

Origin Energy Resources NZ Limited
Kauri-E Hydraulic Fracturing
Monitoring Programme Report
2013-2015

Technical Report 2015-03

ISSN: 1178-1467 (Online)
Document: 1503831 (Word)
Document: 1506842 (Pdf)

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June 2015

Executive summary

Origin Energy Resources NZ Limited (Origin) operate the Kauri-E wellsite, located at Geary Road, Kakaramea. The wellsite lies within the Waikaikai catchment and contains a hydrocarbon producing well and associated infrastructure.

Origin hold resource consent 9645-1, authorising the discharge of water based hydraulic fracturing fluids into land at depths greater than 2,400 m TVD beneath the Kauri-E wellsite. The consent was issued by Taranaki Regional Council (the Council) on 12 September 2013 and contains a total of 16 special conditions which set out the requirements that Origin must satisfy.

The following report for the period July 2012 to February 2015 outlines and discusses the results of the monitoring programme implemented by the Council in relation to the programme of hydraulic fracturing undertaken by Origin, within their Kauri-E wellsite. The report also assesses Origin's level of environmental performance and compliance with the resource consent held in relation to the activity.

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

The programme of hydraulic fracturing undertaken by Origin at the Kauri-E wellsite included the fracturing of one well, Kauri E11. The hydraulic fracturing of this well took place on 24 December 2013.

The programme of monitoring implemented by the Council in relation to this activity spanned the 2013-2014 and 2014-2015 monitoring periods. The programme included the analysis of samples taken from a monitoring well south of the wellsite. 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 both the hydraulic fracturing fluid and the formation fluids produced back to the wellhead immediately following fracturing were obtained for analysis.

The monitoring carried out by the Council indicates that the hydraulic fracturing activities undertaken by Origin 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.

Overall, Origin demonstrated a high level of environmental and administrative performance and compliance with the resource consent over the reporting period.

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

This report includes recommendations for the 2015-2016 year.

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1. Introduction

1.1 Compliance monitoring programme reports and the Resource Management Act 1991

1.1.1 Introduction

The following report outlines and discusses the results of the monitoring programme implemented by the Taranaki Regional Council (the Council) in relation to the programme of hydraulic fracturing undertaken by Origin Energy Resources NZ Limited (Origin) at their Kauri-E wellsite, Geary Road, Kakaramea over the period December 2013 to February 2015. The wellsite is located in the Waikaikai catchment. The report also assesses Origin's level of environmental performance and compliance with the resource consent held in relation to the activity.

The programme of hydraulic fracturing undertaken by Origin at the Kauri-E wellsite included the fracturing of one well; Kauri 11.

The programme of monitoring implemented by the Council in relation to these activities spanned the 2013-2014 and 2014-2015 monitoring periods and included groundwater, surface water and discharge monitoring components. This is the first monitoring report produced by the Council in relation to hydraulic fracturing at the Kauri-E wellsite.

1.1.2 Structure of this report

Section 1 of this report is a background section. It sets out general information about compliance monitoring under the *Resource Management Act 1991* (RMA) and the Council's obligations and general approach to monitoring sites through annual programmes, the resource consent held by Greymouth for discharges into land associated with hydraulic fracturing in the Waikaikai catchment, a description of the activities undertaken under these consents, and the nature of the monitoring programme in place for the period under review.

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

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

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

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

1.1.3 The Resource Management Act 1991 and monitoring

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

- (a) the neighbourhood or the wider community around an activity, and may include cultural and social-economic effects;
- (b) physical effects on the locality, including landscape, amenity and visual effects;
- (c) ecosystems, including effects on plants, animals, or habitats, whether aquatic or terrestrial;
- (d) natural and physical resources having special significance (for example 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 during the period under review, this report also assigns a rating as to Origin'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 were addressed promptly and co-operatively.
- **Good** Perhaps some administrative requirements of the resource consents were not met at a particular time, however these were 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 Kauri-E wellsite history

The Kauri-E wellsite has been in operation since 2003. The area around the wellsite and Geary Road is rural with low population density. The predominant land use surrounding the site is intense dairy farming. There are some runoff properties in the vicinity aswell. Oil and gas exploration, production and associated activities are an established land use within the area with 13 wellsites present.. The Kauri E wellsite is situated on a coastal cliff 150 metres (m) from the coast at approximately 40 m above sea level.

The well workover programme on Kauri E11 started on 4 December 2013 and hydraulic fracturing occurred on 24 December 2013. Monitoring continued for more

than a year beyond the end of fracturing activity. The location of the wellsite is illustrated in Figure 1. Well construction schematics for Kauri E11 are included in Appendix I.

A summary of all hydraulic fracturing activities carried out by Origin at the Kauri-E wellsite during the period being reported is provided below in Table 1.

Table 1 Summary of hydraulic fracturing activity (2013-2015)

Well	Wellsite	Consent	Date	Injection zone (m TVDss)	Formation
Kauri E11	Kauri-E	9645-1	24/12/13	2,472.35 to 2477.20	Lower Kauri Sand



Figure 1 Location of Kauri-E wellsite

1.3 Resource consent

1.3.1 Discharges onto and into land

Section 15(1)(b) of the RMA stipulates 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.

Origin holds resource consent **9645-1**, authorising the discharge of contaminants into land at the Kauri-E wellsite. The consent was issued by the Council on 12 September 2013, under Section 87(e) of the RMA. This is the consent under which Kauri E11 was fractured. Consent 9645-1 contains a total of 16 special conditions which set out the requirements that Origin must satisfy.

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

Condition 2 requires that no hydraulic fluids be discharged into the reservoir after 1 June 2016.

Condition 3 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).

Conditions 4, 5, 6 and 7 relate to fresh water monitoring requirements, to allow compliance with condition 3 to be assessed.

Condition 8 requires the consent holder to carry out pressure testing of equipment prior to discharging.

Condition 9 requires the consent holder to submit a pre-fracturing discharge report prior to any discharge occurring.

Condition 10 is a notification requirement.

Condition 11 requires the consent holder to submit a post-fracturing discharge report after the completion of the hydraulic fracturing programme for each well.

Condition 12 stipulates how the reports required by conditions 9 and 11 are to be submitted.

Condition 13 requires the consent holder to allow the Council access to a location where samples of hydraulic fracturing and return fluids can be obtained.

Condition 14 requires the consent holder to adopt best practicable options.

Condition 15 relates to the composition of the fracturing fluid.

Consent 16 is a review provision

A copy of this discharge permit may be found 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 Kauri E11 well consisted of three primary components.

1.4.2 Programme liaison and management

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

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

1.4.3 Review of consent holder submitted data

As required by the conditions of consents 9645-1, Origin submitted pre and post-fracturing discharge reports to the Council for the well fractured during the period under review. Pre-fracturing discharge reports provide an outline of the proposed fracturing operations in relation to the 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 consent.

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 the Kauri-E wellsite and the analysis of the results.

In order to select suitable sites for sampling, the Council carried out a survey in the vicinity of the wellsite to identify existing groundwater abstractions. The survey was undertaken within a defined 'area of review' which extended 1 km radially from the Kauri-E wellsite. There were no groundwater monitoring sites identified during the survey. On 30 October 2013 a groundwater monitoring well (GND2371) was drilled for

the purpose of monitoring shallow groundwater in relation to hydraulic fracturing at the site. The details of GND2371 are included in Table 2 and its proximity to the wellsite is illustrated in Figure 2.

Table 2 Details of groundwater site included in the monitoring programme

Monitoring site	Distance from fractured well (m)	Total depth (m)	Screened interval (m)	Aquifer
GND2371	53	50	15 - 24	Marine Terraces

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

All samples were sent to Hill Laboratories Limited for analysis following standard chain of custody procedures.

In addition to the sampling of local groundwater, samples of 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.



Figure 2 Location of groundwater sampling sites in relation to Kauri E11 well (GND2376)

2. Results

2.1 Consent holder submitted data

2.1.1 Kauri E11 post-fracturing discharge report

The conclusions from the Kauri E11 post-fracturing discharge report are summarised as follows:

- One discrete zone was fractured on 24 December 2013, at depths between 2,472.35 to 2,477.20 m TVDss.
- A total of 1,392 barrels (bbls) (215 m³) of liquid was discharged across the fractured zone. The total proppant weight was 51,749 kg.
- By volume the fluid injected was comprised of 82.47% water, 16.38% proppant and 1.15% chemicals.
- 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.
- The Kauri E11 well was opened for flow back on 10 February 2014. From 10 February to 31 March 2014, approximately 2,690 bbls (428 m³) of water were returned to the surface with the hydrocarbons. Some completion brine was lost into the reservoir(s) during workover operation (post hydraulic fracturing to end of completion string installation) due to depleted Lower and Upper Kauri reservoirs. It is not possible to differentiate between the volume of completion brine and the volume of hydraulic fracturing liquid in the produced water. Completion brine is used to help extend the life of a well by controlling issues such as corrosion and wellbore stability. Completion brine was prepared using fresh water as base fluid, and a small amount of either potassium chloride or calcium chloride was added for inhibition (to reduce swelling of clays) and to achieve required density. The total volume of proppant remaining in the formation is estimated to be around 99,400 lbs consisting of a mixture of Carbolite 12/18 and Flex Sand. Additional fluid is likely to be returned back to the surface as the well produces.
- The majority of hydraulic fracturing return fluid from the Kauri E11 well was disposed via deep well injection in the New Zealand Energy Corp (NZEK) Waihapa 7A well which is located on the Waihapa F wellsite, 7 Bird Road, Stratford. NZEK holds consent 4094-2 which permits the discharge of produced water, contaminated stormwater, water based drilling fluids and hydraulic fracturing fluids, including return fluids, by deepwell injection into the Matemateaonga Formation. Approximately 1,562 bbls (248m³) of hydraulic fracture return fluids and fluids used for circulation during the coil tubing operation was disposed via the Waihapa 7A reinjection well. A coil tubing operation is a well intervention method which modifies the well in order to achieve optimal production. An additional 264 bbls (42m³) was discharged via the Transpacific handling facility in Wellington. This liquid consisted of pre-made fracturing liquid that wasn't injected due to the screen out that occurred.

This pre made fracturing liquid had a high pH and therefore wasn't deep well injected at the NZEC facility.

- There was one screen out incident during the hydraulic fracture treatment. This was thought to be due to restrictions in the perforations, but the ultimate cause of screen out was not conclusively established. Due to the screen out incident, the volume of proppant pumped into Lower Kauri formation was lower than the planned volume. Both conditions 1 (The discharge point shall be deeper than 2,400 mTVDs) and 2 (There shall be no discharge of hydraulic fracturing fluids in the reservoir after 1 June 2016) of consent 9645-1 were still fully complied with.
- It is considered that the mitigation measures implemented by Origin were effective in ensuring there were no adverse environmental effects associated with fracturing operations.

2.2 Chemical sampling

2.2.1 Kauri E11 groundwater sampling survey

One site, GND2371, was sampled to monitor the effects of the hydraulic fracturing of the Kauri E11 well on local groundwater resources.

The results of the laboratory analysis of samples from site GND2371 indicate a slight increase in bicarbonate, chloride and barium concentrations as well as conductivity in the post-fracturing samples. The changes in the concentrations of these analytes are a result of natural variations in water composition and are unrelated to fracturing activities. There was no dissolved methane detected in any of the samples obtained. There were no traces of substances associated with hydraulic fracturing fluids, or hydrocarbons relating to fracturing activities in any of the post-fracturing samples.

A full summary of results for all groundwater samples taken in relation to hydraulic fracturing of the Kauri E11 well is included below in Table 3. The certificates of analysis are included in Appendix III.

Table 3 Results of groundwater sampling carried out in the vicinity of the Kauri E11 well

Parameter	Unit	GND2371		
		Pre-frac	Post-frac	
Sample Date	-	03 Dec 2013	14 Mar 2014	17 Feb 2015
Lab Number	-	TRC137979	TRC149561	TRC150971
Alkalinity	g/m ³ CaCO ₃	55	60	72
Barium	mg/kg	0.0177	0.0176	0.0195
Benzene	g/m ³	<0.0010	<0.0010	<0.0010
Bromine	g/m ³	0.162	0.179	0.23
Calcium	g/m ³	23	23	30
Chloride	g/m ³	59	60	81

Parameter	Unit	GND2371		
		Pre-frac	Post-frac	
Conductivity	mS/m@20C	48.4	45.7	57.7
Dissolved copper	g/m ³	0.0014	0.0011	0.0013
Ethylbenzene	g/m ³	<0.0010	<0.0010	<0.0010
Ethane	g/m ³	<0.003	<0.003	<0.003
Ethylene	g/m ³	<0.003	<0.003	<0.003
Dissolved iron	g/m ³	<0.02	<0.02	<0.02
Formaldehyde	g/m ³	<0.02	<0.02	<0.02
Ethylene glycol	g/m ³	<4	<4	<4
Hydrocarbons	g/m ³	<0.7	<0.7	<0.7
Bicarbonate	g/m ³ HCO ₃	67.1	73.2	88
Total hardness	g/m ³ CaCO ₃	126	124	163
Dissolved mercury	g/m ³	<0.00008	<0.00008	<0.00008
Potassium	g/m ³	7.4	6.6	7.6
Methanol	g/m ³	<2	<2	<2
Methane	g/m ³	<0.002	<0.002	<0.002
Magnesium	g/m ³	16.9	16.2	21
Manganese	g/m ³	0.023	0.0081	0.0022
Sodium	g/m ³	46	36	43
Nickel	mg/kg	0.0018	0.0007	<0.0005
Nitrate & nitrite nitrogen	g/m ³ N	12.7	12.3	12.9
Nitrite nitrogen	g/m ³ N	0.020	<0.002	<0.002
Nitrate nitrogen	g/m ³ N	12.7	12.3	12.9
pH	pH units	6.9	6.9	6.6
Propylene glycol	g/m ³	<4	<4	<4
Sulphate	g/m ³	35	35	34
Sum of anions	meq/l	4.4	4.5	5.4
Sum of cations	meq/l	4.7	4.2	5.3
Total dissolved solids	g/m ³	340	340	390
Temperature	Deg.C	16.4	17.2	16.12
Toluene	g/m ³	<0.0010	<0.0010	<0.0010
o-Xylene	g/m ³	<0.0010	<0.0010	<0.0010
m-Xylene	g/m ³	<0.002	<0.002	<0.002
Dissolved zinc	g/m ³	0.0094	0.045	0.0050

2.2.2 Hydraulic fracturing and return fluids

The results of the analyses carried out on samples of the hydraulic fracturing fluid used in the treatment of the Kauri E11 well are summarised below in Table 4. The certificates of analysis are included in Appendix IV.

The viscosity of the fluid samples obtained was gel like in composition. The range of analytical tests that were able to be performed on each sample was therefore limited. 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 4 Results of hydraulic fracturing fluid sampling

Parameter	Unit	Kauri E11
Sample date		24/12/2013
Lab number		TRC148341
Benzene	g/m ³	<0.0010
Ethylbenzene	g/m ³	0.0015
Ethylene glycol	g/m ³	<4
Total hydrocarbons	g/m ³	550
Methane	g/m ³	<2
Propylene glycol	g/m ³	6
Toluene	g/m ³	0.0013
o-Xylene	g/m ³	0.0037
m-Xylene	g/m ³	0.005

Samples of return fluids collected on three consecutive days from Kauri E11 were 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 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 that 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 the Kauri E11 well are summarised below in Table 5. The certificates of analysis are included in Appendix IV. The relatively high levels of salinity (sodium and chloride) in each sample indicate that the composite samples prepared contained a greater proportion of saline reservoir fluids than fluids introduced during fracturing activities (comprised predominantly of freshwater). The presence of elevated levels of hydrocarbon and BTEX compounds are indicative of fluids being drawn from a hydrocarbon bearing reservoir.

Table 5 Results of hydraulic fracturing return fluid sampling

Parameter	Unit	Kauri E11		
		10 Feb 2014	11 Feb 2014	12 Feb 2014
Sample date	-	10 Feb 2014	11 Feb 2014	12 Feb 2014
Lab number	-	TRC149048	TRC149049	TRC149050
Total alkalinity	g/m ³ CaCO ₃	78	72	69
Barium	mg/kg	1.92	1.92	1.60
Benzene	g/m ³	9.1	12.2	11.5
Bromide	g/m ³	27	24	18.5
Calcium	g/m ³	2900	3100	2900
Chloride	g/m ³	9700	9800	8800
Conductivity	mS/m@20C	3290	3160	2790
Dissolved copper	g/m ³	0.020	0.024	0.009
Ethylbenzene	g/m ³	0.035	0.28	0.29
Dissolved iron	g/m ³	0.92	11.1	7.5
Formaldehyde	g/m ³	0.22	0.15	0.10
Ethylene glycol	g/m ³	<4	<4	<4
Hydrocarbons	g/m ³	5.9	19.5	29
Bicarbonate	g/m ³ HCO ₃	82	71	78
Total hardness	g/m ³ CaCO ₃	7400	8000	7500
Dissolved mercury	g/m ³	<0.011	<0.011	<0.011
Potassium	g/m ³	4700	3500	2500
Methanol	g/m ³	<2	<2	<2
Magnesium	g/m ³	42	40	36
Dissolved manganese	g/m ³	2.4	1.49	1.15
Sodium	g/m ³	1410	1560	1450
Nickel	mg/kg	<0.03	<0.03	<0.03
Nitrate & nitrite nitrogen	g/m ³ N	0.20	0.20	0.053
Nitrite	g/m ³ N	0.09	0.16	0.006
Nitrate	g/m ³ N	0.11	0.05	0.047
pH	pH units	6.4	6.7	6.7
Propylene glycol	g/m ³	<4	<4	<4
Dissolved sulphur	g/m ³	5	<5	<5
Sulphate	g/m ³	16	<15	<15
Total dissolved solids	g/m ³	21000	19400	17100
Toluene	g/m ³	1.99	3.1	3.0
o-Xylene	g/m ³	0.36	0.58	0.59
m-Xylene	g/m ³	0.50	0.88	0.87
Dissolved zinc	g/m ³	0.04	0.12	0.22

2.3 Investigations, interventions, and incidents

The monitoring programme for the two monitoring periods was based on what was considered to be an appropriate level of monitoring, review of data, and liaison with the consent holder. During each period matters may arise which require additional activity by the Council, for example provision of advice and information, or investigation of potential or actual 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 Origin's resource consents or provisions in Regional Plans in relation to this site.

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 Origin 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 Origin during the period being reported, the monitoring programme implemented by the Council included the monitoring of groundwater. The primary component of the programme required the sampling of groundwater at a selected site in the vicinity of the Kauri-E wellsite. Groundwater was surveyed prior to any hydraulic fracturing occurring to determine baseline conditions, allowing comparisons to be made with post-fracturing results.

The results of post-fracturing groundwater sampling carried out in the vicinity of the Kauri E11 well, showed only very minor variations in water composition in comparison to baseline results. The minor variations in some analytes are typical of natural variations in water composition and are therefore considered unrelated to fracturing activities. No dissolved methane was detected in either pre or post fracturing samples. No traces of substances associated with hydraulic fracturing fluids, or hydrocarbons relating to fracturing activities were present in the groundwater.

In summary, the monitoring carried out by the Council indicates that the hydraulic fracturing activities undertaken by Origin, during 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 Table 6.

Table 6 Summary of performance for Consent 9645-1
To discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 2,400 mTVDs beneath the Kauri-E wellsite.

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Any discharge shall occur below 2,400 mTVD	Assessment of consent holder submitted data	Yes
2. No discharge shall occur after 1 June 2016	Assessment of consent holder submitted data	N/A
3. 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
4. Consent holder shall undertake sampling programme	Development and certification of a monitoring programme	Yes
5. Monitoring programme to include sampling from an installed groundwater bore	Results of groundwater monitoring	Yes
6. 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
7. 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
8. Well and equipment pressure testing to be carried out prior to any hydraulic fracturing programme commencing	Assessment of consent holder submitted data	Yes
9. A pre-fracturing discharge report is to be provided to the Council 14 days prior to discharge	Pre-fracturing discharge report received	Yes
10. Consent holder shall notify the Council of hydraulic fracturing discharge	Notification received	Yes
11. 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
12. The reports outlined in conditions 9 and 11 must be emailed to consents@trc.govt.nz	Reports received via email	Yes

13. 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
14. Consent holder to adopt best practicable option at all times	Site inspections, sampling and assessment of consent holder submitted data	Yes
15. No hydrocarbon based hydraulic fracturing fluid shall be discharged	Assessment of consent holder submitted data and sampling of fracturing fluid	Yes
16. 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 2013-2015 monitoring periods, Origin demonstrated a high level of environmental and administrative performance and compliance with its resource consent as defined in Section 1.1.4.

3.3 Alterations to monitoring programmes for 2015-2016

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

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

3.4 Exercise of optional review of consent

Resource consent 9645-1 provides for an optional review of the consent on an annual basis, with the next optional review date being June 2015. Condition 16 of this consent allows the Council to review consent conditions to ensure they are adequate to deal with any significant adverse effects on the environment arising from the exercise of this consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time. The Council can also review the consent in order to further specify the best practicable option and/or to ensure that hydraulic fracturing operations appropriately take into account any best practice guidance published by a recognised industry association or environmental regulator.

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

4. Recommendations

1. THAT no further monitoring be carried out in relation to previously undertaken hydraulic fracturing events at the Kauri-E wellsite. Monitoring should recommence however if any further fracturing is undertaken at the site.
2. THAT the option for a review of resource consent in June 2015, as set out in condition 16 of consent 9645-1, is not exercised, on the grounds that the current conditions of the consents are adequate to ensure that any significant adverse effects on the environment are avoided.

Glossary of common terms and abbreviations

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

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 ³	Grams per cubic metre, and equivalent to milligrams per litre (mg/L). In water, this is also equivalent to parts per million (ppm), but the same does not apply to gaseous mixtures.
Incident	An event that is alleged or is found to have occurred that may have actual or potential environmental consequences or may involve non-compliance with a consent or rule in a regional plan. Registration of an incident by the Council does not automatically mean such an outcome had actually occurred.
Intervention	Action/s taken by Council to instruct or direct actions be taken to avoid or reduce the likelihood of an incident occurring.
Investigation	Action taken by Council to establish the circumstances/events surrounding an incident including any allegations of an incident.
mS/m	Millisiemens per metre.
m ³	Cubic metre (1,000 litres).
pH	A numerical system for measuring acidity in solutions, with 7 as neutral. Numbers lower than 7 are increasingly acidic and higher than 7 are increasingly alkaline. The scale is logarithmic i.e. a change of 1 represents a ten-fold change in strength. For example, a pH of 4 is ten times more acidic than a pH of 5.
Resource consent	Refer Section 87 of the RMA. Resource consents include land use consents (refer Sections 9 and 13 of the RMA), coastal permits (Sections 12, 14 and 15), water permits (Section 14) and discharge permits (Section 15).
RMA	<i>Resource Management Act 1991</i> and including all subsequent amendments.

Bibliography and references

Origin Energy Resources NZ Limited (2014) Kauri 11 post Fracturing Discharge Report.

Taranaki Regional Council (2013) Origin Energy Resources NZ (Rimu) Limited Hydraulic Fracturing - Kauri-E Wellsite Water Quality Monitoring Programme.

Appendix I

Well construction geological stratigraphy schematics

Well: KAURI_E11



COMPANY: Swift Energy NZ Ltd

DATUM FOR ELEVATION: Mean Sea Level

LOCATION: Onshore Taranaki Basin

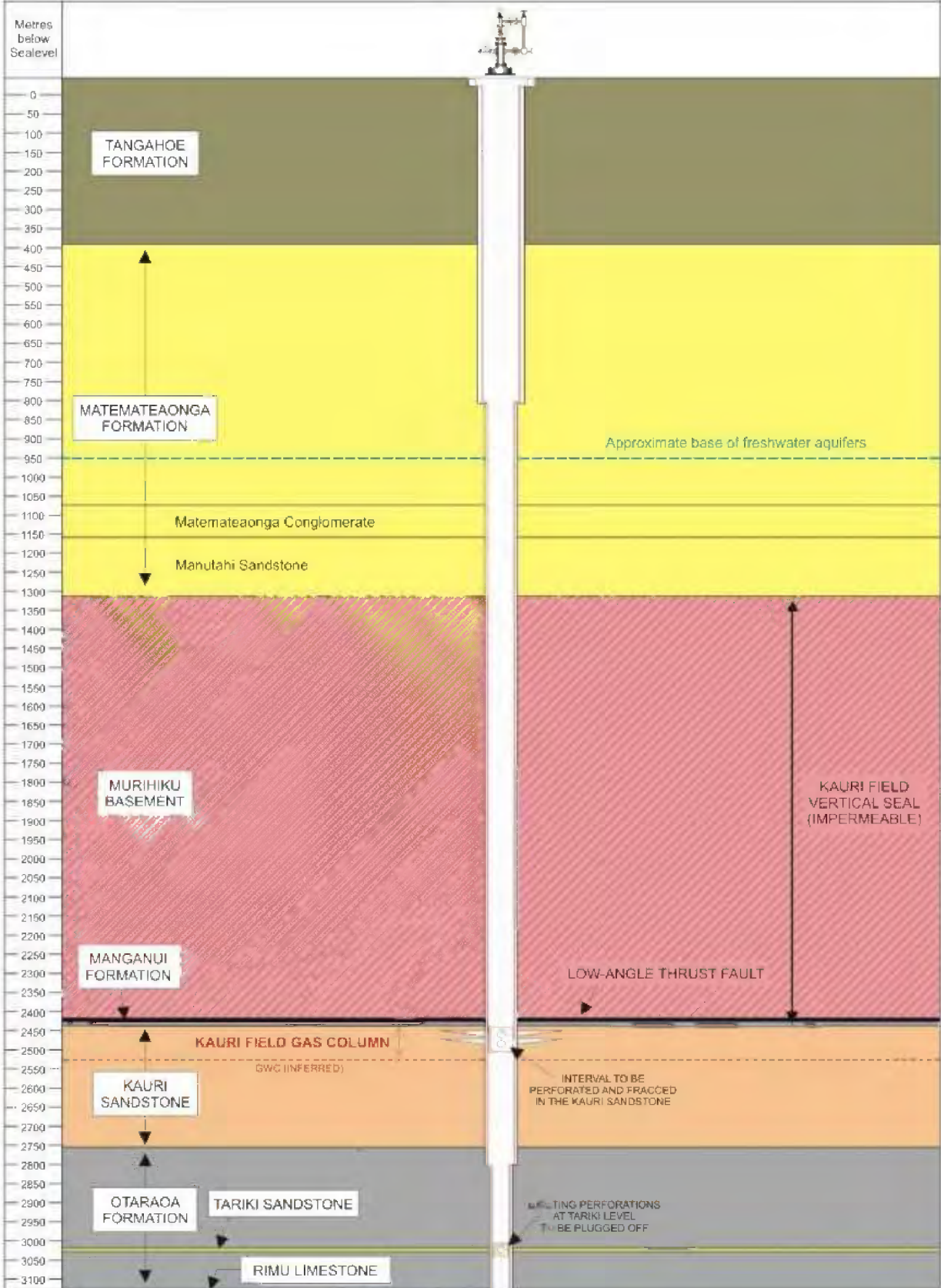
SURFACE ELEVATION: 39.00

VERTICAL UNITS: METRES

MEASUREMENT REF.: RT

VERTICAL SCALE: 1:10000

ELEVATION MEAS. REF.: 44.50



Appendix II

Resource consent held by Origin

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

Name of Consent Holder: Origin Energy Resources NZ (Rimu) Limited
Private Bag 2022
NEW PLYMOUTH 4342

Decision Date: 12 September 2013

Commencement Date: 12 September 2013

Conditions of Consent

Consent Granted: To discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 2400 mTVDss beneath the Kauri-E wellsite

Expiry Date: 1 June 2021

Review Date(s): June Annually

Site Location: Kauri-E wellsite, Geary Road, Kakaramea
(Property owner: AR Geary)

Legal Description: Lots 1, 9, 10 & 13 DP 14551 Blk 1 Carlyle SD
(Discharge source & site)

Grid Reference (NZTM) 1718870E-5605318N

Catchment: Tasman Sea
Waikaikai

*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 2400 mTVDss.
Note: mTVDss = metres true vertical depth subsea, i.e. the true vertical depth in metres below mean sea level.
2. There shall be no discharge of hydraulic fracturing fluids into the reservoir after 1 June 2016.
3. 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.
4. 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 3 (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.
5. The Monitoring Programme shall include sampling of groundwater from a bore installed in accordance with NZS 4411:2001. The bore shall be of a depth, location and design determined after consultation with the Chief Executive, Taranaki Regional Council.
6. 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 4 and 6 could be taken and analysed by the Council or other contracted party on behalf of the consent holder.

7. 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 3.

Note: The Sampling and Analysis Plan may be combined with the Monitoring Programme required by condition 4.

8. 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.
9. 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, the intended fracture interval(s) ('fracture interval' is the discrete subsurface zone to receive a hydraulic fracture treatment), and the duration of the hydraulic fracturing programme;
 - (b) the number of discharges proposed and the geographical position (i.e. depth and lateral position) of each intended discharge point;
 - (c) the total volume of fracture fluid planned to be pumped down the well, including mini- fracture treatments, and their intended composition, including a list of all contaminants and Material Safety Data Sheets for all the chemicals to be used;
 - (d) the results of the reviews required by condition 16;
 - (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 3;
 - (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.

10. The consent holder shall notify the Taranaki Regional Council of each discharge by emailing 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 9, 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.
11. 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 6(a) to 6(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 or after that period of production;
 - (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 8, and the top hole pressure (psi), slurry rate (bpm), surface proppant concentration (lb/gal), bottom hole proppant concentration (lb/gal), and calculated bottom hole pressure (psi), as well as predicted values for each of these parameters; prior to, during and after each hydraulic fracture treatment;
 - (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.
12. The reports described in conditions 9 and 11 shall be emailed to consents@trc.govt.nz with a reference to the number of this consent.
13. 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.

Consent 9645-1

14. 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.
15. The fracture fluid shall be comprised of no less than 95% water and proppant by volume.
16. 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 14; 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 12 September 2013

For and on behalf of
Taranaki Regional Council

Director-Resource Management

Appendix III

Certificates of analysis (Groundwater)

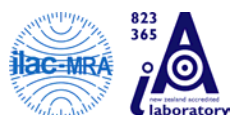


ANALYSIS REPORT

Client:	Taranaki Regional Council	Lab No:	1210384	SPV1
Contact:	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	Date Registered:	03-Dec-2013	
		Date Reported:	10-Dec-2013	
		Quote No:	47915	
		Order No:		
		Client Reference:	Kaurie - Pre H/F GW Sample	
		Submitted By:	Regan Phipps	

Sample Type: Aqueous

Sample Name:	GND2371 02-Dec-2013 11:22 am				
Lab Number:	1210384.1				
Individual Tests					
Sum of Anions	meq/L	4.4	-	-	-
Sum of Cations	meq/L	4.7	-	-	-
pH	pH Units	6.9	-	-	-
Total Alkalinity	g/m ³ as CaCO ₃	55	-	-	-
Bicarbonate	g/m ³ at 25°C	67	-	-	-
Total Hardness	g/m ³ as CaCO ₃	126	-	-	-
Electrical Conductivity (EC)	mS/m	48.4	-	-	-
Total Dissolved Solids (TDS)	g/m ³	340	-	-	-
Dissolved Barium	g/m ³	0.0177	-	-	-
Dissolved Bromine*	g/m ³	0.162	-	-	-
Dissolved Calcium	g/m ³	23	-	-	-
Dissolved Copper	g/m ³	0.0014	-	-	-
Dissolved Iron	g/m ³	< 0.02	-	-	-
Dissolved Magnesium	g/m ³	16.9	-	-	-
Dissolved Manganese	g/m ³	0.023	-	-	-
Dissolved Mercury	g/m ³	< 0.00008	-	-	-
Dissolved Nickel	g/m ³	0.0018	-	-	-
Dissolved Potassium	g/m ³	7.4	-	-	-
Dissolved Sodium	g/m ³	46	-	-	-
Dissolved Zinc	g/m ³	0.0094	-	-	-
Chloride	g/m ³	59	-	-	-
Nitrite-N	g/m ³	0.020	-	-	-
Nitrate-N	g/m ³	12.7	-	-	-
Nitrate-N + Nitrite-N	g/m ³	12.7	-	-	-
Sulphate	g/m ³	35	-	-	-
Ethylene Glycol in Water					
Ethylene glycol*	g/m ³	< 4	-	-	-
Propylene Glycol in Water					
Propylene glycol*	g/m ³	< 4	-	-	-
Methanol in Water - Aqueous Solvents					
Methanol*	g/m ³	< 2	-	-	-
BTEX in Water by Headspace GC-MS					
Benzene	g/m ³	< 0.0010	-	-	-
Toluene	g/m ³	< 0.0010	-	-	-
Ethylbenzene	g/m ³	< 0.0010	-	-	-
m&p-Xylene	g/m ³	< 0.002	-	-	-



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

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

Sample Type: Aqueous						
Sample Name:	GND2371 02-Dec-2013 11:22 am					
Lab Number:	1210384.1					
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m ³	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m ³	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m ³	< 0.003	-	-	-	-
Ethylene	g/m ³	< 0.003	-	-	-	-
Methane	g/m ³	< 0.002	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m ³	< 0.10	-	-	-	-
C10 - C14	g/m ³	< 0.2	-	-	-	-
C15 - C36	g/m ³	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m ³	< 0.7	-	-	-	-

SUMMARY OF METHODS

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

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	-	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	-	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	-	1
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	-	1
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	-	1
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	-	1
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L.	0.07 meq/L	1
Total cations for anion/cation balance check	Calculation: sum of cations as mEquiv/L.	0.05 meq/L	1
pH	pH meter. APHA 4500-H+ B 22 nd 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 nd ed. 2012.	1.0 g/m ³ as CaCO ₃	1
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO ₂ D 22 nd ed. 2012.	1.0 g/m ³ at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22 nd ed. 2012.	1.0 g/m ³ as CaCO ₃	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22 nd 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 nd ed. 2012.	10 g/m ³	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.00010 g/m ³	1
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.005 g/m ³	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.05 g/m ³	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.0005 g/m ³	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.02 g/m ³	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.02 g/m ³	1

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

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

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

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

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



ANALYSIS REPORT

Client:	Taranaki Regional Council	Lab No:	1248630	SPV1
Contact:	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	Date Registered:	15-Mar-2014	
		Date Reported:	27-Mar-2014	
		Quote No:	47915	
		Order No:		
		Client Reference:	Kauri E - Post HF GW	
		Submitted By:	Regan Phipps	

Sample Type: Aqueous

Sample Name:	GND2371 14-Mar-2014 12:40 pm				
Lab Number:	1248630.1				

Individual Tests

Sum of Anions	meq/L	4.5	-	-	-	-
Sum of Cations	meq/L	4.2	-	-	-	-
pH	pH Units	6.9	-	-	-	-
Total Alkalinity	g/m ³ as CaCO ₃	60	-	-	-	-
Bicarbonate	g/m ³ at 25°C	73	-	-	-	-
Total Hardness	g/m ³ as CaCO ₃	124	-	-	-	-
Electrical Conductivity (EC)	mS/m	45.7	-	-	-	-
Total Dissolved Solids (TDS)	g/m ³	340	-	-	-	-
Dissolved Barium	g/m ³	0.0176	-	-	-	-
Dissolved Bromine*	g/m ³	0.179	-	-	-	-
Dissolved Calcium	g/m ³	23	-	-	-	-
Dissolved Copper	g/m ³	0.0011	-	-	-	-
Dissolved Iron	g/m ³	< 0.02	-	-	-	-
Dissolved Magnesium	g/m ³	16.2	-	-	-	-
Dissolved Manganese	g/m ³	0.0081	-	-	-	-
Dissolved Mercury	g/m ³	< 0.00008	-	-	-	-
Dissolved Nickel	g/m ³	0.0007	-	-	-	-
Dissolved Potassium	g/m ³	6.6	-	-	-	-
Dissolved Sodium	g/m ³	36	-	-	-	-
Dissolved Zinc	g/m ³	0.045	-	-	-	-
Chloride	g/m ³	60	-	-	-	-
Nitrite-N	g/m ³	< 0.002	-	-	-	-
Nitrate-N	g/m ³	12.3	-	-	-	-
Nitrate-N + Nitrite-N	g/m ³	12.3	-	-	-	-
Sulphate	g/m ³	35	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m ³	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m ³	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m ³	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m ³	< 0.0010	-	-	-	-
Toluene	g/m ³	< 0.0010	-	-	-	-
Ethylbenzene	g/m ³	< 0.0010	-	-	-	-
m&p-Xylene	g/m ³	< 0.002	-	-	-	-



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

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

Sample Type: Aqueous						
Sample Name:	GND2371 14-Mar-2014 12:40 pm					
Lab Number:	1248630.1					
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m ³	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m ³	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m ³	< 0.003	-	-	-	-
Ethylene	g/m ³	< 0.003	-	-	-	-
Methane	g/m ³	< 0.002	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m ³	< 0.10	-	-	-	-
C10 - C14	g/m ³	0.3	-	-	-	-
C15 - C36	g/m ³	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m ³	< 0.7	-	-	-	-

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	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m ³	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m ³	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m ³	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m ³	1
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m ³	1
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m ³	1
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	0.10 - 0.7 g/m ³	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 nd 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 nd ed. 2012.	1.0 g/m ³ as CaCO ₃	1
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO ₂ D 22 nd ed. 2012.	1.0 g/m ³ at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22 nd ed. 2012.	1.0 g/m ³ as CaCO ₃	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22 nd 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 nd ed. 2012.	10 g/m ³	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.00010 g/m ³	1
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.005 g/m ³	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.05 g/m ³	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.0005 g/m ³	1

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

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

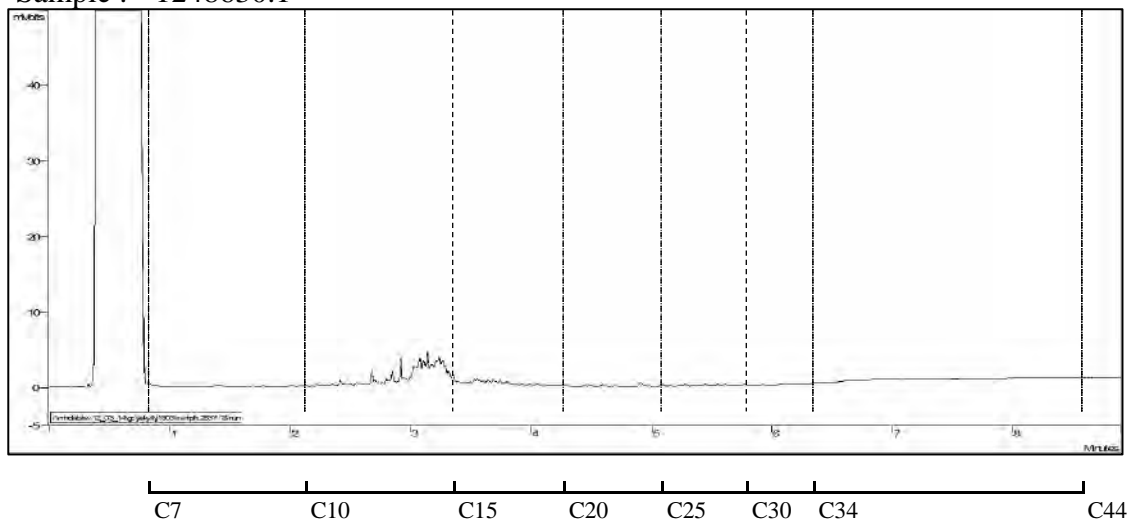
Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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

Sample : 1248630.1



ANALYSIS REPORT

Page 1 of 3

Client:	Taranaki Regional Council	Lab No:	1386147	SPV1
Contact:	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	Date Registered:	18-Feb-2015	
		Date Reported:	26-Feb-2015	
		Quote No:	47915	
		Order No:		
		Client Reference:	Kauri E 1 Year Post HF	
		Submitted By:	R McDonnell	

Sample Type: Aqueous

Sample Name:	GND 2371 17-Feb-2015 1:13 pm				
Lab Number:	1386147.1				
Individual Tests					
Sum of Anions	meq/L	5.4	-	-	-
Sum of Cations	meq/L	5.3	-	-	-
pH	pH Units	6.6	-	-	-
Total Alkalinity	g/m ³ as CaCO ₃	72	-	-	-
Bicarbonate	g/m ³ at 25°C	88	-	-	-
Total Hardness	g/m ³ as CaCO ₃	163	-	-	-
Electrical Conductivity (EC)	mS/m	57.7	-	-	-
Total Dissolved Solids (TDS)	g/m ³	390	-	-	-
Dissolved Barium	g/m ³	0.0195	-	-	-
Dissolved Bromine*	g/m ³	0.23	-	-	-
Dissolved Calcium	g/m ³	30	-	-	-
Dissolved Copper	g/m ³	0.0013	-	-	-
Dissolved Iron	g/m ³	< 0.02	-	-	-
Dissolved Magnesium	g/m ³	21	-	-	-
Dissolved Manganese	g/m ³	0.0022	-	-	-
Dissolved Mercury	g/m ³	< 0.00008	-	-	-
Dissolved Nickel	g/m ³	< 0.0005	-	-	-
Dissolved Potassium	g/m ³	7.6	-	-	-
Dissolved Sodium	g/m ³	43	-	-	-
Dissolved Zinc	g/m ³	0.0050	-	-	-
Chloride	g/m ³	81	-	-	-
Nitrite-N	g/m ³	< 0.002	-	-	-
Nitrate-N	g/m ³	12.9	-	-	-
Nitrate-N + Nitrite-N	g/m ³	12.9	-	-	-
Sulphate	g/m ³	34	-	-	-
Ethylene Glycol in Water					
Ethylene glycol*	g/m ³	< 4	-	-	-
Propylene Glycol in Water					
Propylene glycol*	g/m ³	< 4	-	-	-
Methanol in Water - Aqueous Solvents					
Methanol*	g/m ³	< 2	-	-	-
BTEX in Water by Headspace GC-MS					
Benzene	g/m ³	< 0.0010	-	-	-
Toluene	g/m ³	< 0.0010	-	-	-
Ethylbenzene	g/m ³	< 0.0010	-	-	-
m&p-Xylene	g/m ³	< 0.002	-	-	-

Sample Type: Aqueous						
Sample Name:	GND 2371 17-Feb-2015 1:13 pm					
Lab Number:	1386147.1					
BTEX in Water by Headspace GC-MS						
o-Xylene	g/m ³	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m ³	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m ³	< 0.003	-	-	-	-
Ethylene	g/m ³	< 0.003	-	-	-	-
Methane	g/m ³	< 0.002	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m ³	< 0.10	-	-	-	-
C10 - C14	g/m ³	< 0.2	-	-	-	-
C15 - C36	g/m ³	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m ³	< 0.7	-	-	-	-

SUMMARY OF METHODS

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

Sample Type: Aqueous			
Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m ³	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m ³	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m ³	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m ³	1
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS	0.02 g/m ³	1
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis.	0.002 - 0.003 g/m ³	1
Total Petroleum Hydrocarbons in Water	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734]	0.10 - 0.7 g/m ³	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 calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 22 nd ed. 2012.	0.07 meq/L	1
Total cations for anion/cation balance check	Sum of cations as mEq/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H ⁺) also included in calculation if available. APHA 1030 E 22 nd ed. 2012.	0.05 meq/L	1
pH	pH meter. APHA 4500-H ⁺ B 22 nd 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 nd ed. 2012.	1.0 g/m ³ as CaCO ₃	1
Bicarbonate	Calculation: from alkalinity and pH, valid where TDS is not >500 mg/L and alkalinity is almost entirely due to hydroxides, carbonates or bicarbonates. APHA 4500-CO ₂ D 22 nd ed. 2012.	1.0 g/m ³ at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22 nd ed. 2012.	1.0 g/m ³ as CaCO ₃	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22 nd 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 nd ed. 2012.	10 g/m ³	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.00010 g/m ³	1
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.005 g/m ³	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.05 g/m ³	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22 nd ed. 2012.	0.0005 g/m ³	1

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

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

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

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

Appendix IV

Certificates of analysis (Hydraulic fracturing and return fluid)



ANALYSIS REPORT

Client:	Taranaki Regional Council	Lab No:	1223473	SPV2
Contact:	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	Date Registered:	15-Jan-2014	
		Date Reported:	04-Feb-2014	
		Quote No:	50522	
		Order No:		
		Client Reference:	Kauri E - HF Fluid	
		Submitted By:	Regan Phipps	

Amended Report

This report replaces an earlier report issued on the 29 Jan 2014 at 5:22 pm
 The sampling date has been amended.

Sample Type: Saline

Sample Name:	GND2376 24-Dec-2013 12:00 pm				
Lab Number:	1223473.1				
Ethylene Glycol in Water					
Ethylene glycol	g/m ³	< 4	-	-	-
Propylene Glycol in Water					
Propylene glycol	g/m ³	6	-	-	-
Methanol in Water - Aqueous Solvents					
Methanol	g/m ³	< 2	-	-	-
BTEX in Water by Headspace GC-MS					
Benzene	g/m ³	< 0.0010	-	-	-
Toluene	g/m ³	0.0013	-	-	-
Ethylbenzene	g/m ³	0.0015	-	-	-
m&p-Xylene	g/m ³	0.005	-	-	-
o-Xylene	g/m ³	0.0037	-	-	-
Total Petroleum Hydrocarbons in Water					
C7 - C9	g/m ³	1.91	-	-	-
C10 - C14	g/m ³	195	-	-	-
C15 - C36	g/m ³	350	-	-	-
Total hydrocarbons (C7 - C36)	g/m ³	550	-	-	-

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	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.

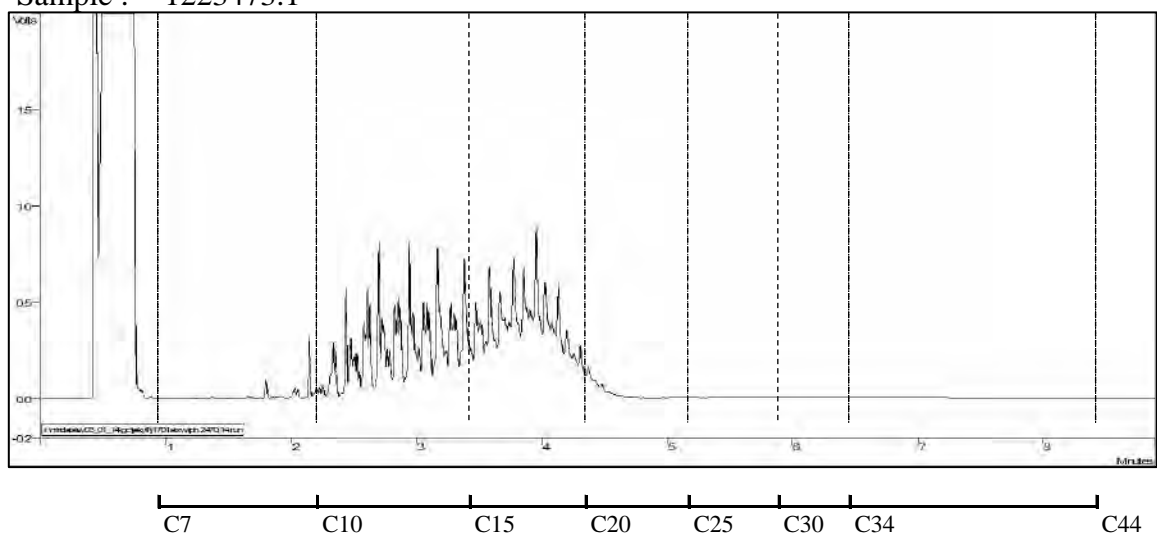
Samples are held at the laboratory after reporting for a length of time depending on the preservation used and the stability of the analytes being tested. Once the storage period is completed the samples are discarded unless otherwise advised by the client.

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A handwritten signature in blue ink, consisting of several overlapping, stylized strokes.

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

Sample : 1223473.1



ANALYSIS REPORT

Page 1 of 3

Client:	Taranaki Regional Council	Lab No:	1236818	SPV1
Contact:	Regan Phipps C/- Taranaki Regional Council Private Bag 713 STRATFORD 4352	Date Registered:	18-Feb-2014	
		Date Reported:	03-Mar-2014	
		Quote No:	49265	
		Order No:		
		Client Reference:	Kauri E Return Fluid	
		Submitted By:	R McDonnell	

Sample Type: Saline

Sample Name:	GND2376 10/02/14 18:00	GND2376 11/02/14 12:00	GND2376 12/02/14 12:00		
Lab Number:	1236818.1	1236818.2	1236818.3		
Individual Tests					
pH*	pH Units	6.4	6.7	6.7	-
Total Alkalinity*	g/m ³ as CaCO ₃	78	72	69	-
Analysis Temperature for Bicarbonate	°C	21	21	21	-
Bicarbonate	g/m ³ at Analysis Temperature	82	71	78	-
Total Hardness*	g/m ³ as CaCO ₃	7,400	8,000	7,500	-
Electrical Conductivity (EC)*	mS/m	3,290	3,160	2,790	-
Total Dissolved Solids (TDS)*	g/m ³	21,000	19,400	17,100	-
Dissolved Barium*	g/m ³	1.92	1.92	1.60	-
Dissolved Bromine*	g/m ³	27	24	18.5	-
Dissolved Calcium*	g/m ³	2,900	3,100	2,900	-
Dissolved Copper*	g/m ³	0.020	0.024	0.009	-
Dissolved Iron*	g/m ³	0.92	11.1	7.5	-
Dissolved Magnesium*	g/m ³	42	40	36	-
Dissolved Manganese*	g/m ³	2.4	1.49	1.15	-
Total Mercury*	g/m ³	< 0.011	< 0.011	< 0.011	-
Dissolved Nickel*	g/m ³	< 0.03	< 0.03	< 0.03	-
Dissolved Potassium*	g/m ³	4,700	3,500	2,500	-
Dissolved Sodium*	g/m ³	1,410	1,560	1,450	-
Dissolved Sulphur*	g/m ³	5	< 5	< 5	-
Dissolved Zinc*	g/m ³	0.04	0.12	0.22	-
Chloride*	g/m ³	9,700	9,800	8,800	-
Nitrite-N	g/m ³	0.09	0.16	0.006	-
Nitrate-N	g/m ³	0.11	0.05	0.047	-
Nitrate*	g/m ³	0.50	0.21	0.21	-
Nitrate-N + Nitrite-N	g/m ³	0.20	0.20	0.053	-
Sulphate*	g/m ³	16	< 15	< 15	-
Ethylene Glycol in Water					
Ethylene glycol*	g/m ³	< 4	< 4	< 4	-
Propylene Glycol in Water					
Propylene glycol*	g/m ³	< 4	< 4	< 4	-
Methanol in Water - Aqueous Solvents					
Methanol*	g/m ³	< 2	< 2	< 2	-
BTEX in Water by Headspace GC-MS					
Benzene*	g/m ³	9.1	12.2	11.5	-
Toluene*	g/m ³	1.99	3.1	3.0	-
Ethylbenzene*	g/m ³	0.035	0.28	0.29	-
m&p-Xylene*	g/m ³	0.50	0.88	0.87	-

Sample Type: Saline						
Sample Name:		GND2376 10/02/14 18:00	GND2376 11/02/14 12:00	GND2376 12/02/14 12:00		
Lab Number:		1236818.1	1236818.2	1236818.3		
BTEX in Water by Headspace GC-MS						
o-Xylene*	g/m ³	0.36	0.58	0.59	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m ³	0.22	0.15	0.10	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9*	g/m ³	2.4	4.7	5.4	-	-
C10 - C14*	g/m ³	2.5	9.6	10.7	-	-
C15 - C36*	g/m ³	1.0	5.2	12.8	-	-
Total hydrocarbons (C7 - C36)*	g/m ³	5.9	19.5	29	-	-

Analyst's Comments

Please note that the TPH and BTEX analyses were performed on sub-samples from plastic containers which risks phthalate contamination and volatile loss.

Appendix No.1 - Total Petroleum Hydrocarbon Chromatograms

Appendix No.2 - Bicarbonate Results - 1236818

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	4 g/m ³	1-3
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m ³	1-3
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m ³	1-3
BTEX in Water by Headspace GC-MS*	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m ³	1-3
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS	0.02 g/m ³	1-3
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 ³	1-3
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	1-3
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E 22 nd ed. 2012 (modified).	-	1-3
pH*	Saline water, pH meter. APHA 4500-H+ B 22 nd ed. 2012.	0.1 pH Units	1-3
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m ³ as CaCO ₃	1-3
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	1-3
Bicarbonate	Bicarbonate (HCO ₃) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988.	20 g/m ³ at Analysis Temperature	1-3
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 22 nd ed. 2012.	1.0 g/m ³ as CaCO ₃	1-3
Electrical Conductivity (EC)*	Saline water, Conductivity meter, 25°C. APHA 2510 B 22 nd ed. 2012.	0.10 mS/m	1-3
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 nd ed. 2012.	50 g/m ³	1-3
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22 nd ed. 2012.	-	1-3
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 nd ed. 2012.	0.0006 g/m ³	1-3
Dissolved Bromine*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 nd ed. 2012.	0.10 g/m ³	1-3
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 nd ed. 2012.	1.0 g/m ³	1-3
Dissolved Copper*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 nd ed. 2012.	0.0010 g/m ³	1-3
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 nd ed. 2012.	0.004 g/m ³	1-3

Sample Type: Saline			
Test	Method Description	Default Detection Limit	Sample No
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 nd ed. 2012.	0.4 g/m ³	1-3
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 nd ed. 2012.	0.0010 g/m ³	1-3
Total Mercury*	Nitric acid digestion, ICP-MS, screen level. APHA 3125 B 22 nd ed. 2012.	0.0021 g/m ³	1-3
Dissolved Nickel*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 nd ed. 2012.	0.006 g/m ³	1-3
Dissolved Potassium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 nd ed. 2012.	1.0 g/m ³	1-3
Dissolved Sodium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22 nd ed. 2012.	0.4 g/m ³	1-3
Dissolved Sulphur*	Filtered sample, ICP-OES.	0.10 g/m ³	1-3
Dissolved Zinc*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22 nd ed. 2012.	0.004 g/m ³	1-3
Chloride*	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl ⁻ E (modified from continuous flow analysis) 22 nd ed. 2012.	0.5 g/m ³	1-3
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO ₂ ⁻ I 22 nd ed. 2012.	0.002 g/m ³	1-3
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO ₂ N. In-House.	0.0010 g/m ³	1-3
Nitrate*	Calculation from Nitrate-N.	0.010 g/m ³	1-3
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO ₃ ⁻ I 22 nd ed. 2012.	0.002 g/m ³	1-3
Soluble Sulphate*	Calculation: from dissolved sulphur.	2 g/m ³	1-3

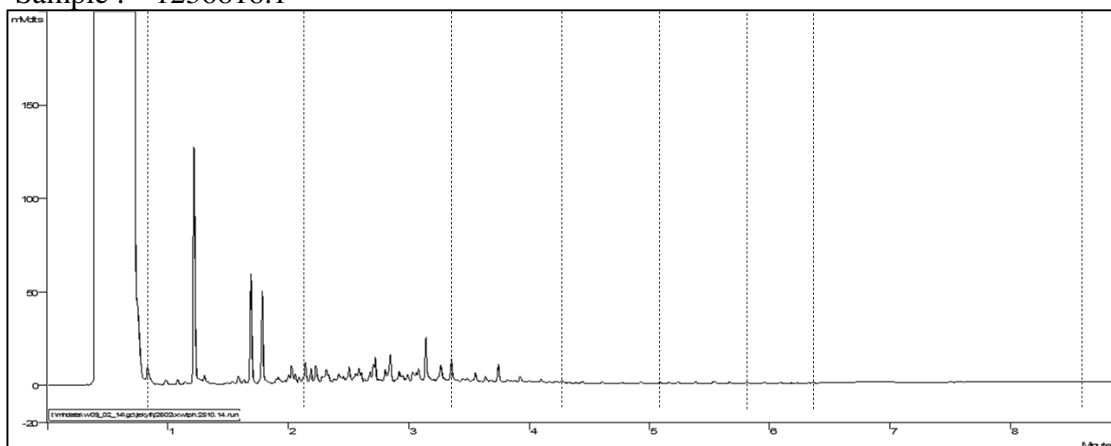
These samples were collected by yourselves (or your agent) and analysed as received at the laboratory.

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

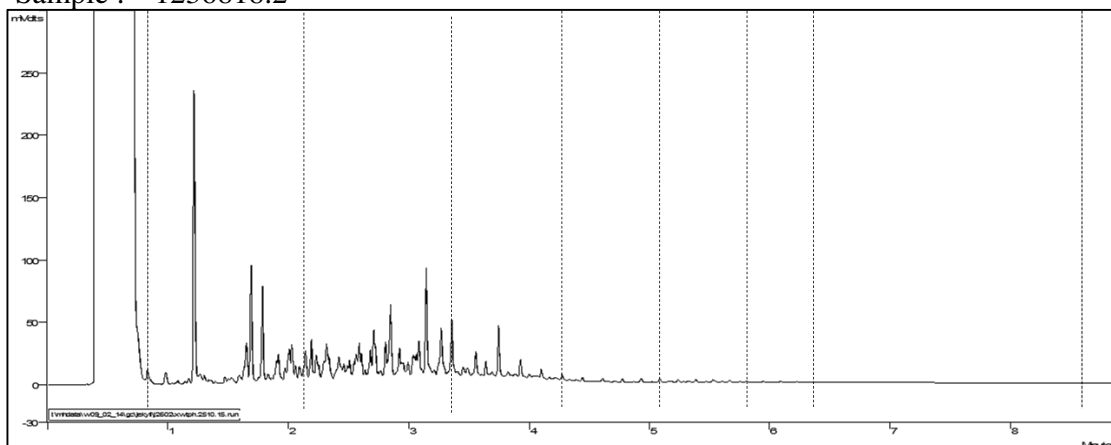
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Martin Cowell - BSc
Client Services Manager - Environmental Division

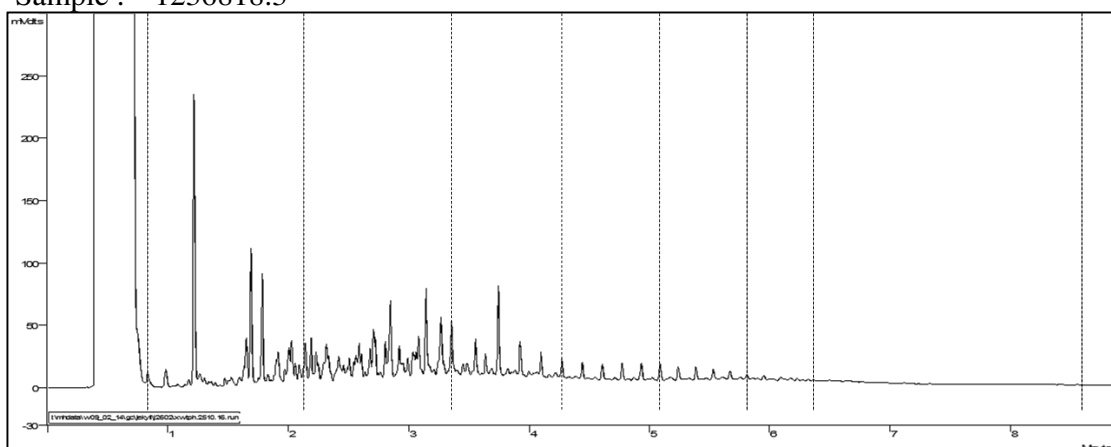
Sample : 1236818.1



Sample : 1236818.2



Sample : 1236818.3



C7 C10 C15 C20 C25 C30 C34 C44

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

Report No: 2014022101

Customer Ref:137187

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

GNS Sample No.	2014001132	2014001133	2014001134	
Collection Date:				
Site ID:	1236818/1	1236818/2	1236818/3	
Field ID	GND2376	GND2376	GND2376	
pH	7.14	6.79	6.73	-
Bicarbonate (Total) mg/l	82	71	78	-
HCO ₃ Analysis Temperature °C	21	21	21	-
HCO ₃ Analysis Date	21/02/2014	21/02/2014	21/02/2014	-

SUMMARY OF METHODS AND DETECTION LIMITS

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

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

