary of the Inaha Stream, adjacent to the KA6/11/17 wellsite, found a decrease in MCI scores at both the upstream control site and the downstream site post-fracturing. The decrease in MCI scores can be attributed to the greater length of time between 'freshes' between sampling events. Freshes are important in maintaining healthy stream communities as they remove excess silt and nuisance periphyton and this was possibly a reason why the percentage of silt, normally negatively correlated with MCI score, increased from 80% to 100%. The pre-fracturing survey (May 2012) was conducted 10 days after a 3 x median base flow fresh and 45 days after a 7 x median base flow fresh, while the post-fracturing survey (November 2013) was completed 36 days after a 3 x median base flow fresh and 607 days after a 7 x median base flow fresh. The SQMCI<sub>s</sub> score however, did not change significantly between the two surveys for the downstream site, or from that recorded at the upstream site. The fact that changes occurred at the control site upstream of the wellsite discharge location means that the changes in community composition were unrelated to any discharges from the KA6/11/17 wellsite.

### **2.3.3 KA-19 well (KA1/7/19/20 wellsite)**

The results of the biomonitoring surveys carried out in the tributary of the Kapuni Stream, adjacent to the KA1/7/19/20 wellsite, showed no significant changes in MCI and SQMCI<sub>s</sub> scores post-fracturing.

A full report on the biomonitoring carried out in the vicinity of each wellsite is included in Appendix V.



## 2.4 Investigations, interventions, and incidents

The monitoring programme for the period under review was based on what was considered to be an appropriate level of monitoring, review of data, and liaison with the consent holder. During the duration of monitoring 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 STOS' resource consents or provisions in Regional Plans.

### **3. Discussion**

#### **3.1 Environmental effects of hydraulic fracturing on useable freshwater resources**

The primary objective of the monitoring programme implemented by the Council was to assess whether the hydraulic fracturing activities undertaken by STOS during the period being reported had resulted in any adverse effects on useable freshwater resources. As defined in the conditions of the relevant resource consents, useable freshwater includes both groundwater and surface water systems.

To assess the level of environmental performance and compliance by STOS 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 each hydraulically fractured well. The surface water monitoring component of the programme comprised biomonitoring surveys carried out in surface water systems adjacent to each wellsite from which hydraulic fracturing occurred. Both groundwater and surface water systems were 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 KA-14 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 are unrelated to fracturing activities. The measured concentrations of all analytes were within the ranges expected for shallow Taranaki groundwater.

The results of post-fracturing groundwater sampling carried out in the vicinity of the KA-17 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. A minor trace of toluene was detected in one pre-fracturing sample. The toluene concentration in the post-fracturing sample from the same site was below the laboratory detection limit and therefore the presence of toluene was unrelated to fracturing activities at the site. Dissolved methane concentrations at all sites sampled in relation to fracturing of the KA-17 were within expected ranges for shallow groundwater across Taranaki. Furthermore, the methane/ethane ratios indicate that the methane gas is biogenic in origin and not derived from deep gas reservoirs.

The results of post-fracturing groundwater sampling carried out in the vicinity of the KA-19 well showed some minor variations in pH and dissolved metals concentrations in comparison to baseline results. The changes in pH levels are a result of natural chemical processes that are likely to have occurred within the samples themselves during the time period between sampling and analysis in the laboratory. The variations in metals concentrations are primarily attributed to variations in field sample preparation. A minor trace of benzene was detected in one pre-fracturing sample. The benzene concentration in the post-fracturing sample from the same site was below the laboratory detection limit and therefore the presence of benzene was unrelated to fracturing activities at the site. Hydrocarbons were detected in the pre-fracturing

sample taken from an emergency water supply bore located on the KA9 wellsite, but were not detected in the post-fracturing sample. Dissolved methane concentrations at all sites sampled in relation to fracturing of the KA-19 well were within expected ranges for shallow groundwater across Taranaki. Furthermore, the methane/ethane ratios indicate that the methane gas is biogenic in origin and not derived from deep gas reservoirs.

The results of all biomonitoring surveys undertaken as part of the monitoring programme show that hydraulic fracturing operations did not result in adverse effects on local surface water resources.

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

### 3.2 Evaluation of performance

A tabular summary of the consent holder's compliance record for the period under review is set out in Tables 9 to 11.

**Table 9** Summary of performance for Consent 7995-1: To discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3,000 mTVDss beneath the KA1/7/19/20 wellsite

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Any discharge shall occur below 3,000 mTVDss	Assessment of consent holder submitted data	Yes
2. Exercise of consent shall not result in any contaminants reaching any useable freshwater (groundwater or surface water)	Results of groundwater and surface water monitoring	Yes
3. Consent holder shall undertake sampling programme	Development and certification of a Monitoring Programme	Yes
4. Sampling programme shall follow recognised field procedures and be analysed for a specified range of chemical parameters	Development and certification of a Monitoring Programme and assessment of results	Yes
5. 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
6. Well and equipment pressure testing to be carried out prior to any hydraulic fracturing programme commencing	Assessment of consent holder submitted data	Yes
7. A pre-fracturing discharge report is to be provided to the Council 14 days prior to the second and subsequent discharges	Pre-fracturing discharge report received	Yes
8. Consent holder shall notify the Council of hydraulic fracturing discharge	Notification received	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
9. A post-fracturing discharge report is to be provided to the Council within 60 days after the hydraulic fracturing programme is completed	Post-fracturing discharge report received	Yes
10. The reports outlined in conditions 7 and 9 must be emailed to consents@trc.govt.nz	Reports received via email	Yes
11. 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
12. Consent holder to adopt best practicable option at all times	Site inspections, sampling and assessment of consent holder submitted data	Yes
13. No hydrocarbon based hydraulic fracturing fluid shall be discharged	Assessment of consent holder submitted data and sampling of fracturing fluid	Yes
14. 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		<b>High</b>
Overall assessment of administrative performance and compliance in respect of this consent		<b>High</b>

**Table 10** Summary of performance for Consent 7996-1: To discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3000 mTVDss beneath the KA4/14 wellsite

Condition requirement	Means of monitoring during period under review	Compliance achieved?
15. Any discharge shall occur below 3,000 mTVDss	Assessment of consent holder submitted data	Yes
16. Exercise of consent shall not result in any contaminants reaching any useable freshwater (groundwater or surface water)	Results of groundwater and surface water monitoring	Yes
17. Consent holder shall undertake sampling programme	Development and certification of a Monitoring Programme	Yes
18. Sampling programme shall follow recognised field procedures and be analysed for a specified range of chemical parameters	Development and certification of a Monitoring Programme and assessment of results	Yes
19. 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
20. Well and equipment pressure testing to be carried out prior to any hydraulic fracturing programme commencing	Assessment of consent holder submitted data	Yes

21. A pre-fracturing discharge report is to be provided to the Council 14 days prior to the second and subsequent discharges	Pre-fracturing discharge report received	Yes
22. Consent holder shall notify the Council of hydraulic fracturing discharge	Notification received	Yes
23. A post-fracturing discharge report is to be provided to the Council within 60 days after the hydraulic fracturing programme is completed	Post-fracturing discharge report received	Yes
24. The reports outlined in conditions 7 and 9 must be emailed to consents@trc.govt.nz	Reports received via email	Yes
25. 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
26. Consent holder to adopt best practicable option at all times	Site inspections, sampling and assessment of consent holder submitted data	Yes
27. No hydrocarbon based hydraulic fracturing fluid shall be discharged	Assessment of consent holder submitted data and sampling of fracturing fluid	Yes
28. 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		<b>High</b>
Overall assessment of administrative performance and compliance in respect of this consent		<b>High</b>

**Table 11** Summary of performance for Consent 7998-1: To discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3000 mTVDss beneath the KA6/11/17 wellsite

Condition requirement	Means of monitoring during period under review	Compliance achieved?
29. Any discharge shall occur below 3,000 mTVDss	Assessment of consent holder submitted data	Yes
30. Exercise of consent shall not result in any contaminants reaching any useable freshwater (groundwater or surface water)	Results of groundwater and surface water monitoring	Yes
31. Consent holder shall undertake sampling programme	Development and certification of a Monitoring Programme	Yes
32. Sampling programme shall follow recognised field procedures and be analysed for a specified range of chemical parameters	Development and certification of a Monitoring Programme and assessment of results	Yes
33. 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

34. Well and equipment pressure testing to be carried out prior to any hydraulic fracturing programme commencing	Assessment of consent holder submitted data	Yes
35. A pre-fracturing discharge report is to be provided to the Council 14 days prior to the second and subsequent discharges	Pre-fracturing discharge report received	Yes
36. Consent holder shall notify the Council of hydraulic fracturing discharge	Notification received	Yes
37. A post-fracturing discharge report is to be provided to the Council within 60 days after the hydraulic fracturing programme is completed	Post-fracturing discharge report received	Yes
38. The reports outlined in conditions 7 and 9 must be emailed to consents@trc.govt.nz	Reports received via email	Yes
39. 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
40. Consent holder to adopt best practicable option at all times	Site inspections, sampling and assessment of consent holder submitted data	Yes
41. No hydrocarbon based hydraulic fracturing fluid shall be discharged	Assessment of consent holder submitted data and sampling of fracturing fluid	Yes
42. 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 2012-2014 monitoring period, STOS demonstrated a high level of environmental and administrative performance and compliance with its resource consents as defined in Section 1.1.4.

### 3.3 Alterations to monitoring programmes for 2014-2015

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 2014-2015 year a further round of groundwater sampling be carried out across all sites previously surveyed to assess for any delayed effects on local groundwater resources.

### **3.4 Exercise of optional review of consent**

Resource consents 7995-1, 7996-6 and 7996-8 provide for an optional review of the consent on an annual basis, with the next optional review date being June 2015. Condition 14 of each of the consents 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 during the 2014-2015 year, a further round of groundwater sampling be carried out across all sites previously surveyed to assess for any delayed effects on local groundwater resources.
2. THAT following an assessment of the results of the groundwater sampling recommended above, a review be undertaken to determine if any further monitoring is warranted, or whether the programmes can be discontinued, provided no further fracturing occurs at any of the wellsites which were the subject of this programme.
3. THAT the option for a review of resource consents in June 2015, as set out in condition 14 of the consents, 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.
Bbls	Barrel. Unit of measure used in the oil and gas industry (equivalent to approximately 159 litres).
Fresh	Elevated flow in a stream, such as after heavy rainfall.
g/m <sup>3</sup>	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.
Macroinvertebrate	An invertebrate that is large enough to be seen without the use of a microscope.
MCI	Macroinvertebrate community index; a numerical indication of the state of biological life in a stream that takes into account the sensitivity of the taxa present to organic pollution in stony habitats.
Median flow	The flow that is exceeded 50% of the time over a given time period.
mS/m	Millisiemens per metre.
m <sup>3</sup>	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.
Physicochemical	Measurement of both physical properties (e.g. temperature, clarity, density) and chemical determinants (e.g. metals and nutrients) to characterise the state of an environment.
Resource consent	Refer Section 87 of the RMA. Resource consents include land use consents (refer Sections 9 and 13 of the RMA), coastal permits (Sections 12, 14 and 15), water permits (Section 14) and discharge permits (Section 15).
RMA	<i>Resource Management Act</i> 1991 and including all subsequent amendments.
Screen Out	A condition that occurs when the solids carried in a treatment fluid, such as proppant in a fracture fluid, create a bridge across the perforations or similar restricted flow area. This creates a sudden and significant restriction to fluid flow that causes a rapid rise in pump pressure.
SQMCI	Semi quantitative macroinvertebrate community index.
Workover	The repair or stimulation of an existing production well for the purpose of restoring, prolonging or enhancing the production of hydrocarbons.

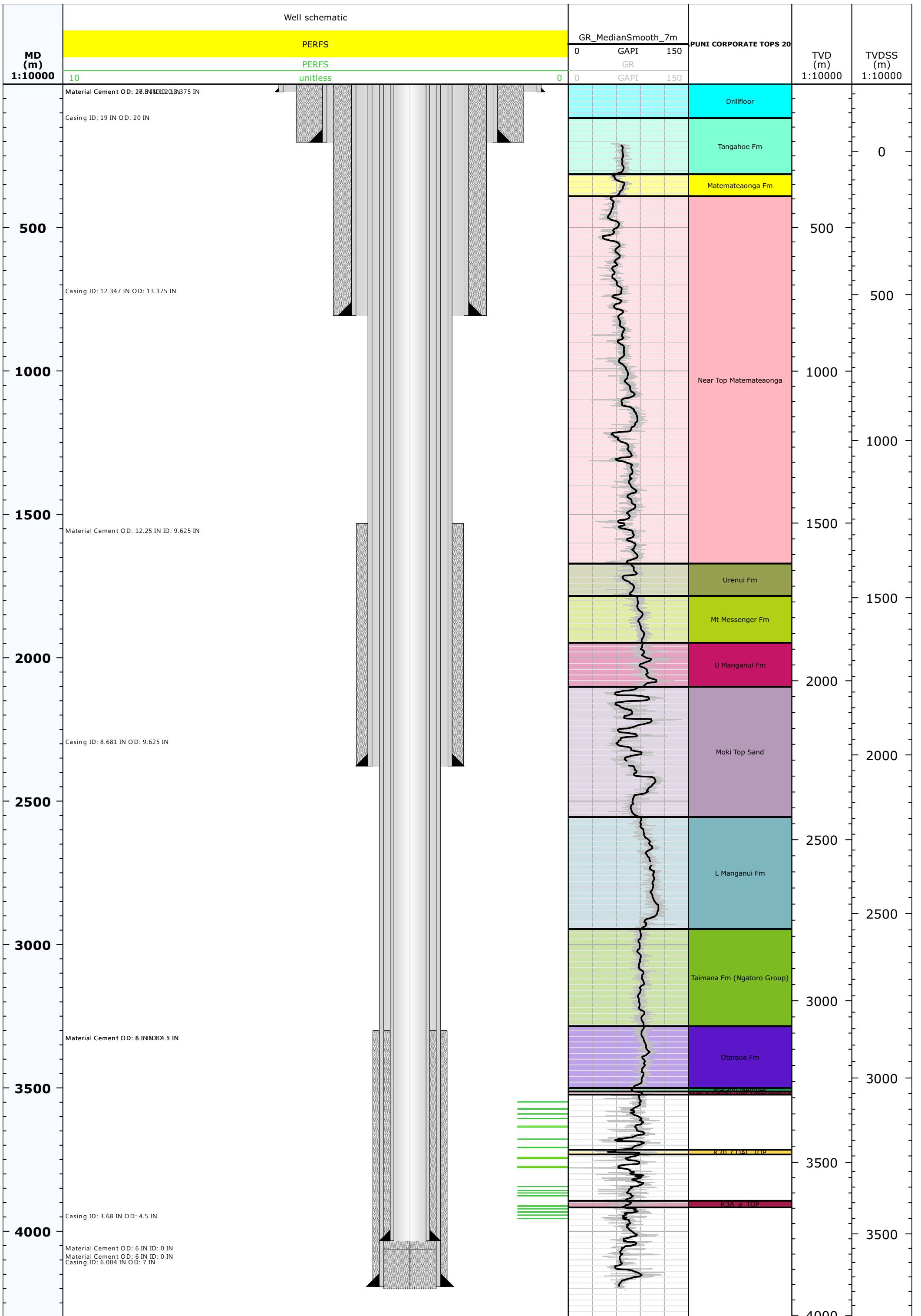
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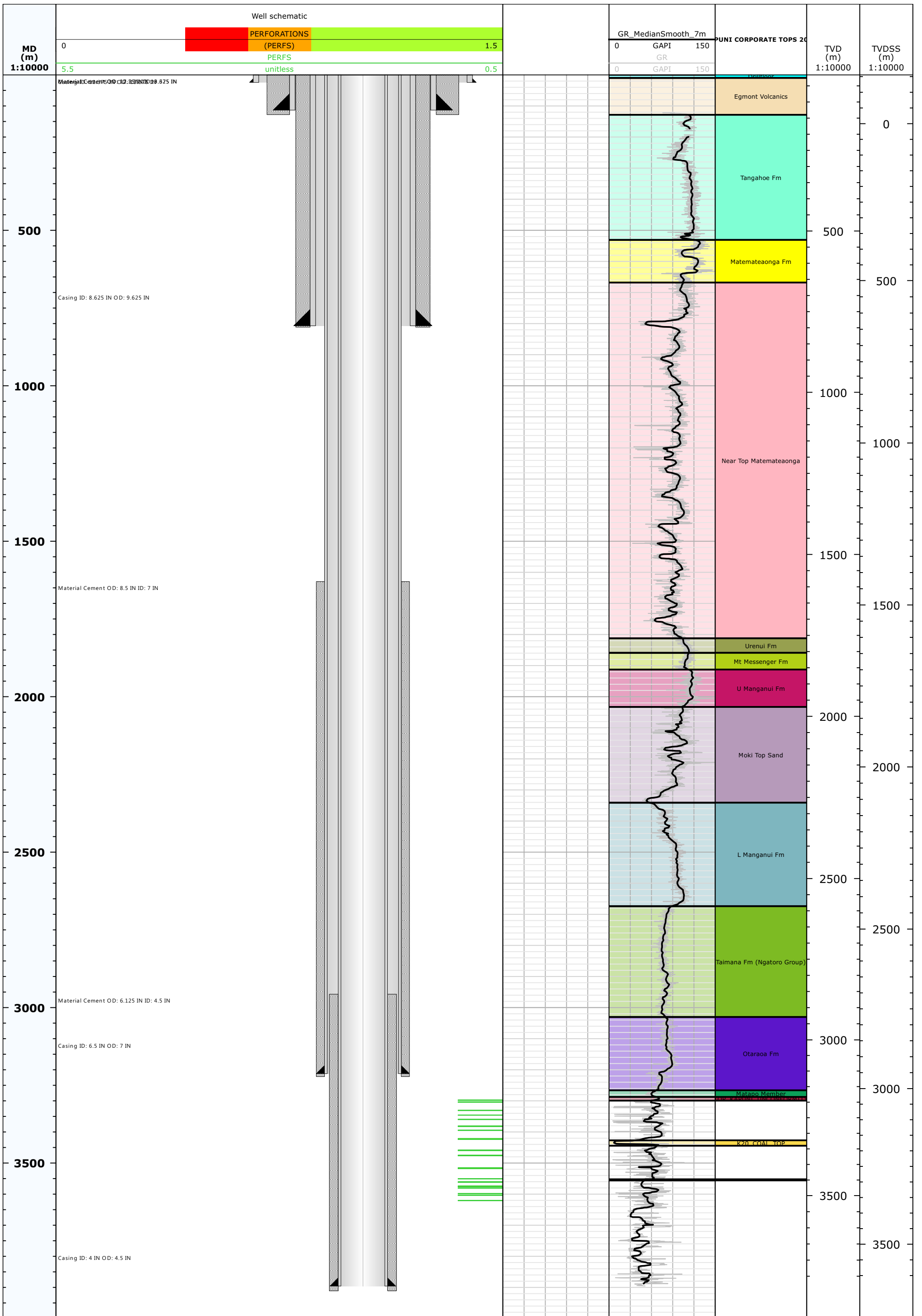
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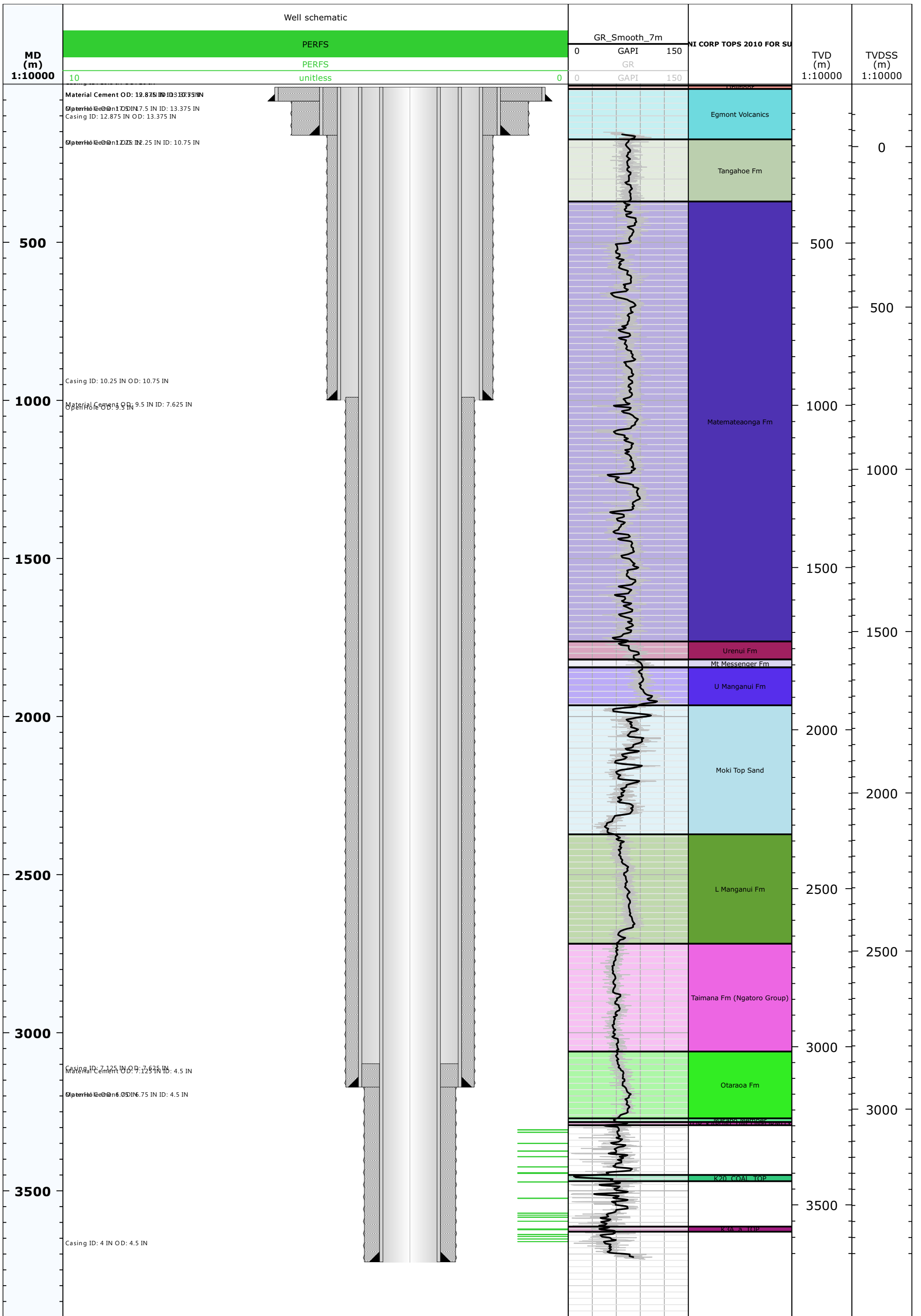
## **Appendix I**

### **Well construction geological stratigraphy schematics**













## **Appendix II**

### **Resource consents held by STOS**



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

Name of  
Consent Holder: Shell Todd Oil Services Ltd  
Private Bag 2035  
NEW PLYMOUTH 4342

Decision Date: 28 March 2012

Commencement  
Date: 28 March 2012

**Conditions of Consent**

Consent Granted: To discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3000 mTVDss beneath the KA-1/7/19/20 wellsite at or about (NZTM) 1701152E-5630141N

Expiry Date: 1 June 2017

Review Date(s): June 2012, June 2013, June 2014, June 2015, June 2016

Site Location: KA-1/7/19/20 wellsite, 360 Palmer Road, Kapuni

Legal Description: Lot 2 DP 11138 Blk XVI Kaupokonui SD  
(Discharge source & site)

Catchment: Kapuni

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

### General condition

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

### Special conditions

1. The discharge point shall be deeper than 3000 mTVDss.

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

2. The consent holder shall ensure that the exercise of this consent does not result in contaminants reaching any useable fresh water (groundwater or surface water). Usable fresh groundwater is defined as any groundwater having a Total Dissolved Solids concentration of less than 1000 mg/l.

3. The consent holder shall undertake a programme of sampling and testing that monitors the effects of the exercise of this consent on fresh water resources to assess compliance with condition 2 (the 'Monitoring Programme'). The Monitoring Programme shall be certified by the Chief Executive, Taranaki Regional Council ('the Chief Executive'), before this consent is exercised, and shall include:

- (a) the location of the discharge point(s);
- (b) the location of sampling sites; and
- (c) sampling frequency with reference to a hydraulic fracturing programme.

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

- (a) pH;
- (b) conductivity;
- (c) total dissolved solids;
- (d) major ions (Ca, Mg, K, Na, total alkalinity, bromide, chloride, nitrate-nitrogen, and sulphate);
- (e) trace metals (barium, copper, iron, manganese, nickel, and zinc);
- (f) total petroleum hydrocarbons;
- (g) formaldehyde;
- (h) dissolved methane and ethane gas;
- (i) methanol;
- (j) glycols;
- (k) benzene, toluene, ethylbenzene, and xylenes (BTEX); and
- (l) carbon-13 composition of any dissolved methane gas discovered ( $^{13}\text{C-CH}_4$ ).

Note: *The samples required, under conditions 3 and 4, could be taken and analysed by the Council or other contracted party on behalf of the consent holder.*

5. All sampling and analysis shall be undertaken in accordance with a *Sampling and Analysis Plan*, which shall be submitted to the Chief Executive for review and certification before the first sampling is undertaken. This plan shall specify the use of standard protocols recognised to constitute good professional practice including quality control and assurance. An International Accreditation New Zealand (IANZ) accredited laboratory shall be used for all sample analysis. Results shall be provided to the Chief Executive within 30 days of sampling and shall include supporting quality control and assurance information. These results will be used to assess compliance with condition 2.

*Note: The Sampling and Analysis Plan may be combined with the Monitoring Programme required by condition 2.*

6. The consent holder shall undertake well and equipment pressure testing prior to any hydraulic fracture programme on a given well to ensure any discharge will not affect the integrity of the well and hydraulic fracturing equipment.
7. Any hydraulic fracture discharge shall only occur after the consent holder has provided a comprehensive 'Pre-fracturing discharge report' to the Chief Executive. The report shall be provided at least 14 days before the discharge is proposed to commence and shall detail the hydraulic fracturing programme proposed, including as a minimum:
  - (a) the specific well in which each discharge is to occur and the intended fracture interval(s) ('fracture interval' is the discrete subsurface zone to receive a hydraulic fracture treatment);
  - (b) the number of discharges proposed and the geographical position (i.e. depth and lateral position) of each intended discharge point;
  - (c) the total volume of fracture fluid planned to be pumped down the well and its intended composition, including a list of all contaminants and Material Safety Data Sheets for all the chemicals to be used;
  - (d) the results of the reviews required by condition 12;
  - (e) results of modelling showing an assessment of the likely extent and dimensions of the fractures that will be generated by the discharge;
  - (f) the preventative and mitigation measures to be in place to ensure the discharge does not cause adverse environmental effects and complies with condition 2;
  - (g) the extent and permeability characteristics of the geology above the discharge point to the surface;
  - (h) any identified faults within the modeled fracture length plus a margin of 50%, and the potential for adverse environmental effects due to the presence of the identified faults;
  - (i) the burst pressure of the well and the anticipated maximum well and discharge pressures and the duration of the pressures; and
  - (j) details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal.

*Note: For the avoidance of doubt, the information provided with a resource consent application would usually be sufficient to constitute a 'Pre-fracturing discharge report' for any imminent hydraulic fracturing discharge. The Pre-fracturing discharge report provided for any later discharge may refer to the resource consent application or earlier Pre-fracturing discharge reports noting any differences.*

8. The consent holder shall notify the Taranaki Regional Council of each discharge by emailing [worknotification@trc.govt.nz](mailto:worknotification@trc.govt.nz). Notification shall include the date that the discharge is to occur and identify the 'Pre-fracturing discharge report', required by condition 7, which details the discharge. Where practicable and reasonable notice shall be given between 3 days and 14 days before the discharge occurs, but in any event 24 hours notice shall be given.
9. At the conclusion of a hydraulic fracturing programme on a given well, the consent holder shall submit a comprehensive 'Post-fracturing discharge report' to the Chief Executive. The report shall be provided within 60 days after the programme is completed and, as a minimum, shall contain:
  - (a) confirmation of the interval(s) where fracturing occurred for that programme, and the geographical position (i.e. depth and lateral position) of the discharge point for each fracture interval;
  - (b) the contaminant volumes and compositions discharged into each fracture interval;
  - (c) the volume of return fluids from each fracture interval;
  - (d) an analysis for the constituents set out in conditions 4(a) to 4(k), in a return fluid sample taken within the first two hours of flow back, for each fracture interval if flowed back individually, or for the well if flowed back with all intervals comingled;
  - (e) an estimate of the volume of fluids (and proppant) remaining underground;
  - (f) the volume of water produced with the hydrocarbons (produced water) over the period beginning at the start of the hydraulic fracturing programme and ending 50 days after the programme is completed;
  - (g) an assessment of the extent and dimensions of the fractures that were generated by the discharge, based on modelling undertaken after the discharge has occurred and other diagnostic techniques, including production analysis, available to determine fracture length, height and containment;
  - (h) the results of pressure testing required by condition 6, and the well and discharge pressure durations and the maximum pressure reached during the hydraulic fracture discharge;
  - (i) details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal;
  - (j) details of any incidents where hydraulic fracture fluid is unable to pass through the well perforations (screen outs) that occurred, their likely cause and implications for compliance with conditions 1 and 2; and
  - (k) an assessment of the effectiveness of the mitigation measures in place with specific reference to those described in the application for this consent.
10. The reports described in conditions 7 and 9 shall be emailed to [consents@trc.govt.nz](mailto:consents@trc.govt.nz) with a reference to the number of this consent.
11. The consent holder shall provide access to a location where the Taranaki Regional Council officers can obtain a sample of the hydraulic fracturing fluids and the return fluids.

12. The consent holder shall at all times adopt the best practicable option, as defined in section 2 of the Resource Management Act 1991, to prevent or minimize any actual or likely adverse effect of the activity on the environment by, as a minimum, ensuring that:
  - (a) the discharge is contained within the fracture interval;
  - (b) regular reviews are undertaken of the preventative and mitigation measures adopted to ensure the discharge does not cause adverse environmental effects; and
  - (c) regular reviews of the chemicals used are undertaken with a view to reducing the toxicity of the chemicals used.
13. The fracture fluid shall be comprised of no less than 95% water and proppant by volume.
14. The Taranaki Regional Council may review any or all of the conditions of this consent by giving notice of review during the month of June each year, for the purposes of:
  - (a) ensuring that the conditions are adequate to deal with any significant adverse effects on the environment arising from the exercise of this consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time; and/or
  - (b) further specifying the best practicable option as required by condition 12; and/or
  - (c) ensuring hydraulic fracturing operations appropriately take into account any best practice guidance published by a recognised industry association or environmental regulator.

Signed at Stratford on 28 March 2012

For and on behalf of  
Taranaki Regional Council

---

**Director-Resource Management**





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

Name of  
Consent Holder: Shell Todd Oil Services Ltd  
Private Bag 2035  
NEW PLYMOUTH 4342

Decision Date: 28 March 2012

Commencement  
Date: 28 March 2012

**Conditions of Consent**

Consent Granted: To discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3000 mTVDss beneath the KA-4/14 wellsite at or about (NZTM) 1700895E-5632589N

Expiry Date: 1 June 2017

Review Date(s): June 2012, June 2013, June 2014, June 2015, June 2016

Site Location: KA-4/14 wellsite, 598 Palmer Road, Kapuni

Legal Description: Lot 1 DP 9050 Blk XII XVI Kaupokonui SD  
(Discharge source & site)

Catchment: Waiokura

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

### General condition

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

### Special conditions

1. The discharge point shall be deeper than 3000 mTVDss.

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

2. The consent holder shall ensure that the exercise of this consent does not result in contaminants reaching any useable fresh water (groundwater or surface water). Usable fresh groundwater is defined as any groundwater having a Total Dissolved Solids concentration of less than 1000 mg/l.

3. The consent holder shall undertake a programme of sampling and testing that monitors the effects of the exercise of this consent on fresh water resources to assess compliance with condition 2 (the 'Monitoring Programme'). The Monitoring Programme shall be certified by the Chief Executive, Taranaki Regional Council ('the Chief Executive'), before this consent is exercised, and shall include:

- (a) the location of the discharge point(s);
- (b) the location of sampling sites; and
- (c) sampling frequency with reference to a hydraulic fracturing programme.

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

- (a) pH;
- (b) conductivity;
- (c) total dissolved solids;
- (d) major ions (Ca, Mg, K, Na, total alkalinity, bromide, chloride, nitrate-nitrogen, and sulphate);
- (e) trace metals (barium, copper, iron, manganese, nickel, and zinc);
- (f) total petroleum hydrocarbons;
- (g) formaldehyde;
- (h) dissolved methane and ethane gas;
- (i) methanol;
- (j) glycols;
- (k) benzene, toluene, ethylbenzene, and xylenes (BTEX); and
- (l) carbon-13 composition of any dissolved methane gas discovered (<sup>13</sup>C-CH<sub>4</sub>).

Note: *The samples required, under conditions 3 and 4, could be taken and analysed by the Council or other contracted party on behalf of the consent holder.*

5. All sampling and analysis shall be undertaken in accordance with a *Sampling and Analysis Plan*, which shall be submitted to the Chief Executive for review and certification before the first sampling is undertaken. This plan shall specify the use of standard protocols recognised to constitute good professional practice including quality control and assurance. An International Accreditation New Zealand (IANZ) accredited laboratory shall be used for all sample analysis. Results shall be provided to the Chief Executive within 30 days of sampling and shall include supporting quality control and assurance information. These results will be used to assess compliance with condition 2.

*Note: The Sampling and Analysis Plan may be combined with the Monitoring Programme required by condition 2.*

6. The consent holder shall undertake well and equipment pressure testing prior to any hydraulic fracture programme on a given well to ensure any discharge will not affect the integrity of the well and hydraulic fracturing equipment.
7. Any hydraulic fracture discharge shall only occur after the consent holder has provided a comprehensive 'Pre-fracturing discharge report' to the Chief Executive. The report shall be provided at least 14 days before the discharge is proposed to commence and shall detail the hydraulic fracturing programme proposed, including as a minimum:
  - (a) the specific well in which each discharge is to occur and the intended fracture interval(s) ('fracture interval' is the discrete subsurface zone to receive a hydraulic fracture treatment);
  - (b) the number of discharges proposed and the geographical position (i.e. depth and lateral position) of each intended discharge point;
  - (c) the total volume of fracture fluid planned to be pumped down the well and its intended composition, including a list of all contaminants and Material Safety Data Sheets for all the chemicals to be used;
  - (d) the results of the reviews required by condition 12;
  - (e) results of modelling showing an assessment of the likely extent and dimensions of the fractures that will be generated by the discharge;
  - (f) the preventative and mitigation measures to be in place to ensure the discharge does not cause adverse environmental effects and complies with condition 2;
  - (g) the extent and permeability characteristics of the geology above the discharge point to the surface;
  - (h) any identified faults within the modeled fracture length plus a margin of 50%, and the potential for adverse environmental effects due to the presence of the identified faults;
  - (i) the burst pressure of the well and the anticipated maximum well and discharge pressures and the duration of the pressures; and
  - (j) details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal.

*Note: For the avoidance of doubt, the information provided with a resource consent application would usually be sufficient to constitute a 'Pre-fracturing discharge report' for any imminent hydraulic fracturing discharge. The Pre-fracturing discharge report provided for any later discharge may refer to the resource consent application or earlier Pre-fracturing discharge reports noting any differences.*

8. The consent holder shall notify the Taranaki Regional Council of each discharge by emailing [worknotification@trc.govt.nz](mailto:worknotification@trc.govt.nz). Notification shall include the date that the discharge is to occur and identify the 'Pre-fracturing discharge report', required by condition 7, which details the discharge. Where practicable and reasonable notice shall be given between 3 days and 14 days before the discharge occurs, but in any event 24 hours notice shall be given.
9. At the conclusion of a hydraulic fracturing programme on a given well, the consent holder shall submit a comprehensive 'Post-fracturing discharge report' to the Chief Executive. The report shall be provided within 60 days after the programme is completed and, as a minimum, shall contain:
  - (a) confirmation of the interval(s) where fracturing occurred for that programme, and the geographical position (i.e. depth and lateral position) of the discharge point for each fracture interval;
  - (b) the contaminant volumes and compositions discharged into each fracture interval;
  - (c) the volume of return fluids from each fracture interval;
  - (d) an analysis for the constituents set out in conditions 4(a) to 4(k), in a return fluid sample taken within the first two hours of flow back, for each fracture interval if flowed back individually, or for the well if flowed back with all intervals comingled;
  - (e) an estimate of the volume of fluids (and proppant) remaining underground;
  - (f) the volume of water produced with the hydrocarbons (produced water) over the period beginning at the start of the hydraulic fracturing programme and ending 50 days after the programme is completed;
  - (g) an assessment of the extent and dimensions of the fractures that were generated by the discharge, based on modelling undertaken after the discharge has occurred and other diagnostic techniques, including production analysis, available to determine fracture length, height and containment;
  - (h) the results of pressure testing required by condition 6, and the well and discharge pressure durations and the maximum pressure reached during the hydraulic fracture discharge;
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11. The consent holder shall provide access to a location where the Taranaki Regional Council officers can obtain a sample of the hydraulic fracturing fluids and the return fluids.

12. The consent holder shall at all times adopt the best practicable option, as defined in section 2 of the Resource Management Act 1991, to prevent or minimize any actual or likely adverse effect of the activity on the environment by, as a minimum, ensuring that:
  - (a) the discharge is contained within the fracture interval;
  - (b) regular reviews are undertaken of the preventative and mitigation measures adopted to ensure the discharge does not cause adverse environmental effects; and
  - (c) regular reviews of the chemicals used are undertaken with a view to reducing the toxicity of the chemicals used.
13. The fracture fluid shall be comprised of no less than 95% water and proppant by volume.
14. The Taranaki Regional Council may review any or all of the conditions of this consent by giving notice of review during the month of June each year, for the purposes of:
  - (a) ensuring that the conditions are adequate to deal with any significant adverse effects on the environment arising from the exercise of this consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time; and/or
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  - (c) ensuring hydraulic fracturing operations appropriately take into account any best practice guidance published by a recognised industry association or environmental regulator.

Signed at Stratford on 28 March 2012

For and on behalf of  
Taranaki Regional Council

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**Director-Resource Management**



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

Name of  
Consent Holder: Shell Todd Oil Services Ltd  
Private Bag 2035  
NEW PLYMOUTH 4342

Decision Date: 5 April 2012

Commencement  
Date: 5 April 2012

**Conditions of Consent**

Consent Granted: To discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3000 mTVDss beneath the KA-6/11/17 wellsite at or about (NZTM) 1701956E-5627688N

Expiry Date: 1 June 2017

Review Date(s): June 2012, June 2013, June 2014, June 2015, June 2016

Site Location: KA-6/11/17 wellsite, 849 Ahipaipa Road, Kapuni

Legal Description: Lot 1 DP 10950 Blk XVI Kaupokonui SD  
(Discharge source & site)

Catchment: Inaha

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

### General condition

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

### Special conditions

1. The discharge point shall be deeper than 3000 mTVDss.

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

2. The consent holder shall ensure that the exercise of this consent does not result in contaminants reaching any useable fresh water (groundwater or surface water). Usable fresh groundwater is defined as any groundwater having a Total Dissolved Solids concentration of less than 1000 mg/l.

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- (e) trace metals (barium, copper, iron, manganese, nickel, and zinc);
- (f) total petroleum hydrocarbons;
- (g) formaldehyde;
- (h) dissolved methane and ethane gas;
- (i) methanol;
- (j) glycols;
- (k) benzene, toluene, ethylbenzene, and xylenes (BTEX); and
- (l) carbon-13 composition of any dissolved methane gas discovered ( $^{13}\text{C-CH}_4$ ).

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  - (d) the results of the reviews required by condition 12;
  - (e) results of modelling showing an assessment of the likely extent and dimensions of the fractures that will be generated by the discharge;
  - (f) the preventative and mitigation measures to be in place to ensure the discharge does not cause adverse environmental effects and complies with condition 2;
  - (g) the extent and permeability characteristics of the geology above the discharge point to the surface;
  - (h) any identified faults within the modeled fracture length plus a margin of 50%, and the potential for adverse environmental effects due to the presence of the identified faults;
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  - (e) an estimate of the volume of fluids (and proppant) remaining underground;
  - (f) the volume of water produced with the hydrocarbons (produced water) over the period beginning at the start of the hydraulic fracturing programme and ending 50 days after the programme is completed;
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## Consent 7998-1

12. The consent holder shall at all times adopt the best practicable option, as defined in section 2 of the Resource Management Act 1991, to prevent or minimize any actual or likely adverse effect of the activity on the environment by, as a minimum, ensuring that:
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14. The Taranaki Regional Council may review any or all of the conditions of this consent by giving notice of review during the month of June each year, for the purposes of:
  - (a) ensuring that the conditions are adequate to deal with any significant adverse effects on the environment arising from the exercise of this consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time; and/or
  - (b) further specifying the best practicable option as required by condition 12; and/or
  - (c) ensuring hydraulic fracturing operations appropriately take into account any best practice guidance published by a recognised industry association or environmental regulator.

Signed at Stratford on 5 April 2012

For and on behalf of  
Taranaki Regional Council

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**Director-Resource Management**



## **Appendix III**

### **Certificates of analysis (Groundwater)**



# ANALYSIS REPORT

Page 1 of 3

<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	1129270	SPV1
<b>Contact:</b>	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	<b>Date Registered:</b>	30-Apr-2013	
		<b>Date Reported:</b>	07-May-2013	
		<b>Quote No:</b>	47915	
		<b>Order No:</b>		
		<b>Client Reference:</b>	Groundwater	
		<b>Submitted By:</b>	Regan Phipps	

## Sample Type: Aqueous

<b>Sample Name:</b>	GND1689 29-Apr-2013 1:10 pm				
<b>Lab Number:</b>	1129270.1				

### Individual Tests

Sum of Anions	meq/L	6.0	-	-	-	-
Sum of Cations	meq/L	7.1	-	-	-	-
pH	pH Units	7.3	-	-	-	-
Total Alkalinity	g/m <sup>3</sup> as CaCO <sub>3</sub>	220	-	-	-	-
Bicarbonate	g/m <sup>3</sup> at 25°C	270	-	-	-	-
Total Hardness	g/m <sup>3</sup> as CaCO <sub>3</sub>	42	-	-	-	-
Electrical Conductivity (EC)	mS/m	58.9	-	-	-	-
Total Dissolved Solids (TDS)	g/m <sup>3</sup>	350	-	-	-	-
Dissolved Barium	g/m <sup>3</sup>	0.091	-	-	-	-
Dissolved Calcium	g/m <sup>3</sup>	7.3	-	-	-	-
Dissolved Copper	g/m <sup>3</sup>	< 0.0005	-	-	-	-
Dissolved Iron	g/m <sup>3</sup>	10.7	-	-	-	-
Dissolved Magnesium	g/m <sup>3</sup>	5.6	-	-	-	-
Dissolved Manganese	g/m <sup>3</sup>	0.73	-	-	-	-
Dissolved Mercury	g/m <sup>3</sup>	< 0.00008	-	-	-	-
Dissolved Nickel	g/m <sup>3</sup>	0.0006	-	-	-	-
Dissolved Potassium	g/m <sup>3</sup>	22	-	-	-	-
Dissolved Sodium	g/m <sup>3</sup>	122	-	-	-	-
Dissolved Zinc	g/m <sup>3</sup>	0.0036	-	-	-	-
Bromide	g/m <sup>3</sup>	0.14	-	-	-	-
Chloride	g/m <sup>3</sup>	59	-	-	-	-
Nitrite-N	g/m <sup>3</sup>	< 0.002	-	-	-	-
Nitrate-N	g/m <sup>3</sup>	0.004	-	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	0.005	-	-	-	-
Sulphate	g/m <sup>3</sup>	0.6	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Toluene	g/m <sup>3</sup>	0.0032	-	-	-	-
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
m&p-Xylene	g/m <sup>3</sup>	< 0.002	-	-	-	-

Sample Type: Aqueous						
<b>Sample Name:</b>	GND1689 29-Apr-2013 1:10 pm					
<b>Lab Number:</b>	1129270.1					
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m <sup>3</sup>	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m <sup>3</sup>	< 0.003	-	-	-	-
Ethylene	g/m <sup>3</sup>	< 0.004	-	-	-	-
Methane	g/m <sup>3</sup>	4.4	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m <sup>3</sup>	< 0.10	-	-	-	-
C10 - C14	g/m <sup>3</sup>	< 0.2	-	-	-	-
C15 - C36	g/m <sup>3</sup>	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	< 0.7	-	-	-	-

## SUMMARY OF METHODS

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

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B	-	1
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	-	1
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	-	1
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines	-	1
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1
Total anions for anion/cation balance check	Calculation: sum of anions as mEq/L.	0.07 meq/L	1
Total cations for anion/cation balance check	Calculation: sum of cations as mEq/L.	0.05 meq/L	1
pH	pH meter. APHA 4500-H <sup>+</sup> B 21 <sup>st</sup> ed. 2005.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 21 <sup>st</sup> ed. 2005.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	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 <sub>2</sub> D 21 <sup>st</sup> ed. 2005.	1.0 g/m <sup>3</sup> at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 21 <sup>st</sup> ed. 2005.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21 <sup>st</sup> ed. 2005.	0.1 mS/m	1
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 21 <sup>st</sup> ed. 2005.	10 g/m <sup>3</sup>	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.00010 g/m <sup>3</sup>	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.05 g/m <sup>3</sup>	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0005 g/m <sup>3</sup>	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.02 g/m <sup>3</sup>	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.02 g/m <sup>3</sup>	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0005 g/m <sup>3</sup>	1
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m <sup>3</sup>	1



Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0005 g/m <sup>3</sup>	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.05 g/m <sup>3</sup>	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.02 g/m <sup>3</sup>	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0010 g/m <sup>3</sup>	1
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B 21 <sup>st</sup> ed. 2005.	0.05 g/m <sup>3</sup>	1
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl <sup>-</sup> E (modified from continuous flow analysis) 21 <sup>st</sup> ed. 2005.	0.5 g/m <sup>3</sup>	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>2</sub> <sup>-</sup> I (Modified) 21 <sup>st</sup> ed. 2005.	0.002 g/m <sup>3</sup>	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N.	0.002 g/m <sup>3</sup>	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO <sub>3</sub> <sup>-</sup> I (Modified) 21 <sup>st</sup> ed. 2005.	0.002 g/m <sup>3</sup>	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 21 <sup>st</sup> ed. 2005.	0.5 g/m <sup>3</sup>	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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Martin Cowell - BSc (Chem)  
Client Services Manager - Environmental Division



# ANALYSIS REPORT

Page 1 of 3

<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	1127519	SPV2
<b>Contact:</b>	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	<b>Date Registered:</b>	24-Apr-2013	
		<b>Date Reported:</b>	15-Jan-2015	
		<b>Quote No:</b>	47915	
		<b>Order No:</b>		
		<b>Client Reference:</b>		
		<b>Submitted By:</b>	Regan Phipps	

## Sample Type: Aqueous

<b>Sample Name:</b>	GND2333 23-Apr-2013 12:00 pm				
<b>Lab Number:</b>	1127519.3				

### Individual Tests

Sum of Anions	meq/L	2.0	-	-	-	-
Sum of Cations	meq/L	1.98	-	-	-	-
pH	pH Units	7.0	-	-	-	-
Total Alkalinity	g/m <sup>3</sup> as CaCO <sub>3</sub>	47	-	-	-	-
Bicarbonate	g/m <sup>3</sup> at 25°C	57	-	-	-	-
Total Hardness	g/m <sup>3</sup> as CaCO <sub>3</sub>	58	-	-	-	-
Electrical Conductivity (EC)	mS/m	21.9	-	-	-	-
Total Dissolved Solids (TDS)	g/m <sup>3</sup>	164	-	-	-	-
Dissolved Barium	g/m <sup>3</sup>	0.0099	-	-	-	-
Dissolved Calcium	g/m <sup>3</sup>	13.6	-	-	-	-
Dissolved Copper	g/m <sup>3</sup>	0.0017	-	-	-	-
Dissolved Iron	g/m <sup>3</sup>	< 0.02	-	-	-	-
Dissolved Magnesium	g/m <sup>3</sup>	5.9	-	-	-	-
Dissolved Manganese	g/m <sup>3</sup>	0.0012	-	-	-	-
Dissolved Mercury	g/m <sup>3</sup>	< 0.00008	-	-	-	-
Dissolved Nickel	g/m <sup>3</sup>	< 0.0005	-	-	-	-
Dissolved Potassium	g/m <sup>3</sup>	4.4	-	-	-	-
Dissolved Sodium	g/m <sup>3</sup>	16.1	-	-	-	-
Dissolved Zinc	g/m <sup>3</sup>	0.0088	-	-	-	-
Bromide	g/m <sup>3</sup>	0.09	-	-	-	-
Chloride	g/m <sup>3</sup>	17.9	-	-	-	-
Nitrite-N	g/m <sup>3</sup>	< 0.002	-	-	-	-
Nitrate-N	g/m <sup>3</sup>	3.5	-	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	3.5	-	-	-	-
Sulphate	g/m <sup>3</sup>	16.7	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Toluene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
m&p-Xylene	g/m <sup>3</sup>	< 0.002	-	-	-	-

Sample Type: Aqueous						
<b>Sample Name:</b>	GND2333 23-Apr-2013 12:00 pm					
<b>Lab Number:</b>	1127519.3					
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m <sup>3</sup>	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m <sup>3</sup>	< 0.003	-	-	-	-
Ethylene	g/m <sup>3</sup>	< 0.004	-	-	-	-
Methane	g/m <sup>3</sup>	< 0.002	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m <sup>3</sup>	< 0.10	-	-	-	-
C10 - C14	g/m <sup>3</sup>	< 0.2	-	-	-	-
C15 - C36	g/m <sup>3</sup>	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	< 0.7	-	-	-	-

### Analyst's Comments

Supplement to test report 11275199v1 issued on 8/5/13.

## 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/m <sup>3</sup>	3
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m <sup>3</sup>	3
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m <sup>3</sup>	3
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m <sup>3</sup>	3
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m <sup>3</sup>	3
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m <sup>3</sup>	3
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/m <sup>3</sup>	3
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	3
Total anions for anion/cation balance check	Calculation: sum of anions as mEq/L.	0.07 meq/L	3
Total cations for anion/cation balance check	Calculation: sum of cations as mEq/L.	0.05 meq/L	3
pH	pH meter. APHA 4500-H+ B 22 <sup>nd</sup> ed. 2012.	0.1 pH Units	3
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	3
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 <sub>2</sub> D 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> at 25°C	3
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	3
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22 <sup>nd</sup> ed. 2012.	0.1 mS/m	3
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) 22 <sup>nd</sup> ed. 2012.	10 g/m <sup>3</sup>	3
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.00010 g/m <sup>3</sup>	3
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.05 g/m <sup>3</sup>	3
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	3
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	3

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Sample No
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	3
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	3
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m <sup>3</sup>	3
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	3
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.05 g/m <sup>3</sup>	3
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	3
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0010 g/m <sup>3</sup>	3
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B 22 <sup>nd</sup> ed. 2012.	0.05 g/m <sup>3</sup>	3
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl <sup>-</sup> E (modified from continuous flow analysis) 22 <sup>nd</sup> ed. 2012.	0.5 g/m <sup>3</sup>	3
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>2</sub> <sup>-</sup> I 22 <sup>nd</sup> ed. 2012.	0.002 g/m <sup>3</sup>	3
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N. In-House.	0.0010 g/m <sup>3</sup>	3
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO <sub>3</sub> <sup>-</sup> I 22 <sup>nd</sup> ed. 2012.	0.002 g/m <sup>3</sup>	3
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22 <sup>nd</sup> ed. 2012.	0.5 g/m <sup>3</sup>	3

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



# ANALYSIS REPORT

Page 1 of 3

<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	1138819	SPV1
<b>Contact:</b>	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	<b>Date Registered:</b>	24-May-2013	
		<b>Date Reported:</b>	31-May-2013	
		<b>Quote No:</b>	47915	
		<b>Order No:</b>		
		<b>Client Reference:</b>	Kapuni HF - WTP	
		<b>Submitted By:</b>	Regan Phipps	

## Sample Type: Aqueous

<b>Sample Name:</b>	GND 2011 23-May-2013 1:30 pm				
<b>Lab Number:</b>	1138819.1				
Individual Tests					
Sum of Anions	meq/L	3.4	-	-	-
Sum of Cations	meq/L	3.5	-	-	-
pH	pH Units	8.2	-	-	-
Total Alkalinity	g/m <sup>3</sup> as CaCO <sub>3</sub>	147	-	-	-
Bicarbonate	g/m <sup>3</sup> at 25°C	176	-	-	-
Total Hardness	g/m <sup>3</sup> as CaCO <sub>3</sub>	92	-	-	-
Electrical Conductivity (EC)	mS/m	31.6	-	-	-
Total Dissolved Solids (TDS)	g/m <sup>3</sup>	198	-	-	-
Dissolved Barium	g/m <sup>3</sup>	0.0036	-	-	-
Dissolved Bromine*	g/m <sup>3</sup>	0.051	-	-	-
Dissolved Calcium	g/m <sup>3</sup>	24	-	-	-
Dissolved Copper	g/m <sup>3</sup>	< 0.0005	-	-	-
Dissolved Iron	g/m <sup>3</sup>	0.11	-	-	-
Dissolved Magnesium	g/m <sup>3</sup>	8.0	-	-	-
Dissolved Manganese	g/m <sup>3</sup>	0.026	-	-	-
Dissolved Mercury	g/m <sup>3</sup>	< 0.00008	-	-	-
Dissolved Nickel	g/m <sup>3</sup>	< 0.0005	-	-	-
Dissolved Potassium	g/m <sup>3</sup>	4.8	-	-	-
Dissolved Sodium	g/m <sup>3</sup>	34	-	-	-
Dissolved Zinc	g/m <sup>3</sup>	0.027	-	-	-
Chloride	g/m <sup>3</sup>	15.0	-	-	-
Nitrite-N	g/m <sup>3</sup>	< 0.002	-	-	-
Nitrate-N	g/m <sup>3</sup>	< 0.002	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	< 0.002	-	-	-
Sulphate	g/m <sup>3</sup>	< 0.5	-	-	-
Ethylene Glycol in Water					
Ethylene glycol*	g/m <sup>3</sup>	< 4	-	-	-
Propylene Glycol in Water					
Propylene glycol*	g/m <sup>3</sup>	< 4	-	-	-
Methanol in Water - Aqueous Solvents					
Methanol*	g/m <sup>3</sup>	< 2	-	-	-
BTEX in Water by Headspace GC-MS					
Benzene	g/m <sup>3</sup>	< 0.0010	-	-	-
Toluene	g/m <sup>3</sup>	< 0.0010	-	-	-
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	-	-	-
m&p-Xylene	g/m <sup>3</sup>	< 0.002	-	-	-

Sample Type: Aqueous						
<b>Sample Name:</b>	GND 2011 23-May-2013 1:30 pm					
<b>Lab Number:</b>	1138819.1					
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m <sup>3</sup>	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m <sup>3</sup>	< 0.003	-	-	-	-
Ethylene	g/m <sup>3</sup>	< 0.003	-	-	-	-
Methane	g/m <sup>3</sup>	1.54	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m <sup>3</sup>	< 0.10	-	-	-	-
C10 - C14	g/m <sup>3</sup>	< 0.2	-	-	-	-
C15 - C36	g/m <sup>3</sup>	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	< 0.7	-	-	-	-

## SUMMARY OF METHODS

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

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [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 mEq/L.	0.07 meq/L	1
Total cations for anion/cation balance check	Calculation: sum of cations as mEq/L.	0.05 meq/L	1
pH	pH meter. APHA 4500-H+ B 21 <sup>st</sup> ed. 2005.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 21 <sup>st</sup> ed. 2005.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	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 <sub>2</sub> D 21 <sup>st</sup> ed. 2005.	1.0 g/m <sup>3</sup> at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 21 <sup>st</sup> ed. 2005.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21 <sup>st</sup> ed. 2005.	0.1 mS/m	1
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 21 <sup>st</sup> ed. 2005.	10 g/m <sup>3</sup>	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.00010 g/m <sup>3</sup>	1
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.005 g/m <sup>3</sup>	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.05 g/m <sup>3</sup>	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0005 g/m <sup>3</sup>	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.02 g/m <sup>3</sup>	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.02 g/m <sup>3</sup>	1



Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0005 g/m <sup>3</sup>	1
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m <sup>3</sup>	1
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0005 g/m <sup>3</sup>	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.05 g/m <sup>3</sup>	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.02 g/m <sup>3</sup>	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0010 g/m <sup>3</sup>	1
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl <sup>-</sup> E (modified from continuous flow analysis) 21 <sup>st</sup> ed. 2005.	0.5 g/m <sup>3</sup>	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>2</sub> <sup>-</sup> I (Modified) 21 <sup>st</sup> ed. 2005.	0.002 g/m <sup>3</sup>	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N.	0.002 g/m <sup>3</sup>	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO <sub>3</sub> <sup>-</sup> I 21 <sup>st</sup> ed. 2005.	0.002 g/m <sup>3</sup>	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 21 <sup>st</sup> ed. 2005.	0.5 g/m <sup>3</sup>	1

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

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Martin Cowell - BSc (Chem)  
Client Services Manager - Environmental Division



# ANALYSIS REPORT

Page 1 of 3

<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	1138819	SPV1
<b>Contact:</b>	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	<b>Date Registered:</b>	24-May-2013	
		<b>Date Reported:</b>	31-May-2013	
		<b>Quote No:</b>	47915	
		<b>Order No:</b>		
		<b>Client Reference:</b>	Kapuni HF - WTP	
		<b>Submitted By:</b>	Regan Phipps	

## Sample Type: Aqueous

<b>Sample Name:</b>	GND 2011 23-May-2013 1:30 pm				
<b>Lab Number:</b>	1138819.1				
Individual Tests					
Sum of Anions	meq/L	3.4	-	-	-
Sum of Cations	meq/L	3.5	-	-	-
pH	pH Units	8.2	-	-	-
Total Alkalinity	g/m <sup>3</sup> as CaCO <sub>3</sub>	147	-	-	-
Bicarbonate	g/m <sup>3</sup> at 25°C	176	-	-	-
Total Hardness	g/m <sup>3</sup> as CaCO <sub>3</sub>	92	-	-	-
Electrical Conductivity (EC)	mS/m	31.6	-	-	-
Total Dissolved Solids (TDS)	g/m <sup>3</sup>	198	-	-	-
Dissolved Barium	g/m <sup>3</sup>	0.0036	-	-	-
Dissolved Bromine*	g/m <sup>3</sup>	0.051	-	-	-
Dissolved Calcium	g/m <sup>3</sup>	24	-	-	-
Dissolved Copper	g/m <sup>3</sup>	< 0.0005	-	-	-
Dissolved Iron	g/m <sup>3</sup>	0.11	-	-	-
Dissolved Magnesium	g/m <sup>3</sup>	8.0	-	-	-
Dissolved Manganese	g/m <sup>3</sup>	0.026	-	-	-
Dissolved Mercury	g/m <sup>3</sup>	< 0.00008	-	-	-
Dissolved Nickel	g/m <sup>3</sup>	< 0.0005	-	-	-
Dissolved Potassium	g/m <sup>3</sup>	4.8	-	-	-
Dissolved Sodium	g/m <sup>3</sup>	34	-	-	-
Dissolved Zinc	g/m <sup>3</sup>	0.027	-	-	-
Chloride	g/m <sup>3</sup>	15.0	-	-	-
Nitrite-N	g/m <sup>3</sup>	< 0.002	-	-	-
Nitrate-N	g/m <sup>3</sup>	< 0.002	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	< 0.002	-	-	-
Sulphate	g/m <sup>3</sup>	< 0.5	-	-	-
Ethylene Glycol in Water					
Ethylene glycol*	g/m <sup>3</sup>	< 4	-	-	-
Propylene Glycol in Water					
Propylene glycol*	g/m <sup>3</sup>	< 4	-	-	-
Methanol in Water - Aqueous Solvents					
Methanol*	g/m <sup>3</sup>	< 2	-	-	-
BTEX in Water by Headspace GC-MS					
Benzene	g/m <sup>3</sup>	< 0.0010	-	-	-
Toluene	g/m <sup>3</sup>	< 0.0010	-	-	-
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	-	-	-
m&p-Xylene	g/m <sup>3</sup>	< 0.002	-	-	-

Sample Type: Aqueous						
<b>Sample Name:</b>	GND 2011 23-May-2013 1:30 pm					
<b>Lab Number:</b>	1138819.1					
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m <sup>3</sup>	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m <sup>3</sup>	< 0.003	-	-	-	-
Ethylene	g/m <sup>3</sup>	< 0.003	-	-	-	-
Methane	g/m <sup>3</sup>	1.54	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m <sup>3</sup>	< 0.10	-	-	-	-
C10 - C14	g/m <sup>3</sup>	< 0.2	-	-	-	-
C15 - C36	g/m <sup>3</sup>	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	< 0.7	-	-	-	-

## SUMMARY OF METHODS

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

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [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 mEq/L.	0.07 meq/L	1
Total cations for anion/cation balance check	Calculation: sum of cations as mEq/L.	0.05 meq/L	1
pH	pH meter. APHA 4500-H+ B 21 <sup>st</sup> ed. 2005.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 21 <sup>st</sup> ed. 2005.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	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 <sub>2</sub> D 21 <sup>st</sup> ed. 2005.	1.0 g/m <sup>3</sup> at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 21 <sup>st</sup> ed. 2005.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21 <sup>st</sup> ed. 2005.	0.1 mS/m	1
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 21 <sup>st</sup> ed. 2005.	10 g/m <sup>3</sup>	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.00010 g/m <sup>3</sup>	1
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.005 g/m <sup>3</sup>	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.05 g/m <sup>3</sup>	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0005 g/m <sup>3</sup>	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.02 g/m <sup>3</sup>	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.02 g/m <sup>3</sup>	1

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0005 g/m <sup>3</sup>	1
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m <sup>3</sup>	1
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0005 g/m <sup>3</sup>	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.05 g/m <sup>3</sup>	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.02 g/m <sup>3</sup>	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0010 g/m <sup>3</sup>	1
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl <sup>-</sup> E (modified from continuous flow analysis) 21 <sup>st</sup> ed. 2005.	0.5 g/m <sup>3</sup>	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>2</sub> <sup>-</sup> I (Modified) 21 <sup>st</sup> ed. 2005.	0.002 g/m <sup>3</sup>	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N.	0.002 g/m <sup>3</sup>	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO <sub>3</sub> <sup>-</sup> I 21 <sup>st</sup> ed. 2005.	0.002 g/m <sup>3</sup>	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 21 <sup>st</sup> ed. 2005.	0.5 g/m <sup>3</sup>	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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Martin Cowell - BSc (Chem)  
Client Services Manager - Environmental Division



# ANALYSIS REPORT

Page 1 of 3

<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	1130620	SPV1
<b>Contact:</b>	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	<b>Date Registered:</b>	02-May-2013	
		<b>Date Reported:</b>	13-May-2013	
		<b>Quote No:</b>	47915	
		<b>Order No:</b>		
		<b>Client Reference:</b>	Groundwater	
		<b>Submitted By:</b>	Regan Phipps	

## Sample Type: Aqueous

<b>Sample Name:</b>	GND2348 01-May-2013 1:45 pm	GND2349 01-May-2013 11:35 am			
<b>Lab Number:</b>	1130620.1	1130620.2			

### Individual Tests

Parameter	Unit	1130620.1	1130620.2			
Sum of Anions	meq/L	4.3	3.3	-	-	-
Sum of Cations	meq/L	4.2	3.3	-	-	-
pH	pH Units	6.6	6.4	-	-	-
Total Alkalinity	g/m <sup>3</sup> as CaCO <sub>3</sub>	49	85	-	-	-
Bicarbonate	g/m <sup>3</sup> at 25°C	60	104	-	-	-
Total Hardness	g/m <sup>3</sup> as CaCO <sub>3</sub>	80	61	-	-	-
Electrical Conductivity (EC)	mS/m	45.2	34.0	-	-	-
Total Dissolved Solids (TDS)	g/m <sup>3</sup>	330	240	-	-	-
Dissolved Barium	g/m <sup>3</sup>	0.066	0.052	-	-	-
Dissolved Calcium	g/m <sup>3</sup>	17.5	13.6	-	-	-
Dissolved Copper	g/m <sup>3</sup>	< 0.0005	< 0.0005	-	-	-
Dissolved Iron	g/m <sup>3</sup>	32	16.2	-	-	-
Dissolved Magnesium	g/m <sup>3</sup>	8.8	6.7	-	-	-
Dissolved Manganese	g/m <sup>3</sup>	0.57	0.38	-	-	-
Dissolved Mercury	g/m <sup>3</sup>	< 0.00008	< 0.00008	-	-	-
Dissolved Nickel	g/m <sup>3</sup>	0.0009	< 0.0005	-	-	-
Dissolved Potassium	g/m <sup>3</sup>	8.2	7.7	-	-	-
Dissolved Sodium	g/m <sup>3</sup>	28	26	-	-	-
Dissolved Zinc	g/m <sup>3</sup>	0.65	2.9	-	-	-
Bromide	g/m <sup>3</sup>	0.30	-	-	-	-
Chloride	g/m <sup>3</sup>	99	40	-	-	-
Nitrite-N	g/m <sup>3</sup>	< 0.02	0.003 #1	-	-	-
Nitrate-N	g/m <sup>3</sup>	< 0.02	< 0.002	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	< 0.02	< 0.002 #1	-	-	-
Sulphate	g/m <sup>3</sup>	25	22	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	< 4	< 4	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 4	< 4	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	< 2	< 2	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m <sup>3</sup>	0.0019	< 0.0010	-	-	-
Toluene	g/m <sup>3</sup>	< 0.0010	0.0012	-	-	-
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	< 0.0010	-	-	-
m&p-Xylene	g/m <sup>3</sup>	< 0.002	< 0.002	-	-	-

Sample Type: Aqueous						
<b>Sample Name:</b>	GND2348 01-May-2013 1:45 pm	GND2349 01-May-2013 11:35 am				
<b>Lab Number:</b>	1130620.1	1130620.2				
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m <sup>3</sup>	< 0.0010	< 0.0010	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m <sup>3</sup>	< 0.02	< 0.02	-	-	-
Gases in groundwater						
Ethane	g/m <sup>3</sup>	< 0.003	< 0.003	-	-	-
Ethylene	g/m <sup>3</sup>	< 0.004	< 0.004	-	-	-
Methane	g/m <sup>3</sup>	0.65	1.36	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m <sup>3</sup>	< 0.10	< 0.10	-	-	-
C10 - C14	g/m <sup>3</sup>	< 0.2	< 0.2	-	-	-
C15 - C36	g/m <sup>3</sup>	< 0.4	< 0.4	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	< 0.7	< 0.7	-	-	-

### Analyst's Comments

Severe matrix interferences required that a dilution be performed prior to analysis of sample 1130620.1, resulting in a detection limit higher than that normally achieved for the NOxN/ NO2N analysis.

Please note that the bromide result by ion chromatography could not be provided for sample 1130620.2 due to matrix interference, however the dissolved bromine result by ICPMS was 0.14g/m<sup>3</sup>.

#1 It has been noted that the result for Nitrite-N was greater than that for Nitrate-N + Nitrite-N, but within the analytical variation of these methods.

## SUMMARY OF METHODS

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

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1-2
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1-2
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1-2
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	-	1-2
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	-	1-2
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	-	1-2
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	-	1-2
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-2
Total anions for anion/cation balance check	Calculation: sum of anions as mEq/L.	0.07 meq/L	1-2
Total cations for anion/cation balance check	Calculation: sum of cations as mEq/L.	0.05 meq/L	1-2
pH	pH meter. APHA 4500-H+ B 21 <sup>st</sup> ed. 2005.	0.1 pH Units	1-2
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 21 <sup>st</sup> ed. 2005.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	1-2
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 <sub>2</sub> D 21 <sup>st</sup> ed. 2005.	1.0 g/m <sup>3</sup> at 25°C	1-2
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 21 <sup>st</sup> ed. 2005.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	1-2
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21 <sup>st</sup> ed. 2005.	0.1 mS/m	1-2
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) 21 <sup>st</sup> ed. 2005.	10 g/m <sup>3</sup>	1-2



Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.00010 g/m <sup>3</sup>	1-2
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.05 g/m <sup>3</sup>	1-2
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0005 g/m <sup>3</sup>	1-2
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.02 g/m <sup>3</sup>	1-2
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.02 g/m <sup>3</sup>	1-2
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0005 g/m <sup>3</sup>	1-2
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m <sup>3</sup>	1-2
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0005 g/m <sup>3</sup>	1-2
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.05 g/m <sup>3</sup>	1-2
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.02 g/m <sup>3</sup>	1-2
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0010 g/m <sup>3</sup>	1-2
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B 21 <sup>st</sup> ed. 2005.	0.05 g/m <sup>3</sup>	1
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl <sup>-</sup> E (modified from continuous flow analysis) 21 <sup>st</sup> ed. 2005.	0.5 g/m <sup>3</sup>	1-2
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>2</sub> <sup>-</sup> I (Modified) 21 <sup>st</sup> ed. 2005.	0.002 g/m <sup>3</sup>	1-2
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N.	0.002 g/m <sup>3</sup>	1-2
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO <sub>3</sub> <sup>-</sup> I (Modified) 21 <sup>st</sup> ed. 2005.	0.002 g/m <sup>3</sup>	1-2
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 21 <sup>st</sup> ed. 2005.	0.5 g/m <sup>3</sup>	1-2

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

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

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



## ANALYSIS REPORT

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<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	1131224	SPV2
<b>Contact:</b>	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	<b>Date Registered:</b>	03-May-2013	
		<b>Date Reported:</b>	15-Jan-2015	
		<b>Quote No:</b>	47915	
		<b>Order No:</b>		
		<b>Client Reference:</b>	Groundwater	
		<b>Submitted By:</b>	Regan Phipps	

### Sample Type: Aqueous

<b>Sample Name:</b>	GND2357 02-May-2013 12:23 pm				
<b>Lab Number:</b>	1131224.2				

#### Individual Tests

Sum of Anions	meq/L	2.5	-	-	-	-
Sum of Cations	meq/L	1.81	-	-	-	-
pH	pH Units	6.8	-	-	-	-
Total Alkalinity	g/m <sup>3</sup> as CaCO <sub>3</sub>	85	-	-	-	-
Bicarbonate	g/m <sup>3</sup> at 25°C	104	-	-	-	-
Total Hardness	g/m <sup>3</sup> as CaCO <sub>3</sub>	25	-	-	-	-
Electrical Conductivity (EC)	mS/m	19.4	-	-	-	-
Total Dissolved Solids (TDS)	g/m <sup>3</sup>	162	-	-	-	-
Dissolved Barium	g/m <sup>3</sup>	0.0196	-	-	-	-
Dissolved Calcium	g/m <sup>3</sup>	5.9	-	-	-	-
Dissolved Copper	g/m <sup>3</sup>	0.0035	-	-	-	-
Dissolved Iron	g/m <sup>3</sup>	0.89	-	-	-	-
Dissolved Magnesium	g/m <sup>3</sup>	2.6	-	-	-	-
Dissolved Manganese	g/m <sup>3</sup>	0.051	-	-	-	-
Dissolved Mercury	g/m <sup>3</sup>	< 0.00008	-	-	-	-
Dissolved Nickel	g/m <sup>3</sup>	0.0010	-	-	-	-
Dissolved Potassium	g/m <sup>3</sup>	3.9	-	-	-	-
Dissolved Sodium	g/m <sup>3</sup>	23	-	-	-	-
Dissolved Zinc	g/m <sup>3</sup>	5.7	-	-	-	-
Bromide	g/m <sup>3</sup>	< 0.05	-	-	-	-
Chloride	g/m <sup>3</sup>	14.0	-	-	-	-
Nitrite-N	g/m <sup>3</sup>	< 0.002	-	-	-	-
Nitrate-N	g/m <sup>3</sup>	0.005	-	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	0.007	-	-	-	-
Sulphate	g/m <sup>3</sup>	18.1	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Toluene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
m&p-Xylene	g/m <sup>3</sup>	< 0.002	-	-	-	-

Sample Type: Aqueous						
<b>Sample Name:</b>	GND2357 02-May-2013 12:23 pm					
<b>Lab Number:</b>	1131224.2					
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m <sup>3</sup>	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m <sup>3</sup>	< 0.003	-	-	-	-
Ethylene	g/m <sup>3</sup>	< 0.004	-	-	-	-
Methane	g/m <sup>3</sup>	3.7	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m <sup>3</sup>	< 0.10	-	-	-	-
C10 - C14	g/m <sup>3</sup>	5.2	-	-	-	-
C15 - C36	g/m <sup>3</sup>	6.6	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	11.8	-	-	-	-

### Analyst's Comments

Supplement to test report 1131224v1 issued on 13/5/13.

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

## SUMMARY OF METHODS

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

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m <sup>3</sup>	2
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m <sup>3</sup>	2
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m <sup>3</sup>	2
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m <sup>3</sup>	2
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m <sup>3</sup>	2
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m <sup>3</sup>	2
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/m <sup>3</sup>	2
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	2
Total anions for anion/cation balance check	Calculation: sum of anions as mEq/L.	0.07 meq/L	2
Total cations for anion/cation balance check	Calculation: sum of cations as mEq/L.	0.05 meq/L	2
pH	pH meter. APHA 4500-H+ B 22 <sup>nd</sup> ed. 2012.	0.1 pH Units	2
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	2
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 <sub>2</sub> D 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> at 25°C	2
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	2
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22 <sup>nd</sup> ed. 2012.	0.1 mS/m	2
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) 22 <sup>nd</sup> ed. 2012.	10 g/m <sup>3</sup>	2
Filtration for dissolved metals analysis	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22 <sup>nd</sup> ed. 2012.	-	2
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.00010 g/m <sup>3</sup>	2
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.05 g/m <sup>3</sup>	2

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Sample No
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	2
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	2
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	2
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	2
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m <sup>3</sup>	2
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	2
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.05 g/m <sup>3</sup>	2
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	2
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0010 g/m <sup>3</sup>	2
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B 22 <sup>nd</sup> ed. 2012.	0.05 g/m <sup>3</sup>	2
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl <sup>-</sup> E (modified from continuous flow analysis) 22 <sup>nd</sup> ed. 2012.	0.5 g/m <sup>3</sup>	2
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>2</sub> <sup>-</sup> I 22 <sup>nd</sup> ed. 2012.	0.002 g/m <sup>3</sup>	2
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N. In-House.	0.0010 g/m <sup>3</sup>	2
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO <sub>3</sub> <sup>-</sup> I 22 <sup>nd</sup> ed. 2012.	0.002 g/m <sup>3</sup>	2
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22 <sup>nd</sup> ed. 2012.	0.5 g/m <sup>3</sup>	2

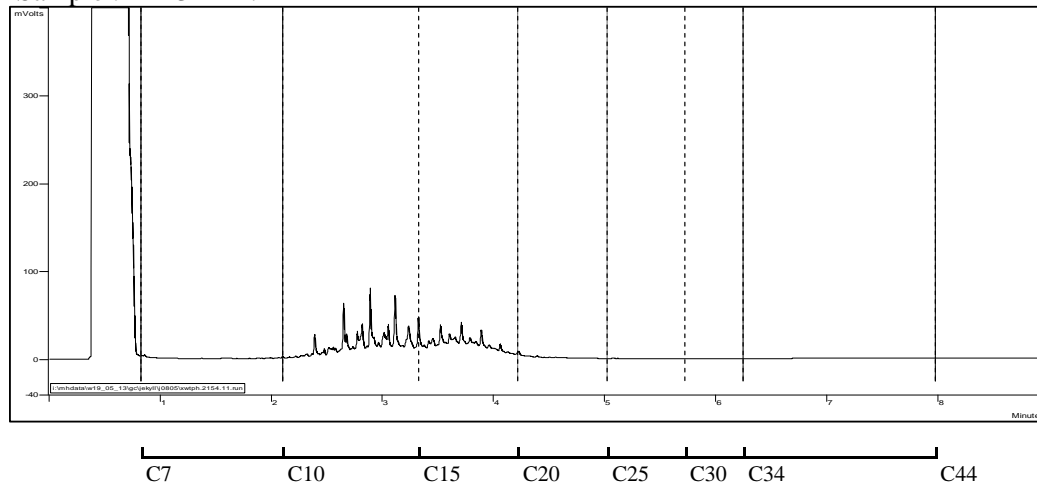
These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

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

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

Sample : 1131224.2



# ANALYSIS REPORT

Page 1 of 3

<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	1145262	SPV1
<b>Contact:</b>	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	<b>Date Registered:</b>	13-Jun-2013	
		<b>Date Reported:</b>	19-Jun-2013	
		<b>Quote No:</b>	47915	
		<b>Order No:</b>		
		<b>Client Reference:</b>	Kapuni HF GW Program	
		<b>Submitted By:</b>	Regan Phipps	

## Sample Type: Aqueous

<b>Sample Name:</b>	GND2342 12-Jun-2013 9:45 am				
<b>Lab Number:</b>	1145262.1				
Individual Tests					
Sum of Anions	meq/L	1.03	-	-	-
Sum of Cations	meq/L	1.05	-	-	-
pH	pH Units	7.4	-	-	-
Total Alkalinity	g/m <sup>3</sup> as CaCO <sub>3</sub>	29	-	-	-
Bicarbonate	g/m <sup>3</sup> at 25°C	35	-	-	-
Total Hardness	g/m <sup>3</sup> as CaCO <sub>3</sub>	25	-	-	-
Electrical Conductivity (EC)	mS/m	10.6	-	-	-
Total Dissolved Solids (TDS)	g/m <sup>3</sup>	93	-	-	-
Dissolved Barium	g/m <sup>3</sup>	0.0197	-	-	-
Dissolved Bromine*	g/m <sup>3</sup>	0.078	-	-	-
Dissolved Calcium	g/m <sup>3</sup>	6.2	-	-	-
Dissolved Copper	g/m <sup>3</sup>	0.0006	-	-	-
Dissolved Iron	g/m <sup>3</sup>	0.04	-	-	-
Dissolved Magnesium	g/m <sup>3</sup>	2.4	-	-	-
Dissolved Manganese	g/m <sup>3</sup>	0.0031	-	-	-
Dissolved Mercury	g/m <sup>3</sup>	< 0.00008	-	-	-
Dissolved Nickel	g/m <sup>3</sup>	0.0025	-	-	-
Dissolved Potassium	g/m <sup>3</sup>	3.2	-	-	-
Dissolved Sodium	g/m <sup>3</sup>	10.5	-	-	-
Dissolved Zinc	g/m <sup>3</sup>	0.0152	-	-	-
Chloride	g/m <sup>3</sup>	11.9	-	-	-
Nitrite-N	g/m <sup>3</sup>	< 0.002	-	-	-
Nitrate-N	g/m <sup>3</sup>	0.73	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	0.73	-	-	-
Sulphate	g/m <sup>3</sup>	3.2	-	-	-
Ethylene Glycol in Water					
Ethylene glycol*	g/m <sup>3</sup>	19	-	-	-
Propylene Glycol in Water					
Propylene glycol*	g/m <sup>3</sup>	< 4	-	-	-
Methanol in Water - Aqueous Solvents					
Methanol*	g/m <sup>3</sup>	< 2	-	-	-
BTEX in Water by Headspace GC-MS					
Benzene	g/m <sup>3</sup>	< 0.0010	-	-	-
Toluene	g/m <sup>3</sup>	< 0.0010	-	-	-
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	-	-	-
m&p-Xylene	g/m <sup>3</sup>	< 0.002	-	-	-

Sample Type: Aqueous						
<b>Sample Name:</b>	GND2342 12-Jun-2013 9:45 am					
<b>Lab Number:</b>	1145262.1					
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m <sup>3</sup>	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m <sup>3</sup>	< 0.003	-	-	-	-
Ethylene	g/m <sup>3</sup>	< 0.004	-	-	-	-
Methane	g/m <sup>3</sup>	< 0.002	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m <sup>3</sup>	< 0.10	-	-	-	-
C10 - C14	g/m <sup>3</sup>	< 0.2	-	-	-	-
C15 - C36	g/m <sup>3</sup>	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	< 0.7	-	-	-	-

## SUMMARY OF METHODS

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

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [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 mEq/L.	0.07 meq/L	1
Total cations for anion/cation balance check	Calculation: sum of cations as mEq/L.	0.05 meq/L	1
pH	pH meter. APHA 4500-H+ B 21 <sup>st</sup> ed. 2005.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 21 <sup>st</sup> ed. 2005.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	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 <sub>2</sub> D 21 <sup>st</sup> ed. 2005.	1.0 g/m <sup>3</sup> at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 21 <sup>st</sup> ed. 2005.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21 <sup>st</sup> ed. 2005.	0.1 mS/m	1
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 21 <sup>st</sup> ed. 2005.	10 g/m <sup>3</sup>	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.00010 g/m <sup>3</sup>	1
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.005 g/m <sup>3</sup>	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.05 g/m <sup>3</sup>	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0005 g/m <sup>3</sup>	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.02 g/m <sup>3</sup>	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.02 g/m <sup>3</sup>	1



Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0005 g/m <sup>3</sup>	1
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m <sup>3</sup>	1
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0005 g/m <sup>3</sup>	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.05 g/m <sup>3</sup>	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.02 g/m <sup>3</sup>	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0010 g/m <sup>3</sup>	1
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl <sup>-</sup> E (modified from continuous flow analysis) 21 <sup>st</sup> ed. 2005.	0.5 g/m <sup>3</sup>	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>2</sub> <sup>-</sup> I (Modified) 21 <sup>st</sup> ed. 2005.	0.002 g/m <sup>3</sup>	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N.	0.002 g/m <sup>3</sup>	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO <sub>3</sub> <sup>-</sup> I 21 <sup>st</sup> ed. 2005.	0.002 g/m <sup>3</sup>	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 21 <sup>st</sup> ed. 2005.	0.5 g/m <sup>3</sup>	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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Ara Heron BSc (Tech)  
Client Services Manager - Environmental Division



# ANALYSIS REPORT

Page 1 of 3

<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	1130074	SPV1
<b>Contact:</b>	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	<b>Date Registered:</b>	01-May-2013	
		<b>Date Reported:</b>	07-May-2013	
		<b>Quote No:</b>	47915	
		<b>Order No:</b>		
		<b>Client Reference:</b>	Groundwater	
		<b>Submitted By:</b>	Regan Phipps	

## Sample Type: Aqueous

<b>Sample Name:</b>	GND2352 30-Apr-2013 11:17 am				
<b>Lab Number:</b>	1130074.1				

### Individual Tests

Sum of Anions	meq/L	3.3	-	-	-	-
Sum of Cations	meq/L	3.8	-	-	-	-
pH	pH Units	6.2	-	-	-	-
Total Alkalinity	g/m <sup>3</sup> as CaCO <sub>3</sub>	41	-	-	-	-
Bicarbonate	g/m <sup>3</sup> at 25°C	50	-	-	-	-
Total Hardness	g/m <sup>3</sup> as CaCO <sub>3</sub>	87	-	-	-	-
Electrical Conductivity (EC)	mS/m	37.9	-	-	-	-
Total Dissolved Solids (TDS)	g/m <sup>3</sup>	260	-	-	-	-
Dissolved Barium	g/m <sup>3</sup>	0.023	-	-	-	-
Dissolved Calcium	g/m <sup>3</sup>	18.1	-	-	-	-
Dissolved Copper	g/m <sup>3</sup>	< 0.0005	-	-	-	-
Dissolved Iron	g/m <sup>3</sup>	3.6	-	-	-	-
Dissolved Magnesium	g/m <sup>3</sup>	10.1	-	-	-	-
Dissolved Manganese	g/m <sup>3</sup>	0.197	-	-	-	-
Dissolved Mercury	g/m <sup>3</sup>	< 0.00008	-	-	-	-
Dissolved Nickel	g/m <sup>3</sup>	0.0050	-	-	-	-
Dissolved Potassium	g/m <sup>3</sup>	6.0	-	-	-	-
Dissolved Sodium	g/m <sup>3</sup>	40	-	-	-	-
Dissolved Zinc	g/m <sup>3</sup>	0.023	-	-	-	-
Bromide	g/m <sup>3</sup>	0.12	-	-	-	-
Chloride	g/m <sup>3</sup>	37	-	-	-	-
Nitrite-N	g/m <sup>3</sup>	0.151	-	-	-	-
Nitrate-N	g/m <sup>3</sup>	2.9	-	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	3.0	-	-	-	-
Sulphate	g/m <sup>3</sup>	61	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Toluene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
m&p-Xylene	g/m <sup>3</sup>	< 0.002	-	-	-	-

Sample Type: Aqueous						
<b>Sample Name:</b>	GND2352 30-Apr-2013 11:17 am					
<b>Lab Number:</b>	1130074.1					
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m <sup>3</sup>	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m <sup>3</sup>	< 0.003	-	-	-	-
Ethylene	g/m <sup>3</sup>	< 0.004	-	-	-	-
Methane	g/m <sup>3</sup>	0.007	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m <sup>3</sup>	< 0.10	-	-	-	-
C10 - C14	g/m <sup>3</sup>	< 0.2	-	-	-	-
C15 - C36	g/m <sup>3</sup>	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	< 0.7	-	-	-	-

## SUMMARY OF METHODS

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

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B	-	1
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	-	1
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	-	1
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines	-	1
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1
Total anions for anion/cation balance check	Calculation: sum of anions as mEq/L.	0.07 meq/L	1
Total cations for anion/cation balance check	Calculation: sum of cations as mEq/L.	0.05 meq/L	1
pH	pH meter. APHA 4500-H+ B 21 <sup>st</sup> ed. 2005.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 21 <sup>st</sup> ed. 2005.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	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 <sub>2</sub> D 21 <sup>st</sup> ed. 2005.	1.0 g/m <sup>3</sup> at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 21 <sup>st</sup> ed. 2005.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 21 <sup>st</sup> ed. 2005.	0.1 mS/m	1
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 21 <sup>st</sup> ed. 2005.	10 g/m <sup>3</sup>	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.00010 g/m <sup>3</sup>	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.05 g/m <sup>3</sup>	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0005 g/m <sup>3</sup>	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.02 g/m <sup>3</sup>	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.02 g/m <sup>3</sup>	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0005 g/m <sup>3</sup>	1
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m <sup>3</sup>	1

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Samples
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0005 g/m <sup>3</sup>	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.05 g/m <sup>3</sup>	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.02 g/m <sup>3</sup>	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0010 g/m <sup>3</sup>	1
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B 21 <sup>st</sup> ed. 2005.	0.05 g/m <sup>3</sup>	1
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl <sup>-</sup> E (modified from continuous flow analysis) 21 <sup>st</sup> ed. 2005.	0.5 g/m <sup>3</sup>	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>2</sub> <sup>-</sup> I (Modified) 21 <sup>st</sup> ed. 2005.	0.002 g/m <sup>3</sup>	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N.	0.002 g/m <sup>3</sup>	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO <sub>3</sub> <sup>-</sup> I (Modified) 21 <sup>st</sup> ed. 2005.	0.002 g/m <sup>3</sup>	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 21 <sup>st</sup> ed. 2005.	0.5 g/m <sup>3</sup>	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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Ara Heron BSc (Tech)  
Client Services Manager - Environmental Division



## ANALYSIS REPORT

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<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	1248043	SPV1
<b>Contact:</b>	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	<b>Date Registered:</b>	14-Mar-2014	
		<b>Date Reported:</b>	21-Mar-2014	
		<b>Quote No:</b>	47915	
		<b>Order No:</b>		
		<b>Client Reference:</b>	ST05 KA19 Post HF GW	
		<b>Submitted By:</b>	R McDonnell	

### Sample Type: Aqueous

<b>Sample Name:</b>	GND0093 13-Mar-2014 12:21 pm	GND2348 13-Mar-2014 2:42 pm			
<b>Lab Number:</b>	1248043.1	1248043.2			

#### Individual Tests

Parameter	Unit	1248043.1	1248043.2			
Sum of Anions	meq/L	2.2	3.3	-	-	-
Sum of Cations	meq/L	2.0	3.9	-	-	-
pH	pH Units	7.9	6.8	-	-	-
Total Alkalinity	g/m <sup>3</sup> as CaCO <sub>3</sub>	67	50	-	-	-
Bicarbonate	g/m <sup>3</sup> at 25°C	81	60	-	-	-
Total Hardness	g/m <sup>3</sup> as CaCO <sub>3</sub>	39	76	-	-	-
Electrical Conductivity (EC)	mS/m	23.2	38.7	-	-	-
Total Dissolved Solids (TDS)	g/m <sup>3</sup>	112	250	-	-	-
Dissolved Barium	g/m <sup>3</sup>	0.107	0.056	-	-	-
Dissolved Bromine*	g/m <sup>3</sup>	0.181	0.30	-	-	-
Dissolved Calcium	g/m <sup>3</sup>	9.7	16.6	-	-	-
Dissolved Copper	g/m <sup>3</sup>	< 0.0005	0.0005	-	-	-
Dissolved Iron	g/m <sup>3</sup>	0.45	27	-	-	-
Dissolved Magnesium	g/m <sup>3</sup>	3.6	8.4	-	-	-
Dissolved Manganese	g/m <sup>3</sup>	0.146	0.53	-	-	-
Dissolved Mercury	g/m <sup>3</sup>	< 0.00008	< 0.00008	-	-	-
Dissolved Nickel	g/m <sup>3</sup>	< 0.0005	0.0020	-	-	-
Dissolved Potassium	g/m <sup>3</sup>	9.0	8.7	-	-	-
Dissolved Sodium	g/m <sup>3</sup>	23	27	-	-	-
Dissolved Zinc	g/m <sup>3</sup>	0.042	0.47	-	-	-
Chloride	g/m <sup>3</sup>	30	83	-	-	-
Nitrite-N	g/m <sup>3</sup>	< 0.002	< 0.02 #1	-	-	-
Nitrate-N	g/m <sup>3</sup>	0.007	< 0.02	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	0.008	< 0.02 #1	-	-	-
Sulphate	g/m <sup>3</sup>	0.5	< 0.5	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	< 4	< 4	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 4	< 4	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	< 2	2	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m <sup>3</sup>	< 0.0010	< 0.0010	-	-	-
Toluene	g/m <sup>3</sup>	< 0.0010	< 0.0010	-	-	-
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	< 0.0010	-	-	-
m&p-Xylene	g/m <sup>3</sup>	< 0.002	< 0.002	-	-	-

Sample Type: Aqueous						
<b>Sample Name:</b>	GND0093 13-Mar-2014 12:21 pm	GND2348 13-Mar-2014 2:42 pm				
<b>Lab Number:</b>	1248043.1	1248043.2				
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m <sup>3</sup>	< 0.0010	< 0.0010	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m <sup>3</sup>	< 0.02	< 0.02	-	-	-
Gases in groundwater						
Ethane	g/m <sup>3</sup>	< 0.003	< 0.003	-	-	-
Ethylene	g/m <sup>3</sup>	< 0.003	< 0.003	-	-	-
Methane	g/m <sup>3</sup>	2.1	1.02	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m <sup>3</sup>	< 0.10	< 0.10	-	-	-
C10 - C14	g/m <sup>3</sup>	< 0.2	< 0.2	-	-	-
C15 - C36	g/m <sup>3</sup>	< 0.4	< 0.4	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	< 0.7	< 0.7	-	-	-

### Analyst's Comments

#1 Severe matrix interferences required that a dilution be performed prior to analysis of this sample, resulting in a detection limit higher than that normally achieved for the NO<sub>2</sub>N, NO<sub>3</sub>N and NO<sub>x</sub>N analysis.

## 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/m <sup>3</sup>	1-2
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m <sup>3</sup>	1-2
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m <sup>3</sup>	1-2
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m <sup>3</sup>	1-2
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m <sup>3</sup>	1-2
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m <sup>3</sup>	1-2
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/m <sup>3</sup>	1-2
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-2
Total anions for anion/cation balance check	Calculation: sum of anions as mEq/L.	0.07 meq/L	1-2
Total cations for anion/cation balance check	Calculation: sum of cations as mEq/L.	0.05 meq/L	1-2
pH	pH meter. APHA 4500-H+ B 22 <sup>nd</sup> ed. 2012.	0.1 pH Units	1-2
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	1-2
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 <sub>2</sub> D 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> at 25°C	1-2
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	1-2
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22 <sup>nd</sup> ed. 2012.	0.1 mS/m	1-2
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) 22 <sup>nd</sup> ed. 2012.	10 g/m <sup>3</sup>	1-2
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.00010 g/m <sup>3</sup>	1-2
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.005 g/m <sup>3</sup>	1-2
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.05 g/m <sup>3</sup>	1-2
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	1-2



Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Sample No
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	1-2
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	1-2
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	1-2
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m <sup>3</sup>	1-2
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	1-2
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.05 g/m <sup>3</sup>	1-2
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	1-2
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0010 g/m <sup>3</sup>	1-2
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl <sup>-</sup> E (modified from continuous flow analysis) 22 <sup>nd</sup> ed. 2012.	0.5 g/m <sup>3</sup>	1-2
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>2</sub> <sup>-</sup> I 22 <sup>nd</sup> ed. 2012.	0.002 g/m <sup>3</sup>	1-2
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N. In-House.	0.0010 g/m <sup>3</sup>	1-2
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO <sub>3</sub> <sup>-</sup> I 22 <sup>nd</sup> ed. 2012.	0.002 g/m <sup>3</sup>	1-2
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22 <sup>nd</sup> ed. 2012.	0.5 g/m <sup>3</sup>	1-2

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



## ANALYSIS REPORT

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<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	1248629	SPV1
<b>Contact:</b>	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	<b>Date Registered:</b>	15-Mar-2014	
		<b>Date Reported:</b>	31-Mar-2014	
		<b>Quote No:</b>	47915	
		<b>Order No:</b>		
		<b>Client Reference:</b>	KA19 Post HF GW	
		<b>Submitted By:</b>	Regan Phipps	

### Sample Type: Aqueous

<b>Sample Name:</b>	GND2357 14-Mar-2014 10:10 am	GND2011 14-Mar-2014 2:00 pm			
<b>Lab Number:</b>	1248629.1	1248629.2			

#### Individual Tests

Parameter	Unit	GND2357	GND2011			
Sum of Anions	meq/L	1.93	3.3	-	-	-
Sum of Cations	meq/L	2.3	3.2	-	-	-
pH	pH Units	8.7	8.2	-	-	-
Total Alkalinity	g/m <sup>3</sup> as CaCO <sub>3</sub>	75	146	-	-	-
Bicarbonate	g/m <sup>3</sup> at 25°C	87	176	-	-	-
Total Hardness	g/m <sup>3</sup> as CaCO <sub>3</sub>	25	87	-	-	-
Electrical Conductivity (EC)	mS/m	17.0	31.3	-	-	-
Total Dissolved Solids (TDS)	g/m <sup>3</sup>	151	210	-	-	-
Dissolved Barium	g/m <sup>3</sup>	0.023	0.0036	-	-	-
Dissolved Bromine*	g/m <sup>3</sup>	0.042	0.050	-	-	-
Dissolved Calcium	g/m <sup>3</sup>	5.6	22	-	-	-
Dissolved Copper	g/m <sup>3</sup>	0.0149	< 0.0005	-	-	-
Dissolved Iron	g/m <sup>3</sup>	9.1	0.06	-	-	-
Dissolved Magnesium	g/m <sup>3</sup>	2.7	7.6	-	-	-
Dissolved Manganese	g/m <sup>3</sup>	0.050	0.021	-	-	-
Dissolved Mercury	g/m <sup>3</sup>	< 0.00008	< 0.00008	-	-	-
Dissolved Nickel	g/m <sup>3</sup>	0.0014	< 0.0005	-	-	-
Dissolved Potassium	g/m <sup>3</sup>	5.1	4.8	-	-	-
Dissolved Sodium	g/m <sup>3</sup>	25	31	-	-	-
Dissolved Zinc	g/m <sup>3</sup>	7.4	0.0032	-	-	-
Chloride	g/m <sup>3</sup>	13.3	14.8	-	-	-
Nitrite-N	g/m <sup>3</sup>	< 0.002	< 0.002	-	-	-
Nitrate-N	g/m <sup>3</sup>	< 0.002	0.010	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	< 0.002	0.011	-	-	-
Sulphate	g/m <sup>3</sup>	2.8	< 0.5	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	< 4	< 4	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 4	< 4	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	< 2	< 2	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m <sup>3</sup>	< 0.0010	< 0.0010	-	-	-
Toluene	g/m <sup>3</sup>	< 0.0010	< 0.0010	-	-	-
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	< 0.0010	-	-	-
m&p-Xylene	g/m <sup>3</sup>	< 0.002	< 0.002	-	-	-

Sample Type: Aqueous						
<b>Sample Name:</b>	GND2357 14-Mar-2014 10:10 am	GND2011 14-Mar-2014 2:00 pm				
<b>Lab Number:</b>	1248629.1	1248629.2				
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m <sup>3</sup>	< 0.0010	< 0.0010	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m <sup>3</sup>	< 0.02	< 0.02	-	-	-
Gases in groundwater						
Ethane	g/m <sup>3</sup>	< 0.003	< 0.003	-	-	-
Ethylene	g/m <sup>3</sup>	< 0.003	< 0.003	-	-	-
Methane	g/m <sup>3</sup>	8.0	3.6	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m <sup>3</sup>	< 0.10	< 0.10	-	-	-
C10 - C14	g/m <sup>3</sup>	< 0.2	< 0.2	-	-	-
C15 - C36	g/m <sup>3</sup>	< 0.4	< 0.4	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	< 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/m <sup>3</sup>	1-2
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m <sup>3</sup>	1-2
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m <sup>3</sup>	1-2
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m <sup>3</sup>	1-2
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m <sup>3</sup>	1-2
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m <sup>3</sup>	1-2
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/m <sup>3</sup>	1-2
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1-2
Total anions for anion/cation balance check	Calculation: sum of anions as mEq/L.	0.07 meq/L	1-2
Total cations for anion/cation balance check	Calculation: sum of cations as mEq/L.	0.05 meq/L	1-2
pH	pH meter. APHA 4500-H+ B 22 <sup>nd</sup> ed. 2012.	0.1 pH Units	1-2
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	1-2
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 <sub>2</sub> D 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> at 25°C	1-2
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	1-2
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22 <sup>nd</sup> ed. 2012.	0.1 mS/m	1-2
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) 22 <sup>nd</sup> ed. 2012.	10 g/m <sup>3</sup>	1-2
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.00010 g/m <sup>3</sup>	1-2
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.005 g/m <sup>3</sup>	1-2
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.05 g/m <sup>3</sup>	1-2
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	1-2
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	1-2
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	1-2

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Sample No
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	1-2
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m <sup>3</sup>	1-2
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	1-2
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.05 g/m <sup>3</sup>	1-2
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	1-2
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0010 g/m <sup>3</sup>	1-2
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl <sup>-</sup> E (modified from continuous flow analysis) 22 <sup>nd</sup> ed. 2012.	0.5 g/m <sup>3</sup>	1-2
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>2</sub> <sup>-</sup> I 22 <sup>nd</sup> ed. 2012.	0.002 g/m <sup>3</sup>	1-2
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N. In-House.	0.0010 g/m <sup>3</sup>	1-2
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO <sub>3</sub> <sup>-</sup> I 22 <sup>nd</sup> ed. 2012.	0.002 g/m <sup>3</sup>	1-2
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22 <sup>nd</sup> ed. 2012.	0.5 g/m <sup>3</sup>	1-2

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

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

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



## ANALYSIS REPORT

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<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	1212979	SPV2
<b>Contact:</b>	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	<b>Date Registered:</b>	07-Dec-2013	
		<b>Date Reported:</b>	15-Jan-2015	
		<b>Quote No:</b>	47915	
		<b>Order No:</b>		
		<b>Client Reference:</b>	ST05 Kapuni HF/GW	
		<b>Submitted By:</b>	Regan Phipps	

### Sample Type: Aqueous

<b>Sample Name:</b>	GND2342 06-Dec-2013 9:00 am				
<b>Lab Number:</b>	1212979.2				

#### Individual Tests

Sum of Anions	meq/L	3.4	-	-	-	-
Sum of Cations	meq/L	3.4	-	-	-	-
pH	pH Units	6.7	-	-	-	-
Total Alkalinity	g/m <sup>3</sup> as CaCO <sub>3</sub>	75	-	-	-	-
Bicarbonate	g/m <sup>3</sup> at 25°C	91	-	-	-	-
Total Hardness	g/m <sup>3</sup> as CaCO <sub>3</sub>	70	-	-	-	-
Electrical Conductivity (EC)	mS/m	35.9	-	-	-	-
Total Dissolved Solids (TDS)	g/m <sup>3</sup>	240	-	-	-	-
Dissolved Barium	g/m <sup>3</sup>	0.021	-	-	-	-
Dissolved Bromine*	g/m <sup>3</sup>	0.168	-	-	-	-
Dissolved Calcium	g/m <sup>3</sup>	14.3	-	-	-	-
Dissolved Copper	g/m <sup>3</sup>	0.0028	-	-	-	-
Dissolved Iron	g/m <sup>3</sup>	< 0.02	-	-	-	-
Dissolved Magnesium	g/m <sup>3</sup>	8.3	-	-	-	-
Dissolved Manganese	g/m <sup>3</sup>	0.0009	-	-	-	-
Dissolved Mercury	g/m <sup>3</sup>	< 0.00008	-	-	-	-
Dissolved Nickel	g/m <sup>3</sup>	< 0.0005	-	-	-	-
Dissolved Potassium	g/m <sup>3</sup>	12.3	-	-	-	-
Dissolved Sodium	g/m <sup>3</sup>	38	-	-	-	-
Dissolved Zinc	g/m <sup>3</sup>	0.0130	-	-	-	-
Chloride	g/m <sup>3</sup>	35	-	-	-	-
Nitrite-N	g/m <sup>3</sup>	< 0.002	-	-	-	-
Nitrate-N	g/m <sup>3</sup>	1.42	-	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	1.42	-	-	-	-
Sulphate	g/m <sup>3</sup>	37	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Toluene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
m&p-Xylene	g/m <sup>3</sup>	< 0.002	-	-	-	-

Sample Type: Aqueous						
<b>Sample Name:</b>	GND2342 06-Dec-2013 9:00 am					
<b>Lab Number:</b>	1212979.2					
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m <sup>3</sup>	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m <sup>3</sup>	< 0.003	-	-	-	-
Ethylene	g/m <sup>3</sup>	< 0.003	-	-	-	-
Methane	g/m <sup>3</sup>	< 0.002	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m <sup>3</sup>	< 0.10	-	-	-	-
C10 - C14	g/m <sup>3</sup>	< 0.2	-	-	-	-
C15 - C36	g/m <sup>3</sup>	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	< 0.7	-	-	-	-

### Analyst's Comments

Supplement to test report 1212979v1 issued on 13/12/13.

## 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/m <sup>3</sup>	2
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m <sup>3</sup>	2
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m <sup>3</sup>	2
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m <sup>3</sup>	2
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m <sup>3</sup>	2
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m <sup>3</sup>	2
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/m <sup>3</sup>	2
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	2
Total anions for anion/cation balance check	Calculation: sum of anions as mEq/L.	0.07 meq/L	2
Total cations for anion/cation balance check	Calculation: sum of cations as mEq/L.	0.05 meq/L	2
pH	pH meter. APHA 4500-H+ B 22 <sup>nd</sup> ed. 2012.	0.1 pH Units	2
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	2
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 <sub>2</sub> D 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> at 25°C	2
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	2
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22 <sup>nd</sup> ed. 2012.	0.1 mS/m	2
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) 22 <sup>nd</sup> ed. 2012.	10 g/m <sup>3</sup>	2
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.00010 g/m <sup>3</sup>	2
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.005 g/m <sup>3</sup>	2
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.05 g/m <sup>3</sup>	2
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	2



Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Sample No
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	2
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	2
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	2
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m <sup>3</sup>	2
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	2
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.05 g/m <sup>3</sup>	2
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	2
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0010 g/m <sup>3</sup>	2
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl <sup>-</sup> E (modified from continuous flow analysis) 22 <sup>nd</sup> ed. 2012.	0.5 g/m <sup>3</sup>	2
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>2</sub> <sup>-</sup> I 22 <sup>nd</sup> ed. 2012.	0.002 g/m <sup>3</sup>	2
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N. In-House.	0.0010 g/m <sup>3</sup>	2
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO <sub>3</sub> <sup>-</sup> I 22 <sup>nd</sup> ed. 2012.	0.002 g/m <sup>3</sup>	2
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22 <sup>nd</sup> ed. 2012.	0.5 g/m <sup>3</sup>	2

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

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



# ANALYSIS REPORT

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<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	1213570	SPV1
<b>Contact:</b>	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	<b>Date Registered:</b>	10-Dec-2013	
		<b>Date Reported:</b>	17-Dec-2013	
		<b>Quote No:</b>	47915	
		<b>Order No:</b>		
		<b>Client Reference:</b>	Groundwater	
		<b>Submitted By:</b>	Regan Phipps	

## Sample Type: Aqueous

<b>Sample Name:</b>	GND2349 09-Dec-2013 1:26 pm				
<b>Lab Number:</b>	1213570.1				

### Individual Tests

Sum of Anions	meq/L	3.0	-	-	-	-
Sum of Cations	meq/L	3.9 #1	-	-	-	-
pH	pH Units	6.8	-	-	-	-
Total Alkalinity	g/m <sup>3</sup> as CaCO <sub>3</sub>	94	-	-	-	-
Bicarbonate	g/m <sup>3</sup> at 25°C	115	-	-	-	-
Total Hardness	g/m <sup>3</sup> as CaCO <sub>3</sub>	65	-	-	-	-
Electrical Conductivity (EC)	mS/m	31.1	-	-	-	-
Total Dissolved Solids (TDS)	g/m <sup>3</sup>	230	-	-	-	-
Dissolved Barium	g/m <sup>3</sup>	0.048	-	-	-	-
Dissolved Bromine*	g/m <sup>3</sup>	0.160	-	-	-	-
Dissolved Calcium	g/m <sup>3</sup>	14.0	-	-	-	-
Dissolved Copper	g/m <sup>3</sup>	< 0.0005	-	-	-	-
Dissolved Iron	g/m <sup>3</sup>	18.5	-	-	-	-
Dissolved Magnesium	g/m <sup>3</sup>	7.3	-	-	-	-
Dissolved Manganese	g/m <sup>3</sup>	0.44	-	-	-	-
Dissolved Mercury	g/m <sup>3</sup>	< 0.00008	-	-	-	-
Dissolved Nickel	g/m <sup>3</sup>	< 0.0005	-	-	-	-
Dissolved Potassium	g/m <sup>3</sup>	18.1	-	-	-	-
Dissolved Sodium	g/m <sup>3</sup>	32	-	-	-	-
Dissolved Zinc	g/m <sup>3</sup>	1.92	-	-	-	-
Chloride	g/m <sup>3</sup>	38	-	-	-	-
Nitrite-N	g/m <sup>3</sup>	0.012	-	-	-	-
Nitrate-N	g/m <sup>3</sup>	< 0.002	-	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	0.012	-	-	-	-
Sulphate	g/m <sup>3</sup>	< 0.5	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Toluene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
m&p-Xylene	g/m <sup>3</sup>	< 0.002	-	-	-	-

Sample Type: Aqueous						
<b>Sample Name:</b>	GND2349 09-Dec-2013 1:26 pm					
<b>Lab Number:</b>	1213570.1					
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m <sup>3</sup>	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m <sup>3</sup>	< 0.003	-	-	-	-
Ethylene	g/m <sup>3</sup>	< 0.003	-	-	-	-
Methane	g/m <sup>3</sup>	2.1	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m <sup>3</sup>	< 0.10	-	-	-	-
C10 - C14	g/m <sup>3</sup>	< 0.2	-	-	-	-
C15 - C36	g/m <sup>3</sup>	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	< 0.7	-	-	-	-

### Analyst's Comments

#1 It was noted that some of the anion / cation balances did not agree to within expected limits. This was largely attributed to the high levels of dissolved iron. We have included dissolved iron in the cation balance equations. However, the precipitation of large amounts of iron in the unpreserved containers (soon after sampling) will result in the loss of ions from solution and consumption of alkalinity. This may well result in the lower anions relative to the cations. The loss of iron and consequent loss in the cation balance would not be seen as the dissolved iron is sampled into an acid preserved container, stabilising the iron in solution.

## 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 mEq/L.	0.07 meq/L	1
Total cations for anion/cation balance check	Calculation: sum of cations as mEq/L.	0.05 meq/L	1
pH	pH meter. APHA 4500-H+ B 22 <sup>nd</sup> ed. 2012.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	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 <sub>2</sub> D 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22 <sup>nd</sup> 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) 22 <sup>nd</sup> ed. 2012.	10 g/m <sup>3</sup>	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.00010 g/m <sup>3</sup>	1
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.005 g/m <sup>3</sup>	1

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Sample No
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.05 g/m <sup>3</sup>	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	1
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m <sup>3</sup>	1
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.05 g/m <sup>3</sup>	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0010 g/m <sup>3</sup>	1
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl <sup>-</sup> E (modified from continuous flow analysis) 22 <sup>nd</sup> ed. 2012.	0.5 g/m <sup>3</sup>	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>2</sub> <sup>-</sup> I 22 <sup>nd</sup> ed. 2012.	0.002 g/m <sup>3</sup>	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N. In-House.	0.0010 g/m <sup>3</sup>	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO <sub>3</sub> <sup>-</sup> I 22 <sup>nd</sup> ed. 2012.	0.002 g/m <sup>3</sup>	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22 <sup>nd</sup> ed. 2012.	0.5 g/m <sup>3</sup>	1

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

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





## ANALYSIS REPORT

<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	1212436	SPV2
<b>Contact:</b>	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	<b>Date Registered:</b>	06-Dec-2013	
		<b>Date Reported:</b>	15-Jan-2015	
		<b>Quote No:</b>	47915	
		<b>Order No:</b>		
		<b>Client Reference:</b>	STOS Kapuni HF GW	
		<b>Submitted By:</b>	Regan Phipps	

### Sample Type: Aqueous

<b>Sample Name:</b>	GNDD2352 05-Dec-2013 12:26 pm				
<b>Lab Number:</b>	1212436.2				

#### Individual Tests

Sum of Anions	meq/L	3.2	-	-	-	-
Sum of Cations	meq/L	3.2	-	-	-	-
pH	pH Units	6.6	-	-	-	-
Total Alkalinity	g/m <sup>3</sup> as CaCO <sub>3</sub>	68	-	-	-	-
Bicarbonate	g/m <sup>3</sup> at 25°C	82	-	-	-	-
Total Hardness	g/m <sup>3</sup> as CaCO <sub>3</sub>	82	-	-	-	-
Electrical Conductivity (EC)	mS/m	35.6	-	-	-	-
Total Dissolved Solids (TDS)	g/m <sup>3</sup>	220	-	-	-	-
Dissolved Barium	g/m <sup>3</sup>	0.0196	-	-	-	-
Dissolved Bromine*	g/m <sup>3</sup>	0.178	-	-	-	-
Dissolved Calcium	g/m <sup>3</sup>	18.2	-	-	-	-
Dissolved Copper	g/m <sup>3</sup>	< 0.0005	-	-	-	-
Dissolved Iron	g/m <sup>3</sup>	1.85	-	-	-	-
Dissolved Magnesium	g/m <sup>3</sup>	8.8	-	-	-	-
Dissolved Manganese	g/m <sup>3</sup>	0.120	-	-	-	-
Dissolved Mercury	g/m <sup>3</sup>	< 0.00008	-	-	-	-
Dissolved Nickel	g/m <sup>3</sup>	0.0041	-	-	-	-
Dissolved Potassium	g/m <sup>3</sup>	5.6	-	-	-	-
Dissolved Sodium	g/m <sup>3</sup>	32	-	-	-	-
Dissolved Zinc	g/m <sup>3</sup>	0.0155	-	-	-	-
Chloride	g/m <sup>3</sup>	38	-	-	-	-
Nitrite-N	g/m <sup>3</sup>	0.018	-	-	-	-
Nitrate-N	g/m <sup>3</sup>	4.2	-	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	4.2	-	-	-	-
Sulphate	g/m <sup>3</sup>	25	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Toluene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
m&p-Xylene	g/m <sup>3</sup>	< 0.002	-	-	-	-



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

Sample Type: Aqueous						
<b>Sample Name:</b>	GNDD2352					
	05-Dec-2013					
	12:26 pm					
<b>Lab Number:</b>	1212436.2					
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m <sup>3</sup>	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m <sup>3</sup>	< 0.003	-	-	-	-
Ethylene	g/m <sup>3</sup>	< 0.003	-	-	-	-
Methane	g/m <sup>3</sup>	0.068	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m <sup>3</sup>	< 0.10	-	-	-	-
C10 - C14	g/m <sup>3</sup>	< 0.2	-	-	-	-
C15 - C36	g/m <sup>3</sup>	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	< 0.7	-	-	-	-

### Analyst's Comments

Supplement to test report 1212436v1 issued on 13/12/13.

## 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/m <sup>3</sup>	2
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m <sup>3</sup>	2
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m <sup>3</sup>	2
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m <sup>3</sup>	2
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m <sup>3</sup>	2
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m <sup>3</sup>	2
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/m <sup>3</sup>	2
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	2
Total anions for anion/cation balance check	Calculation: sum of anions as mEq/L.	0.07 meq/L	2
Total cations for anion/cation balance check	Calculation: sum of cations as mEq/L.	0.05 meq/L	2
pH	pH meter. APHA 4500-H+ B 22 <sup>nd</sup> ed. 2012.	0.1 pH Units	2
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	2
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 <sub>2</sub> D 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> at 25°C	2
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	2
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22 <sup>nd</sup> ed. 2012.	0.1 mS/m	2
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) 22 <sup>nd</sup> ed. 2012.	10 g/m <sup>3</sup>	2
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.00010 g/m <sup>3</sup>	2
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.005 g/m <sup>3</sup>	2
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.05 g/m <sup>3</sup>	2
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	2



Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Sample No
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	2
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	2
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	2
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. US EPA Method 245.7, Feb 2005.	0.00008 g/m <sup>3</sup>	2
Dissolved Nickel	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0005 g/m <sup>3</sup>	2
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.05 g/m <sup>3</sup>	2
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.02 g/m <sup>3</sup>	2
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0010 g/m <sup>3</sup>	2
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl <sup>-</sup> E (modified from continuous flow analysis) 22 <sup>nd</sup> ed. 2012.	0.5 g/m <sup>3</sup>	2
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>2</sub> <sup>-</sup> I 22 <sup>nd</sup> ed. 2012.	0.002 g/m <sup>3</sup>	2
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N. In-House.	0.0010 g/m <sup>3</sup>	2
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. APHA 4500-NO <sub>3</sub> <sup>-</sup> I 22 <sup>nd</sup> ed. 2012.	0.002 g/m <sup>3</sup>	2
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22 <sup>nd</sup> ed. 2012.	0.5 g/m <sup>3</sup>	2

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

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

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



## **Appendix IV**

### **Certificates of analysis (Hydraulic fracturing and return fluid)**



# ANALYSIS REPORT

Page 1 of 2

<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	1145869	SPV1
<b>Contact:</b>	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	<b>Date Registered:</b>	14-Jun-2013	
		<b>Date Reported:</b>	28-Jun-2013	
		<b>Quote No:</b>	50522	
		<b>Order No:</b>		
		<b>Client Reference:</b>	STOS KA4/14 HF Fluid	
		<b>Submitted By:</b>	Regan Phipps	

Sample Type: Aqueous						
<b>Sample Name:</b>	GND 1693 13-Jun-2013 3:00 pm					
<b>Lab Number:</b>	1145869.1					
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	143	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
Toluene	g/m <sup>3</sup>	0.0025	-	-	-	-
Ethylbenzene	g/m <sup>3</sup>	< 0.0010	-	-	-	-
m&p-Xylene	g/m <sup>3</sup>	< 0.002	-	-	-	-
o-Xylene	g/m <sup>3</sup>	0.0019	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m <sup>3</sup>	< 0.4	-	-	-	-
C10 - C14	g/m <sup>3</sup>	48	-	-	-	-
C15 - C36	g/m <sup>3</sup>	102	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	150	-	-	-	-

**Analyst's Comments**  
Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

## SUMMARY OF METHODS

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

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

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

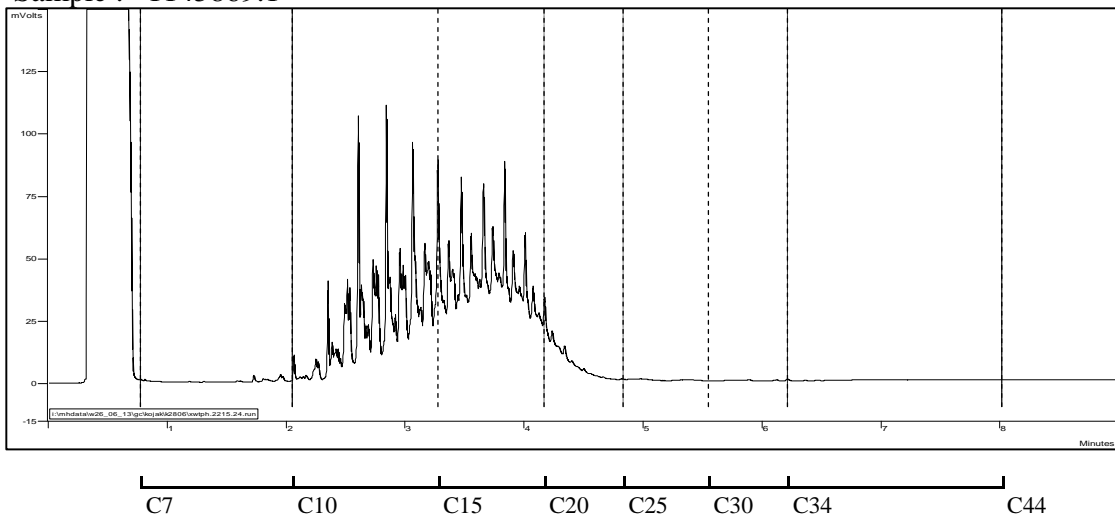
Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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

Sample : 1145869.1







# ANALYSIS REPORT

Page 1 of 2

<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	1163287	SPV1
<b>Contact:</b>	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	<b>Date Registered:</b>	03-Aug-2013	
		<b>Date Reported:</b>	13-Aug-2013	
		<b>Quote No:</b>	50522	
		<b>Order No:</b>		
		<b>Client Reference:</b>	Hydraulic fracturing fluid Ka1	
		<b>Submitted By:</b>	Regan Phipps	

## Sample Type: Aqueous

<b>Sample Name:</b>	GND2366 28-Jul-2013 12:00 pm				
<b>Lab Number:</b>	1163287.1				
Ethylene Glycol in Water					
Ethylene glycol*	g/m <sup>3</sup>	250	-	-	-
Propylene Glycol in Water					
Propylene glycol*	g/m <sup>3</sup>	< 4	-	-	-
Methanol in Water - Aqueous Solvents					
Methanol*	g/m <sup>3</sup>	4	-	-	-
BTEX in Water by Headspace GC-MS					
Benzene	g/m <sup>3</sup>	0.053	-	-	-
Toluene	g/m <sup>3</sup>	0.039	-	-	-
Ethylbenzene	g/m <sup>3</sup>	0.0021	-	-	-
m&p-Xylene	g/m <sup>3</sup>	0.006	-	-	-
o-Xylene	g/m <sup>3</sup>	0.0032	-	-	-
Total Petroleum Hydrocarbons in Water					
C7 - C9	g/m <sup>3</sup>	0.79	-	-	-
C10 - C14	g/m <sup>3</sup>	37	-	-	-
C15 - C36	g/m <sup>3</sup>	92	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	130	-	-	-

## Analyst's Comments

It must be noted that the solid in the unpreserved bottle settled out and formed a large white gelatinous mass, and only the liquid was analysed.

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

## SUMMARY OF METHODS

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

### Sample Type: Aqueous

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



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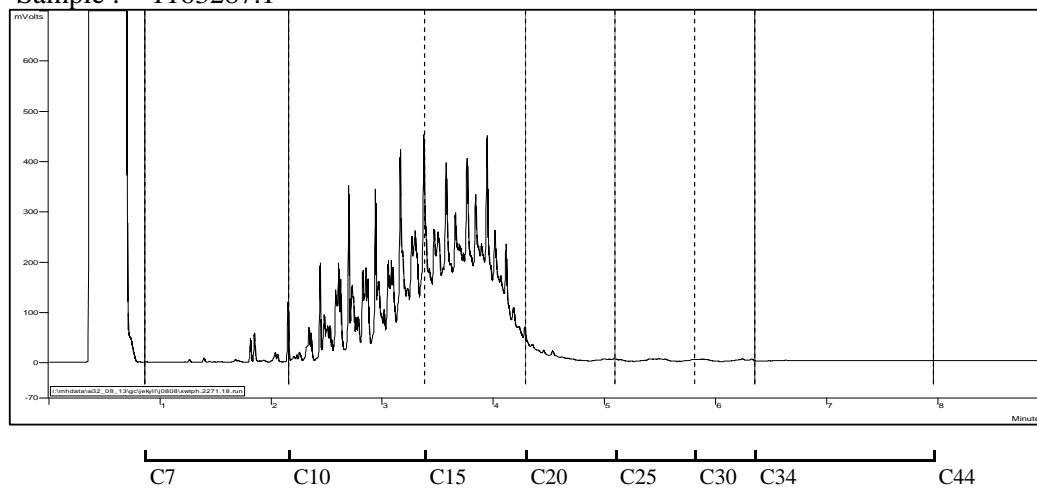
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Ara Heron BSc (Tech)  
Client Services Manager - Environmental Division

Sample : 1163287.1





# ANALYSIS REPORT

Page 1 of 2

<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	1212957	SPV1
<b>Contact:</b>	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	<b>Date Registered:</b>	07-Dec-2013	
		<b>Date Reported:</b>	16-Dec-2013	
		<b>Quote No:</b>	50522	
		<b>Order No:</b>		
		<b>Client Reference:</b>	HF Fluid KA19	
		<b>Submitted By:</b>	Regan Phipps	

## Sample Type: Aqueous

<b>Sample Name:</b>	GND2431 14-Nov-2013 12:00 pm					
<b>Lab Number:</b>	1212957.1					
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	127	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	3	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m <sup>3</sup>	0.0010	-	-	-	-
Toluene	g/m <sup>3</sup>	0.0091	-	-	-	-
Ethylbenzene	g/m <sup>3</sup>	0.0045	-	-	-	-
m&p-Xylene	g/m <sup>3</sup>	0.025	-	-	-	-
o-Xylene	g/m <sup>3</sup>	0.0129	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m <sup>3</sup>	5.2	-	-	-	-
C10 - C14	g/m <sup>3</sup>	530	-	-	-	-
C15 - C36	g/m <sup>3</sup>	1,220	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m <sup>3</sup>	1,750	-	-	-	-

## Analyst's Comments

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

## SUMMARY OF METHODS

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

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
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	-	1

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

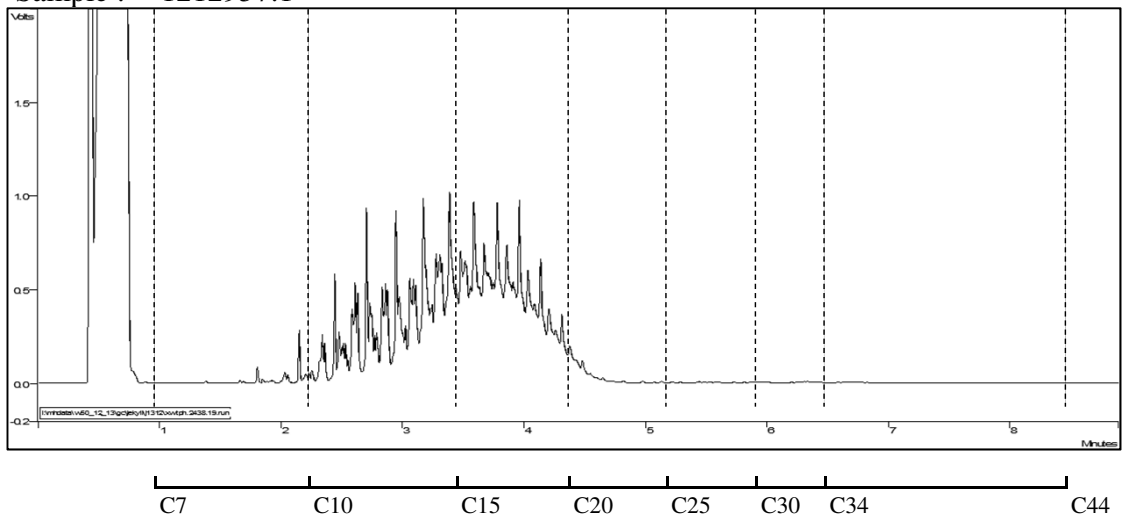
Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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Martin Cowell - BSc  
Client Services Manager - Environmental Division

Sample : 1212957.1









## ANALYSIS REPORT

<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	1212980	SPV1
<b>Contact:</b>	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	<b>Date Registered:</b>	07-Dec-2013	
		<b>Date Reported:</b>	24-Dec-2013	
		<b>Quote No:</b>	49265	
		<b>Order No:</b>		
		<b>Client Reference:</b>	KA 19 Flow Back Fluid	
		<b>Submitted By:</b>	Regan Phipps	

### Sample Type: Saline

<b>Sample Name:</b>	GND2431 24-Nov-2013 7:00 pm				
<b>Lab Number:</b>	1212980.1				

#### Individual Tests

pH*	pH Units	7.1	-	-	-	-
Total Alkalinity*	g/m <sup>3</sup> as CaCO <sub>3</sub>	3,000	-	-	-	-
Analysis Temperature for Bicarbonate	°C	22	-	-	-	-
Bicarbonate	g/m <sup>3</sup> at Analysis Temperature	3,020	-	-	-	-
Total Hardness*	g/m <sup>3</sup> as CaCO <sub>3</sub>	125	-	-	-	-
Electrical Conductivity (EC)*	mS/m	851	-	-	-	-
Total Dissolved Solids (TDS)*	g/m <sup>3</sup>	9,300	-	-	-	-
Dissolved Barium*	g/m <sup>3</sup>	2.0	-	-	-	-
Dissolved Bromine*	g/m <sup>3</sup>	5.2 #1	-	-	-	-
Dissolved Calcium*	g/m <sup>3</sup>	40	-	-	-	-
Dissolved Copper*	g/m <sup>3</sup>	0.057	-	-	-	-
Dissolved Iron*	g/m <sup>3</sup>	4.4	-	-	-	-
Dissolved Magnesium*	g/m <sup>3</sup>	6	-	-	-	-
Dissolved Manganese*	g/m <sup>3</sup>	2.3	-	-	-	-
Total Mercury*	g/m <sup>3</sup>	< 0.011	-	-	-	-
Dissolved Nickel*	g/m <sup>3</sup>	0.36	-	-	-	-
Dissolved Potassium*	g/m <sup>3</sup>	40	-	-	-	-
Dissolved Sodium*	g/m <sup>3</sup>	2,100	-	-	-	-
Dissolved Sulphur*	g/m <sup>3</sup>	30	-	-	-	-
Dissolved Zinc*	g/m <sup>3</sup>	0.11	-	-	-	-
Chloride*	g/m <sup>3</sup>	1,180	-	-	-	-
Nitrite-N	g/m <sup>3</sup>	29	-	-	-	-
Nitrate-N	g/m <sup>3</sup>	23	-	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	53	-	-	-	-
Sulphate*	g/m <sup>3</sup>	90	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	111	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene*	g/m <sup>3</sup>	2.0	-	-	-	-
Toluene*	g/m <sup>3</sup>	3.1	-	-	-	-
Ethylbenzene*	g/m <sup>3</sup>	0.21	-	-	-	-
m&p-Xylene*	g/m <sup>3</sup>	1.48	-	-	-	-



This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.

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

Sample Type: Saline						
<b>Sample Name:</b>	GND2431 24-Nov-2013 7:00 pm					
<b>Lab Number:</b>	1212980.1					
BTEX in Water by Headspace GC-MS						
o-Xylene*	g/m <sup>3</sup>	0.52	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m <sup>3</sup>	< 0.02	-	-	-	-
Gases in groundwater						
Ethane*	g/m <sup>3</sup>	0.30	-	-	-	-
Ethylene*	g/m <sup>3</sup>	< 0.003	-	-	-	-
Methane*	g/m <sup>3</sup>	1.38	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9*	g/m <sup>3</sup>	15.7	-	-	-	-
C10 - C14*	g/m <sup>3</sup>	140	-	-	-	-
C15 - C36*	g/m <sup>3</sup>	270	-	-	-	-
Total hydrocarbons (C7 - C36)*	g/m <sup>3</sup>	420	-	-	-	-

### Analyst's Comments

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

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

Appendix No.2 - NZ Geothermal Analytical Laboratory report

## SUMMARY OF METHODS

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

Sample Type: Saline			
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 Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E 22 <sup>nd</sup> ed. 2012 (modified).	-	1
pH*	Saline water, pH meter. APHA 4500-H+ B 22 <sup>nd</sup> ed. 2012.	0.1 pH Units	1
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	1
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	1
Bicarbonate	Bicarbonate (HCO <sub>3</sub> ) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988.	20 g/m <sup>3</sup> at Analysis Temperature	1
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	1
Electrical Conductivity (EC)*	Saline water, Conductivity meter, 25°C. APHA 2510 B 22 <sup>nd</sup> ed. 2012.	0.10 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) 22 <sup>nd</sup> ed. 2012.	50 g/m <sup>3</sup>	1
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22 <sup>nd</sup> ed. 2012.	-	1
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0006 g/m <sup>3</sup>	1

Sample Type: Saline			
Test	Method Description	Default Detection Limit	Sample No
Dissolved Bromine*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.10 g/m <sup>3</sup>	1
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup>	1
Dissolved Copper*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0010 g/m <sup>3</sup>	1
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.004 g/m <sup>3</sup>	1
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.4 g/m <sup>3</sup>	1
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0010 g/m <sup>3</sup>	1
Total Mercury*	Nitric acid digestion, ICP-MS, screen level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0021 g/m <sup>3</sup>	1
Dissolved Nickel*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.006 g/m <sup>3</sup>	1
Dissolved Potassium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup>	1
Dissolved Sodium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.4 g/m <sup>3</sup>	1
Dissolved Sulphur*	Filtered sample, ICP-OES.	0.10 g/m <sup>3</sup>	1
Dissolved Zinc*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.004 g/m <sup>3</sup>	1
Chloride*	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl <sup>-</sup> E (modified from continuous flow analysis) 22 <sup>nd</sup> ed. 2012.	0.5 g/m <sup>3</sup>	1
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>2</sub> <sup>-</sup> I 22 <sup>nd</sup> ed. 2012.	0.002 g/m <sup>3</sup>	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N. In-House.	0.0010 g/m <sup>3</sup>	1
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO <sub>3</sub> <sup>-</sup> I 22 <sup>nd</sup> ed. 2012.	0.002 g/m <sup>3</sup>	1
Soluble Sulphate*	Calculation: from dissolved sulphur.	2 g/m <sup>3</sup>	1

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

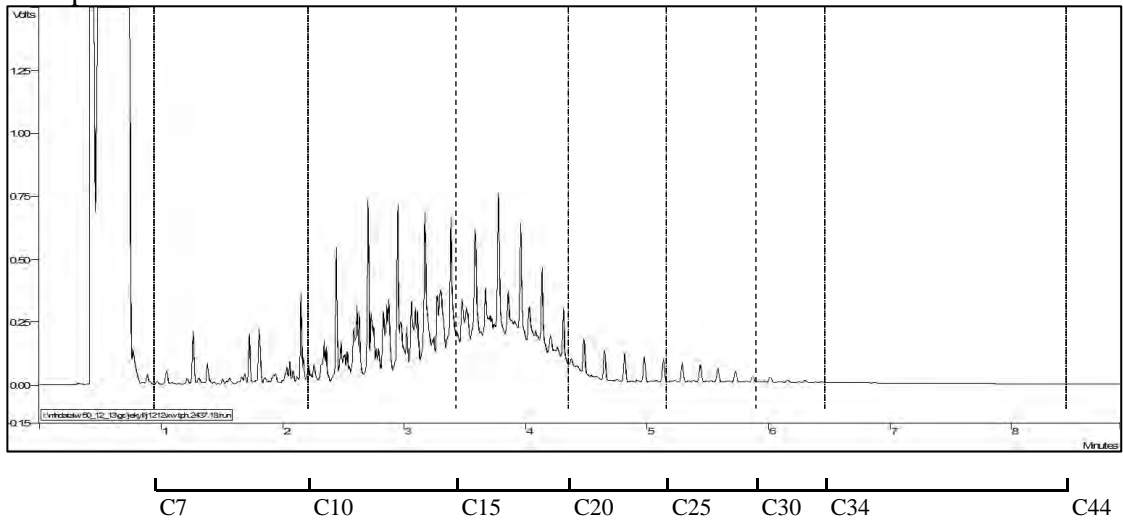
Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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

Sample : 1212980.1





**ANALYTICAL LABORATORY**  
 Private Bag 2000, Taupo  
 Phone: (07) 374 8211  
 Fax: (07) 374 8199  
 Email: w.labmanager@gns.cri.nz

**CERTIFICATE OF ANALYSIS****TOTAL BICARBONATE**

Report No: 2013121104

Customer Ref:136415

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

**GNS Sample No.** 2013007620

**Collection Date:**

**Site ID:** 1212980/1

**Field ID**

pH		7.35	-	-	-
Bicarbonate (Total)	mg/l	3023	-	-	-
HCO <sub>3</sub> Analysis Temperature	°C	22	-	-	-
HCO <sub>3</sub> Analysis Date		14/12/2013	-	-	-


**SUMMARY OF METHODS AND DETECTION LIMITS**

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

Parameter	Method	*Detection Limit	
Bicarbonate (total)	HCO <sub>3</sub> Titration Method ASTM Standards D513-82 Vol.11.01 1988	20	mg/l
pH	Electrometric Method - APHA 4500-H+ B 22nd Edition 2012	-	-

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

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

  
 Bruce Mountain, Ph.D.  
 Geochemist



## ANALYSIS REPORT

Page 1 of 3

<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	1168231	SPV1
<b>Contact:</b>	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	<b>Date Registered:</b>	16-Aug-2013	
		<b>Date Reported:</b>	26-Aug-2013	
		<b>Quote No:</b>	49265	
		<b>Order No:</b>		
		<b>Client Reference:</b>	KA17 Return Fluid	
		<b>Submitted By:</b>	Regan Phipps	

### Sample Type: Saline

<b>Sample Name:</b>	GND2366 10-Aug-2013 4:30 pm				
<b>Lab Number:</b>	1168231.1				

#### Individual Tests

pH*	pH Units	7.0	-	-	-	-
Total Alkalinity*	g/m <sup>3</sup> as CaCO <sub>3</sub>	930	-	-	-	-
Total Hardness*	g/m <sup>3</sup> as CaCO <sub>3</sub>	42	-	-	-	-
Electrical Conductivity (EC)*	mS/m	224	-	-	-	-
Dissolved Barium*	g/m <sup>3</sup>	0.151	-	-	-	-
Dissolved Bromine*	g/m <sup>3</sup>	0.6	-	-	-	-
Dissolved Calcium*	g/m <sup>3</sup>	11	-	-	-	-
Dissolved Copper*	g/m <sup>3</sup>	0.007	-	-	-	-
Dissolved Iron*	g/m <sup>3</sup>	12.0	-	-	-	-
Dissolved Magnesium*	g/m <sup>3</sup>	4	-	-	-	-
Dissolved Manganese*	g/m <sup>3</sup>	0.73	-	-	-	-
Dissolved Nickel*	g/m <sup>3</sup>	0.09	-	-	-	-
Dissolved Potassium*	g/m <sup>3</sup>	11	-	-	-	-
Dissolved Sodium*	g/m <sup>3</sup>	540	-	-	-	-
Dissolved Sulphur*	g/m <sup>3</sup>	9	-	-	-	-
Dissolved Zinc*	g/m <sup>3</sup>	0.05	-	-	-	-
Chloride*	g/m <sup>3</sup>	176	-	-	-	-
Nitrite-N	g/m <sup>3</sup>	< 0.002	-	-	-	-
Nitrate-N	g/m <sup>3</sup>	0.003	-	-	-	-
Nitrate*	g/m <sup>3</sup>	0.011	-	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	0.003	-	-	-	-
Sulphate*	g/m <sup>3</sup>	26	-	-	-	-

#### Ethylene Glycol in Water

Ethylene glycol*	g/m <sup>3</sup>	1,910	-	-	-	-
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#### Propylene Glycol in Water

Propylene glycol*	g/m <sup>3</sup>	< 20	-	-	-	-
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#### Methanol in Water - Aqueous Solvents

Methanol*	g/m <sup>3</sup>	< 20	-	-	-	-
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#### BTEX in Water by Headspace GC-MS

Benzene*	g/m <sup>3</sup>	0.93	-	-	-	-
Toluene*	g/m <sup>3</sup>	3.8	-	-	-	-
Ethylbenzene*	g/m <sup>3</sup>	0.32	-	-	-	-
m&p-Xylene*	g/m <sup>3</sup>	4.8	-	-	-	-
o-Xylene*	g/m <sup>3</sup>	0.70	-	-	-	-

#### Formaldehyde in Water by DNPH & LCMSMS

Formaldehyde*	g/m <sup>3</sup>	< 0.15	-	-	-	-
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Sample Type: Saline						
<b>Sample Name:</b>	GND2366 10-Aug-2013 4:30 pm					
<b>Lab Number:</b>	1168231.1					
Gases in groundwater						
Ethane*	g/m <sup>3</sup>	0.116	-	-	-	-
Ethylene*	g/m <sup>3</sup>	< 0.004	-	-	-	-
Methane*	g/m <sup>3</sup>	0.27	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9*	g/m <sup>3</sup>	66	-	-	-	-
C10 - C14*	g/m <sup>3</sup>	380	-	-	-	-
C15 - C36*	g/m <sup>3</sup>	820	-	-	-	-
Total hydrocarbons (C7 - C36)*	g/m <sup>3</sup>	1,270	-	-	-	-

Sample Type: Aqueous						
<b>Sample Name:</b>	GND2366 [Mercury Testing] 10-Aug-2013 4:30 pm					
<b>Lab Number:</b>	1168231.2					
Individual Tests						
Total Mercury	g/m <sup>3</sup>	< 0.011	-	-	-	-

**Analyst's Comments**

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

## SUMMARY OF METHODS

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

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



Sample Type: Saline			
Test	Method Description	Default Detection Limit	Samples
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.0010 g/m <sup>3</sup>	1
Dissolved Nickel*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.006 g/m <sup>3</sup>	1
Dissolved Potassium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	1.0 g/m <sup>3</sup>	1
Dissolved Sodium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.4 g/m <sup>3</sup>	1
Dissolved Sulphur*	Filtered sample, ICP-OES.	0.10 g/m <sup>3</sup>	1
Dissolved Zinc*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 21 <sup>st</sup> ed. 2005.	0.004 g/m <sup>3</sup>	1
Chloride*	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl <sup>-</sup> E (modified from continuous flow analysis) 21 <sup>st</sup> ed. 2005.	0.5 g/m <sup>3</sup>	1
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>2</sub> <sup>-</sup> I (Modified) 21 <sup>st</sup> ed. 2005.	0.002 g/m <sup>3</sup>	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N.	0.002 g/m <sup>3</sup>	1
Nitrate*	Calculation from Nitrate-N.	0.010 g/m <sup>3</sup>	1
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO <sub>3</sub> <sup>-</sup> I 21 <sup>st</sup> ed. 2005.	0.002 g/m <sup>3</sup>	1
Soluble Sulphate*	Calculation: from dissolved sulphur.	2 g/m <sup>3</sup>	1

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

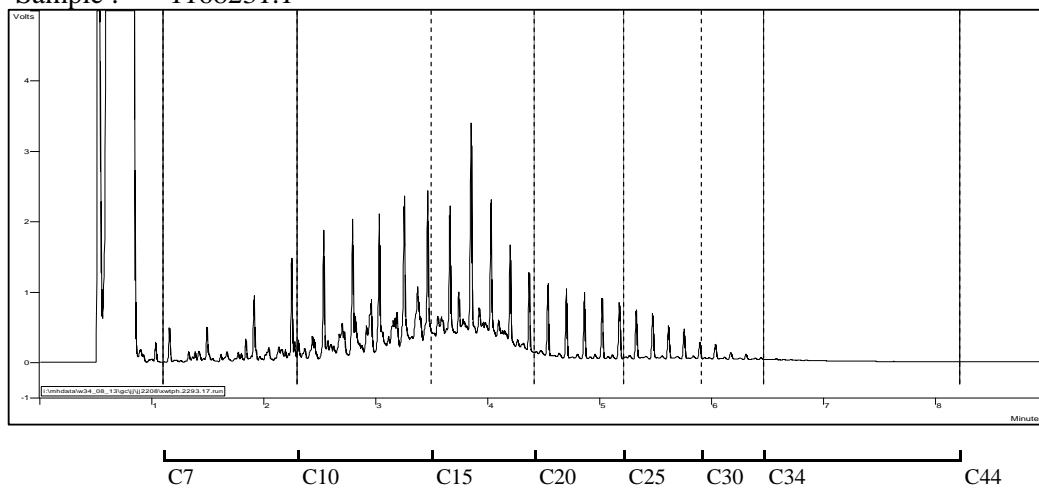
These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

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

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

Sample : 1168231.1





## ANALYSIS REPORT

<b>Client:</b>	Taranaki Regional Council	<b>Lab No:</b>	1212980	SPV1
<b>Contact:</b>	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	<b>Date Registered:</b>	07-Dec-2013	
		<b>Date Reported:</b>	24-Dec-2013	
		<b>Quote No:</b>	49265	
		<b>Order No:</b>		
		<b>Client Reference:</b>	KA 19 Flow Back Fluid	
		<b>Submitted By:</b>	Regan Phipps	

### Sample Type: Saline

<b>Sample Name:</b>	GND2431 24-Nov-2013 7:00 pm				
<b>Lab Number:</b>	1212980.1				

#### Individual Tests

pH*	pH Units	7.1	-	-	-	-
Total Alkalinity*	g/m <sup>3</sup> as CaCO <sub>3</sub>	3,000	-	-	-	-
Analysis Temperature for Bicarbonate	°C	22	-	-	-	-
Bicarbonate	g/m <sup>3</sup> at Analysis Temperature	3,020	-	-	-	-
Total Hardness*	g/m <sup>3</sup> as CaCO <sub>3</sub>	125	-	-	-	-
Electrical Conductivity (EC)*	mS/m	851	-	-	-	-
Total Dissolved Solids (TDS)*	g/m <sup>3</sup>	9,300	-	-	-	-
Dissolved Barium*	g/m <sup>3</sup>	2.0	-	-	-	-
Dissolved Bromine*	g/m <sup>3</sup>	5.2 #1	-	-	-	-
Dissolved Calcium*	g/m <sup>3</sup>	40	-	-	-	-
Dissolved Copper*	g/m <sup>3</sup>	0.057	-	-	-	-
Dissolved Iron*	g/m <sup>3</sup>	4.4	-	-	-	-
Dissolved Magnesium*	g/m <sup>3</sup>	6	-	-	-	-
Dissolved Manganese*	g/m <sup>3</sup>	2.3	-	-	-	-
Total Mercury*	g/m <sup>3</sup>	< 0.011	-	-	-	-
Dissolved Nickel*	g/m <sup>3</sup>	0.36	-	-	-	-
Dissolved Potassium*	g/m <sup>3</sup>	40	-	-	-	-
Dissolved Sodium*	g/m <sup>3</sup>	2,100	-	-	-	-
Dissolved Sulphur*	g/m <sup>3</sup>	30	-	-	-	-
Dissolved Zinc*	g/m <sup>3</sup>	0.11	-	-	-	-
Chloride*	g/m <sup>3</sup>	1,180	-	-	-	-
Nitrite-N	g/m <sup>3</sup>	29	-	-	-	-
Nitrate-N	g/m <sup>3</sup>	23	-	-	-	-
Nitrate-N + Nitrite-N	g/m <sup>3</sup>	53	-	-	-	-
Sulphate*	g/m <sup>3</sup>	90	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m <sup>3</sup>	111	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m <sup>3</sup>	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m <sup>3</sup>	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene*	g/m <sup>3</sup>	2.0	-	-	-	-
Toluene*	g/m <sup>3</sup>	3.1	-	-	-	-
Ethylbenzene*	g/m <sup>3</sup>	0.21	-	-	-	-
m&p-Xylene*	g/m <sup>3</sup>	1.48	-	-	-	-



This Laboratory is accredited by International Accreditation New Zealand (IANZ), which represents New Zealand in the International Laboratory Accreditation Cooperation (ILAC). Through the ILAC Mutual Recognition Arrangement (ILAC-MRA) this accreditation is internationally recognised.

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

Sample Type: Saline						
<b>Sample Name:</b>	GND2431 24-Nov-2013 7:00 pm					
<b>Lab Number:</b>	1212980.1					
BTEX in Water by Headspace GC-MS						
o-Xylene*	g/m <sup>3</sup>	0.52	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m <sup>3</sup>	< 0.02	-	-	-	-
Gases in groundwater						
Ethane*	g/m <sup>3</sup>	0.30	-	-	-	-
Ethylene*	g/m <sup>3</sup>	< 0.003	-	-	-	-
Methane*	g/m <sup>3</sup>	1.38	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9*	g/m <sup>3</sup>	15.7	-	-	-	-
C10 - C14*	g/m <sup>3</sup>	140	-	-	-	-
C15 - C36*	g/m <sup>3</sup>	270	-	-	-	-
Total hydrocarbons (C7 - C36)*	g/m <sup>3</sup>	420	-	-	-	-

### Analyst's Comments

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

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

Appendix No.2 - NZ Geothermal Analytical Laboratory report

## SUMMARY OF METHODS

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

Sample Type: Saline			
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 Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E 22 <sup>nd</sup> ed. 2012 (modified).	-	1
pH*	Saline water, pH meter. APHA 4500-H <sup>+</sup> B 22 <sup>nd</sup> ed. 2012.	0.1 pH Units	1
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	1
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	1
Bicarbonate	Bicarbonate (HCO <sub>3</sub> ) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988.	20 g/m <sup>3</sup> at Analysis Temperature	1
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup> as CaCO <sub>3</sub>	1
Electrical Conductivity (EC)*	Saline water, Conductivity meter, 25°C. APHA 2510 B 22 <sup>nd</sup> ed. 2012.	0.10 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) 22 <sup>nd</sup> ed. 2012.	50 g/m <sup>3</sup>	1
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22 <sup>nd</sup> ed. 2012.	-	1
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0006 g/m <sup>3</sup>	1

Sample Type: Saline			
Test	Method Description	Default Detection Limit	Sample No
Dissolved Bromine*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.10 g/m <sup>3</sup>	1
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup>	1
Dissolved Copper*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0010 g/m <sup>3</sup>	1
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.004 g/m <sup>3</sup>	1
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.4 g/m <sup>3</sup>	1
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0010 g/m <sup>3</sup>	1
Total Mercury*	Nitric acid digestion, ICP-MS, screen level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.0021 g/m <sup>3</sup>	1
Dissolved Nickel*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.006 g/m <sup>3</sup>	1
Dissolved Potassium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	1.0 g/m <sup>3</sup>	1
Dissolved Sodium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.4 g/m <sup>3</sup>	1
Dissolved Sulphur*	Filtered sample, ICP-OES.	0.10 g/m <sup>3</sup>	1
Dissolved Zinc*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 <sup>nd</sup> ed. 2012.	0.004 g/m <sup>3</sup>	1
Chloride*	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl <sup>-</sup> E (modified from continuous flow analysis) 22 <sup>nd</sup> ed. 2012.	0.5 g/m <sup>3</sup>	1
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO <sub>2</sub> <sup>-</sup> I 22 <sup>nd</sup> ed. 2012.	0.002 g/m <sup>3</sup>	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO <sub>2</sub> N. In-House.	0.0010 g/m <sup>3</sup>	1
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO <sub>3</sub> <sup>-</sup> I 22 <sup>nd</sup> ed. 2012.	0.002 g/m <sup>3</sup>	1
Soluble Sulphate*	Calculation: from dissolved sulphur.	2 g/m <sup>3</sup>	1

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

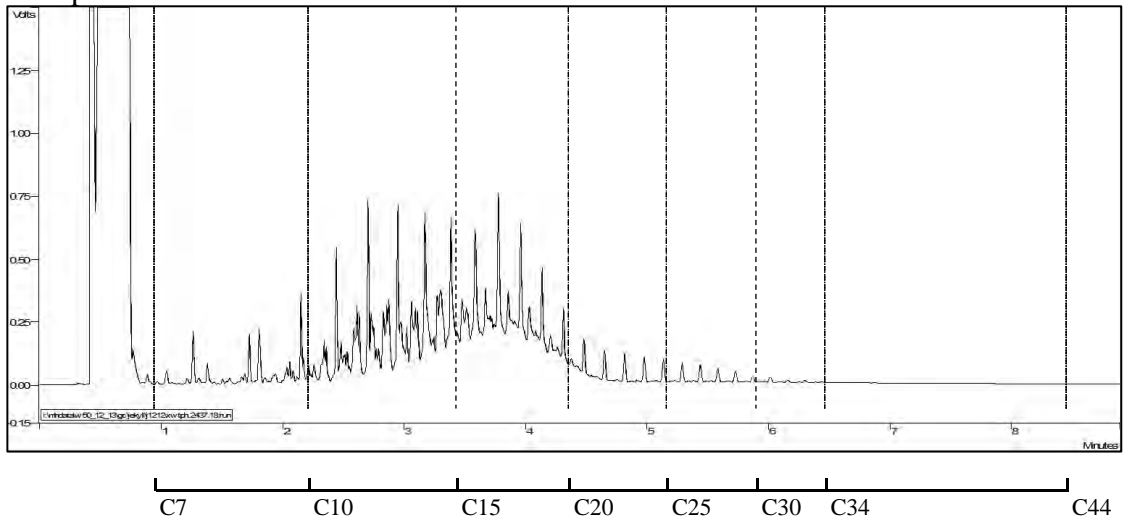
Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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

Sample : 1212980.1





**ANALYTICAL LABORATORY**  
Private Bag 2000, Taupo  
Phone: (07) 374 8211  
Fax: (07) 374 8199  
Email: w.labmanager@gns.cri.nz

**CERTIFICATE OF ANALYSIS****TOTAL BICARBONATE**

Report No: 2013121104

Customer Ref:136415

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

**GNS Sample No.** 2013007620

**Collection Date:**

**Site ID:** 1212980/1

**Field ID**

pH		7.35	-	-	-
Bicarbonate (Total)	mg/l	3023	-	-	-
HCO <sub>3</sub> Analysis Temperature	°C	22	-	-	-
HCO <sub>3</sub> Analysis Date		14/12/2013	-	-	-

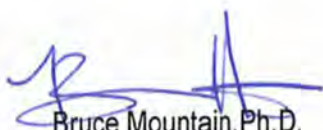
**SUMMARY OF METHODS AND DETECTION LIMITS**

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

Parameter	Method	*Detection Limit	
Bicarbonate (total)	HCO <sub>3</sub> Titration Method ASTM Standards D513-82 Vol.11.01 1988	20	mg/l
pH	Electrometric Method - APHA 4500-H+ B 22nd Edition 2012	-	-

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

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

  
Bruce Mountain, Ph.D.  
Geochemist





**Appendix V**  
**Biomonitoring report**



To Job Manager; Callum McKenzie  
 From Scientific Officers; Darin Sutherland and Brooke Thomas  
 Report No DS003  
 Date 16 January 2015

## **Biomonitoring of the Kapuni Stream and tributaries of the Inaha Stream and Waiokura Stream pre and post hydraulic fracturing by Shell Todd Oil Services Ltd at wellsites KA1/7/19/20, KA4/14 and KA6/11/17, November 2013, June 2013 and July - August 2013.**

### **Introduction**

These biological surveys were performed to assess the affects of hydraulic fracturing at three wellsites; KA1/7/19/20, KA4/14 and KA6/11/17. The intention of these surveys was to determine the health of the macroinvertebrate communities after hydraulic fracturing had taken place and compare these results with pre hydraulic fracturing surveys in order assess if hydraulic fracturing had any detrimental effects on the health of the macroinvertebrate communities of various surface waters in the vicinity of the wellsites..

### **Methods**

The standard 'kick-sampling' and 'vegetation sweep' sampling techniques were used to collect streambed macroinvertebrates in the Kapuni stream and unnamed tributaries of the Inaha and Waiokura Streams in relation to three wellsites; KA1/7/19/20, KA4/14 and KA6/11/17 (Table 1).

The 'kick-sampling' technique is very similar to C1 (hard-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark et al, 2001). The 'vegetation sweep' technique is very similar to Protocol C2 (soft-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark *et al*, 2001).

**Table 1** Biomonitoring sites and sampling techniques used in relation to fracturing works carried out by Shell Todd Oil Services Ltd

Wellsite	Site code	GPS reference (NZTM)	Location	Sampling method used pre-fracturing	Sampling method used post-fracturing
KA1/7/19/20	KPN000279	E 1701343 N 5630194	Immediately upstream of pipeline bridge (upstream of well KA-1/7)	Streambed kick	Streambed kick
	KPN000281	E 1701216 N 5629958	150m u/s water treatment plant	Streambed kick	Streambed kick
KA4/14	WKR000653	E 1700717 N 5632521	Immediately u/s of Neil Rd, d/s of stormwater discharge	Vegetation sweep	Streambed kick
KA6/11/17	INH000428	E 1701824 N 5627781	50m upstream of the stormwater discharge point	Vegetation sweep	Kick-sweep
	INH000429	E 1701796 N 5627722	20m downstream of the stormwater discharge point	Kick-sweep	Kick-sweep

Samples were preserved with Kahle's Fluid for later sorting and identification under a stereomicroscope according to Taranaki Regional Council methodology using Protocol P1 of NZMVG protocols of sampling macroinvertebrates in wadeable streams (Stark et al, 2001). Macroinvertebrate taxa found in each sample were recorded as:

R (rare)	= less than 5 individuals;
C (common)	= 5-19 individuals;
A (abundant)	= estimated 20-99 individuals;
VA (very abundant)	= estimated 100-499 individuals;
XA (extremely abundant)	= estimated 500 individuals or more.

Stark (1985) developed a scoring system for macroinvertebrate taxa according to their sensitivity to organic pollution in stony New Zealand streams. Highly 'sensitive' taxa were assigned the highest scores of 9 or 10, while the most 'tolerant' forms scored 1. Sensitivity scores for certain taxa have been modified in accordance with Taranaki experience.

By averaging the scores obtained from a list of taxa taken from one site and multiplying by a scaling factor of 20, a Macroinvertebrate Community Index (MCI) value was obtained. The MCI is a measure of the overall sensitivity of macroinvertebrate communities to the effects of organic pollution. More 'sensitive' communities inhabit less polluted waterways. A difference of 11 units or more in MCI values is considered significantly different (Stark 1998).

A semi-quantitative MCI value (SQMCI<sub>s</sub>) has also been calculated for the taxa present at each site by multiplying each taxon score by a loading factor (related to its abundance), totalling these products, and dividing by the sum of the loading factors (Stark, 1998 and 1999). The loading factors were 1 for rare (R), 5 for common (C), 20 for abundant (A), 100 for very abundant (VA) and 500 for extremely abundant (XA). Unlike the MCI, the SQMCI<sub>s</sub> is not multiplied by a scaling factor of 20, so that its corresponding range of values is 20x lower. A difference of 0.9 units or more in SQMCI<sub>s</sub> is considered significantly different (Stark, 1998).

## Results

### KA1/7/19/20

During the May 2012 survey the water temperature in the Kapuni Stream was 10.1°C at site KPN000279 and 10.2°C at site KPN000281. During the November 2014 survey the water temperature at site KPN000279 was 13.3°C and 12.8°C at site KPN000281. A moderate flow, of clear and uncoloured water was present at both sites during both surveys. During both surveys the substrate comprised a mixture of coarse gravel, cobbles and boulders. Only slippery periphyton mats were recorded with no periphyton filaments or macrophytes recorded.



**Figure 1** Biomonitoring site in the Kapuni Stream sampled in relation to the KA1/7/19/20 wellsite

### Macroinvertebrate communities at KA1/7/19/20 wellsite

Table 2 summarises the results of the two macroinvertebrate surveys performed in relation to fracturing of the KA1/7/19/20 wellsite. Comparative data for sites in similar streams to the unnamed tributary of the Kapuni Stream are presented in Table 3. The full macroinvertebrate results of both surveys are presented in Table 4.

**Table 2** Number of taxa, MCI and SQMCI<sub>s</sub> values for the unnamed tributary of the Kapuni Stream prior to (25/05/12) and after (10/11/14) hydraulic fracturing of the KA1/7/19/20 wellsite

Site code	No of taxa		MCI value		SQMCI <sub>s</sub> value	
	Pre-fracturing	Post-fracturing	Pre-fracturing	Post-fracturing	Pre-fracturing	Post-fracturing
KPN000279	20	24	116	120	7.5	7.3
KPN000281	17	20	122	119	7.8	7.4

**Table 3** Range and median number of taxa, MCI values and SQMCI<sub>s</sub> scores for ring plain streams rising inside of the National Park at altitudes 155-199 m asl ((TRC, 1999 (updated 2014)).

	No. of taxa	MCI value	SQMCI <sub>s</sub> value
No. Samples	376	376	273
Range	1-38	64-108	1.9-8.0
Median	20	108	6

**Table 4**

Macroinvertebrate fauna of the unnamed tributary of the Kapuni Stream in relation to the KA1/7/19/20 pre-fracturing and post-fracturing surveys sampled 25 May 2012 and 10 November 2014

Taxa List	Site Code	MCI score	Pre-fracturing	Post-fracturing	Pre-fracturing	Post-fracturing
			KPN000279	KPN000279	KPN000281	KPN000281
			FWB12289	FWB14334	FWB12290	FWB14335
ANNELIDA (WORMS)	Oligochaeta	1	R	R	R	R
EPHEMEROPTERA (MAYFLIES)	<i>Acanthophlebia</i>	9	-	R	-	-
	<i>Austroclima</i>	7	-	-	-	C
	<i>Coloburiscus</i>	7	A	VA	C	VA
	<i>Deleatidium</i>	8	XA	XA	XA	XA
	<i>Nesameletus</i>	9	C	A	C	C
PLECOPTERA (STONEFLIES)	<i>Acroperla</i>	5	-	R	-	R
	<i>Megaleptoperla</i>	9	R	R	-	-
	<i>Stenoperla</i>	10	-	R	-	-
	<i>Zelandobius</i>	5	R	R	R	R
	<i>Zelandoperla</i>	8	R	-	R	-
	COLEOPTERA (BEETLES)	Elmidae	6	VA	VA	A
MEGALOPTERA (DOBSONFLIES)	<i>Archichauliodes</i>	7	A	A	R	C
TRICHOPTERA (CADDISFLIES)	<i>Aoteapsyche</i>	4	A	C	C	C
	<i>Costachorema</i>	7	R	R	R	R
	<i>Hydrobiosis</i>	5	C	C	R	R
	<i>Psilochorema</i>	6	-	-	-	R
	<i>Beraeoptera</i>	8	VA	VA	A	VA
	<i>Olinga</i>	9	C	A	R	C
	<i>Pycnocentria</i>	7	-	R	-	C
	<i>Pycnocentroides</i>	5	C	VA	R	VA
	DIPTERA (TRUE FLIES)	<i>Aphrophila</i>	5	C	A	R
	Eriopterini	5	A	R	C	-
	Orthocladiinae	2	R	R	-	-
	<i>Polypedilum</i>	3	-	-	-	R
	Tanypodinae	5	-	R	-	R
	Empididae	3	R	-	-	-
	<i>Austrosimulium</i>	3	-	R	-	-
	Tabanidae	3	R	R	-	-
ACARINA (MITES)	Acarina	5	-	-	R	-
No of taxa			20	17	24	20
MCI			116	122	120	119
SQMCIs			7.5	7.8	7.3	7.4
EPT (taxa)			12	11	15	14
%EPT (taxa)			60	65	63	70
'Tolerant' taxa		'Moderately sensitive' taxa	'Highly sensitive' taxa			

R = Rare    C = Common    A = Abundant    VA = Very Abundant    XA = Extremely Abundant

## Pre-fracturing survey

The pre-fracturing survey showed that the macroinvertebrate communities at both sites were in good condition with high taxa, MCI and SQMCI<sub>s</sub> scores for both sites compared with similar sites (TRC, 1999 (updated 2014)) (Table 2 and 3). Overall the MCI scores indicated that site KPN000279 was in good condition and KPN000281 was in very good condition (TRC, 2014) but the actual difference was only four units and therefore non-significant (Stark, 1999).

## Post-fracturing survey

The post-fracturing survey revealed very little change to the macroinvertebrate community at either site with no significant changes detected in MCI and SQMCI<sub>s</sub> scores compared with the pre-fracturing survey (. There was also no significant difference between the control site of KPN000279 and the downstream site of KPN000281 that would potentially be affected by wellsite discharges. Taxa numbers at both sites increased slightly post-fracturing.

## KA4/14

One site (WKR000653) was monitored in relation to the KA4/14 wellsite (Figure 2). Further upstream the unnamed tributary had been piped, which meant an upstream sample could not be collected. The water temperature in the unnamed tributary of the Waiokura Stream during the pre-fracturing survey was 13.6°C. An uncoloured, clear, moderate and steady flow was recorded. The substrate was comprised entirely of silt. Macrophytes (namely water cress) were recorded growing at the edges and on the bed of the stream. No periphyton was recorded and the stream bed was not shaded. During the Post-fracturing survey the water temperature was not recorded. Again, an uncoloured, clear, moderate and steady flow was noted. Macrophytes were recorded growing at the edges but not on the bed of the stream. Unlike the pre-fracturing survey slippery mats of periphyton were present. The substrate differed from the pre-fracturing survey and comprised of silt, sand, cobbles and gravels.



**Figure 2** Biomonitoring site in the unnamed tributary of the Waiokura Stream sampled in relation to the



## Macroinvertebrate communities at KA4/14 wellsite

Table 5 summarises the results of the two macroinvertebrate surveys performed in relation to the fracturing of the KA4/14 wellsite. Comparative data for sites in similar streams to the unnamed tributary of the Waiokura Stream are presented in Table 6. The full macroinvertebrate results of both surveys are presented in Table 7.

**Table 5** Number of taxa, MCI and SQMCI<sub>s</sub> values for the unnamed tributary of the Waiokura Stream prior to and during fracturing of the KA4/14 wellsite

Stream	Site code	No of taxa		MCI value		SQMCI <sub>s</sub> value	
		Pre-fracturing	Post-fracturing	Pre-fracturing	Post-fracturing	Pre-fracturing	Post-fracturing
Unnamed tributary: Waiokura Stream	WKR000653	22	15	93	91	6.6	5.6

**Table 6** Range and median number of taxa, MCI values and SQMCI<sub>s</sub> scores for ring plain streams rising outside of the National Park at altitudes 200-249 m asl ((TRC, 1999 (updated 2014)).

	No. of taxa	MCI value	SQMCI <sub>s</sub> value
No. Samples	103	103	43
Range	2-37	60-116	1.9-6.7
Median	24	95	4

**Table 7** Macroinvertebrate fauna of the unnamed tributary of the Waiokura Stream in relation to pre and post fracturing surveys completed on 07 May 2012 and 04 July 2013.

Taxa List	Site Code Sample Number	MCI score	Pre-fracturing	Post-fracturing
			WKR000653	WKR000653
			FWB12250	FWB13237
ANNELIDA (WORMS)	Oligochaeta	1	R	A
MOLLUSCA	<i>Potamopyrgus</i>	4	R	R
CRUSTACEA	Ostracoda	1	-	R
	Paraleptamphopidae	5	VA	VA
	Talitridae	5	R	-
	<i>Paranephrops</i>	5	R	R
EPHEMEROPTERA (MAYFLIES)	<i>Austroclima</i>	7	R	-
	<i>Coloburiscus</i>	7	C	-
	<i>Zephlebia group</i>	7	XA	VA
COLEOPTERA (BEETLES)	Staphylinidae	5	R	-
TRICHOPTERA (CADDISFLIES)	<i>Hydrobiosis</i>	5	C	-
	<i>Orthopsyche</i>	9	A	A
	<i>Psilochorema</i>	6	C	R
	Oeconesidae	5	R	R
DIPTERA (TRUE FLIES)	<i>Paralimnophila</i>	6	-	R
	<i>Zelandotipula</i>	6	R	C
	Orthoclaadiinae	2	C	R
	<i>Polypedilum</i>	3	C	A
	Dolichopodidae	3	R	-
	<i>Paradixa</i>	4	R	R
	Ephydriidae	4	C	R
	Psychodidae	1	C	-
	<i>Austrosimulium</i>	3	R	-
ACARINA (MITES)	Acarina	5	R	-
No of taxa			22	15
MCI			93	91
SQMCI <sub>s</sub>			6.6	5.6
EPT (taxa)			7	4
%EPT (taxa)			32	27
'Tolerant' taxa		'Moderately sensitive' taxa	'Highly sensitive' taxa	
R = Rare	C = Common	A = Abundant	VA = Very Abundant	XA = Extremely Abundant

### Pre-fracturing survey

A moderately high community richness of 22 taxa was found at site WKR000653 (Table 5 and Table 7), two taxa less than the median richness found at similar sites elsewhere in the region (Table 6). The macroinvertebrate community was comprised of a significant proportion of 'sensitive' taxa (59 %), which was reflected in the MCI score of 93 units. This MCI score was slightly lower (by 1 unit) than the median MCI score for 'control' sites in similar streams at comparative altitudes (Table 6).

The community at this site was characterised by two 'moderately sensitive' taxa (amphipods Paraleptamphopidae and mayfly *Zephlebia group*) and one 'highly sensitive' taxon net-building caddis *Orthopsyche*).

The numerical dominance of three 'sensitive' taxa resulted in a SQMCI<sub>s</sub> score of 6.6 units, which was significantly higher (by 2.6 units) than the median score for 'control' sites in similar streams at this altitude (Table 6).

## Post-fracturing survey

A moderate community richness of 15 taxa was found at WKR000653 (Table 5 and Table 7), seven taxa fewer than what was recorded in the pre-fracturing survey. The proportion of 'sensitive' taxa recorded in the community (53%) was slightly lower than recorded in the pre-fracturing survey, resulting in a slight decrease in MCI score of two units (91 units).

The dominant community at this site was similar to that recorded in the pre-fracturing survey, with the addition of two 'tolerant' taxa (oligochaete worms and midge *Polypedilum*).

The numerical dominance of three 'sensitive' taxa was tempered by two 'tolerant' taxa, resulting in a SQMCI<sub>s</sub> score of 5.6 units, which was significantly lower (by 1.0 unit) than that recorded in the pre-fracturing survey, but significantly higher (by 1.6 units) than the median score for 'control' sites in similar streams at this altitude (Table 6) (Stark, 1998). The significant decrease in SQMCI<sub>s</sub> score from the pre-fracturing survey can be attributed to a significant increase in abundance of two 'tolerant' taxa and significant decrease in abundance of two 'sensitive' taxa. A change in sampling method used (from vegetation-sweep to streambed-kick sampling) is likely to have affected results as well as the change in the available habitat (from mainly macrophytes on a silt substrate to periphyton on a cobble/ gravel substrate).

## KA6/11/17

During the May 2012 survey the water temperature in the unnamed tributary of the Inaha Stream was 11.7°C at site 1 and 12.1°C at site 2. During the November 2013 survey the water temperature at site 1 was 16.6°C and 16.4°C at site 2. A moderate flow, of clear and uncoloured water was present at both sites during both surveys. During the May 2012 survey the substrate comprised entirely of silt at site 1, while wood and roots were also present at site 2. During the November 2013 survey the substrate at site 2 was comprised entirely of silt, while some wood and root in addition to silt was recorded at site 1. No periphyton was recorded at either site during both surveys and macrophytes were recorded as widespread. During the May 2012 survey there was no shading at site 1 and partial shading at site 2, whereas during the November 2013 survey there was partial shading at site 1 and complete shading at site 2. There was a 3 x median fresh 10 days before sampling for the May 2012 survey while for the November 2013 survey there was a 3 x median fresh 36 days prior to sampling.



**Figure 3** Biomonitoring site in the unnamed tributary of the Inaha Stream sampled in relation to the KA4/14 wellsite

### Macroinvertebrate communities at KA6/11/17

Table 8 summarises the results of the two macroinvertebrate surveys performed in relation to the fracturing of the KA6/11/17 wellsite. Comparative data for sites in similar streams to the Inaha Stream are presented in Table 9. Full results for both surveys are presented in Table 10.

**Table 8** Number of taxa, MCI and SQMCI<sub>s</sub> values for the unnamed tributary of the Inaha Stream prior to and during fracturing works at KA6/11/17 wellsite.

Site Code	No of taxa		MCI value		SQMCI <sub>s</sub> value	
	7 May 2012	21 Nov 2012	7 May 2012	21 Nov 2012	07 May 2012	21 Nov 2012
INH000428	13	19	77	66	4.9	4.6
INH000429	14	12	90	75	5.2	5.0

**Table 9** Range and median number of taxa, MCI values and SQMCI<sub>s</sub> scores for ring plain streams rising outside of the National Park at altitudes 125-154 m asl ((TRC, 1999 (updated 2014)).

	No. of taxa	MCI value	SQMCI <sub>s</sub> value
No. Samples	34	34	28
Range	13-32	66-114	1.3-6.4
Median	23	94	5

**Table 10** Macroinvertebrate fauna of the unnamed tributary of the Inaha Stream sampled on 7 May 2012 and 21 November 2013 in relation to the fracturing of the KA6/11/17 wellsite

Taxa List	Site Code	MCI score	Pre-fracturing	Post-fracturing	Pre-fracturing	Post-fracturing
			INH000428	INH000428	INH000429	INH000429
			FWB12246	FWB13340	FWB12247	FWB13341
COELENTERATA	Coelenterata	3	-	C	-	R
NEMERTEA	Nemertea	3	-	-	-	R
NEMATODA	Nematoda	3	-	C	-	R
ANNELIDA (WORMS)	Oligochaeta	1	R	A	C	C
MOLLUSCA	Lymnaeidae	3	-	R	-	-
	<i>Potamopyrgus</i>	4	VA	VA	C	C
CRUSTACEA	Ostracoda	1	R	A	-	R
	Isopoda	5	R	-	-	-
	<i>Paracalliope</i>	5	XA	XA	VA	XA
	Paraleptamphopidae	5	XA	C	XA	A
	<i>Paranephrops</i>	5	C	-	R	-
EPHEMEROPTERA (MAYFLIES)	<i>Zephlebia</i> group	7	A	A	VA	A
ODONATA (DRAGONFLIES)	<i>Austrolestes</i>	4	-	R	-	-
TRICHOPTERA (CADDISFLIES)	<i>Polypectropus</i>	6	R	-	R	-
	<i>Tripletides</i>	5	-	-	C	-
DIPTERA (TRUE FLIES)	Hexatomini	5	-	R	-	-
	<i>Paralimnophila</i>	6	-	-	R	-
	<i>Zelandotipula</i>	6	-	-	R	R
	<i>Corynoneura</i>	3	-	R	-	-
	Orthoclaadiinae	2	C	R	R	-
	Tanytarsini	3	-	A	-	R
	<i>Paradixa</i>	4	C	C	R	R
	Empididae	3	-	R	-	-
	Ephydriidae	4	R	-	R	-
	Psychodidae	1	R	R	-	-
<i>Austrosimulium</i>	3	-	-	R	-	
Stratiomyidae	5	-	R	-	-	
Syrphidae	1	-	R	-	-	
No of taxa			13	19	14	12
MCI			77	66	90	75
SQMCIs			4.9	4.6	5.2	5.0
EPT (taxa)			2	1	3	1
%EPT (taxa)			15	5	21	8
'Tolerant' taxa		'Moderately sensitive' taxa	'Highly sensitive' taxa			
R = Rare		C = Common	A = Abundant	VA = Very Abundant	XA = Extremely Abundant	

## Pre-fracturing survey

### INH000428

On 7 May 2012, 13 taxa were found at site INH000428, upstream of the KA6/11/17 wellsite discharge point (Table 10). This was less than the median number of taxa (23 taxa) found by 31 previous surveys at 'control' sites at a similar altitude in other ringplain streams that rise outside of Egmont National Park (TRC, 1999 (updated 2014)) (Table 9), and at the lower end of the range of what could be expected. The community was characterised by one 'tolerant' taxon (*Potamopyrgus* snails) and three 'moderately sensitive' taxa (amphipods *Paracalliope* and Paraleptamphopidae and mayfly *Zephlebia* group) (Table 10).

A moderately high proportion of 'tolerant' taxa in the community (54% of taxa) was reflected in the MCI score (77 units) which was significantly lower than the median MCI score (94) recorded from 31 previous surveys conducted at similar 'control' sites (TRC, 1999 (updated 2014)) (Stark, 1998) and represented poor biological health at this site.

The SQMCI<sub>s</sub> score of 4.9 units recorded at this site was similar to the median SQMCI<sub>s</sub> score (5.0) recorded from 25 previous surveys conducted at similar 'control' sites (TRC, 1999 (updated 2014)).

#### **INH000429**

On 07 May 2012, 14 taxa were found at site INH000429, downstream of the of the KA6/11/17 wellsite discharge point. This was one taxon more than that recorded at site 1, upstream of the wellsite discharge (Table 10). This community comprised 57% 'sensitive' taxa, resulting in an MCI score of 90 units. This was a significant (Stark, 1998) 13 units more than that recorded upstream during the same survey and similar to the median MCI score recorded by similar 'control' sites around the region (TRC, 1999 (updated 2014)).

The community was dominated by three 'moderately sensitive' taxa (amphipods *Paracalliope* and Paraleptamphopidae and mayfly *Zephlebia* group) (Table 10). There were only two significant differences in abundance from site INH000428, being a decrease in abundance of 'tolerant' *Potamopyrgus* snails and an increase in abundance of the 'moderately sensitive' stick caddis *Triplectides*. Both changes are not considered an indication of any real difference in community composition and this was reflected by the SQMCI<sub>s</sub> score (5.2), which was an insignificant (Stark, 1998) 0.3 unit higher than that recorded upstream at site INH000428 (Table 10).

#### **Post-fracturing survey**

#### **INH000428**

On 21 November 2013, 19 taxa were recorded in this community, higher than that recorded in the previous survey, but still below the median richness from similar control sites (Table 9). An increased proportion of 'tolerant' taxa was present in the community at this time (74%), and this resulted in a lower MCI score of 66 units when compared with the pre-fracturing survey. The macroinvertebrate community was characterised by four 'tolerant' taxa (oligochaete worms, *Potamopyrgus* snails, ostracod seed shrimp, and midge Tanytarsini) and two 'moderately sensitive' taxa (amphipod *Paracalliope* and mayfly *Zephlebia* group) (Table 10).

There were six significant changes in taxon abundances between the pre-fracturing and post-fracturing surveys including the significant increase of five 'tolerant' taxa and significant decrease of one 'moderately sensitive' taxon. These changes in abundance are considered to be a direct reflection of the flows that preceded the surveys. There was a 36 day period between a 3 x median fresh and the November 2013 survey, whereas there was only a 10 day period between a 3 x median fresh and the May 2012 survey. Higher flows can lead to the flushing out of some 'tolerant' taxa, while long periods of low flow can support 'tolerant' taxa. Despite these significant changes in abundance, there was only a (0.3 unit) difference in SQMCI<sub>s</sub> score between the two surveys (Table 10). The SQMCI<sub>s</sub> score of 4.6 was similar to the median SQMCI<sub>s</sub> score recorded by similar 'control' sites around the region (TRC, 1999 (updated 2014)).

## **INH000429**

A moderately low community richness of 12 taxa was recorded at this site which was two taxa less than that recorded in the May 2012 survey and seven taxa less than that recorded at the upstream site (Table 10). The proportion of 'sensitive' taxa (33%) had decreased from the previous survey which was reflected in the MCI score of 75 units, which was a significant (Stark, 1998) 15 units fewer than that recorded by the previous survey at this site. This MCI score was however not significantly different to that recorded upstream at site INH000428.

The community at site INH000429 during the post-fracturing survey was dominated by the same taxa as those recorded by the pre-fracturing survey at this site (Table 10). The SQMCI<sub>s</sub> score of 5.0 units was similar to the score recorded by the pre-fracturing survey at this site and slightly higher (by 0.4 unit) to that recorded upstream at site INH000428 (Table 8).

## **Discussion**

The Council's standard 'kick-sampling' and 'vegetation sweep' sampling techniques were used to collect streambed macroinvertebrates from the Kapuni Stream and tributaries of the Inaha stream and Waiokura Stream in relation to fracturing at the KA1/7/19/20, KA4/14 and KA6/11/17 wellsites. The intention of these surveys was to determine the health of the macroinvertebrate communities prior to fracturing, which then allowed a comparison with the health of the macroinvertebrate communities once fracturing had been completed at the sites. Samples were processed to provide number of taxa (richness), MCI and SQMCI<sub>s</sub> scores for each site.

The MCI is a measure of the overall sensitivity of the macroinvertebrate community to the effects of organic pollution in stony streams. It is based on the presence/absence of taxa with varying degrees of sensitivity to environmental conditions. The SQMCI<sub>s</sub> takes into account taxa abundances as well as sensitivity to pollution. It may indicate subtle changes in communities, and therefore be the more relevant index if non-organic impacts are occurring. Significant differences in either the MCI or the SQMCI<sub>s</sub> between sites indicate the degree of adverse effects (if any) of the discharges being monitored.

## **KA1/7/19/20**

The results indicate that fracturing had absolutely no affect on the downstream macroinvertebrate communities at site KPN000281. The site showed no significant differences between the pre and post fracturing surveys and the control site for both the MCI or the SQMCI<sub>s</sub> scores and taxa numbers increased slightly, possibly due to a seasonal affect.

## **KA4/14**

The pre-fracturing survey of the KA4/14 wellsite, undertaken May 2012 in the unnamed tributary of the Waiokura Stream found that the community at WKR000653 contained typical community richnesses, and that these communities were in moderate biological health. The MCI score was similar to that recorded at 'control' sites in similar streams at comparable altitudes whereas the SQMCI<sub>s</sub> score was significantly higher (Stark, 1998).

The post-fracturing survey of KA4/14 wellsite, undertaken in July 2013, found that the taxa richness and MCI score recorded at WKR000653 in the unnamed tributary of the Waiokura Stream had decreased slightly from the pre-fracturing survey, however was still similar to scores recorded in 'control' sites in similar streams at comparable altitudes. A significant decrease in SQMCI<sub>s</sub> score was recorded between the pre-fracturing and post-fracturing surveys, however the score was still significantly higher than the median score of 'control' sites in similar streams at comparable altitudes (Stark, 1998). The significant decrease in SQMCI<sub>s</sub> score can be attributed to the change in substrate recorded and to a change in sampling method used between the two surveys, rather than due to any discharges caused by fracturing.

### **KA6/11/17**

The decrease in MCI scores for both the upstream control site and the downstream site post-fracturing can be attributed to the greater length of time between freshes. Freshes are important in maintaining healthy stream communities as they remove excess silt and nuisance periphyton and was possibly a reason why the percentage of silt, normally negatively correlated with MCI score, increased from 80% to 100%. The May 2012 survey was conducted 10 days after a 3 x median base flow fresh and 45 days after a 7 x median base flow fresh while the November 2013 survey was completed 36 days after a 3 x median base flow fresh and 607 days after a 7 x median base flow fresh. The SQMCI<sub>s</sub> score however, did not change significantly between the two surveys for the downstream site or from that recorded at the upstream site.

## **Summary**

- There was no significant change to the macroinvertebrate community at wellsite KA1/7/19/20 following fracturing indicating that wellsite discharges and no affect on the health of the macroinvertebrate community.
- There was a significant decrease to the SQMCI<sub>s</sub> score at the site downstream of wellsite KA4/14 but this was likely caused by a change in substrate rather than fracturing discharges. There was no change to the MCI score and fracturing did not appear to have any affect on the macroinvertebrate community.
- There was a significant decrease in the MCI score post fracturing at wellsite KA6/11/17 but this can be attributed to the lack of a recent fresh rather than fracturing as both the control and downstream sites had a decrease in MCI scores.

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