Petrochem Ltd
Kowhai-D Hydraulic Fracturing
Monitoring Programme
2017-2018

Technical Report 19-04

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Executive summary

Petrochem Ltd (Petrochem), a subsidiary of Greymouth Petroleum Ltd, operates the Kowhai-D hydrocarbon exploration site located on Manganui Road, in the Waitara River catchment. This report for the period July 2016 to June 2018 describes the monitoring programme implemented by the Taranaki Regional Council (the Council) to assess the Company's environmental and consent compliance performance during the period under review. The report also details the results of the monitoring undertaken and assesses the environmental effects of the Company's activities.

This report outlines and discusses the results of the monitoring programme implemented by the Taranaki Regional Council (the Council) in relation to hydraulic fracturing activities conducted by Petrochem at the Kowhai-D wellsite over the period 2 May 2017 to 9 November 2017.

The programme of hydraulic fracturing undertaken by Petrochem at the Kowhai-D wellsite included the hydraulic fracturing of one well. The well targeted for stimulation was the Kowhai-4 well.

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

The programme of monitoring implemented by the Council in relation to these hydraulic fracturing activities spanned the 2016-2017 and 2017-2018 monitoring years. Monitoring included pre and post-discharge groundwater sampling. Biomonitoring surveys were also carried out to assess the impact of any site discharges during the fracturing programme on an unnamed tributary of the Waitara River. Samples of hydraulic fracturing fluids, and fluids returning to the wellhead post-fracturing, were also obtained for physicochemical analysis in order to characterise the discharges and to determine compliance with consent conditions.

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

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

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

For reference, in the 2017-2018 year, consent holders were found to achieve a high level of environmental performance and compliance for 76% of the consents monitored through the Taranaki tailored monitoring programmes, while for another 20% of the consents, a good level of environmental performance and compliance was achieved.

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

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1.1 Compliance monitoring programme reports and the Resource Management Act 1991

1.1.1 Introduction

This report outlines and discusses the results of the monitoring programme implemented by the Taranaki Regional Council (the Council) in relation to the programme of hydraulic fracturing undertaken by Petrochem Ltd (Petrochem) a subsidiary of Greymouth Petroleum Ltd at the Kowhai-D wellsite, over the period 2 May to 9 November 2017. The report also assesses the Company's level of environmental performance and compliance with the resource consent held in relation to the activity.

The programme of hydraulic fracturing undertaken by Petrochem at the Kowhai-D wellsite included the hydraulic fracturing of one well. The well targeted for stimulation was the Kowhai-4 well (GND2597).

The programme of monitoring implemented by the Council in relation to these hydraulic fracturing activities spanned the 2016-2017 and 2017-2018 monitoring years. Monitoring included a mixture of groundwater, surface water and discharge monitoring components. This is the first monitoring report produced by the Council in relation to hydraulic fracturing activities at the Kowhai-D wellsite.

1.1.2 Structure of this report

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

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

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

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

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

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

1.1.3 The Resource Management Act 1991 and monitoring

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

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

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

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

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

e. risks to the neighbourhood or environment.

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

1.1.4 Evaluation of environmental and administrative performance

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

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

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

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

Environmental Performance

High: No or inconsequential (short-term duration, less than minor in severity) breaches of consent or regional plan parameters resulting from the activity; no adverse effects of significance noted or likely in the receiving environment. The Council did not record any verified unauthorised incidents involving 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 performance

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

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

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

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

For reference, in the 2017-2018 year, consent holders were found to achieve a high level of environmental performance and compliance for 76% of the consents monitored through the Taranaki tailored monitoring programmes, while for another 20% of the consents, a good level of environmental performance and compliance was achieved.

1.2 Process description

1.2.1 Hydraulic fracturing

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

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

1.2.1.1 Gel fracturing

Gel fracturing utilises cross-linked gel solutions, which are liquid at the surface but, when mixed, form long-chain polymer bonds and thus become viscous gels. These gels are used to transport the proppant into the formation. Once in the formation they 'break' back with time, temperature and the aid of gel breaking chemicals into a liquid state and are flowed back to surface, without disturbing the proppant which remains in place and enhances the flow of hydrocarbons back to the surface.

1.2.1.2 Slick water fracturing

Slick water fracturing utilises water based fracturing fluids with friction-reducing additives. The addition of the friction reducers allows the fracturing fluids and proppant to be pumped to the target zone at higher rates and reduced pressures, than when using water alone. The higher rate creates turbulence within the fluid column holding the proppant and enabling its placement into the open fractures and enhancing the flow of hydrocarbons back to the surface. [1]

1.2.1.3 Nitrogen gas fracturing

Nitrogen gas assisted fracturing involves replacing some of the fluid used in the fracturing process with nitrogen gas, which can fracture rock at high pressures much like water. While nitrogen (N^2) is a gas at room temperature, it can be maintained in a liquid state through cooling and pressurisation. Nitrogen assisted fracturing is extremely beneficial from a production standpoint as inevitably during the fracturing process some of the water pumped down the well remains underground in the rock formation, which can block some of the small pores inhibiting hydrocarbon recovery. Nitrogen gas achieves the same purpose as water but returns more easily to the surface. [2] More indirectly, a reduction in the volume of water used also reduces the total concentration of chemical additives required and the volume of water returning to the surface that requires subsequent disposal. [2]

1.2.2 The Kowhai-D wellsite and hydraulic fracturing activities

The Kowhai-D wellsite is located on Manganui Road and lies within the Waitara Catchment. A tributary of the Waitara River is located around 120 m to the north-east and the main channel of the Waitara River is located approximately 610 m north east of the wellsite.

The area surrounding the site is rural in nature and farming and forestry activities co-exist with active petroleum exploration and production operations. The location of the wellsite is illustrated in Figure 1. A summary of the hydraulic fracturing activities carried out by Petrochem at the Kowhai-D wellsite during the period being reported is provided below in Table 1.

Table 1 Summary of hydraulic fracturing details

Well	Bore id.	Fracturing date	Interval	Injection zone (m TVDss)	Formation
Kowhai-4	GND2597	2-05-2017	1	4,393.9-4,410.9	Mangahewa
		10-05-2017	2	4,086.9-4,089.9	
		6-07-2017	2	4,086.9-4,089.6	
		11-08-2017	3	4,035.0-4,055.0	
		28-08-2017	4	3,975.5-3,978.5	
		23-09-2017	5	3,693.2-3,696.2	

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[1] *http://geology.com/energy/hydraulic-fracturing-fluids/*

[2] *http://frackwire.com/nitrogen-gas-fracking*

Well	Bore id.	Fracturing date	Interval	Injection zone (m TVDss)	Formation
		11-10-2017	6	3,793.2-3,796.2	
		2-11-2017	7	3,628.2-3,631.2	
		9-11-2017	8	3,598.2-3,601.2	

Figure 1 Location map

1.3 Resource consents

1.3.1 Discharges of wastes to land

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

Petrochem was granted resource consent **10297-1** on 24 May 2016. The consent permits the discharge of contaminants in association with hydraulic fracturing activities at the Kowhai-D wellsite, Maunganui Road, Everett Park. The consent was issued by the Council under Section 87(e) of the RMA. The consent requires the injection of fracturing fluids to occur below a depth of 3,385m TVDss. The consent is due to expire 1 June 2033.

Consent 10297-1 has 20 special conditions, as summarised below:

- Condition 1 stipulates the minimum depth below which the injection of hydraulic fracturing fluids must occur;
- Condition 2 requires that no further hydraulic fracturing be undertaken after 1 June 2028;
- Condition 3 sets out the requirements the consent holder must take should the Geonet seismic monitoring network record a seismic event higher than magnitude 3 within 5 km of the discharge;
- Condition 4 stipulates the reporting requirements following any seismic event described in condition 3;
- Condition 5 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 6, 7, 8 and 9 relate to freshwater monitoring requirements, to allow compliance with condition 5 to be assessed;
- Condition 10 requires the consent holder to carry out pressure testing of equipment prior to discharging;
- Condition 11 requires the consent holder to submit a pre-fracturing discharge report prior to any discharge occurring;
- Condition 12 is a notification requirement;
- Condition 13 requires the consent holder to submit a post-fracturing discharge report after the completion of the hydraulic fracturing programme for each well;
- Condition 14 stipulates the requirements for interim post-fracturing reports;
- Condition 15 stipulates how the reports required by conditions 11, 13 and 14 are to be submitted;
- Condition 16 requires the consent holder to allow the Council access to a location where samples of hydraulic fracturing and return fluids can be obtained;
- Condition 17 requires the consent holder to adopt best practicable options;
- Condition 18 relates to the composition of the fracturing fluid;
- Condition 19 is a lapse clause; and
- Condition 20 is a review provision.

This summary of consent conditions may not reflect the full requirements of each condition. The consent conditions in full can be found in the resource consent appended to this report (Appendix I).

1.4 Monitoring programme

1.4.1 Introduction

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

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

The monitoring programme for the Kowhai-D wellsite consisted of four primary components.

1.4.2 Programme liaison and management

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

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

1.4.3 Assessment of data submitted by the consent holder

As required by the conditions of consent 10297-1, Petrochem submitted pre and post-fracturing discharge reports to the Council for the well fractured during the period under review. Pre-fracturing discharge reports provide an outline of the proposed fracturing operations in relation to each well, while post-fracturing reports confirm details of what actually occurred. The specific range of information required in each report is stipulated in the conditions of the consent.

1.4.4 Physiochemical sampling

1.4.4.1 Groundwater

No groundwater wells were identified during a survey of existing groundwater sites within a 1 km radius (area of review) of the Kowhai-D wellsite. As a generally accepted rule, all existing bores or wells within this radius are assessed for their suitability (or otherwise) and included in the monitoring programme.

Given the lack of suitable existing groundwater sites for monitoring within the survey area, a purpose built monitoring bore (GND2632) was drilled by Petrochem in order to comply with condition 7 of consent 10297-1. The location and bore details of this monitoring bore are summarised in Table 1. The location of the bore is displayed in Figure 1. GND2632 is the only groundwater monitoring site included in the monitoring programme.

Table 2 Details of groundwater sites included in the monitoring programme

Monitoring site	Distance from wellsite (m)	Total depth (m)	Screened/open interval (m)	Aquifer
GND2632	onsite	27	18-27	Volcanics and fluvial sediments

Samples of groundwater were obtained pre-fracturing to provide a baseline reference of groundwater composition, with further rounds of sampling carried out three months after commencement and three months and one year after cessation of the activities.

1.4.4.2 Hydraulic fracturing and return fluids

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

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

Samples of hydraulic fracturing fluid were obtained by Petrochem during the activity and were sent to Hill Laboratories Ltd for analysis.

1.4.5 Surface water quality monitoring

A tributary of the Waitara River is located around 40 m to the north east of the wellsite. Stormwater and treated site water are discharged onto land and into the unnamed tributary under consent 10294-1. Sites have been selected to monitor upstream and downstream of the estimated location of groundwater/subsurface drainage from the wellsite. Details of the three sites monitored on the unnamed tributary are included in Table 3. The locations are illustrated on Figure 1.

Table 3 Surface water monitoring site details

Monitoring site	Description	Location	Eastings	Northings
WTR000743	Tributary of the Waitara River upstream of Kowhai-D wellsite	5 m upstream of a track to farm shed	1710423	5674733
WTR000744	Tributary of the Waitara River downstream of Kowhai-D wellsite	Downstream edge of wetland	1710095	5675012
WTR000745	Tributary of the Waitara River downstream of Kowhai-D wellsite	50m downstream of wetland	1710042	5675020

1.4.5.1 Biomonitoring surveys

Biomonitoring surveys are undertaken to determine whether stormwater discharges from the wellsite have had any detrimental impacts on the macroinvertebrate communities of the unnamed tributary of the waitara River. Samples are processed to provide number of taxa (richness), MCI and SQMCI$_S$ scores, and EPT taxa 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 $SQMCI_S$ takes into account taxa abundance as well as sensitivity to pollution, and may reveal more subtle changes in communities. It may be the more appropriate index if non-organic impacts are occurring.

Significant differences in either the MCI or the $SQMCI_S$ between sites indicate the degree of adverse effects (if any) of the discharges being monitored.

A pre-drill biomonitoring survey was carried out on 16 February 2017 at three sites, established at the time of sampling (Table 3, Figure 1). A pre-hydraulic fracturing survey was carried out at the same sites on 26 April 2017 and a post-hydraulic fracturing survey was carried out on 29 November 2017.

2 Results

2.1 Consent holder submitted data

2.1.1 Kowhai-4 post-fracturing discharge report

The conclusions from the Kowhai-4 post-fracturing discharge report are summarised as follows:

- A total of eight zones were fractured over the period 2 May to 9 November 2017 at depths between 3,598 to 4,503 m TVss.
- A total of 19,539 bbls (3,106 m^3) of liquid was discharged across the eight fractured zones. The total proppant weight was 529 tonnes (1,166,663 lbs).
- The Kowhai-4 well was opened for flow-back following the completion of fracturing operations. In total 28,761 bbls (4,573 m^3) of fluid was returned from the well over the initial flow-back period.
- A greater volume of fluid than that injected was returned from six of the eight zones during flow back. Zone 3 and Zone 8 where the exceptions with 182.7 bbls (1,343 m^3) and 890.1 bbls respectively remaining in the formation following initial flow back.
- Approximately 417 tonnes (920,015 lbs) or 79 % of proppant injected remained within the formation.
- One screen out occurred while fracturing during treatment 2 resulting in under displacement of proppant in the zone. All proppant pumped into the zone was sub sequentially recovered with no implications for compliance with consent conditions reported.
- All return fluid from the Kowhai-4 fracturing operations was disposed of by deep well injection at the Kaimiro-G wellsite, under consent 9470-1.
- Pressure testing was undertaken of all surface equipment, including flow lines and the wellhead, prior to injection.
- There was no escape of fluids during hydraulic fracturing operations.
- It is considered that the mitigation measures implemented by Petrochem were effective in ensuring there were no adverse environmental effects associated with fracturing operations.

2.2 Physiochemical sampling

2.2.1 Groundwater

Hydraulic fracturing activities commenced at the Kowhai-D wellsite on 2 May 2017 and continued until 9 November 2017. A pre-fracturing baseline sample was collected on 24 April 2017. Post-fracturing samples were collected on 23 August 2017, 1 March 2018 and one year post-completion of the hydraulic fracturing activities on 30 August 2018.

Methane concentrations >1 gm^3 and trace ethane were reported in all samples both pre and post-hydraulic fracturing activities. To determine whether the source of the methane was biogenic or thermogenic samples were sent to Geological and Nuclear Sciences (GNS) for carbon 13 isotope analysis. The presence of carbon 13 isotopes concentrations at less than -50‰ indicate a thermogenic deep gas source and concentrations greater than -50‰ a shallow biogenic gas source. Carbon 13 concentrations ranged between -67.1 to -68.2‰ indicating the source of methane was predominantly biogenic and within the expected ranges for shallow groundwater across Taranaki.

As traces of ethane were also reported in the samples the ratio of methane to ethane can also be used to give an indication of the source of the dissolved gases, with higher ratios (<1,000) indicating the potential presence of a deep thermogenic source.

The wetness[3] ratios calculated ranged between 920 and 1,088 indicating that the shallow groundwater resources at the site may be influenced by a deep thermogenic gas seep, which are a common occurrence both on and offshore throughout the region.

The presence of methane and trace ethane alone are of little or no concern when not accompanied by additional hydrocarbons and/or increased chloride concentrations. Results indicate that the gases in the local groundwater may be from a mixed biogenic and thermogenic source.

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

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

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

Parameter	**Bore id**	**GND2632**			
	Unit	**Pre-frac (baseline)**	**3 mth post-frac**	**Interim post-frac**	**1 year post-frac**
Sample date	**-**	**24/04/2017**	**23/08/2017**	**01/03/2018**	**30/08/2018**
Lab number (Hill)	**-**	**1763808**	**1830751**	**1935494**	**2040610**
pH	pH	8.3	8.2	8.2	8.2
Total alkalinity	g/m^3 CaCO3	150	149	150	148
Bicarbonate	g/m^3 HCO_3	179	179	181	178
Total hardness	g/m^3 $CaCO_3$	87	88	83	84
Electrical conductivity	mS/m	32.0	32.1	32.0	31.3
Total dissolved solids	g/m^3	175	181	188	180
Dissolved calcium	g/m^3	21	21	20	19.4
Chloride	g/m^3	11.2	11.9	11.6	12.0
Dissolved magnesium	g/m^3	8.5	8.7	8.1	8.7
Dissolved potassium	g/m^3	3.2	3.0	3.0	3.1
Dissolved sodium	g/m^3	34	33	32	33
Nitrite nitrogen	g/m^3 N	<0.002	<0.002	<0.002	<0.002
Nitrate nitrogen	g/m^3 N	<0.002	0.004	<0.002	<0.002
Nitrate & nitrite nitrogen	g/m^3 N	<0.002	0.004	<0.002	<0.002
Sulphate	g/m^3	<0.5	<0.5	<0.5	<0.5
Dissolved barium	mg/kg	0.0052	0.005	0.0048	0.006
Dissolved bromine	g/m^3	0.039	-	-	-
Bromide	g/m^3	-	0.08	0.06	0.07
Dissolved copper	g/m^3	<0.0005	<0.0005	<0.0005	<0.0005
Dissolved iron	g/m^3	0.04	0.04	0.04	0.04
Dissolved manganese	g/m^3	0.0093	0.0095	0.0087	0.0091

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[3] *Biogenic gas is formed at shallow depths and low temperatures by anaerobic decomposition of organic matter, this gas is lacking in C2+ hydrocarbons i.e. it is very dry. Thermogenic gas is formed at deeper depths by thermal cracking of organic matter into petroleum liquids and wet gas.*

Parameter	Bore id	GND2632			
	Unit	Pre-frac (baseline)	3 mth post-frac	Interim post-frac	1 year post-frac
Sample date	-	**24/04/2017**	**23/08/2017**	**01/03/2018**	**30/08/2018**
Lab number (Hill)	-	**1763808**	**1830751**	**1935494**	**2040610**
Dissolved mercury	g/m^3	<0.00008	<0.00008	<0.00008	<0.00008
Dissolved Nickel	mg/kg	<0.0005	<0.005	<0.005	<0.005
Dissolved zinc	g/m^3	<0.0010	<0.0010	<0.0010	<0.0010
Ethylene glycol	g/m^3	<4	<4	<4	<4
Propylene glycol	g/m^3	<4	<4	<4	<4
Methanol	g/m^3	<2	<2	<2	<2
Benzene	g/m^3	<0.0010	<0.0010	<0.0010	<0.0010
Toluene	g/m^3	<0.0010	<0.0010	<0.0010	<0.0010
Ethylbenzene	g/m^3	<0.0010	<0.0010	<0.0010	<0.0010
m-Xylene	g/m^3	<0.002	<0.002	<0.002	<0.002
o-Xylene	g/m^3	<0.0010	<0.0010	<0.0010	<0.0010
Formaldehyde	g/m^3	<0.02	<0.02	<0.02	<0.02
Ethane	g/m^3	0.01	0.01	0.008	0.008
Ethylene	g/m^3	<0.004	<0.004	<0.004	<0.004
Methane	g/m^3	9.5	9.2	8.7	8.6
C7-C9	g/m^3	<0.06	<0.06	<0.06	<0.06
C10-C14	g/m^3	<0.2	<0.2	<0.2	<0.2
C15-C36	g/m^3	<0.4	<0.4	<0.4	<0.4
Total hydrocarbons	g/m^3	<0.7	<0.7	<0.7	<0.7
δ13C value*	‰ (-)	67.8	68.2	67.3	67.1

*Note: *δ13C values below 50‰ (-) indicate a biogenic source and above 50‰ (-) a thermogenic source*

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 Kowhai-4 well are shown below in Table 5. The certificates of analysis are included in Appendix III. Depending on the viscosity of the sample received at the laboratory, samples may require dilution prior to analysis which results in the higher detection limit (<200 and <400 g/m^3) seen for some of the parameters reported in Treatment 9.

The results of the analyses carried out on the return fluid samples obtained following the hydraulic fracturing of the Kowhai-4 well are summarised below in Table 6 and certificates of analysis are included in Appendix III. Return fluids were collected during the flow back of each interval and demonstrate the variability of groundwater quality and hydrocarbon concentrations with depth. The relatively high levels of chloride, sodium and hydrocarbons in each sample indicate that the composite samples prepared contained a greater proportion of reservoir fluids than hydraulic fracturing fluids introduced during the fracturing activities, which are comprised predominantly of freshwater.

Table 5 Results of hydraulic fracturing fluid sampling

Parameter	**Well id**	**Kowhai-4 (GND2597)**								
Reference	**Unit**	**Zone 1**	**Zone 2**	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 5**	**Zone 6**	**Zone 7**	**Zone 8**
Treatment	**-**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Date	**-**	**02/05/2017**	**10/05/2017**	**06/07/2017**	**11/08/2017**	**28/08/2017**	**23/09/2017**	**11/10/2017**	**2/11/2017**	**9/11/2017**
Lab number	**Hill**	**1773281**	**1789419**	**1808079**	**1827538**	**1837536**	**1852320**	**1864185**	**1874156**	**1882658**
Ethylene glycol*	g/m^3	87	39	<20	<20	<20	<40	<4	<40	<400
Propylene glycol*	g/m^3	<20	<20	<20	<20	<20	<40	<4	<40	<400
Methanol*	g/m^3	<20	<20	<20	<20	<20	<20	<2	<20	<1,100
Benzene	g/m^3	0.0012	0.0011	0.01	0.012	0.0034	<0.010	0.0012	0.0023	0.056
Toluene	g/m^3	0.0021	0.0055	0.02	0.038	0.0082	0.015	0.0035	0.0051	0.122
Ethylbenzene	g/m^3	<0.0010	<0.0010	0.01	<0.010	0.0019	<0.010	0.0026	0.001	0.0053
m-Xylene	g/m^3	0.003	<0.002	0.03	0.03	0.006	<0.02	0.004	0.003	0.031
o-Xylene	g/m^3	0.0015	<0.0010	0.011	0.014	0.0035	<0.010	0.0024	0.0016	0.0048
C7-C9	g/m^3	0.44	0.17	0.4	8.8	0.29	7.2	3.1	0.28	1.98
C10-C14	g/m^3	570	24	750	630	16	43	920	9	340
C15-C36	g/m^3	960	50	1,020	820	33	80	1,050	18	580
Total hydrocarbons	g/m^3	1,530	75	1,770	1,460	49	130	1,970	27	910

** Some samples required dilution in the lab due to high viscosity which has resulted in a range of detection limits for some parameters*

Table 6 Results of hydraulic fracturing return fluid sampling

Parameter	Well id	Kowhai-4 (GND2597)								
Reference	**Unit**	**Zone 1**	**Zone 2**	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 5**	**Zone 6**	**Zone 7**	**Zone 8**
Treatment	**-**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Lab number	**Hill**	**1773280**	**1789418**	**1808078**	**1827529**	**1837537**	**1854324**	**1864183**	**1874155**	**1874155**
pH	pH	7	6.6	6.6	6.8	6.6	7.2	6.7	7	6.8
Total alkalinity	g/m^3 CaCO3	940	1,030	990	1,200	1,030	1,770	930	1,520	1,410
Bicarbonate	g/m^3 HCO_3	1,177	1,085	1,068	1,244	1,111	2,080	904	1688	1355
Total hardness	g/m^3 $CaCO_3$	80	280	200	161	370	131	230	120	123
Electrical conductivity	mS/m	924	2,110	1,481	1,441	2,010	2,080	1,699	1,215	1,613
Total dissolved solids	g/m^3	7,800	13,700	11,100	10,800	13,500	13,400	12,700	10,200	12,400
Dissolved barium	mg/kg	9.1	66	34	38	61	54	39	10.7	28
Dissolved bromine	g/m^3	4.9	24	12.2	9.9	14.4	54	13	14.4	12.5
Dissolved calcium	g/m^3	26	98	68	56	129	41	75	30	35
Dissolved copper	g/m^3	0.057	0.0144	0.0052	0.024	0.016	0.009	0.008	0.01	0.0096
Dissolved iron	g/m^3	7.2	2.1	1.65	1.6	2.9	1.34	16.6	7.5	6.4
Dissolved magnesium	g/m^3	4	8.6	8.3	5	10	7	10	11	8.5
Dissolved manganese	g/m^3	2.6	3.3	3.4	2.7	4	1.37	1.6	1.46	1.54
Total Nickel	mg/kg	0.09	<0.03	<0.03	0.014	0.05	0.021	0.03	0.1	0.16
Total potassium	g/m^3	310	450	470	610	440	460	450	320	390
Total sodium	g/m^3	1,890	4,500	2,900	2,800	4,100	3,900	3,200	2,400	3,900
Total sulphur	g/m^3	11	13	9	12	8	6	8	11	6
Total zinc	g/m^3	0.099	0.05	0.046	0.104	0.181	0.081	0.051	0.179	0.38
Chloride	g/m^3	2,300	7,200	4,500	4,200	6,300	4,600	5,300	2,400	4,300
Nitrite nitrogen	g/m^3 N	Not analysed	<0.2	<0.2	<0.2	<0.2	<0.2	0.02	0.027	<0.2
Nitrate nitrogen	g/m^3 N	Not analysed	<0.2	<0.2	<0.2	<0.2	<0.2	<0.02	0.025	<0.2
Nitrate & nitrite nitrogen	g/m^3 N	Not analysed	<0.2	<0.2	0.2	<0.2	<0.2	<0.02	0.052	<0.2
Sulphate	g/m^3	34	39	26	37	24	18	25	32	19
Ethylene glycol	g/m^3	<20	<20	<20	<20	<30	<40	<40	<40	<400
Propylene glycol	g/m^3	<20	<20	<20	<20	<20	<40	<40	<40	<400

Parameter	**Well id**	**Kowhai-4 (GND2597)**								
Reference	**Unit**	**Zone 1**	**Zone 2**	**Zone 2**	**Zone 3**	**Zone 4**	**Zone 5**	**Zone 6**	**Zone 7**	**Zone 8**
Treatment	**-**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Lab number	**Hill**	**1773280**	**1789418**	**1808078**	**1827529**	**1837537**	**1854324**	**1864183**	**1874155**	**1874155**
Methanol	g/m^3	<20	<20	<20	<20	<20	<20	89,000	46	940
Benzene	g/m^3	Not analysed	22	6	13.2	19	5.1	2.7	26	94
Toluene	g/m^3	Not analysed	52	4.4	30	40	6.6	5.2	63	183
Ethylbenzene	g/m^3	Not analysed	7.3	0.37	4.4	5.3	0.68	0.64	6.9	41
m-Xylene	g/m^3	Not analysed	41	2	25	33	4.3	4	43	145
o-Xylene	g/m^3	Not analysed	11.9	0.75	8.7	9.9	1.53	1.42	129	80
Formaldehyde	g/m^3	0.15	0.49	0.27	0.15	0.16	<0.15	<1.5	<15	1.6
C7-C9	g/m^3	8.7	400	15.9	200	210	39	38	290	1,550
C10-C14	g/m^3	39	610	65	330	620	220	250	640	760
C15-C36	g/m^3	59	860	114	430	570	330	310	440	410
Total hydrocarbons	g/m^3	137	1,870	195	960	1,400	590	600	1,380	2,700

2.3 Biomonitoring surveys

Three macroinvertebrate surveys were carried out at three sites near the Kowhai-D wellsite in an unnamed tributary of the Waitara River, in relation to drilling and hydraulic fracturing activities at the Kowhai-D wellsite (Figure 1). The surveys, undertaken on 16 February, 26 April and 29 November 2017, recorded moderately low to moderate taxa richnesses.

MCI scores ranged from 75 to 91 across the three surveys, characterising the macroinvertebrate community health as 'poor' or 'fair' on all occasions. Site 2 recorded a significant decrease between the pre-drill and post-drill surveys, but improved slightly in the post-fracturing survey. Site 3 declined slightly between the pre-drill and post-drill surveys, and again between the post-drill and post-HF survey, resulting in a significant decline between the pre-drill and post-HF surveys. The $SQMCI_S$ scores decreased significantly at site 1, but again subsequent improvement was noted. $SQMCI_S$ scores remained similar at sites 2 and 3 between the three surveys. Overall, these surveys provided no evidence that discharges from the Kowhai-D wellsite have caused any significant detrimental impacts on the macroinvertebrate communities of this unnamed tributary of the Waitara River.

The biomonitoring full report is appended to this report as Appendix IV.

2.4 Investigations, interventions, and incidents

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

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

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

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

3 Discussion

3.1 Environmental effects of exercise of consents

One well (Kowhai-4) was stimulated by hydraulic fracturing at the Kowhai-D wellsite during the period 2 May to 9 November 2017.

The monitoring programme carried out by the Council in relation to the fracturing events undertaken, included both groundwater and surface water monitoring components.

The groundwater monitoring component incorporated pre and post-fracturing sampling at one groundwater monitoring site located just outside the perimeter of the kowhai-D wellsite. The results of the sampling carried out showed only very minor variations in water composition in comparison to baseline results. Methane and traces of ethane were recorded in all the groundwater samples collected at the wellsite and are not interpreted to be a result of hydraulic fracturing activities at the Kowhai-D wellsite. The minor variations in most analytes are a result of natural variations in water composition.

The surface water monitoring component of the programme comprised of three biomonitoring surveys of the unnamed tributary of the Waitara River pre and post-fracturing of the Kowhai-4 well. The results of surveys indicate that the hydraulic fracturing site activities being reported on had no adverse effects on invertebrate communities within the stream.

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

3.2 Evaluation of performance

A tabular summary of the consent holder's compliance record for the year under review is set out in Table 7.

Table 7 Summary of performance for consent 10297-1

Purpose ***To discharge water based hydraulic fracturing fluids into land at depths greater than 3,385 mTVDss beneath the Kowhai-D wellsite at or about (NZTM) 1710128E-5674886N***

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Any discharge shall occur below 3,385 m TVDss	Assessment of consent holder submitted data	Yes
2. No discharge shall occur after 1 June 2028	Assessment of consent holder submitted data	N/A
3. Seismic monitoring requirement	Notification received	N/A
4. Investigation and reporting requirements if an event occurs under condition 3	Report received	N/A
5. Exercise of consent shall not result in any contaminants reaching any useable freshwater	Results of groundwater monitoring	Yes
6. Consent holder shall undertake sampling programme	Development and certification of a monitoring programme	Yes
7. Monitoring programme to include a minimum of one suitable bore	Consultation and installation of monitoring bore	Yes

Purpose *To discharge water based hydraulic fracturing fluids into land at depths greater than 3,385 mTVDss beneath the Kowhai-D wellsite at or about (NZTM) 1710128E-5674886N*		
Condition requirement	**Means of monitoring during period under review**	**Compliance achieved?**
8. 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
9. 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
10. Well and equipment pressure testing to be carried out prior to any hydraulic fracturing programme commencing	Assessment of consent holder submitted data	Yes
11. A pre-fracturing discharge report is to be provided to the Council 14 days prior to discharge	Pre-fracturing discharge report received	Yes
12. Consent holder shall notify the Council of hydraulic fracturing discharge	Notification received	Yes
13. A post-fracturing discharge report is to be provided to the Council within 90 days of any commencement	Post-fracturing discharge report received	Yes
14. An interim post-fracturing discharge report is to be provided in order to meet the 90 day requirement if the consent holder cannot provide all the information required by condition 13	Interim post-fracturing report received	Yes
15. The reports outlined in conditions 7 and 9 must be emailed to consents@trc.govt.nz	Reports received via email	Yes
16. 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
17. Consent holder to adopt best practicable option at all times	Site inspections, sampling and assessment of consent holder submitted data	Yes
18. Fracture fluid composition no less than 95 % water and proppant by volume	Assessment of consent holder submitted data and sampling of fracturing fluid	Yes
19. Lapse clause	Receive notice of exercise of consent	Yes
20. 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**

N/A = not applicable

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

3.3 Alterations to monitoring programmes of future hydraulic fracturing events

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

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

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

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

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

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

3.4 Exercise of optional review of consent

Resource consent 10297-1 provides for an optional review of the consent in June 2019. Condition 20 allows the Council to review the consent, for the purpose of:

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

b. further specifying the best practicable option as required by condition 17; and/or

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

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

4 Recommendations

1. THAT in the first instance, the range of monitoring carried out during the reporting period in relation to Petrochem’s hydraulic fracturing activities be replicated for any future fracturing events at the Kowhai-D wellsite.
2. THAT should there be issues with environmental or administrative performance in future periods, monitoring may be adjusted to reflect any additional investigation or intervention as found necessary.
3. THAT the option for a review of resource consents in June 2019, as set out in condition 20 of the consent not be exercised.

Glossary of common terms and abbreviations

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

Biomonitoring	Assessing the health of the environment using aquatic organisms.
bbls	Barrel. Unit of measure used in the oil and gas industry (equivalent to approximately 159 litres).
EPT	Ephemeroptera (mayfly), Plecoptera (stonefly) and Trichoptera (caddisfly) which are macroinvertebrates sensitive to pollution.
Fresh	Elevated flow in a stream, such as after heavy rainfall.
g/m^3	Grams per cubic metre, and equivalent to milligrams per litre (mg/L). In water, this is also equivalent to parts per million (ppm), but the same does not apply to gaseous mixtures.
Incident	An event that is alleged or is found to have occurred that may have actual or potential environmental consequences or may involve non-compliance with a consent or rule in a regional plan. Registration of an incident by the Council does not automatically mean such an outcome had actually occurred.
Intervention	Action/s taken by Council to instruct or direct actions be taken to avoid or reduce the likelihood of an incident occurring.
Investigation	Action taken by Council to establish the circumstances/events surrounding an incident including any allegations of an incident.
L/s	Litres per second.
Macroinvertebrate	An invertebrate that is large enough to be seen without the use of a microscope.
masl	Metres above sea level.
MCI	Macroinvertebrate community index; a numerical indication of the state of biological life in a stream that takes into account the sensitivity of the taxa present to organic pollution in stony habitats.
mS/m	Millisiemens per metre.
m^3	Cubic metre (1,000 litres).
NZTM	New Zealand Transverse Mercator coordinates.
pH	A numerical system for measuring acidity in solutions, with 7 as neutral. Numbers lower than 7 are increasingly acidic and higher than 7 are increasingly alkaline.
Physicochemical	Measurement of both physical properties (e.g. temperature, clarity, density) and chemical determinants (e.g. metals and nutrients) to characterise the state of an environment.
Resource consent	Refer Section 87 of the RMA. Resource consents include land use consents (refer Sections 9 and 13 of the RMA), coastal permits (Sections 12, 14 and 15), water permits (Section 14) and discharge permits (Section 15).
RMA	Resource Management Act 1991 and including all subsequent amendments.
Screen Out	A condition that occurs when the solids carried in a treatment fluid, such as proppant in a fracture fluid, create a bridge across the perforations or similar restricted flow area. This creates a sudden and significant restriction to fluid flow that causes a rapid rise in pump pressure.
SQMCI	Semi quantitative macroinvertebrate community index.
TVDss	True vertical depth sub-sea.

Workover	The repair or stimulation of an existing production well for the purpose of restoring, prolonging or enhancing the production of hydrocarbons.

Bibliography and references

Geology.Com website at http://geology.com/energy/hydraulic-fracturing-fluids/

Greymouth Petroleum Mining Group Ltd (2017) Kowhai-D Wellsite Water Quality Monitoring Programme April 2017 Frodo Number #1787157

Greymouth Petroleum Mining Group Ltd (2016) Kowhai-4 Pre-Fracturing Discharge Report November 2016 Frodo Number #1784725

Greymouth Petroleum Mining Group Ltd (2017) Kowhai-4 Interim Post-Fracturing Discharge Report July 2017 Frodo Number #1905073

Greymouth Petroleum Mining Group Ltd (2017) Kowhai-4 Final Post-Fracturing Discharge Report December 2017 Frodo Number #1986143

Baker Hughes website at http://blogs.bakerhughes.com/reservoir/2012/02/20/hydraulic-fracturing-an-environmentally-responsible-technology-for-ensuring-our-energy-future-part-iii-of-iii/

Frackwire.com website at *http://frackwire.com/nitrogen-gas-fracking*

Stark JD, (1998). SQMCI: a biotic index for freshwater macroinvertebrate coded abundance data. New Zealand Journal of Marine and Freshwater Research 32(1): 55-66.

Appendix I

Resource consent held by Petrochem Ltd

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

Discharge Permit

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

Name of Consent Holder:	Petrochem Limited PO Box 3394 New Plymouth 4341
Decision Date:	24 May 2016
Commencement Date:	24 May 2016

Conditions of Consent

Consent Granted:	To discharge water based hydraulic fracturing fluids into land at depths greater than 3,385 mTVDss beneath the Kowhai-D wellsite
Expiry Date:	1 June 2033
Review Date(s):	June Annually and in accordance with special condition 20
Site Location:	Kowhai-D wellsite, 17 Manganui Road, Everett Park (Property owner: Clonakillity Farms Limited)
Grid Reference (NZTM)	1710128E-5674886N
Catchment:	Waitara

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

General condition

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

Special conditions

1. The discharge point shall be deeper than 3,385 mTVDss.

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

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

3. If the GeoNet seismic monitoring network records a seismic event higher than a Modified Mercalli intensity of magnitude 3.0 within 5 km of the geographical position (in 3 dimensions) of any hydraulic fracturing discharge, then:

   (a) if a hydraulic fracturing discharge is currently being undertaken it shall cease immediately and not recommence; or

   (b) if a hydraulic fracturing discharge has occurred within the previous 72 hours no further hydraulic fracturing discharges shall occur.

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

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

6. 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 5 (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.

7. Depending on the suitability of existing bores within 500 metres of the wellsite for obtaining a representative groundwater sample, it may be necessary for the Monitoring Programme to include installation of, and sampling from, at least one monitoring bore. The bore(s) would be of a depth, location and design determined after consultation with the Chief Executive, Taranaki Regional Council and installed in accordance with NZS 4411:2001.

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

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

   <u>Note</u>: *The samples required, under conditions of this consent could be taken and analysed by the Taranaki Regional Council or other contracted party on behalf of the consent holder.*

9. 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. The plan shall specify the use of standard protocols recognised to constitute good professional practice including quality control and assurance. An International Accreditation New Zealand (IANZ) accredited laboratory shall be used for all sample analysis. Results shall be provided to the Chief Executive within 30 days of sampling and shall include supporting quality control and assurance information. These results will be used to assess compliance with condition 5.

   <u>Note:</u> *The Sampling and Analysis Plan may be combined with the Monitoring Programme required by* condition 6.

10. 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.

11. 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 monitoring techniques to be used to determine the fate of discharged material;
    (e) the results of the reviews required by condition 17;
    (f) results of modelling showing an assessment of the likely extent and dimensions of the fractures that will be generated by the discharge;
    (g) the preventative and mitigation measures to be in place to ensure the discharge does not cause adverse environmental effects and complies with condition 5;
    (h) the extent and permeability characteristics of the geology above the discharge point to the surface;
    (i) any identified faults within the modelled fracture length plus a margin of 50%, and the potential for adverse environmental effects due to the presence of the identified faults;
    (j) the burst pressure of the well casing and the anticipated maximum well and discharge pressures and the duration of the pressures; and
    (k) details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal; and
    (l) details why the contaminants in the discharge and the monitoring techniques used comply with condition 17.

    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.*

12. The consent holder shall notify the Taranaki Regional Council of the date that each discharge is intended to commence by emailing worknotification@trc.govt.nz. Notification also shall identify the 'Pre-fracturing Discharge Report', required by condition 11, which details the discharge and be given no less than 3 days before the intended discharge date. If any discharge occurs more than 30 days after the notification date, additional notification as specified in this condition is required.

13. Subject to condition 14, within 90 days of any commencement date as advised under condition 12, the consent holder shall submit a comprehensive 'Post-fracturing Discharge Report' to the Chief Executive. The report shall, as a minimum, contain:
    (a) date and time of discharge;
    (b) confirmation of the interval(s) where fracturing occurred for that programme, and the geographical position (i.e., depth and lateral position) of the discharge point for each fracture interval;
    (c) the contaminant volumes and composition of fluid discharged into each fracture interval;
    (d) the volume of return fluids from each fracture interval;
    (e) an analysis for the constituents set out in conditions 8(a) to 8(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;
    (f) an estimate of the volume of fluids (and proppant) remaining underground;
    (g) the volume of water produced with the hydrocarbons (produced water) over the period beginning at the start of the hydraulic fracturing programme and ending 30 days after the programme is completed or after that period of production;
    (h) an assessment of the extent and dimensions of the fractures that were generated by the discharge, based on modelling undertaken after the discharge has occurred and other diagnostic techniques, including production analysis, available to determine fracture length, height and containment;
    (i) the results of pressure testing required by condition 10 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;
    (j) details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal;
    (k) 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 5; and
    (l) results of the monitoring referred to in condition 11 (d); and
    (m) an assessment of the effectiveness of the mitigation measures in place with specific reference to those described in the application for this consent.

14. On occasions, including for programs involving multiple hydraulic fracturing discharges, more than one 'Post-fracturing discharge report' may be required in order to meet the 90-day deadline from commencement required by condition 13. In these situations the consent holder shall submit an 'Interim Post-fracturing Discharge Report', which includes all the information that is available, to the Chief Executive within 90 days and a final Post-fracturing report as soon as practicable but within 90 days of the interim report.

15. The reports described in conditions 11 and 13 shall be emailed to consents@trc.govt.nz with a reference to the number of this consent.

16. 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.

17. The consent holder shall at all times adopt the best practicable option, as defined in section 2 of the Resource Management Act 1991, to prevent or minimize any actual or likely adverse effect of the activity on the environment by, as a minimum, ensuring that:
    (a) the discharge is contained within the fracture interval;
    (b) regular reviews of monitoring techniques used to ensure the discharge does not cause adverse environmental effects are undertaken;
    (c) regular reviews are undertaken of the preventative and mitigation measures adopted to ensure the discharge does not cause adverse environmental effects; and
    (d) regular reviews of the chemicals used are undertaken with a view to reducing the toxicity of the chemicals used.

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

19. This consent shall lapse on 30 June 2021, unless the consent is given effect to before the end of that period or the Taranaki Regional Council fixes a longer period pursuant to section 125(1)(b) of the Resource Management Act 1991.

20. The Taranaki Regional Council may review any or all of the conditions of this consent by giving notice of review:
    a) during the month of June each year, and/or
    b) within 30 days of receiving any investigation and report in accordance with condition 4 above;

    for the purposes of:

    (a) ensuring that the conditions are adequate to deal with any significant adverse effects on the environment arising from the exercise of this consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time; and/or
    (b) further specifying the best practicable option as required by condition 17; 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 24 May 2016

For and on behalf of
Taranaki Regional Council

B G Chamberlain
Chief Executive

Appendix II

Certificates of analysis (groundwater)

Hill Laboratories
TRIED, TESTED AND TRUSTED

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

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

Certificate of Analysis

Client:	Taranaki Regional Council	**Lab No:**	2040610 SPv1
Contact:	Jane Harvey C/- Taranaki Regional Council Private Bag 713 Stratford 4352	**Date Received:**	31-Aug-2018
		Date Reported:	07-Sep-2018
		Quote No:	47915
		Order No:	72831
		Client Reference:	340300418 Kawhai D lyraw
		Submitted By:	Sarah Larkin

Sample Type: Aqueous

Sample Name:		GND2632 TRC183458 30-Aug-2018 12:15 pm				
Lab Number:		2040610.1				
Individual Tests						
Sum of Anions	meq/L	3.3	-	-	-	-
Sum of Cations	meq/L	3.2	-	-	-	-
pH	pH Units	8.2	-	-	-	-
Total Alkalinity	g/m^3 as $CaCO_3$	148	-	-	-	-
Bicarbonate	g/m^3 at 25°C	178	-	-	-	-
Total Hardness	g/m^3 as $CaCO_3$	84	-	-	-	-
Electrical Conductivity (EC)	mS/m	31.3	-	-	-	-
Total Dissolved Solids (TDS)	g/m^3	180	-	-	-	-
Sample Temperature*	°C	14.8	-	-	-	-
Dissolved Barium	g/m^3	0.006	-	-	-	-
Dissolved Calcium	g/m^3	19.4	-	-	-	-
Dissolved Copper	g/m^3	< 0.0005	-	-	-	-
Dissolved Iron	g/m^3	0.04	-	-	-	-
Dissolved Magnesium	g/m^3	8.7	-	-	-	-
Dissolved Manganese	g/m^3	0.0091	-	-	-	-
Dissolved Mercury	g/m^3	< 0.00008	-	-	-	-
Dissolved Nickel	g/m^3	< 0.0005	-	-	-	-
Dissolved Potassium	g/m^3	3.1	-	-	-	-
Dissolved Sodium	g/m^3	33	-	-	-	-
Dissolved Zinc	g/m^3	< 0.0010	-	-	-	-
Bromide	g/m^3	0.07	-	-	-	-
Chloride	g/m^3	12.0	-	-	-	-
Nitrite-N	g/m^3	< 0.002	-	-	-	-
Nitrate-N	g/m^3	< 0.002	-	-	-	-
Nitrate-N + Nitrite-N	g/m^3	< 0.002	-	-	-	-
Sulphate	g/m^3	< 0.5	-	-	-	-
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	-	-	-	-

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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:		GND2632 TRC183458 30-Aug-2018 12:15 pm				
Lab Number:		2040610.1				
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	-	-	-	-
Toluene	g/m^3	< 0.0010	-	-	-	-
Ethylbenzene	g/m^3	< 0.0010	-	-	-	-
m&p-Xylene	g/m^3	< 0.002	-	-	-	-
o-Xylene	g/m^3	< 0.0010	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m^3	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m^3	0.008	-	-	-	-
Ethylene	g/m^3	< 0.004	-	-	-	-
Methane	g/m^3	8.6	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.06	-	-	-	-
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	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m^3	1
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.07 meq/L	1
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.05 meq/L	1
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd 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 22nd ed. 2012.	1.0 g/m^3 at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22nd ed. 2012.	10 g/m^3	1
Sample Temperature*	Supplied by customer, otherwise 20°C.	0.1 °C	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.005 g/m^3	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m^3	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd 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 22nd ed. 2012.	0.0005 g/m^3	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	1
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22nd ed. 2012.	0.05 g/m^3	1
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22nd ed. 2012.	0.5 g/m^3	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. 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 22nd ed. 2012 (modified).	0.002 g/m^3	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22nd ed. 2012.	0.5 g/m^3	1
C7 - C9	Head Space, GCMS analysis.	0.06 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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Ara Heron BSc (Tech)
Client Services Manager - Environmental

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W www.hill-laboratories.com

Certificate of Analysis

Client:	Taranaki Regional Council	**Lab No:**	1935494 SPv1
Contact:	David Olson	**Date Received:**	02-Mar-2018
	C/- Taranaki Regional Council	**Date Reported:**	12-Mar-2018
	Private Bag 713	**Quote No:**	47915
	Stratford 4352	**Order No:**	69430
		Client Reference:	GPL Kowhai D4 3 Month Post Frac
		Submitted By:	David Olson

Sample Type: Aqueous

	Sample Name:	GND 26 32 01-Mar-2018 9:55 am				
	Lab Number:	1935494.1				
Individual Tests						
Sum of Anions	meq/L	3.3	-	-	-	-
Sum of Cations	meq/L	3.1	-	-	-	-
pH	pH Units	8.2	-	-	-	-
Total Alkalinity	g/m^3 as $CaCO_3$	150	-	-	-	-
Bicarbonate	g/m^3 at 25°C	181	-	-	-	-
Total Hardness	g/m^3 as $CaCO_3$	83	-	-	-	-
Electrical Conductivity (EC)	mS/m	32.0	-	-	-	-
Total Dissolved Solids (TDS)	g/m^3	188	-	-	-	-
Dissolved Barium	g/m^3	0.0048	-	-	-	-
Dissolved Calcium	g/m^3	20	-	-	-	-
Dissolved Copper	g/m^3	< 0.0005	-	-	-	-
Dissolved Iron	g/m^3	0.04	-	-	-	-
Dissolved Magnesium	g/m^3	8.1	-	-	-	-
Dissolved Manganese	g/m^3	0.0087	-	-	-	-
Dissolved Mercury	g/m^3	< 0.00008	-	-	-	-
Dissolved Nickel	g/m^3	< 0.0005	-	-	-	-
Dissolved Potassium	g/m^3	3.0	-	-	-	-
Dissolved Sodium	g/m^3	32	-	-	-	-
Dissolved Zinc	g/m^3	< 0.0010	-	-	-	-
Bromide	g/m^3	0.06	-	-	-	-
Chloride	g/m^3	11.6	-	-	-	-
Nitrite-N	g/m^3	< 0.002	-	-	-	-
Nitrate-N	g/m^3	< 0.002	-	-	-	-
Nitrate-N + Nitrite-N	g/m^3	< 0.002	-	-	-	-
Sulphate	g/m^3	< 0.5	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	-	-	-	-
Toluene	g/m^3	< 0.0010	-	-	-	-
Ethylbenzene	g/m^3	< 0.0010	-	-	-	-
m&p-Xylene	g/m^3	< 0.002	-	-	-	-
o-Xylene	g/m^3	< 0.0010	-	-	-	-

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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

Sample Name:		GND 26 32 01-Mar-2018 9:55 am				
Lab Number:		1935494.1				
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m^3	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m^3	0.008	-	-	-	-
Ethylene	g/m^3	< 0.004	-	-	-	-
Methane	g/m^3	8.7	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.06	-	-	-	-
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	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m^3	1
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.07 meq/L	1
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.05 meq/L	1
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field. Samples and Standards are analysed at an equivalent laboratory temperature (typically 18 to 22 °C). Temperature compensation is used.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd 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 22nd ed. 2012.	1.0 g/m^3 at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22nd ed. 2012.	10 g/m^3	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.00010 g/m^3	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m^3	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd 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 22nd ed. 2012.	0.0005 g/m^3	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	1
Bromide	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22nd ed. 2012.	0.05 g/m^3	1
Chloride	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22nd ed. 2012.	0.5 g/m^3	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. 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 22nd ed. 2012 (modified).	0.002 g/m^3	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B (modified) 22nd ed. 2012.	0.5 g/m^3	1
C7 - C9	Head Space, GCMS analysis.	0.06 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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Ara Heron BSc (Tech)
Client Services Manager - Environmental

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ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1830751 SPv1
Contact:	David Olson	**Date Received:**	24-Aug-2017
	C/- Taranaki Regional Council	**Date Reported:**	31-Aug-2017
	Private Bag 713	**Quote No:**	47915
	Stratford 4352	**Order No:**	
		Client Reference:	GPL Kowhai D GW Month Post-Frac
		Submitted By:	David Olson

Sample Type: Aqueous

Sample Name:		GND2632 23-Aug-2017 12:50 pm				
Lab Number:		1830751.1				
Individual Tests						
Sum of Anions	meq/L	3.3	-	-	-	-
Sum of Cations	meq/L	3.3	-	-	-	-
pH	pH Units	8.2	-	-	-	-
Total Alkalinity	g/m^3 as $CaCO_3$	149	-	-	-	-
Bicarbonate	g/m^3 at 25°C	179	-	-	-	-
Total Hardness	g/m^3 as $CaCO_3$	88	-	-	-	-
Electrical Conductivity (EC)	mS/m	32.1	-	-	-	-
Total Dissolved Solids (TDS)	g/m^3	181	-	-	-	-
Dissolved Barium	g/m^3	0.0050	-	-	-	-
Dissolved Calcium	g/m^3	21	-	-	-	-
Dissolved Copper	g/m^3	< 0.0005	-	-	-	-
Dissolved Iron	g/m^3	0.04	-	-	-	-
Dissolved Magnesium	g/m^3	8.7	-	-	-	-
Dissolved Manganese	g/m^3	0.0095	-	-	-	-
Dissolved Mercury	g/m^3	< 0.00008	-	-	-	-
Dissolved Nickel	g/m^3	< 0.0005	-	-	-	-
Dissolved Potassium	g/m^3	3.0	-	-	-	-
Dissolved Sodium	g/m^3	33	-	-	-	-
Dissolved Zinc	g/m^3	< 0.0010	-	-	-	-
Bromide	g/m^3	0.08	-	-	-	-
Chloride	g/m^3	11.9	-	-	-	-
Nitrite-N	g/m^3	< 0.002	-	-	-	-
Nitrate-N	g/m^3	0.004	-	-	-	-
Nitrate-N + Nitrite-N	g/m^3	0.004	-	-	-	-
Sulphate	g/m^3	< 0.5	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	-	-	-	-
Toluene	g/m^3	< 0.0010	-	-	-	-
Ethylbenzene	g/m^3	< 0.0010	-	-	-	-
m&p-Xylene	g/m^3	< 0.002	-	-	-	-
o-Xylene	g/m^3	< 0.0010	-	-	-	-

Sample Type: Aqueous

Sample Name:		GND2632 23-Aug-2017 12:50 pm				
Lab Number:		1830751.1				
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m^3	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m^3	0.010	-	-	-	-
Ethylene	g/m^3	< 0.004	-	-	-	-
Methane	g/m^3	9.2	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.06	-	-	-	-
C10 - C14	g/m^3	< 0.2	-	-	-	-
C15 - C36	g/m^3	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	-	-	-	-

Analyst's Comments

Sample 1 Comment:
Please note that the TPH C7 - C9 band was analysed by the head space/GCMS method, with all other TPH bands analysed by hexane solvent extraction/GC/FID.

SUMMARY OF METHODS

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

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	4 g/m^3	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	4 g/m^3	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	1.0 g/m^3	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629] Analysis performed at 1 Clyde Street, Hamilton	0.0010 - 0.002 g/m^3	1
Formaldehyde in Water by DNPH & LCMSMS	DNPH derivatisation, extraction, LCMSMS Analysis performed at 1 Clyde Street, Hamilton	0.02 g/m^3	1
Gases in groundwater	Manual headspace creation and sub-sampling, GC-FID analysis. Analysis performed at 1 Clyde Street, Hamilton	0.002 - 0.003 g/m^3	1
Total Petroleum Hydrocarbons in Water	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629] Analysis performed at 1 Clyde Street, Hamilton	0.06 - 0.7 g/m^3	1
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter. Analysis performed at 1 Clyde Street, Hamilton.	-	1
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.07 meq/L	1
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.05 meq/L	1
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/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 22nd ed. 2012.	1.0 g/m^3 at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. Analysed at 1 Clyde Street, Hamilton. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. Analysis performed at 1 Clyde Street, Hamilton. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22nd ed. 2012.	10 g/m^3	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	0.00010 g/m^3	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	0.0005 g/m^3	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	0.0005 g/m^3	1
Dissolved Mercury	0.45µm filtration, bromine oxidation followed by atomic fluorescence. Analysed at 1 Clyde Street, Hamilton. US EPA Method 245.7, Feb 2005.	0.00008 g/m^3	1
Dissolved Nickel	Filtered sample, ICP-MS, trace level. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	0.0005 g/m^3	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	1
Bromide	Filtered sample. Ion Chromatography. Analysis performed at 1 Clyde Street, Hamilton. APHA 4110 B 22nd ed. 2012.	0.05 g/m^3	1
Chloride	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. Analysis performed at 1 Clyde Street, Hamilton. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. Analysis performed at 1 Clyde Street, Hamilton. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	1
Nitrate-N + Nitrite-N	Total oxidised nitrogen. Automated cadmium reduction, flow injection analyser. Analysis performed at 1 Clyde Street, Hamilton. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1
Sulphate	Filtered sample. Ion Chromatography. Analysis performed at 1 Clyde Street, Hamilton. APHA 4110 B 22nd ed. 2012.	0.5 g/m^3	1
C7 - C9	Head Space, GCMS analysis. Analysis performed at 1 Clyde Street, Hamilton.	0.06 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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Carole Rodgers-Carroll

Carole Rodgers-Carroll BA, NZCS
Client Services Manager - Environmental

Hill Laboratories
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ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1763808 SPv1
Contact:	Regan Phipps C/- Taranaki Regional Council Private Bag 713 Stratford 4352	**Date Received:**	26-Apr-2017
		Date Reported:	04-May-2017
		Quote No:	47915
		Order No:	
		Client Reference:	GPL Kowhai D PRE-ERAC
		Submitted By:	David Olson

Sample Type: Aqueous

Sample Name:		GND 2632 24-Apr-2017				
Lab Number:		1763808.1				
Individual Tests						
Sum of Anions	meq/L	3.3	-	-	-	-
Sum of Cations	meq/L	3.3	-	-	-	-
pH	pH Units	8.3	-	-	-	-
Total Alkalinity	g/m^3 as $CaCO_3$	150	-	-	-	-
Bicarbonate	g/m^3 at 25°C	179	-	-	-	-
Total Hardness	g/m^3 as $CaCO_3$	87	-	-	-	-
Electrical Conductivity (EC)	mS/m	32.0	-	-	-	-
Total Dissolved Solids (TDS)	g/m^3	175	-	-	-	-
Dissolved Barium	g/m^3	0.0052	-	-	-	-
Dissolved Bromine*	g/m^3	0.039	-	-	-	-
Dissolved Calcium	g/m^3	21	-	-	-	-
Dissolved Copper	g/m^3	< 0.0005	-	-	-	-
Dissolved Iron	g/m^3	0.04	-	-	-	-
Dissolved Magnesium	g/m^3	8.5	-	-	-	-
Dissolved Manganese	g/m^3	0.0093	-	-	-	-
Dissolved Mercury	g/m^3	< 0.00008	-	-	-	-
Dissolved Nickel	g/m^3	< 0.0005	-	-	-	-
Dissolved Potassium	g/m^3	3.2	-	-	-	-
Dissolved Sodium	g/m^3	34	-	-	-	-
Dissolved Zinc	g/m^3	< 0.0010	-	-	-	-
Chloride	g/m^3	11.2	-	-	-	-
Nitrite-N	g/m^3	< 0.002	-	-	-	-
Nitrate-N	g/m^3	< 0.002	-	-	-	-
Nitrate-N + Nitrite-N	g/m^3	< 0.002	-	-	-	-
Sulphate	g/m^3	< 0.5	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m^3	< 0.0010	-	-	-	-
Toluene	g/m^3	< 0.0010	-	-	-	-
Ethylbenzene	g/m^3	< 0.0010	-	-	-	-
m&p-Xylene	g/m^3	< 0.002	-	-	-	-
o-Xylene	g/m^3	< 0.0010	-	-	-	-

ilac-MRA IANZ ACCREDITED LABORATORY

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:		GND 2632 24-Apr-2017				
Lab Number:		1763808.1				
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m^3	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m^3	0.010	-	-	-	-
Ethylene	g/m^3	< 0.004	-	-	-	-
Methane	g/m^3	9.5	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	< 0.06	-	-	-	-
C10 - C14	g/m^3	< 0.2	-	-	-	-
C15 - C36	g/m^3	< 0.4	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m^3	< 0.7	-	-	-	-

Analyst's Comments

Please note that the TPH C7 - C9 band was analysed by the head space/GCMS method, with all other TPH bands analysed by hexane solvent extraction/GC/FID.

SUMMARY OF METHODS

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

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	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m^3	1
Filtration, Unpreserved	Sample filtration through 0.45µm membrane filter.	-	1
Total anions for anion/cation balance check	Calculation: sum of anions as mEquiv/L calculated from Alkalinity (bicarbonate), Chloride and Sulphate. Nitrate-N, Nitrite-N. Fluoride, Dissolved Reactive Phosphorus and Cyanide also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.07 meq/L	1
Total cations for anion/cation balance check	Sum of cations as mEquiv/L calculated from Sodium, Potassium, Calcium and Magnesium. Iron, Manganese, Aluminium, Zinc, Copper, Lithium, Total Ammoniacal-N and pH (H^+) also included in calculation if available. APHA 1030 E 22nd ed. 2012.	0.05 meq/L	1
pH	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	1
Total Alkalinity	Titration to pH 4.5 (M-alkalinity), autotitrator. APHA 2320 B (Modified for alk <20) 22nd ed. 2012.	1.0 g/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 22nd ed. 2012.	1.0 g/m^3 at 25°C	1
Total Hardness	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	1
Electrical Conductivity (EC)	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	1
Total Dissolved Solids (TDS)	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22nd ed. 2012.	10 g/m^3	1
Dissolved Barium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.00010 g/m^3	1

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Dissolved Bromine*	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.005 g/m^3	1
Dissolved Calcium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1
Dissolved Copper	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.0005 g/m^3	1
Dissolved Iron	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1
Dissolved Magnesium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1
Dissolved Manganese	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd 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 22nd ed. 2012.	0.0005 g/m^3	1
Dissolved Potassium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.05 g/m^3	1
Dissolved Sodium	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd ed. 2012.	0.02 g/m^3	1
Dissolved Zinc	Filtered sample, ICP-MS, trace level. APHA 3125 B 22nd 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) 22nd ed. 2012.	0.5 g/m^3	1
Nitrite-N	Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	1
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. 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 22nd ed. 2012 (modified).	0.002 g/m^3	1
Sulphate	Filtered sample. Ion Chromatography. APHA 4110 B 22nd ed. 2012.	0.5 g/m^3	1
C7 - C9	Head Space, GCMS analysis.	0.06 g/m^3	1
C10 - C14	Solvent extraction, GC-FID analysis. US EPA 8015B/NZ OIEWG.	0.2 g/m^3	1
C15 - C36	Solvent extraction, GC-FID analysis. US EPA 8015B/NZ OIEWG.	0.4 g/m^3	1
Total hydrocarbons (C7 - C36)	Solvent extraction, GC-FID analysis and Headspace, GC-MS FS analysis for C7-C9 carbon band.	0.7 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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Martin Cowell - BSc
Client Services Manager - Environmental

Appendix III

Certificates of analysis (hydraulic fracturing fluids)

Hill Laboratories
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W www.hill-laboratories.com

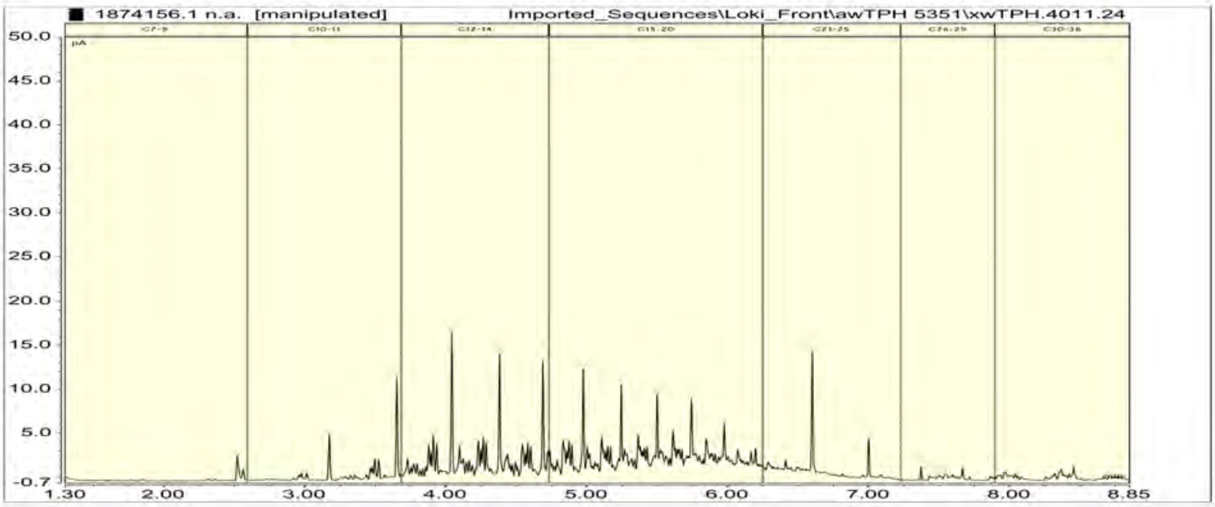
ANALYSIS REPORT

Client:	Greymouth Petroleum Limited	**Lab No:**	1874156 SPv1
Contact:	Skye Loveridge-Easther	**Date Received:**	09-Nov-2017
	C/- Greymouth Petroleum Limited	**Date Reported:**	17-Nov-2017
	14 Connett Road West	**Quote No:**	85159
	Bell Block	**Order No:**	240604
	New Plymouth 4312	**Client Reference:**	Hydraulic fracturing fluid testing
		Submitted By:	Skye Loveridge-Easther

Sample Type: Aqueous

Sample Name:		Kow 4 - Frac 8 Pre-Pumped HF Fluid 02-Nov-2017				
Lab Number:		1874156.1				
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	< 40	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 40	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 20	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	0.0023	-	-	-	-
Toluene	g/m³	0.0051	-	-	-	-
Ethylbenzene	g/m³	< 0.0010	-	-	-	-
m&p-Xylene	g/m³	0.003	-	-	-	-
o-Xylene	g/m³	0.0016	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	0.28	-	-	-	-
C10 - C14	g/m³	9.0	-	-	-	-
C15 - C36	g/m³	18	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	27	-	-	-	-

1874156.1
Kow 4 - Frac 8 Pre-Pumped HF Fluid 02-Nov-2017
Client Chromatogram for TPH by FID



SUMMARY OF METHODS

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

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
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m^3	1
C7 - C9	Head Space, GCMS analysis.	0.06 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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Ara Heron BSc (Tech)
Client Services Manager - Environmental

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ANALYSIS REPORT

Client:	Greymouth Petroleum Limited	**Lab No:**	1874155 SPv1
Contact:	Skye Loveridge-Easther	**Date Received:**	09-Nov-2017
	C/- Greymouth Petroleum Limited	**Date Reported:**	24-Nov-2017
	14 Connett Road West	**Quote No:**	81870
	Bell Block	**Order No:**	240605
	New Plymouth 4312	**Client Reference:**	Return Fluid Composite
		Submitted By:	Skye Loveridge-Easther

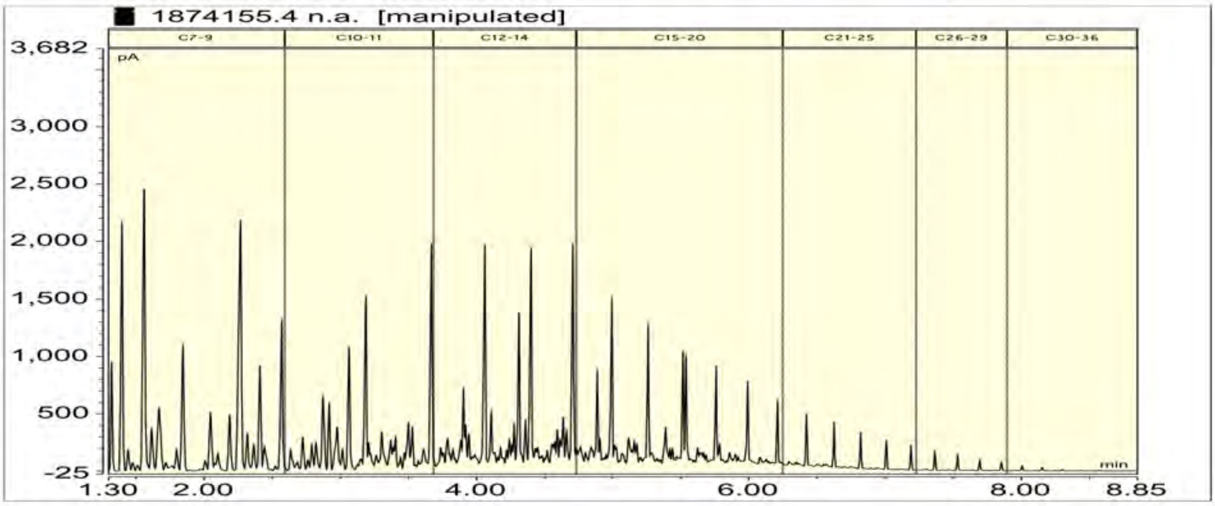
Sample Type: Saline

Sample Name:		Composite of Kow 4 - Frac 8 Return Fluid Start, Kow 4 - Frac 8 Return Fluid Middle & Kow 4 - Frac 8 Return Fluid End				
Lab Number:		1874155.4				
Individual Tests						
pH*	pH Units	7.0	-	-	-	-
Total Alkalinity*	g/m^3 as $CaCO_3$	1,520	-	-	-	-
Analysis Temperature for Bicarbonate	°C	23	-	-	-	-
Bicarbonate	g/m^3 at Analysis Temperature	1,688	-	-	-	-
Total Hardness*	g/m^3 as $CaCO_3$	120	-	-	-	-
Electrical Conductivity (EC)*	mS/m	1,215	-	-	-	-
Total Dissolved Solids (TDS)*	g/m^3	10,200	-	-	-	-
Dissolved Barium*	g/m^3	10.7	-	-	-	-
Dissolved Bromine*	g/m^3	14.4	-	-	-	-
Dissolved Calcium*	g/m^3	30	-	-	-	-
Dissolved Copper*	g/m^3	0.010	-	-	-	-
Dissolved Iron*	g/m^3	7.5	-	-	-	-
Dissolved Magnesium*	g/m^3	11	-	-	-	-
Dissolved Manganese*	g/m^3	1.46	-	-	-	-
Total Nickel*	g/m^3	0.10	-	-	-	-
Total Potassium*	g/m^3	320	-	-	-	-
Total Sodium*	g/m^3	2,400	-	-	-	-
Total Sulphur*	g/m^3	11	-	-	-	-
Total Zinc*	g/m^3	0.179	-	-	-	-
Chloride*	g/m^3	2,400	-	-	-	-
Nitrite-N	g/m^3	0.027 [#1]	-	-	-	-
Nitrate-N	g/m^3	0.025	-	-	-	-
Nitrate*	g/m^3	0.11	-	-	-	-
Nitrate-N + Nitrite-N	g/m^3	0.052 [#1]	-	-	-	-
Sulphate*	g/m^3	32	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 40	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	< 40	-	-	-	-

Sample Type: Saline

Sample Name:		Composite of Kow 4 - Frac 8 Return Fluid Start, Kow 4 - Frac 8 Return Fluid Middle & Kow 4 - Frac 8 Return Fluid End				
Lab Number:		1874155.4				
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	46	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene*	g/m³	26	-	-	-	-
Toluene*	g/m³	63	-	-	-	-
Ethylbenzene*	g/m³	6.9	-	-	-	-
m&p-Xylene*	g/m³	43	-	-	-	-
o-Xylene*	g/m³	12.9	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m³	< 15	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	290	-	-	-	-
C10 - C14*	g/m³	640	-	-	-	-
C15 - C36*	g/m³	440	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	1,380	-	-	-	-

1874155.4
Composite of Kow 4 - Frac 8 Return Fluid Start, Kow 4 - Frac 8 Return Fluid Middle & Kow 4 - Frac 8 Return Fluid End
Client Chromatogram for TPH by FID



Analyst's Comments

[#1] Due to the nature of this sample a dilution was performed prior to analysis, resulting in a detection limit higher than that normally achieved for the NO2Nsal, NO3Nsal and NOxNsal analysis.

Appendix No.1 - HCO3 Report 1874155

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/m³	4
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	4
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m³	4
BTEX in Water by Headspace GC-MS*	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m³	4
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS	0.02 g/m³	4

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m^3	4
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	4
Total Digestion*	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	4
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	4
pH*	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	4
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m^3 as $CaCO_3$	4
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	4
Bicarbonate	Bicarbonate (HCO3) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988.	20 g/m^3 at Analysis Temperature	4
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	4
Electrical Conductivity (EC)*	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	4
Total Dissolved Solids (TDS)*	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22nd ed. 2012.	50 g/m^3	4
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	4
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.0006 g/m^3	4
Dissolved Bromine*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.10 g/m^3	4
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.0 g/m^3	4
Dissolved Copper*	Filtered sample, ICP-MS, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	4
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.004 g/m^3	4
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.4 g/m^3	4
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	4
Total Nickel*	Nitric acid digestion, ICP-MS with universal cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.007 g/m^3	4
Total Potassium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.1 g/m^3	4
Total Sodium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.42 g/m^3	4
Total Sulphur*	Nitric acid digestion, ICP-OES (method may not fully account for H_2S due to volatilisation during digestion). All forms of oxidised and organic sulphur will be determined by this method.	0.5 g/m^3	4
Total Zinc*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0042 g/m^3	4
Chloride*	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	4
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO3- I 22nd ed. 2012 (modified).	0.0010 g/m^3	4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	4
Nitrate*	Calculation from Nitrate-N.	0.010 g/m^3	4
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO3- I 22nd ed. 2012 (modified).	0.0010 g/m^3	4
Total Sulphate*	Calculation: from total sulphur.	2 g/m^3	4
C7 - C9	Head Space, GCMS analysis.	0.06 g/m^3	4

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

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

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

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CERTIFICATE OF ANALYSIS

ENVSUBGNS_WAIRAKEI 34

Report No: 2017111504

Customer Ref:149015

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

GNS Lot No: **2017111504**

GNS Sample No.	2017007970
Collection Date	
Site ID	1874155.4
Field ID	

pH		7.43	-	-	-
Bicarbonate (Total)	mg/l	1688	-	-	-
HCO_3 Analysis Temperature	°C	23	-	-	-
HCO_3 Analysis Date		15/11/2017	-	-	-

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.

A Noddings
Ann Noddings
Senior Technician

ACCREDITED LABORATORY

Tests marked with a † are not accredited and are outside the scope of the laboratory's accreditation

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ANALYSIS REPORT

Client: Greymouth Petroleum Limited
Contact: Skye Loveridge-Easther
C/- Greymouth Petroleum Limited
14 Connett Road West
Bell Block
New Plymouth 4312

Lab No: 1887286 SPv1
Date Received: 01-Dec-2017
Date Reported: 13-Dec-2017
Quote No: 81870
Order No: 240722
Client Reference: Return Fluid Composite
Submitted By: Skye Loveridge-Easther

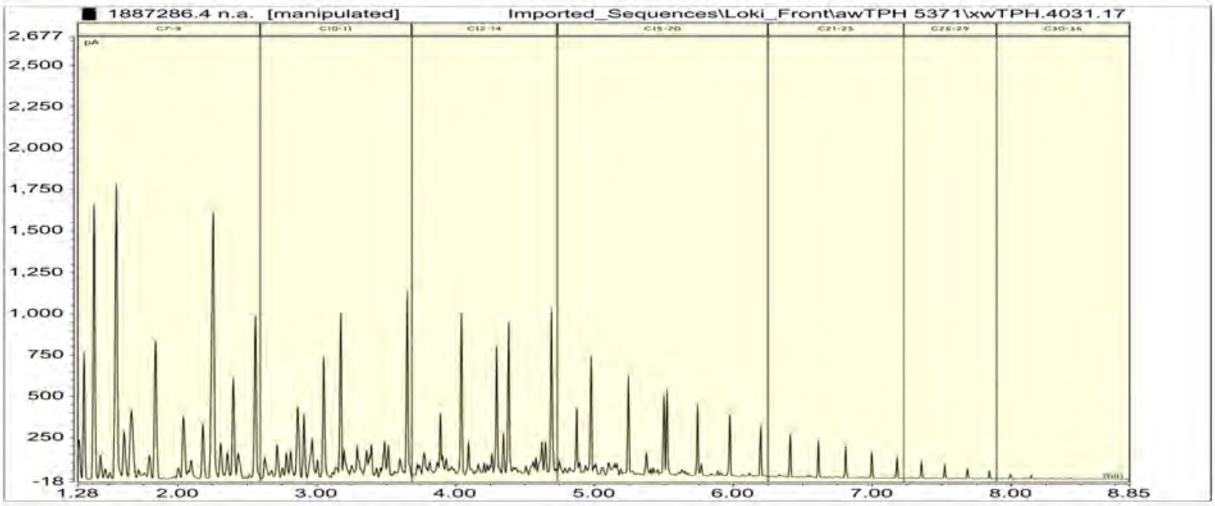
Sample Type: Saline

	Sample Name:	Composite of Kow 4 Frac 9 Return Fluid Start, Middle & End				
	Lab Number:	1887286.4				
Individual Tests						
pH*	pH Units	6.8	-	-	-	-
Total Alkalinity*	g/m^3 as $CaCO_3$	1,410	-	-	-	-
Analysis Temperature for Bicarbonate	°C	20	-	-	-	-
Bicarbonate	g/m^3 at Analysis Temperature	1,355	-	-	-	-
Total Hardness*	g/m^3 as $CaCO_3$	123	-	-	-	-
Electrical Conductivity (EC)*	mS/m	1,613	-	-	-	-
Total Dissolved Solids (TDS)*	g/m^3	12,400	-	-	-	-
Dissolved Barium*	g/m^3	28	-	-	-	-
Dissolved Bromine*	g/m^3	12.5	-	-	-	-
Dissolved Calcium*	g/m^3	35	-	-	-	-
Dissolved Copper*	g/m^3	0.0096	-	-	-	-
Dissolved Iron*	g/m^3	6.4	-	-	-	-
Dissolved Magnesium*	g/m^3	8.5	-	-	-	-
Dissolved Manganese*	g/m^3	1.54	-	-	-	-
Total Nickel*	g/m^3	0.16	-	-	-	-
Total Potassium*	g/m^3	390	-	-	-	-
Total Sodium*	g/m^3	3,900	-	-	-	-
Total Sulphur*	g/m^3	6	-	-	-	-
Total Zinc*	g/m^3	0.38	-	-	-	-
Chloride*	g/m^3	4,300	-	-	-	-
Nitrite-N	g/m^3	< 0.2 [#1]	-	-	-	-
Nitrate-N	g/m^3	< 0.2	-	-	-	-
Nitrate*	g/m^3	< 0.9	-	-	-	-
Nitrate-N + Nitrite-N	g/m^3	< 0.2 [#1]	-	-	-	-
Sulphate*	g/m^3	19	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 400	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	< 400	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	940	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene*	g/m^3	94	-	-	-	-
Toluene*	g/m^3	183	-	-	-	-
Ethylbenzene*	g/m^3	41	-	-	-	-
m&p-Xylene*	g/m^3	145	-	-	-	-

Sample Type: Saline

Sample Name:		Composite of Kow 4 Frac 9 Return Fluid Start, Middle & End				
Lab Number:		1887286.4				
BTEX in Water by Headspace GC-MS						
o-Xylene*	g/m³	80	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m³	1.6	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	1,550	-	-	-	-
C10 - C14*	g/m³	760	-	-	-	-
C15 - C36*	g/m³	410	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	2,700	-	-	-	-

1887286.4
Composite of Kow 4 Frac 9 Return Fluid Start, Middle & End
Client Chromatogram for TPH by FID



Analyst's Comments

[#1] Due to the nature of the sample, a detection limit higher than that normally achieved was reported.

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/m³	4
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	4
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m³	4
BTEX in Water by Headspace GC-MS*	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m³	4
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS	0.02 g/m³	4
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m³	4
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	4
Total Digestion*	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	4
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	4
pH*	pH meter. APHA 4500-H⁺ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	4

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m^3 as $CaCO_3$	4
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	4
Bicarbonate	Bicarbonate (HCO3) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988.	20 g/m^3 at Analysis Temperature	4
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	4
Electrical Conductivity (EC)*	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	4
Total Dissolved Solids (TDS)*	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22nd ed. 2012.	50 g/m^3	4
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	4
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.0006 g/m^3	4
Dissolved Bromine*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.10 g/m^3	4
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.0 g/m^3	4
Dissolved Copper*	Filtered sample, ICP-MS, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	4
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.004 g/m^3	4
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.4 g/m^3	4
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	4
Total Nickel*	Nitric acid digestion, ICP-MS with universal cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.007 g/m^3	4
Total Potassium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.1 g/m^3	4
Total Sodium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.42 g/m^3	4
Total Sulphur*	Nitric acid digestion, ICP-OES (method may not fully account for H_2S due to volatilisation during digestion). All forms of oxidised and organic sulphur will be determined by this method. APHA 3120 23rd ed. 2017.	0.5 g/m^3	4
Total Zinc*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0042 g/m^3	4
Chloride*	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	4
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO3- I 22nd ed. 2012 (modified).	0.0010 g/m^3	4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	4
Nitrate*	Calculation from Nitrate-N.	0.010 g/m^3	4
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO3- I 22nd ed. 2012 (modified).	0.0010 g/m^3	4
Total Sulphate*	Calculation: from total sulphur.	2 g/m^3	4
C7 - C9	Head Space, GCMS analysis.	0.06 g/m^3	4

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

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

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Client Services Manager - Environmental

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W www.hill-laboratories.com

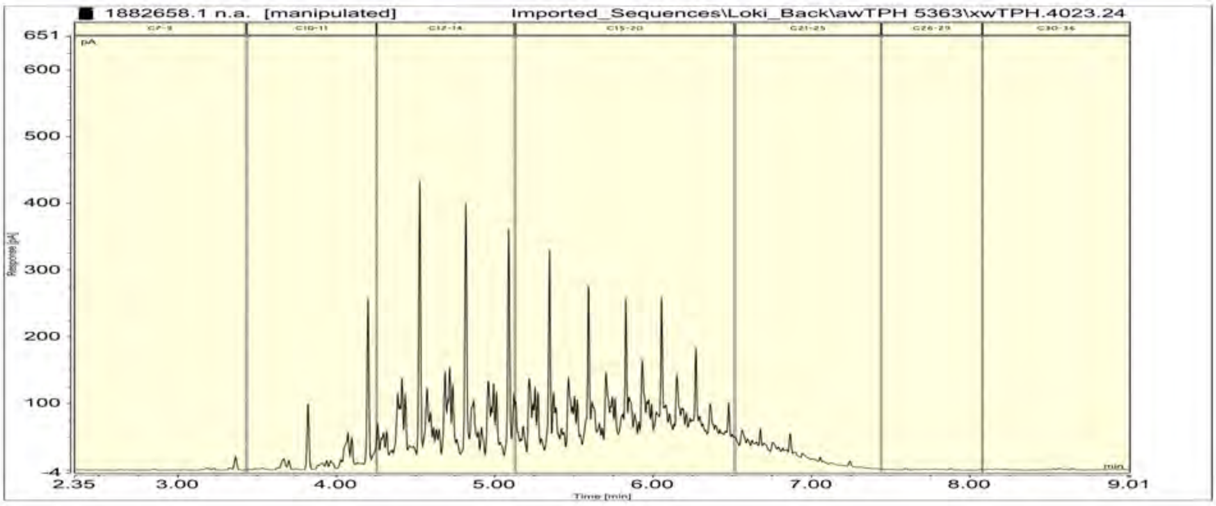
ANALYSIS REPORT

Client:	Greymouth Petroleum Limited	**Lab No:**	1882658	SPv1
Contact:	Skye Loveridge-Easther C/- Greymouth Petroleum Limited 14 Connett Road West Bell Block New Plymouth 4312	**Date Received:**	24-Nov-2017	
		Date Reported:	01-Dec-2017	
		Quote No:	85159	
		Order No:	240721	
		Client Reference:	Hydraulic fracturing fluid testing	
		Submitted By:	Skye Loveridge-Easther	

Sample Type: Aqueous

Sample Name:		Kowhai 4- Frac 9 Prepumped HF 09-Nov-2017				
Lab Number:		1882658.1				
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	< 400	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 400	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 1,100	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	0.056	-	-	-	-
Toluene	g/m³	0.122	-	-	-	-
Ethylbenzene	g/m³	0.0053	-	-	-	-
m&p-Xylene	g/m³	0.031	-	-	-	-
o-Xylene	g/m³	0.0048	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	1.98	-	-	-	-
C10 - C14	g/m³	340	-	-	-	-
C15 - C36	g/m³	580	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	910	-	-	-	-

1882658.1
Kowhai 4- Frac 9 Prepumped HF 09-Nov-2017
Client Chromatogram for TPH by FID



SUMMARY OF METHODS

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

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m³	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m³	1
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m³	1
C7 - C9	Head Space, GCMS analysis.	0.06 g/m³	1

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

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

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Martin Cowell - BSc
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ANALYSIS REPORT

Client:	Greymouth Petroleum Limited	**Lab No:**	1827539	SPv1
Contact:	Skye Loveridge-Easther C/- Greymouth Petroleum Limited 14 Connett Road West Bell Block New Plymouth 4312	**Date Received:**	18-Aug-2017	
		Date Reported:	31-Aug-2017	
		Quote No:	81870	
		Order No:	12869	
		Client Reference:	Return Fluid Composite	
		Submitted By:	Skye Loveridge-Easther	

Sample Type: Saline

	Sample Name:	Composite of Kowhai 4 - Frac 4 Return Fluid START, Kowhai 4 - Frac 4 Return Fluid MIDDLE and Kowhai 4 - Frac 4 Return Fluid END.				
	Lab Number:	1827539.4				
Individual Tests						
pH*	pH Units	6.8	-	-	-	-
Total Alkalinity*	g/m^3 as $CaCO_3$	1,200	-	-	-	-
Analysis Temperature for Bicarbonate	°C	22	-	-	-	-
Bicarbonate	g/m^3 at Analysis Temperature	1,244	-	-	-	-
Total Hardness*	g/m^3 as $CaCO_3$	161	-	-	-	-
Electrical Conductivity (EC)*	mS/m	1,441	-	-	-	-
Total Dissolved Solids (TDS)*	g/m^3	10,800	-	-	-	-
Dissolved Barium*	g/m^3	38	-	-	-	-
Dissolved Bromine*	g/m^3	9.9	-	-	-	-
Dissolved Calcium*	g/m^3	56	-	-	-	-
Dissolved Copper*	g/m^3	0.024	-	-	-	-
Dissolved Iron*	g/m^3	1.60	-	-	-	-
Dissolved Magnesium*	g/m^3	5	-	-	-	-
Dissolved Manganese*	g/m^3	2.7	-	-	-	-
Total Nickel*	g/m^3	0.014	-	-	-	-
Total Potassium*	g/m^3	610	-	-	-	-
Total Sodium*	g/m^3	2,800	-	-	-	-
Total Sulphur*	g/m^3	12	-	-	-	-
Total Zinc*	g/m^3	0.104	-	-	-	-
Chloride*	g/m^3	4,200	-	-	-	-
Nitrite-N	g/m^3	< 0.2	-	-	-	-
Nitrate-N	g/m^3	< 0.2	-	-	-	-
Nitrate*	g/m^3	< 0.9	-	-	-	-
Nitrate-N + Nitrite-N	g/m^3	0.2	-	-	-	-
Sulphate*	g/m^3	37	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 20	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	< 20	-	-	-	-

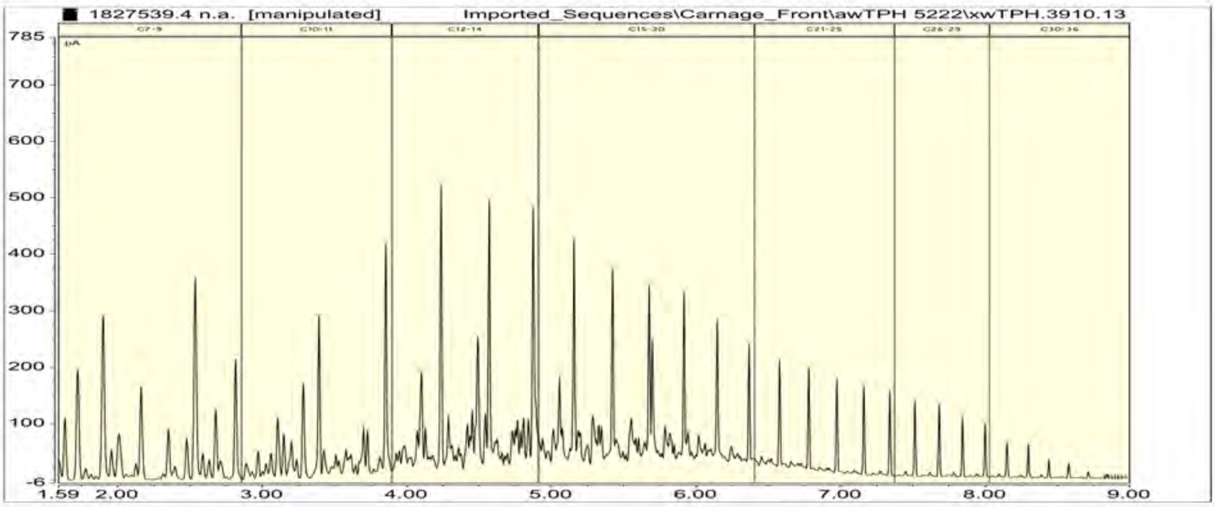
Sample Type: Saline

Sample Name:		Composite of Kowhai 4 - Frac 4 Return Fluid START, Kowhai 4 - Frac 4 Return Fluid MIDDLE and Kowhai 4 - Frac 4 Return Fluid END.				
Lab Number:		1827539.4				
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 20	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene*	g/m³	13.2	-	-	-	-
Toluene*	g/m³	30	-	-	-	-
Ethylbenzene*	g/m³	4.4	-	-	-	-
m&p-Xylene*	g/m³	25	-	-	-	-
o-Xylene*	g/m³	8.7	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m³	0.15	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	200	-	-	-	-
C10 - C14*	g/m³	330	-	-	-	-
C15 - C36*	g/m³	430	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	960	-	-	-	-

1827539.4

Composite of Kowhai 4 - Frac 4 Return Fluid START, Kowhai 4 - Frac 4 Return Fluid MIDDLE and Kowhai 4 - Frac 4 Return Fluid END.

Client Chromatogram for TPH by FID



Analyst's Comments

Sample 4 Comment:
Please note that the TPH C7 - C9 band was analysed by the head space/GCMS method, with all other TPH bands analysed by hexane solvent extraction/GC/FID.

Appendix No.1 - HCO3 Report- 1827539

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 Analysis performed at 25 Te Aroha Street, Hamilton	4 g/m³	4
Propylene Glycol in Water*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	4 g/m³	4

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	1.0 g/m^3	4
BTEX in Water by Headspace GC-MS*	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629] Analysis performed at 1 Clyde Street, Hamilton	0.0010 - 0.002 g/m^3	4
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS Analysis performed at 1 Clyde Street, Hamilton	0.02 g/m^3	4
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629] Analysis performed at 1 Clyde Street, Hamilton	0.06 - 0.7 g/m^3	4
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter. Analysis performed at 1 Clyde Street, Hamilton.	-	4
Total Digestion*	Boiling nitric acid digestion. Analysed at 1 Clyde Street, Hamilton. APHA 3030 E 22nd ed. 2012 (modified).	-	4
Total Digestion of Saline Samples*	Nitric acid digestion. Analysed at 1 Clyde Street, Hamilton. APHA 3030 E 22nd ed. 2012 (modified).	-	4
pH*	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	4
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m^3 as $CaCO_3$	4
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	4
Bicarbonate	Bicarbonate (HCO3) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988.	20 g/m^3 at Analysis Temperature	4
Total Hardness*	Calculation from Calcium and Magnesium. Analysed at 1 Clyde Street, Hamilton. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	4
Electrical Conductivity (EC)*	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	4
Total Dissolved Solids (TDS)*	Filtration through GF/C (1.2 µm), gravimetric. Analysis performed at 1 Clyde Street, Hamilton. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22nd ed. 2012.	50 g/m^3	4
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. Analysed at 1 Clyde Street, Hamilton. APHA 3030 B 22nd ed. 2012.	-	4
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	0.0006 g/m^3	4
Dissolved Bromine*	Filtered sample, ICP-MS, ultratrace level. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	0.10 g/m^3	4
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	1.0 g/m^3	4
Dissolved Copper*	Filtered sample, ICP-MS, ultratrace. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	4
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	0.004 g/m^3	4
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	0.4 g/m^3	4
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	4
Total Nickel*	Nitric acid digestion, ICP-MS with universal cell, ultratrace. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	0.007 g/m^3	4
Total Potassium*	Nitric acid digestion, ICP-MS, ultratrace level. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	1.1 g/m^3	4
Total Sodium*	Nitric acid digestion, ICP-MS, ultratrace level. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	0.42 g/m^3	4
Total Sulphur*	Nitric acid digestion, ICP-OES (method may not fully account for H_2S due to volatilisation during digestion). All forms of oxidised and organic sulphur will be determined by this method. Analysed at 1 Clyde Street, Hamilton.	0.5 g/m^3	4
Total Zinc*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	0.0042 g/m^3	4

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Chloride*	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. Analysis performed at 1 Clyde Street, Hamilton. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	4
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. Analysis performed at 1 Clyde Street, Hamilton. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	4
Nitrate*	Calculation from Nitrate-N.	0.010 g/m^3	4
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. Analysis performed at 1 Clyde Street, Hamilton. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	4
Total Sulphate*	Calculation: from total sulphur. Analysed at 1 Clyde Street, Hamilton.	2 g/m^3	4
C7 - C9	Head Space, GCMS analysis. Analysis performed at 1 Clyde Street, Hamilton.	0.06 g/m^3	4

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

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

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Carole Rodgers-Carroll BA, NZCS
Client Services Manager - Environmental

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CERTIFICATE OF ANALYSIS
ENVSUBGNS_WAIRAKEI 13

Report No: 2017082205

Customer Ref:148595

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

GNS Lot No: **2017082205**

GNS Sample No.	2017005761
Collection Date	
Site ID	1827539.4
Field ID	

pH		7.11	-	-	-
Bicarbonate (Total)	mg/l	1244	-	-	-
HCO_3 Analysis Temperature	°C	22	-	-	-
HCO_3 Analysis Date		23/08/2017	-	-	-

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.

M.K. Appleby

Moya Appleby
Senior Technician

IANZ ACCREDITED LABORATORY

Tests marked with a † are not accredited and are outside the scope of the laboratory's accreditation

Report Date: 30/08/2017
Report No: 2017082205

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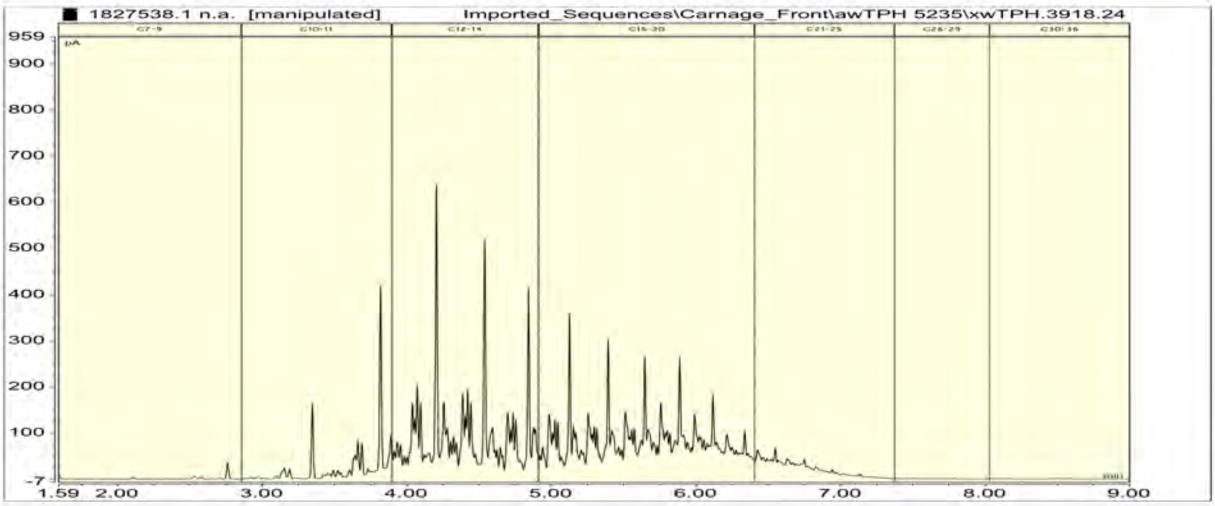
ANALYSIS REPORT

Client:	Greymouth Petroleum Limited	**Lab No:**	1827538 SPv1
Contact:	Skye Loveridge-Easther	**Date Received:**	18-Aug-2017
	C/- Greymouth Petroleum Limited	**Date Reported:**	04-Sep-2017
	14 Connett Road West	**Quote No:**	85159
	Bell Block	**Order No:**	12868
	New Plymouth 4312	**Client Reference:**	Hydraulic fracturing fluid testing
		Submitted By:	Skye Loveridge-Easther

Sample Type: Aqueous

Sample Name:		Kowhai 4 - Frac 4 Prepumped HF Fluid 11-Aug-2017 8:53 am				
Lab Number:		1827538.1				
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	< 20	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 20	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 20	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	0.012	-	-	-	-
Toluene	g/m³	0.038	-	-	-	-
Ethylbenzene	g/m³	< 0.010	-	-	-	-
m&p-Xylene	g/m³	0.03	-	-	-	-
o-Xylene	g/m³	0.014	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	8.8	-	-	-	-
C10 - C14	g/m³	630	-	-	-	-
C15 - C36	g/m³	820	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	1,460	-	-	-	-

1827538.1
Kowhai 4 - Frac 4 Prepumped HF Fluid 11-Aug-2017 8:53 am
Client Chromatogram for TPH by FID



Analyst's Comments

Sample 1 Comment:
Please note that the TPH C7 - C9 band was analysed by the head space/GCMS method, with all other TPH bands analysed by hexane solvent extraction/GC/FID.

SUMMARY OF METHODS

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

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	4 g/m^3	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	4 g/m^3	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	1.0 g/m^3	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629] Analysis performed at 1 Clyde Street, Hamilton	0.0010 - 0.002 g/m^3	1
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629] Analysis performed at 1 Clyde Street, Hamilton	0.06 - 0.7 g/m^3	1
C7 - C9	Head Space, GCMS analysis. Analysis performed at 1 Clyde Street, Hamilton.	0.06 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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Client Services Manager - Environmental

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ANALYSIS REPORT

Client:	Greymouth Petroleum Limited	**Lab No:**	1837537 SPv1
Contact:	Skye Loveridge-Easther	**Date Received:**	05-Sep-2017
	C/- Greymouth Petroleum Limited	**Date Reported:**	15-Sep-2017
	14 Connett Road West	**Quote No:**	81870
	Bell Block	**Order No:**	12891
	New Plymouth 4312	**Client Reference:**	Return Fluid Composite
		Submitted By:	Skye Loveridge-Easther

Sample Type: Saline

Sample Name:		Composite of Start of Frac, Mid Flow Back and End Flow Back				
Lab Number:		1837537.4				
Individual Tests						
pH*	pH Units	6.6	-	-	-	-
Total Alkalinity*	g/m^3 as $CaCO_3$	1,030	-	-	-	-
Analysis Temperature for Bicarbonate	°C	23	-	-	-	-
Bicarbonate	g/m^3 at Analysis Temperature	1,111	-	-	-	-
Total Hardness*	g/m^3 as $CaCO_3$	370	-	-	-	-
Electrical Conductivity (EC)*	mS/m	2,010	-	-	-	-
Total Dissolved Solids (TDS)*	g/m^3	13,500	-	-	-	-
Dissolved Barium*	g/m^3	61	-	-	-	-
Dissolved Bromine*	g/m^3	14.4	-	-	-	-
Dissolved Calcium*	g/m^3	129	-	-	-	-
Dissolved Copper*	g/m^3	0.016	-	-	-	-
Dissolved Iron*	g/m^3	2.9	-	-	-	-
Dissolved Magnesium*	g/m^3	10	-	-	-	-
Dissolved Manganese*	g/m^3	4.0	-	-	-	-
Total Nickel*	g/m^3	0.05	-	-	-	-
Total Potassium*	g/m^3	440	-	-	-	-
Total Sodium*	g/m^3	4,100	-	-	-	-
Total Sulphur*	g/m^3	8	-	-	-	-
Total Zinc*	g/m^3	0.181	-	-	-	-
Chloride*	g/m^3	6,300	-	-	-	-
Nitrite-N	g/m^3	< 0.2 [#1]	-	-	-	-
Nitrate-N	g/m^3	< 0.2	-	-	-	-
Nitrate*	g/m^3	< 0.9	-	-	-	-
Nitrate-N + Nitrite-N	g/m^3	< 0.2 [#1]	-	-	-	-
Sulphate*	g/m^3	24	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 30	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	< 20	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	< 20	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene*	g/m^3	19.0	-	-	-	-
Toluene*	g/m^3	40	-	-	-	-
Ethylbenzene*	g/m^3	5.3	-	-	-	-
m&p-Xylene*	g/m^3	33	-	-	-	-

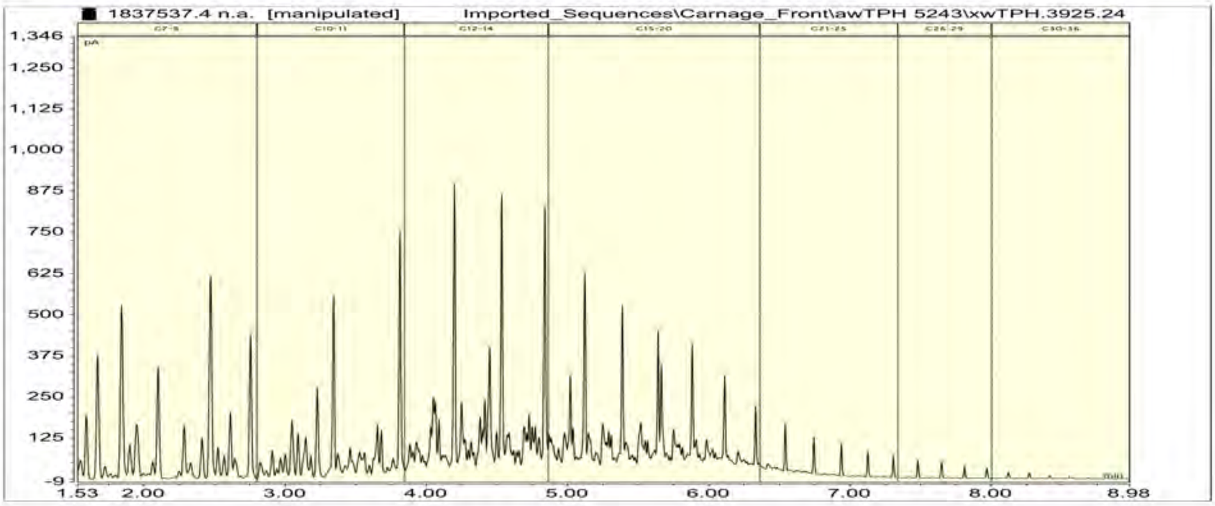
Sample Type: Saline

Sample Name:		Composite of Start of Frac, Mid Flow Back and End Flow Back				
Lab Number:		1837537.4				
BTEX in Water by Headspace GC-MS						
o-Xylene*	g/m³	9.9	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m³	0.16	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	210	-	-	-	-
C10 - C14*	g/m³	620	-	-	-	-
C15 - C36*	g/m³	570	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	1,400	-	-	-	-

1837537.4

Composite of Start of Frac, Mid Flow Back and End Flow Back

Client Chromatogram for TPH by FID



Analyst's Comments

Due to some interference found in the chromatography for Ethylene glycol in the Glycol analysis on sample 1837537.4, the detection limit was raised. Hence the higher detection limit reported.

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

Sample 4 Comment:
Please note that the TPH C7 - C9 band was analysed by the head space/GCMS method, with all other TPH bands analysed by hexane solvent extraction/GC/FID.

SUMMARY OF METHODS

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

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	4 g/m³	4
Propylene Glycol in Water*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	4 g/m³	4
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	1.0 g/m³	4
BTEX in Water by Headspace GC-MS*	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629] Analysis performed at 1 Clyde Street, Hamilton	0.0010 - 0.002 g/m³	4
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS Analysis performed at 1 Clyde Street, Hamilton	0.02 g/m³	4

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629] Analysis performed at 1 Clyde Street, Hamilton	0.06 - 0.7 g/m^3	4
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	4
Total Digestion*	Boiling nitric acid digestion. Analysed at 1 Clyde Street, Hamilton. APHA 3030 E 22nd ed. 2012 (modified).	-	4
Total Digestion of Saline Samples*	Nitric acid digestion. Analysed at 1 Clyde Street, Hamilton. APHA 3030 E 22nd ed. 2012 (modified).	-	4
pH*	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	4
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m^3 as $CaCO_3$	4
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	4
Bicarbonate	Bicarbonate (HCO3) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988.	20 g/m^3 at Analysis Temperature	4
Total Hardness*	Calculation from Calcium and Magnesium. Analysed at 1 Clyde Street, Hamilton. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	4
Electrical Conductivity (EC)*	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	4
Total Dissolved Solids (TDS)*	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22nd ed. 2012.	50 g/m^3	4
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. Analysed at 1 Clyde Street, Hamilton. APHA 3030 B 22nd ed. 2012.	-	4
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.0006 g/m^3	4
Dissolved Bromine*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.10 g/m^3	4
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.0 g/m^3	4
Dissolved Copper*	Filtered sample, ICP-MS, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	4
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.004 g/m^3	4
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.4 g/m^3	4
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	4
Total Nickel*	Nitric acid digestion, ICP-MS with universal cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.007 g/m^3	4
Total Potassium*	Nitric acid digestion, ICP-MS, ultratrace level. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	1.1 g/m^3	4
Total Sodium*	Nitric acid digestion, ICP-MS, ultratrace level. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	0.42 g/m^3	4
Total Sulphur*	Nitric acid digestion, ICP-OES (method may not fully account for H_2S due to volatilisation during digestion). All forms of oxidised and organic sulphur will be determined by this method. Analysed at 1 Clyde Street, Hamilton.	0.5 g/m^3	4
Total Zinc*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. Analysed at 1 Clyde Street, Hamilton. APHA 3125 B 22nd ed. 2012.	0.0042 g/m^3	4
Chloride*	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	4
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	4
Nitrate*	Calculation from Nitrate-N.	0.010 g/m^3	4
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	4
Total Sulphate*	Calculation: from total sulphur. Analysed at 1 Clyde Street, Hamilton.	2 g/m^3	4

Sample Type: Saline			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
C7 - C9	Head Space, GCMS analysis. Analysis performed at 1 Clyde Street, Hamilton.	0.06 g/m^3	4

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

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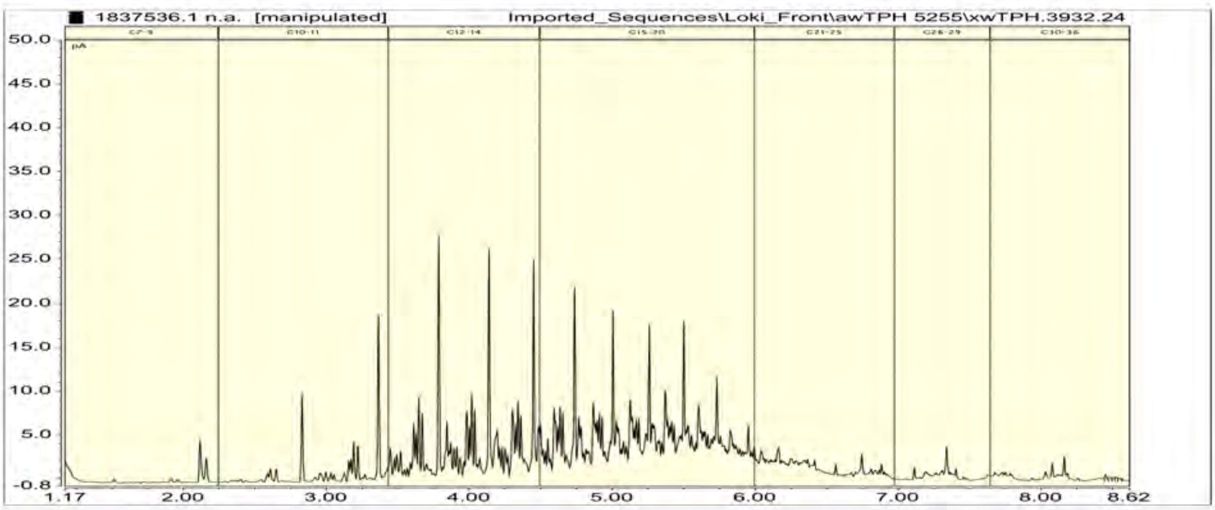
ANALYSIS REPORT

Client:	Greymouth Petroleum Limited	**Lab No:**	1837536 SPv1
Contact:	Skye Loveridge-Easther C/- Greymouth Petroleum Limited 14 Connett Road West Bell Block New Plymouth 4312	**Date Received:**	05-Sep-2017
		Date Reported:	20-Sep-2017
		Quote No:	85159
		Order No:	12890
		Client Reference:	Hydraulic fracturing fluid testing
		Submitted By:	Skye Loveridge-Easther

Sample Type: Aqueous

Sample Name:		Kowhai 4 - Frac 5 Prepumped HF Fluid (TRC Pre Frac)				
Lab Number:		1837536.1				
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	< 20	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 20	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 20	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	0.0034	-	-	-	-
Toluene	g/m³	0.0082	-	-	-	-
Ethylbenzene	g/m³	0.0019	-	-	-	-
m&p-Xylene	g/m³	0.006	-	-	-	-
o-Xylene	g/m³	0.0035	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	0.29	-	-	-	-
C10 - C14	g/m³	16.0	-	-	-	-
C15 - C36	g/m³	33	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	49	-	-	-	-

1837536.1
Kowhai 4 - Frac 5 Prepumped HF Fluid (TRC Pre Frac)
Client Chromatogram for TPH by FID



Analyst's Comments

It has been noted that the spikes for BTEX on sample 1837536.1, was run as part of our in-house QC procedure, had lower than expected recoveries for m&p-Xylene (76% & 80%) and o-Xylene (77% & 79%). Therefore the results maybe underestimated.

Sample 1 Comment:
Please note that the TPH C7 - C9 band was analysed by the head space/GCMS method, with all other TPH bands analysed by hexane solvent extraction/GC/FID.

SUMMARY OF METHODS

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

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	4 g/m^3	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	4 g/m^3	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	1.0 g/m^3	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629] Analysis performed at 1 Clyde Street, Hamilton	0.0010 - 0.002 g/m^3	1
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629] Analysis performed at 1 Clyde Street, Hamilton	0.06 - 0.7 g/m^3	1
C7 - C9	Head Space, GCMS analysis. Analysis performed at 1 Clyde Street, Hamilton.	0.06 g/m^3	1

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

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K Harrison

Kim Harrison MSc
Client Services Manager - Environmental

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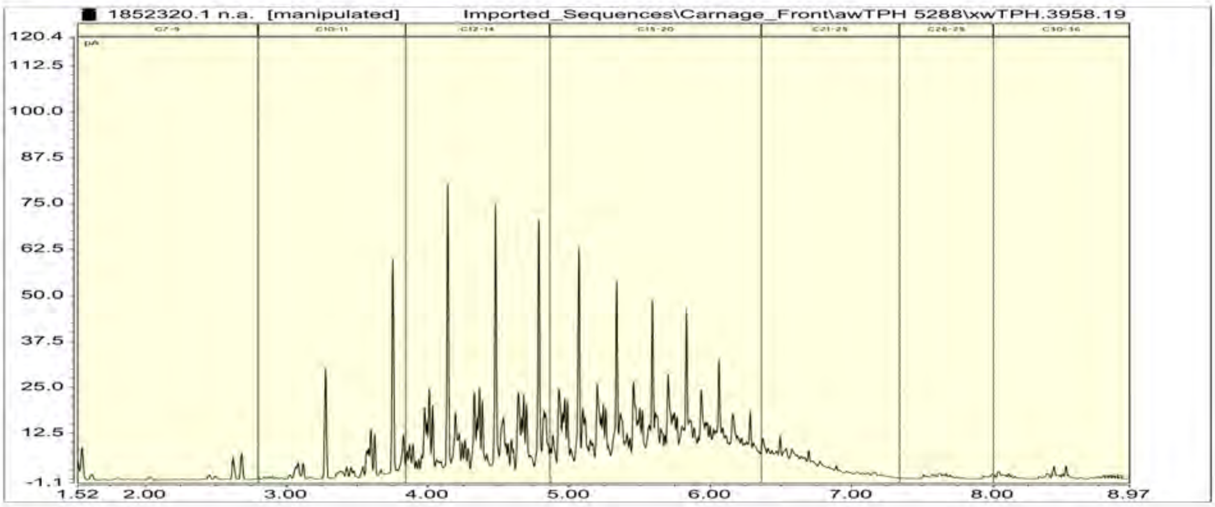
ANALYSIS REPORT

Client:	Greymouth Petroleum Limited	**Lab No:**	1852320 SPv1
Contact:	Skye Loveridge-Easther	**Date Received:**	29-Sep-2017
	C/- Greymouth Petroleum Limited	**Date Reported:**	19-Oct-2017
	14 Connett Road West	**Quote No:**	85159
	Bell Block	**Order No:**	240309
	New Plymouth 4312	**Client Reference:**	Hydraulic fracturing fluid testing
		Submitted By:	Skye Loveridge-Easther

Sample Type: Aqueous

Sample Name:		Kowhai 4 - Frac 6 - Prepumped HF Fluid 23-Sep-2017				
Lab Number:		1852320.1				
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	< 40	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 40	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 20	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	< 0.010	-	-	-	-
Toluene	g/m³	0.015	-	-	-	-
Ethylbenzene	g/m³	< 0.010	-	-	-	-
m&p-Xylene	g/m³	< 0.02	-	-	-	-
o-Xylene	g/m³	< 0.010	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	7.2	-	-	-	-
C10 - C14	g/m³	43	-	-	-	-
C15 - C36	g/m³	80	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	130	-	-	-	-

1852320.1
Kowhai 4 - Frac 6 - Prepumped HF Fluid 23-Sep-2017
Client Chromatogram for TPH by FID



Analyst's Comments

Sample 1 Comment:
Please note that the TPH C7 - C9 band was analysed by the head space/GCMS method, with all other TPH bands analysed by hexane solvent extraction/GC/FID.

SUMMARY OF METHODS

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

Sample Type: Aqueous

Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	4 g/m^3	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	4 g/m^3	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	1.0 g/m^3	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629] Analysis performed at 1 Clyde Street, Hamilton	0.0010 - 0.002 g/m^3	1
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629] Analysis performed at 1 Clyde Street, Hamilton	0.06 - 0.7 g/m^3	1
C7 - C9	Head Space, GCMS analysis. Analysis performed at 1 Clyde Street, Hamilton.	0.06 g/m^3	1

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

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

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ANALYSIS REPORT

Client:	Greymouth Petroleum Limited	**Lab No:**	1852324 SPv1
Contact:	Skye Loveridge-Easther	**Date Received:**	29-Sep-2017
	C/- Greymouth Petroleum Limited	**Date Reported:**	19-Oct-2017
	14 Connett Road West	**Quote No:**	81870
	Bell Block	**Order No:**	240308
	New Plymouth 4312	**Client Reference:**	Return Fluid Composite
		Submitted By:	Skye Loveridge-Easther

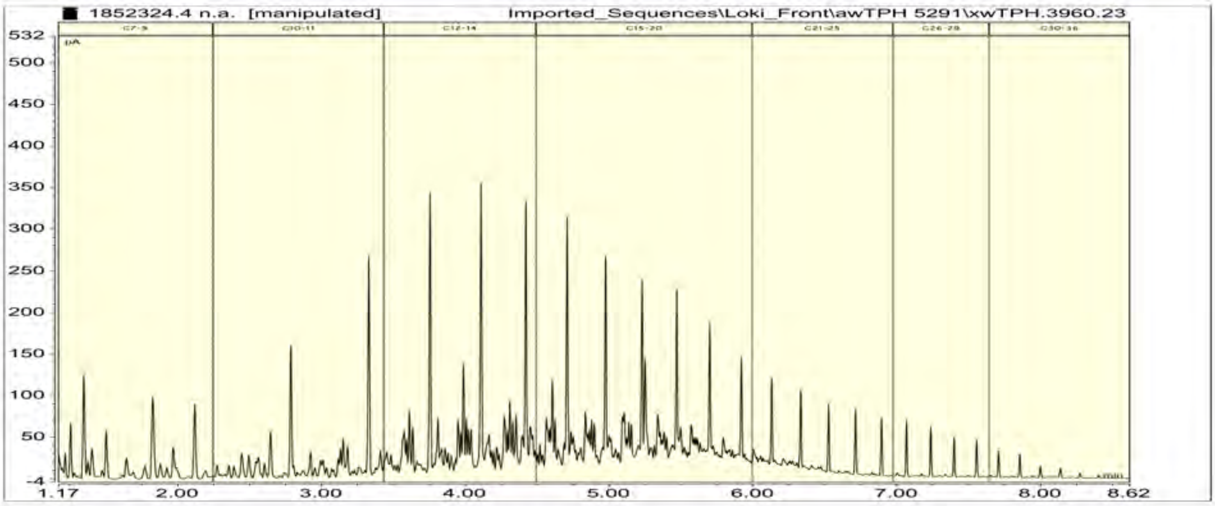
Sample Type: Saline

Sample Name:		Kowhai 4 - Frac 6 - Composite Return Fluid				
Lab Number:		1852324.4				
Individual Tests						
pH*	pH Units	7.2	-	-	-	-
Total Alkalinity*	g/m^3 as $CaCO_3$	1,770	-	-	-	-
Analysis Temperature for Bicarbonate	°C	23	-	-	-	-
Bicarbonate	g/m^3 at Analysis Temperature	2,080	-	-	-	-
Total Hardness*	g/m^3 as $CaCO_3$	131	-	-	-	-
Electrical Conductivity (EC)*	mS/m	1,733	-	-	-	-
Total Dissolved Solids (TDS)*	g/m^3	13,400	-	-	-	-
Dissolved Barium*	g/m^3	54	-	-	-	-
Dissolved Bromine*	g/m^3	9.5	-	-	-	-
Dissolved Calcium*	g/m^3	41	-	-	-	-
Dissolved Copper*	g/m^3	0.009	-	-	-	-
Dissolved Iron*	g/m^3	1.34	-	-	-	-
Dissolved Magnesium*	g/m^3	7	-	-	-	-
Dissolved Manganese*	g/m^3	1.37	-	-	-	-
Total Nickel*	g/m^3	0.021	-	-	-	-
Total Potassium*	g/m^3	460	-	-	-	-
Total Sodium*	g/m^3	3,900	-	-	-	-
Total Sulphur*	g/m^3	6	-	-	-	-
Total Zinc*	g/m^3	0.081	-	-	-	-
Chloride*	g/m^3	4,600	-	-	-	-
Nitrite-N	g/m^3	< 0.2 [#1]	-	-	-	-
Nitrate-N	g/m^3	< 0.2	-	-	-	-
Nitrate*	g/m^3	< 0.9	-	-	-	-
Nitrate-N + Nitrite-N	g/m^3	< 0.2 [#1]	-	-	-	-
Sulphate*	g/m^3	18	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 40	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	< 40	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	< 20	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene*	g/m^3	5.1	-	-	-	-
Toluene*	g/m^3	6.6	-	-	-	-
Ethylbenzene*	g/m^3	0.68	-	-	-	-
m&p-Xylene*	g/m^3	4.3	-	-	-	-
o-Xylene*	g/m^3	1.53	-	-	-	-

Sample Type: Saline

Sample Name:		Kowhai 4 - Frac 6 - Composite Return Fluid				
Lab Number:		1852324.4				
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m³	< 0.15	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	39	-	-	-	-
C10 - C14*	g/m³	220	-	-	-	-
C15 - C36*	g/m³	330	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	590	-	-	-	-

1852324.4
Kowhai 4 - Frac 6 - Composite Return Fluid
Client Chromatogram for TPH by FID



Analyst's Comments

[#1] Due to the nature of this sample a dilution was performed prior to analysis, resulting in a detection limit higher than that normally achieved for the NO2Nsal, NO3Nsal and NOxNsal analysis.

Sample 4 Comment:
Please note that the TPH C7 - C9 band was analysed by the head space/GCMS method, with all other TPH bands analysed by hexane solvent extraction/GC/FID.

Appendix No.1 - HCO3 Report- 1852324

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 Analysis performed at 25 Te Aroha Street, Hamilton	4 g/m³	4
Propylene Glycol in Water*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	4 g/m³	4
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	1.0 g/m³	4
BTEX in Water by Headspace GC-MS*	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629] Analysis performed at 1 Clyde Street, Hamilton	0.0010 - 0.002 g/m³	4
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS Analysis performed at 1 Clyde Street, Hamilton	0.02 g/m³	4
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629] Analysis performed at 1 Clyde Street, Hamilton	0.06 - 0.7 g/m³	4
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	4

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Total Digestion*	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	4
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	4
pH*	Saline water, pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	4
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m^3 as $CaCO_3$	4
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	4
Bicarbonate	Bicarbonate (HCO3) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988.	20 g/m^3 at Analysis Temperature	4
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	4
Electrical Conductivity (EC)*	Saline water, Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.10 mS/m	4
Total Dissolved Solids (TDS)*	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22nd ed. 2012.	50 g/m^3	4
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	4
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.0006 g/m^3	4
Dissolved Bromine*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.10 g/m^3	4
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.0 g/m^3	4
Dissolved Copper*	Filtered sample, ICP-MS, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	4
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.004 g/m^3	4
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.4 g/m^3	4
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	4
Total Nickel*	Nitric acid digestion, ICP-MS with universal cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.007 g/m^3	4
Total Potassium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.1 g/m^3	4
Total Sodium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.42 g/m^3	4
Total Sulphur*	Nitric acid digestion, ICP-OES (method may not fully account for H_2S due to volatilisation during digestion). All forms of oxidised and organic sulphur will be determined by this method. Analysed at 1 Clyde Street, Hamilton.	0.5 g/m^3	4
Total Zinc*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0042 g/m^3	4
Chloride*	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	4
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	4
Nitrate*	Calculation from Nitrate-N.	0.010 g/m^3	4
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	4
Total Sulphate*	Calculation: from total sulphur.	2 g/m^3	4
C7 - C9	Head Space, GCMS analysis. Analysis performed at 1 Clyde Street, Hamilton.	0.06 g/m^3	4

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

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

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CERTIFICATE OF ANALYSIS
ENVSUBGNS_WAIRAKEI 23

Report No: 2017100604

Customer Ref:148837

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

GNS Lot No: **2017100604**

GNS Sample No.	2017006891
Collection Date	
Site ID	1852324.4
Field ID	

pH		7.62	-	-	-	-
Bicarbonate (Total)	mg/l	2075	-	-	-	-
HCO_3 Analysis Temperature	°C	23	-	-	-	-
HCO_3 Analysis Date		9/10/2017	-	-	-	-

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.

M. K. Appleby

Moya Appleby
Senior Technician

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Tests marked with a † are not accredited and are outside the scope of the laboratory's accreditation

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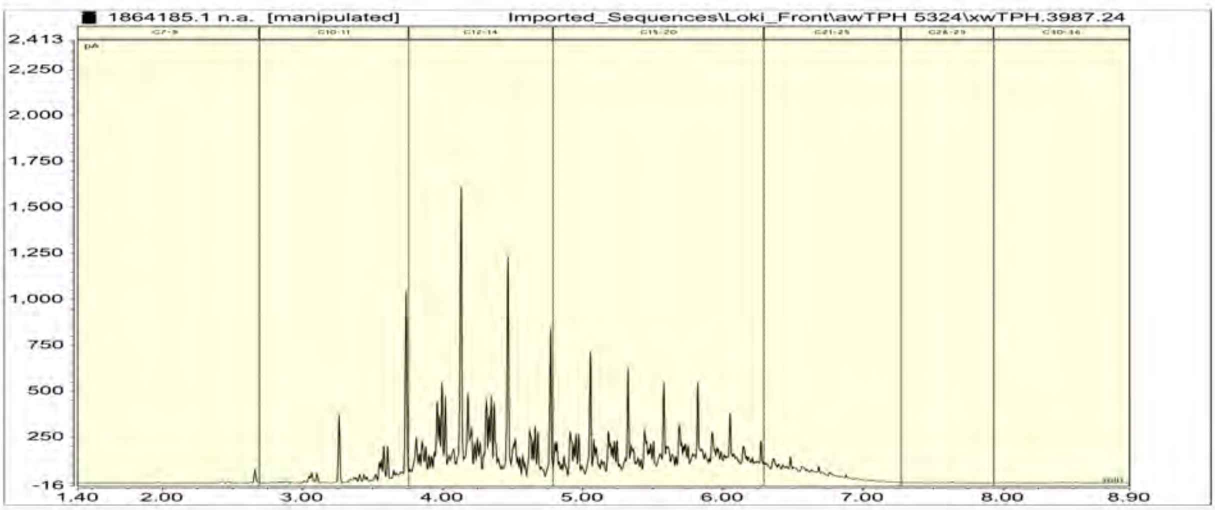
ANALYSIS REPORT

Client:	Greymouth Petroleum Limited	**Lab No:**	1864185 SPv1
Contact:	Skye Loveridge-Easther C/- Greymouth Petroleum Limited 14 Connett Road West Bell Block New Plymouth 4312	**Date Received:**	21-Oct-2017
		Date Reported:	01-Nov-2017
		Quote No:	85159
		Order No:	240484
		Client Reference:	Hydraulic fracturing fluid testing
		Submitted By:	Skye Loveridge-Easther

Sample Type: Aqueous

Sample Name:		KOW4 - Frac7 Prepumped HF 01-Oct-2017 10:05 am				
Lab Number:		1864185.1				
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	< 4	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 4	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 2	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	0.0012	-	-	-	-
Toluene	g/m³	0.0035	-	-	-	-
Ethylbenzene	g/m³	0.0026	-	-	-	-
m&p-Xylene	g/m³	0.004	-	-	-	-
o-Xylene	g/m³	0.0024	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	3.1	-	-	-	-
C10 - C14	g/m³	920	-	-	-	-
C15 - C36	g/m³	1,050	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	1,970	-	-	-	-

1864185.1
KOW4 - Frac7 Prepumped HF 01-Oct-2017 10:05 am
Client Chromatogram for TPH by FID



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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.

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 Analysis performed at 25 Te Aroha Street, Hamilton	4 g/m³	1
Propylene Glycol in Water*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	4 g/m³	1
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	1.0 g/m³	1
BTEX in Water by Headspace GC-MS	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629] Analysis performed at 1 Clyde Street, Hamilton	0.0010 - 0.002 g/m³	1
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629] Analysis performed at 1 Clyde Street, Hamilton	0.06 - 0.7 g/m³	1
C7 - C9	Head Space, GCMS analysis.	0.06 g/m³	1

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

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

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Client Services Manager - Environmental

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ANALYSIS REPORT

Client:	Greymouth Petroleum Limited	**Lab No:**	1864183 SPv1
Contact:	Skye Loveridge-Easther	**Date Received:**	21-Oct-2017
	C/- Greymouth Petroleum Limited	**Date Reported:**	07-Nov-2017
	14 Connett Road West	**Quote No:**	81870
	Bell Block	**Order No:**	240483
	New Plymouth 4312	**Client Reference:**	Return Fluid Composite
		Submitted By:	Skye Loveridge-Easther

Sample Type: Saline

	Sample Name:	Composite of Kow 4 Frac 7 Composite return fluid start, Kow 4 Frac 7 Composite return fluid middle and Kow 4 Frac 7 Composite return fluid end				
	Lab Number:	1864183.4				
Individual Tests						
pH*	pH Units	6.7	-	-	-	-
Total Alkalinity*	g/m^3 as $CaCO_3$	930	-	-	-	-
Analysis Temperature for Bicarbonate	°C	22	-	-	-	-
Bicarbonate	g/m^3 at Analysis Temperature	904	-	-	-	-
Total Hardness*	g/m^3 as $CaCO_3$	230	-	-	-	-
Electrical Conductivity (EC)*	mS/m	1,699	-	-	-	-
Total Dissolved Solids (TDS)*	g/m^3	12,700	-	-	-	-
Dissolved Barium*	g/m^3	39	-	-	-	-
Dissolved Bromine*	g/m^3	13.0	-	-	-	-
Dissolved Calcium*	g/m^3	75	-	-	-	-
Dissolved Copper*	g/m^3	0.008	-	-	-	-
Dissolved Iron*	g/m^3	16.6	-	-	-	-
Dissolved Magnesium*	g/m^3	10	-	-	-	-
Dissolved Manganese*	g/m^3	1.60	-	-	-	-
Total Nickel*	g/m^3	0.03	-	-	-	-
Total Potassium*	g/m^3	450	-	-	-	-
Total Sodium*	g/m^3	3,200	-	-	-	-
Total Sulphur*	g/m^3	8	-	-	-	-
Total Zinc*	g/m^3	0.051	-	-	-	-
Chloride*	g/m^3	5,300	-	-	-	-
Nitrite-N	g/m^3	0.02	-	-	-	-
Nitrate-N	g/m^3	< 0.02	-	-	-	-
Nitrate*	g/m^3	< 0.09	-	-	-	-
Nitrate-N + Nitrite-N	g/m^3	< 0.02	-	-	-	-
Sulphate*	g/m^3	25	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 40	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	< 40	-	-	-	-

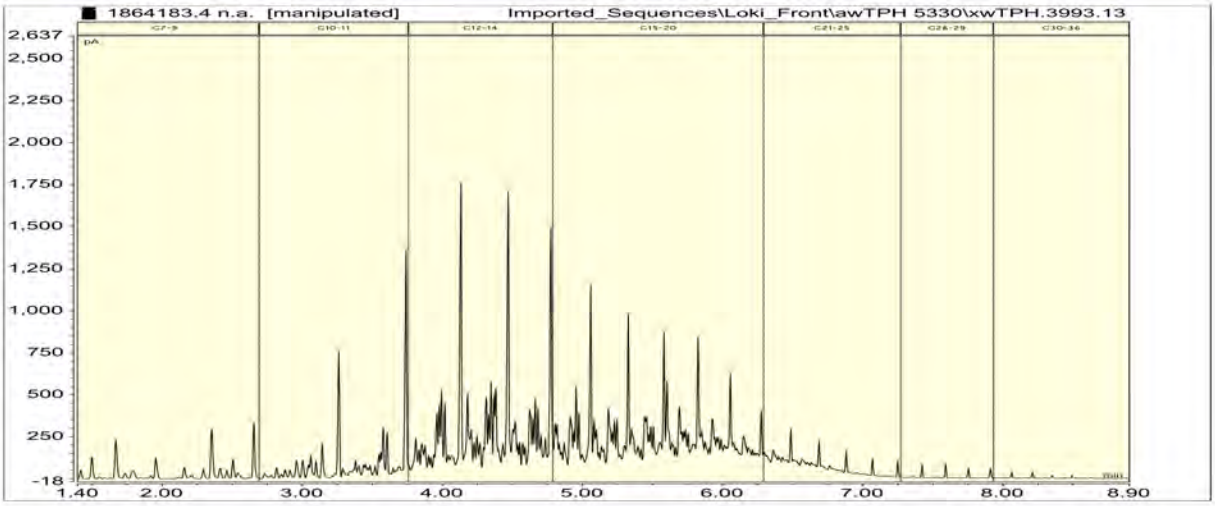
Sample Type: Saline

Sample Name:		Composite of Kow 4 Frac 7 Composite return fluid start, Kow 4 Frac 7 Composite return fluid middle and Kow 4 Frac 7 Composite return fluid end				
Lab Number:		1864183.4				
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	89,000	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene*	g/m³	2.7	-	-	-	-
Toluene*	g/m³	5.2	-	-	-	-
Ethylbenzene*	g/m³	0.64	-	-	-	-
m&p-Xylene*	g/m³	4.0	-	-	-	-
o-Xylene*	g/m³	1.42	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m³	< 1.5	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	38	-	-	-	-
C10 - C14*	g/m³	250	-	-	-	-
C15 - C36*	g/m³	310	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	600	-	-	-	-

1864183.4

Composite of Kow 4 Frac 7 Composite return fluid start, Kow 4 Frac 7 Composite return fluid middle and Kow 4 Frac 7 Composite return

Client Chromatogram for TPH by FID



SUMMARY OF METHODS

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

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Ethylene Glycol in Water*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	4 g/m³	4
Propylene Glycol in Water*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	4 g/m³	4
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID Analysis performed at 25 Te Aroha Street, Hamilton	1.0 g/m³	4
BTEX in Water by Headspace GC-MS*	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629] Analysis performed at 1 Clyde Street, Hamilton	0.0010 - 0.002 g/m³	4
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS Analysis performed at 1 Clyde Street, Hamilton	0.02 g/m³	4

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629] Analysis performed at 1 Clyde Street, Hamilton	0.06 - 0.7 g/m^3	4
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	4
Total Digestion*	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	4
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	4
pH*	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	4
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m^3 as $CaCO_3$	4
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	4
Bicarbonate	Bicarbonate (HCO3) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988.	20 g/m^3 at Analysis Temperature	4
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	4
Electrical Conductivity (EC)*	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	4
Total Dissolved Solids (TDS)*	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22nd ed. 2012.	50 g/m^3	4
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	4
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.0006 g/m^3	4
Dissolved Bromine*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.10 g/m^3	4
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.0 g/m^3	4
Dissolved Copper*	Filtered sample, ICP-MS, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	4
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.004 g/m^3	4
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.4 g/m^3	4
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	4
Total Nickel*	Nitric acid digestion, ICP-MS with universal cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.007 g/m^3	4
Total Potassium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.1 g/m^3	4
Total Sodium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.42 g/m^3	4
Total Sulphur*	Nitric acid digestion, ICP-OES (method may not fully account for H_2S due to volatilisation during digestion). All forms of oxidised and organic sulphur will be determined by this method. Analysed at 1 Clyde Street, Hamilton.	0.5 g/m^3	4
Total Zinc*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0042 g/m^3	4
Chloride*	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	4
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	4
Nitrate*	Calculation from Nitrate-N.	0.010 g/m^3	4
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	4
Total Sulphate*	Calculation: from total sulphur.	2 g/m^3	4
C7 - C9	Head Space, GCMS analysis.	0.06 g/m^3	4

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Client Services Manager - Environmental

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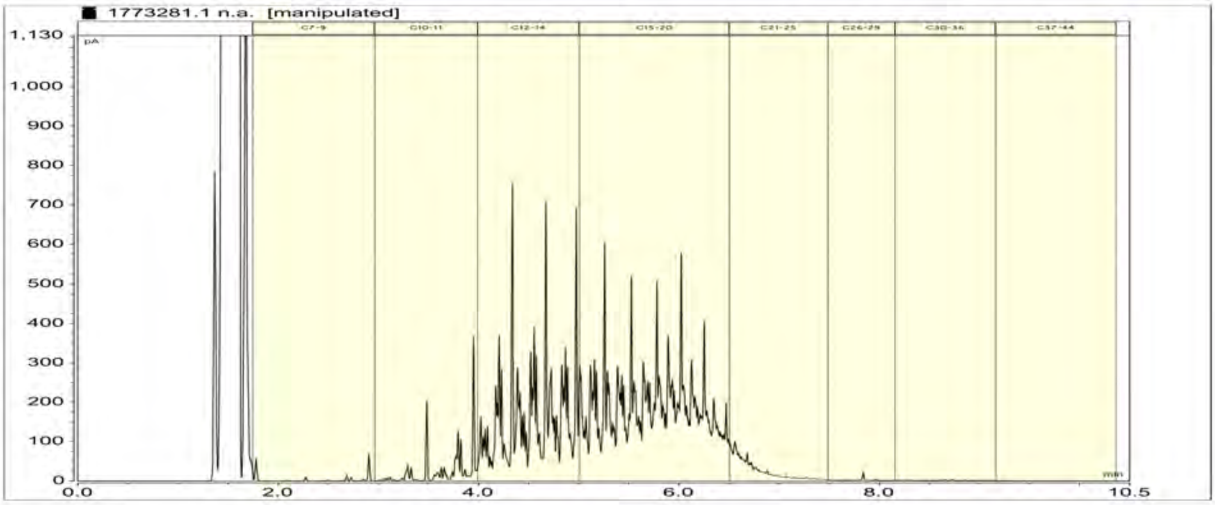
ANALYSIS REPORT

Client:	Greymouth Petroleum Limited	**Lab No:**	1773281 SPv1
Contact:	Skye Loveridge-Easther	**Date Received:**	11-May-2017
	C/- Greymouth Petroleum Limited	**Date Reported:**	22-May-2017
	14 Connett Road West	**Quote No:**	85159
	Bell Block	**Order No:**	12724
	New Plymouth 4312	**Client Reference:**	Hydraulic fracturing fluid testing
		Submitted By:	Skye Loveridge-Easther

Sample Type: Aqueous

Sample Name:		Kowhai D (Zone 1) Pre Pumped Fluid 02-May-2017 3:30 pm				
Lab Number:		1773281.1				
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	87	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 20	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 20	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	0.0012	-	-	-	-
Toluene	g/m³	0.0021	-	-	-	-
Ethylbenzene	g/m³	< 0.0010	-	-	-	-
m&p-Xylene	g/m³	0.003	-	-	-	-
o-Xylene	g/m³	0.0015	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	0.44	-	-	-	-
C10 - C14	g/m³	570	-	-	-	-
C15 - C36	g/m³	960	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	1,530	-	-	-	-

1773281.1
Kowhai D (Zone 1) Pre Pumped Fluid 02-May-2017 3:30 pm
Client Chromatogram for TPH by FID



Analyst's Comments

Sample 1 Comment:
Please note that the TPH C7 - C9 band was analysed by the head space/GCMS method, with all other TPH bands analysed by hexane solvent extraction/GC/FID.

SUMMARY OF METHODS

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

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
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m^3	1
C7 - C9	Head Space, GCMS analysis.	0.06 g/m^3	1
C10 - C14	Solvent extraction, GC-FID analysis. US EPA 8015B/NZ OIEWG.	0.2 g/m^3	1
C15 - C36	Solvent extraction, GC-FID analysis. US EPA 8015B/NZ OIEWG.	0.4 g/m^3	1
Total hydrocarbons (C7 - C36)	Solvent extraction, GC-FID analysis and Headspace, GC-MS FS analysis for C7-C9 carbon band.	0.7 g/m^3	1

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

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

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ANALYSIS REPORT

Client:	Greymouth Petroleum Limited	**Lab No:**	1773280 SPv2
Contact:	Skye Loveridge-Easther	**Date Received:**	11-May-2017
	C/- Greymouth Petroleum Limited	**Date Reported:**	30-May-2017 **(Amended)**
	14 Connett Road West	**Quote No:**	81870
	Bell Block	**Order No:**	12724
	New Plymouth 4312	**Client Reference:**	Return Fluid Composite
		Submitted By:	Skye Loveridge-Easther

Sample Type: Saline

Sample Name:		Composite of Kowhai D Return Fluid Start, Kowhai D Return Fluid Middle and Kowhai D Return Fluid End				
Lab Number:		1773280.4				
Individual Tests						
pH*	pH Units	7.0	-	-	-	-
Total Alkalinity*	g/m^3 as $CaCO_3$	940	-	-	-	-
Analysis Temperature for Bicarbonate	°C	22	-	-	-	-
Bicarbonate	g/m^3 at Analysis Temperature	1,177	-	-	-	-
Total Hardness*	g/m^3 as $CaCO_3$	80	-	-	-	-
Electrical Conductivity (EC)*	mS/m	924	-	-	-	-
Total Dissolved Solids (TDS)*	g/m^3	7,800	-	-	-	-
Dissolved Barium*	g/m^3	9.1	-	-	-	-
Dissolved Bromine*	g/m^3	4.9	-	-	-	-
Dissolved Calcium*	g/m^3	26	-	-	-	-
Dissolved Copper*	g/m^3	0.057	-	-	-	-
Dissolved Iron*	g/m^3	7.2	-	-	-	-
Dissolved Magnesium*	g/m^3	4	-	-	-	-
Dissolved Manganese*	g/m^3	2.6	-	-	-	-
Total Nickel*	g/m^3	0.09	-	-	-	-
Total Potassium*	g/m^3	310	-	-	-	-
Total Sodium*	g/m^3	1,890	-	-	-	-
Total Sulphur*	g/m^3	11	-	-	-	-
Total Zinc*	g/m^3	0.099	-	-	-	-
Chloride*	g/m^3	2,300	-	-	-	-
Nitrite-N	g/m^3	< 0.2 [#1]	-	-	-	-
Nitrate-N	g/m^3	< 0.2	-	-	-	-
Nitrate*	g/m^3	< 0.9	-	-	-	-
Nitrate-N + Nitrite-N	g/m^3	< 0.2 [#1]	-	-	-	-
Sulphate*	g/m^3	34	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 20	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	< 20	-	-	-	-

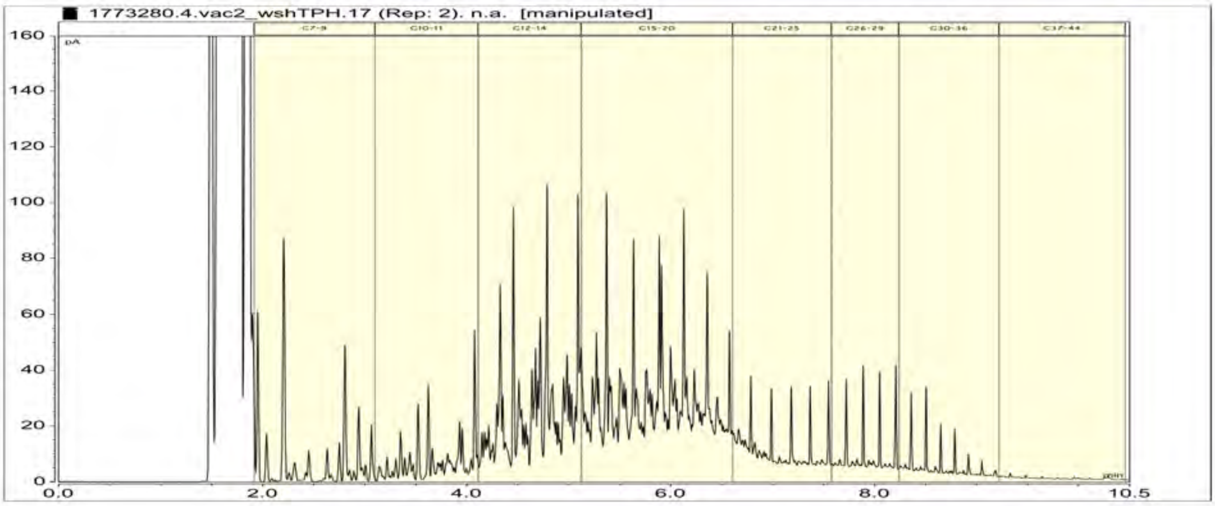
Sample Type: Saline

Sample Name:		Composite of Kowhai D Return Fluid Start, Kowhai D Return Fluid Middle and Kowhai D Return Fluid End				
Lab Number:		1773280.4				
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 20	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m³	0.15	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	8.7	-	-	-	-
C10 - C14*	g/m³	39	-	-	-	-
C15 - C36*	g/m³	89	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	137	-	-	-	-

1773280.4

Composite of Kowhai D Return Fluid Start, Kowhai D Return Fluid Middle and Kowhai D Return Fluid End

Client Chromatogram for TPH by FID



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 NO2Nsal, NO3Nsal and NOxNsal analysis.

Sample 4 Comment:
Please note that the TPH C7 - C9 band was analysed by the head space/GCMS method, with all other TPH bands analysed by hexane solvent extraction/GC/FID.

Amended Report: This report replaces an earlier report issued on 30 May 2017 at 1:51 pm
Reason for amendment: The sample name has been corrected.

Appendix No.1 - HCO3 Report-1773280

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/m³	4
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	4
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m³	4
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS	0.02 g/m³	4

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m^3	4
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	4
Total Digestion*	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	4
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	4
pH*	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	4
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m^3 as $CaCO_3$	4
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	4
Bicarbonate	Bicarbonate (HCO3) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988.	20 g/m^3 at Analysis Temperature	4
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	4
Electrical Conductivity (EC)*	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	4
Total Dissolved Solids (TDS)*	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22nd ed. 2012.	50 g/m^3	4
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	4
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.0006 g/m^3	4
Dissolved Bromine*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.10 g/m^3	4
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.0 g/m^3	4
Dissolved Copper*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	4
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.004 g/m^3	4
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.4 g/m^3	4
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	4
Total Nickel*	Nitric acid digestion, ICP-MS with universal cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.007 g/m^3	4
Total Potassium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.1 g/m^3	4
Total Sodium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.42 g/m^3	4
Total Sulphur*	Nitric acid digestion, ICP-OES (method may not fully account for H_2S due to volatilisation during digestion). All forms of oxidised and organic sulphur will be determined by this method.	0.5 g/m^3	4
Total Zinc*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0042 g/m^3	4
Chloride*	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	4
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	4
Nitrate*	Calculation from Nitrate-N.	0.010 g/m^3	4
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	4
Total Sulphate*	Calculation: from total sulphur.	2 g/m^3	4
C7 - C9	Head Space, GCMS analysis.	0.06 g/m^3	4
C10 - C14*	Solvent extraction, GC-FID analysis. US EPA 8015B/NZ OIEWG.	0.2 g/m^3	4
C15 - C36*	Solvent extraction, GC-FID analysis. US EPA 8015B/NZ OIEWG.	0.4 g/m^3	4

Sample Type: Saline			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total hydrocarbons (C7 - C36)	Solvent extraction, GC-FID analysis and Headspace, GC-MS FS analysis for C7-C9 carbon band.	0.7 g/m^3	4

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

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

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CERTIFICATE OF ANALYSIS

ENVSUBGNS WAIRAKEI 6

Report No: 2017051204

Customer Ref:148074

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

GNS Lot No: **2017051204**

GNS Sample No.	2017003490
Collection Date	
Site ID	1773280.4
Field ID	

pH		7.52	-	-	-	-
Bicarbonate (Total)	mg/l	1177	-	-	-	-
HCO_3 Analysis Temperature	°C	22	-	-	-	-
HCO_3 Analysis Date		16/05/2017	-	-	-	-

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

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

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

M.K. Appleby
Moya Appleby
Senior Technician

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Tests marked with a † are not accredited and are outside the scope of the laboratory's accreditation

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ANALYSIS REPORT

Client:	Greymouth Petroleum Limited	**Lab No:**	1789418 SPv1
Contact:	Skye Loveridge-Easther C/- Greymouth Petroleum Limited 14 Connett Road West Bell Block New Plymouth 4312	**Date Received:**	09-Jun-2017
		Date Reported:	23-Jun-2017
		Quote No:	81870
		Order No:	12786
		Client Reference:	Return Fluid Composite
		Submitted By:	Skye Loveridge-Easther

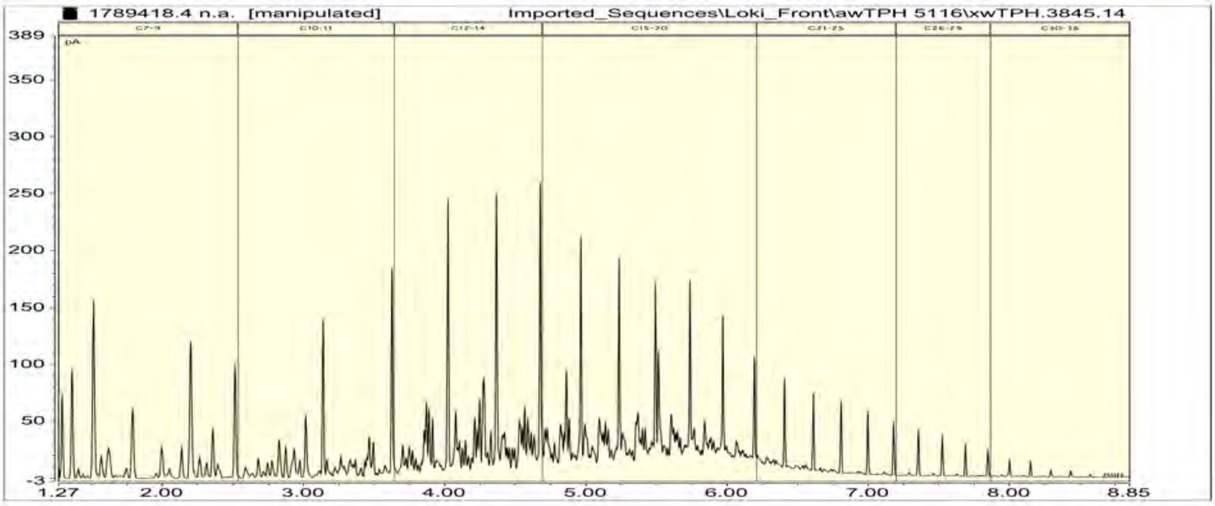
Sample Type: Saline

	Sample Name:	Composite of Kowhai 4 (Zone 2) HF return fluid-Start, Kowhai 4 (Zone 2) HF return fluid-Middle and Kowhai 4 (Zone 2) HF return fluid-End				
	Lab Number:	1789418.4				
Individual Tests						
pH*	pH Units	6.6	-	-	-	-
Total Alkalinity*	g/m^3 as $CaCO_3$	1,030	-	-	-	-
Analysis Temperature for Bicarbonate	°C	24	-	-	-	-
Bicarbonate	g/m^3 at Analysis Temperature	1,085	-	-	-	-
Total Hardness*	g/m^3 as $CaCO_3$	280	-	-	-	-
Electrical Conductivity (EC)*	mS/m	2,110	-	-	-	-
Total Dissolved Solids (TDS)*	g/m^3	13,700	-	-	-	-
Dissolved Barium*	g/m^3	66	-	-	-	-
Dissolved Bromine*	g/m^3	24	-	-	-	-
Dissolved Calcium*	g/m^3	98	-	-	-	-
Dissolved Copper*	g/m^3	0.0144	-	-	-	-
Dissolved Iron*	g/m^3	2.1	-	-	-	-
Dissolved Magnesium*	g/m^3	8.6	-	-	-	-
Dissolved Manganese*	g/m^3	3.3	-	-	-	-
Total Nickel*	g/m^3	< 0.03	-	-	-	-
Total Potassium*	g/m^3	450	-	-	-	-
Total Sodium*	g/m^3	4,500	-	-	-	-
Total Sulphur*	g/m^3	13	-	-	-	-
Total Zinc*	g/m^3	0.050	-	-	-	-
Chloride*	g/m^3	7,200	-	-	-	-
Nitrite-N	g/m^3	< 0.2 $^{\#1}$	-	-	-	-
Nitrate-N	g/m^3	< 0.2	-	-	-	-
Nitrate*	g/m^3	< 0.9	-	-	-	-
Nitrate-N + Nitrite-N	g/m^3	< 0.2 $^{\#1}$	-	-	-	-
Sulphate*	g/m^3	39	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 20	-	-	-	-

Sample Type: Saline

Sample Name:		Composite of Kowhai 4 (Zone 2) HF return fluid- Start, Kowhai 4 (Zone 2) HF return fluid- Middle and Kowhai 4 (Zone 2) HF return fluid- End				
Lab Number:		1789418.4				
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 20	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 20	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene*	g/m³	22	-	-	-	-
Toluene*	g/m³	52	-	-	-	-
Ethylbenzene*	g/m³	7.3	-	-	-	-
m&p-Xylene*	g/m³	41	-	-	-	-
o-Xylene*	g/m³	11.9	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m³	0.49	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	400	-	-	-	-
C10 - C14*	g/m³	610	-	-	-	-
C15 - C36*	g/m³	860	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	1,870	-	-	-	-

1789418.4
Composite of Kowhai 4 (Zone 2) HF return fluid- Start, Kowhai 4 (Zone 2) HF return fluid- Middle and Kowhai 4 (Zone 2) HF return fluid-
Client Chromatogram for TPH by FID



Analyst's Comments

[#1] Due to the nature of this sample a dilution was performed prior to analysis, resulting in a detection limit higher than that normally achieved for the NO2Nsal, NO3Nsal and NOxNsal analysis.

Sample 4 Comment:
Please note that the TPH C7 - C9 band was analysed by the head space/GCMS method, with all other TPH bands analysed by hexane solvent extraction/GC/FID.

SUMMARY OF METHODS

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

Sample Type: Saline

Test	**Method Description**	**Default Detection Limit**	**Sample No**

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	4
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	4
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m^3	4
BTEX in Water by Headspace GC-MS*	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m^3	4
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS	0.02 g/m^3	4
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m^3	4
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	4
Total Digestion*	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	4
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	4
pH*	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	4
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m^3 as $CaCO_3$	4
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	4
Bicarbonate	Bicarbonate (HCO3) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988.	20 g/m^3 at Analysis Temperature	4
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	4
Electrical Conductivity (EC)*	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	4
Total Dissolved Solids (TDS)*	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22nd ed. 2012.	50 g/m^3	4
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	4
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.0006 g/m^3	4
Dissolved Bromine*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.10 g/m^3	4
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.0 g/m^3	4
Dissolved Copper*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	4
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.004 g/m^3	4
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.4 g/m^3	4
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	4
Total Nickel*	Nitric acid digestion, ICP-MS with universal cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.007 g/m^3	4
Total Potassium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.1 g/m^3	4
Total Sodium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.42 g/m^3	4
Total Sulphur*	Nitric acid digestion, ICP-OES (method may not fully account for H_2S due to volatilisation during digestion). All forms of oxidised and organic sulphur will be determined by this method.	0.5 g/m^3	4
Total Zinc*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0042 g/m^3	4
Chloride*	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	4
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	4
Nitrate*	Calculation from Nitrate-N.	0.010 g/m^3	4

Sample Type: Saline			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	4
Total Sulphate*	Calculation: from total sulphur.	2 g/m^3	4
C7 - C9	Head Space, GCMS analysis.	0.06 g/m^3	4
C10 - C14*	Solvent extraction, GC-FID analysis. US EPA 8015B/NZ OIEWG.	0.2 g/m^3	4
C15 - C36*	Solvent extraction, GC-FID analysis. US EPA 8015B/NZ OIEWG.	0.4 g/m^3	4
Total hydrocarbons (C7 - C36)	Solvent extraction, GC-FID analysis and Headspace, GC-MS FS analysis for C7-C9 carbon band.	0.7 g/m^3	4

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

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

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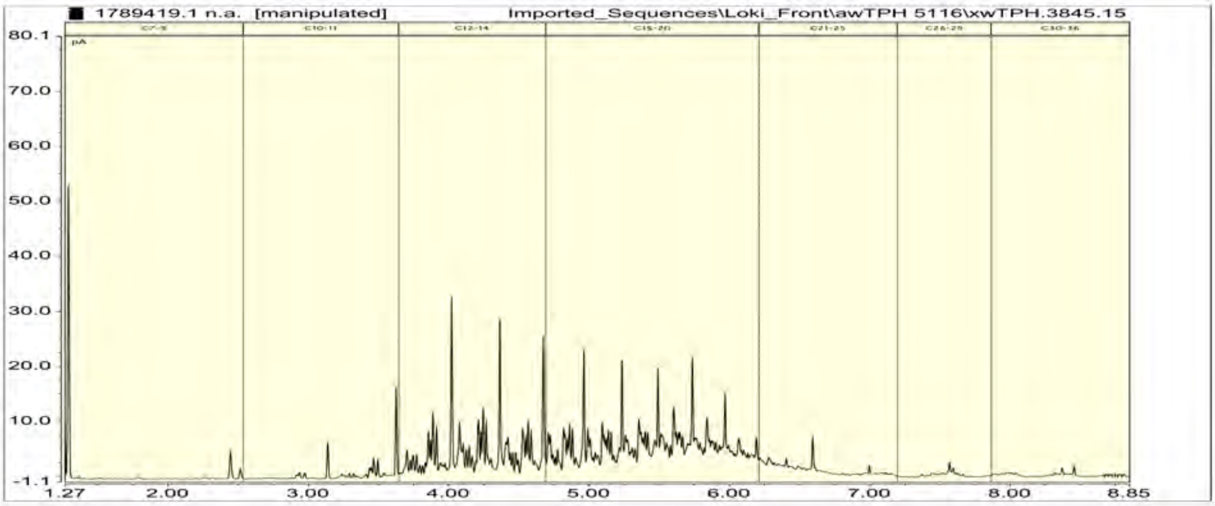
ANALYSIS REPORT

Client:	Greymouth Petroleum Limited	**Lab No:**	1789419 SPv1
Contact:	Skye Loveridge-Easther	**Date Received:**	09-Jun-2017
	C/- Greymouth Petroleum Limited	**Date Reported:**	21-Jun-2017
	14 Connett Road West	**Quote No:**	85159
	Bell Block	**Order No:**	12783
	New Plymouth 4312	**Client Reference:**	Hydraulic fracturing fluid testing
		Submitted By:	Skye Loveridge-Easther

Sample Type: Aqueous

Sample Name:		Kowhai 4 (Zone 2) Pre pumped HF Fluid 10-May-2017 2:30 pm				
Lab Number:		1789419.1				
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	39	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 20	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 20	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	0.0011	-	-	-	-
Toluene	g/m³	0.0055	-	-	-	-
Ethylbenzene	g/m³	< 0.0010	-	-	-	-
m&p-Xylene	g/m³	< 0.002	-	-	-	-
o-Xylene	g/m³	< 0.0010	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	0.17	-	-	-	-
C10 - C14	g/m³	24	-	-	-	-
C15 - C36	g/m³	50	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	75	-	-	-	-

1789419.1
Kowhai 4 (Zone 2) Pre pumped HF Fluid 10-May-2017 2:30 pm
Client Chromatogram for TPH by FID



Analyst's Comments

Sample 1 Comment:
Please note that the TPH C7 - C9 band was analysed by the head space/GCMS method, with all other TPH bands analysed by hexane solvent extraction/GC/FID.

SUMMARY OF METHODS

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

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
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m^3	1
C7 - C9	Head Space, GCMS analysis.	0.06 g/m^3	1
C10 - C14	Solvent extraction, GC-FID analysis. US EPA 8015B/NZ OIEWG.	0.2 g/m^3	1
C15 - C36	Solvent extraction, GC-FID analysis. US EPA 8015B/NZ OIEWG.	0.4 g/m^3	1
Total hydrocarbons (C7 - C36)	Solvent extraction, GC-FID analysis and Headspace, GC-MS FS analysis for C7-C9 carbon band.	0.7 g/m^3	1

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

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

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ANALYSIS REPORT

Client:	Greymouth Petroleum Limited	**Lab No:**	1808078 SPv1
Contact:	Skye Loveridge-Easther	**Date Received:**	13-Jul-2017
	C/- Greymouth Petroleum Limited	**Date Reported:**	27-Jul-2017
	14 Connett Road West	**Quote No:**	81870
	Bell Block	**Order No:**	12830
	New Plymouth 4312	**Client Reference:**	Return Fluid Composite
		Submitted By:	Skye Loveridge-Easther

Sample Type: Saline

	Sample Name:	Composite of Kawhai 4 (Frac 3) HF Return Fluid Start, Kawhai 4 (Frac 3) HF Return Fluid Middle & Kawhai 4 (Frac 3) HF Return Fluid End				
	Lab Number:	1808078.4				
Individual Tests						
pH*	pH Units	6.6	-	-	-	-
Total Alkalinity*	g/m^3 as $CaCO_3$	990	-	-	-	-
Analysis Temperature for Bicarbonate	°C	23	-	-	-	-
Bicarbonate	g/m^3 at Analysis Temperature	1,068	-	-	-	-
Total Hardness*	g/m^3 as $CaCO_3$	200	-	-	-	-
Electrical Conductivity (EC)*	mS/m	1,481	-	-	-	-
Total Dissolved Solids (TDS)*	g/m^3	11,100	-	-	-	-
Dissolved Barium*	g/m^3	34	-	-	-	-
Dissolved Bromine*	g/m^3	12.2	-	-	-	-
Dissolved Calcium*	g/m^3	68	-	-	-	-
Dissolved Copper*	g/m^3	0.0052	-	-	-	-
Dissolved Iron*	g/m^3	1.65	-	-	-	-
Dissolved Magnesium*	g/m^3	8.3	-	-	-	-
Dissolved Manganese*	g/m^3	3.4	-	-	-	-
Total Nickel*	g/m^3	< 0.03	-	-	-	-
Total Potassium*	g/m^3	470	-	-	-	-
Total Sodium*	g/m^3	2,900	-	-	-	-
Total Sulphur*	g/m^3	9	-	-	-	-
Total Zinc*	g/m^3	0.046	-	-	-	-
Chloride*	g/m^3	4,500	-	-	-	-
Nitrite-N	g/m^3	< 0.02 [#1]	-	-	-	-
Nitrate-N	g/m^3	< 0.02	-	-	-	-
Nitrate*	g/m^3	< 0.09	-	-	-	-
Nitrate-N + Nitrite-N	g/m^3	< 0.02 [#1]	-	-	-	-
Sulphate*	g/m^3	26	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 20	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	< 20	-	-	-	-

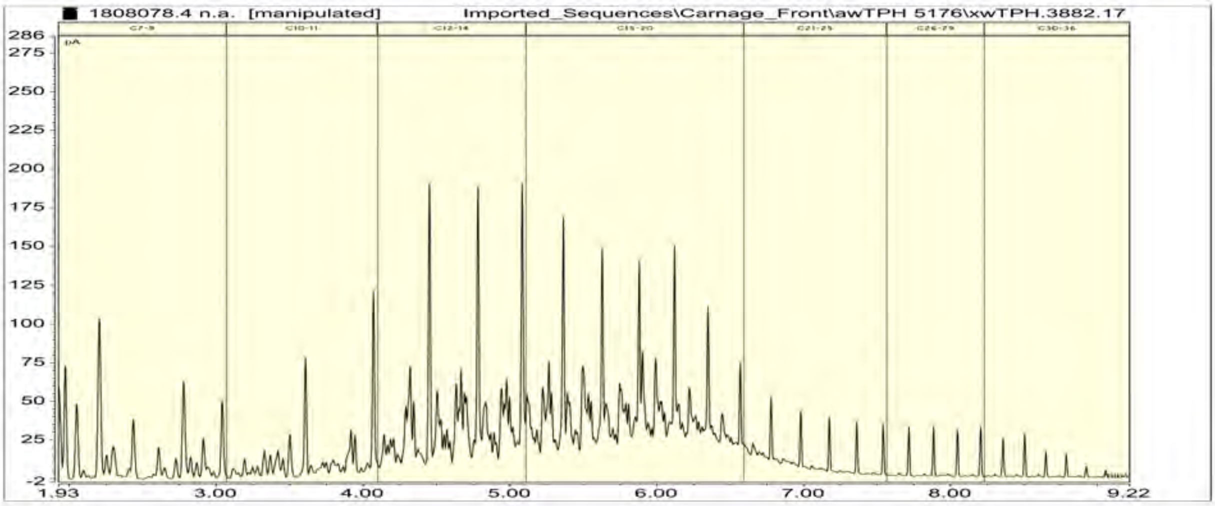
Sample Type: Saline

Sample Name:		Composite of Kawhai 4 (Frac 3) HF Return Fluid Start, Kawhai 4 (Frac 3) HF Return Fluid Middle & Kawhai 4 (Frac 3) HF Return Fluid End				
Lab Number:		1808078.4				
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	< 20	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene*	g/m^3	6.0	-	-	-	-
Toluene*	g/m^3	4.4	-	-	-	-
Ethylbenzene*	g/m^3	0.37	-	-	-	-
m&p-Xylene*	g/m^3	2.0	-	-	-	-
o-Xylene*	g/m^3	0.75	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m^3	0.27	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m^3	15.9	-	-	-	-
C10 - C14*	g/m^3	65	-	-	-	-
C15 - C36*	g/m^3	114	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m^3	195	-	-	-	-

1808078.4

Composite of Kawhai 4 (Frac 3) HF Return Fluid Start, Kawhai 4 (Frac 3) HF Return Fluid Middle & Kawhai 4 (Frac 3) HF Return Fluid End

Client Chromatogram for TPH by FID



Analyst's Comments

[#1] Due to the nature of this sample a dilution was performed prior to analysis, resulting in a detection limit higher than that normally achieved for the NO2Nsal, NO3Nsal and NOxNsal analysis.

Sample 4 Comment:
Please note that the TPH C7 - C9 band was analysed by the head space/GCMS method, with all other TPH bands analysed by hexane solvent extraction/GC/FID.

Appendix No.1 - HCO3 Report- 1808078

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	4

Sample Type: Saline

Test	Method Description	Default Detection Limit	Sample No
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m^3	4
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m^3	4
BTEX in Water by Headspace GC-MS*	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m^3	4
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS	0.02 g/m^3	4
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m^3	4
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	4
Total Digestion*	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	4
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	4
pH*	pH meter. APHA 4500-H^+ B 22nd ed. 2012. Note: It is not possible to achieve the APHA Maximum Storage Recommendation for this test (15 min) when samples are analysed upon receipt at the laboratory, and not in the field.	0.1 pH Units	4
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m^3 as $CaCO_3$	4
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	4
Bicarbonate	Bicarbonate (HCO3) Titration Method conducted at reported temperature. Subcontracted to Geological & Nuclear Sciences, Wairakei. ASTM Standards D513-82 Vol.11.01 of 1988.	20 g/m^3 at Analysis Temperature	4
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	4
Electrical Conductivity (EC)*	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	4
Total Dissolved Solids (TDS)*	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22nd ed. 2012.	50 g/m^3	4
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	4
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.0006 g/m^3	4
Dissolved Bromine*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.10 g/m^3	4
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.0 g/m^3	4
Dissolved Copper*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	4
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.004 g/m^3	4
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.4 g/m^3	4
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	4
Total Nickel*	Nitric acid digestion, ICP-MS with universal cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.007 g/m^3	4
Total Potassium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.1 g/m^3	4
Total Sodium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.42 g/m^3	4
Total Sulphur*	Nitric acid digestion, ICP-OES (method may not fully account for H_2S due to volatilisation during digestion). All forms of oxidised and organic sulphur will be determined by this method.	0.5 g/m^3	4
Total Zinc*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0042 g/m^3	4
Chloride*	Filtered sample. Ferric thiocyanate colorimetry. Discrete Analyser. APHA 4500 Cl^- E (modified from continuous flow analysis) 22nd ed. 2012.	0.5 g/m^3	4
Nitrite-N	Saline sample. Automated Azo dye colorimetry, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	4
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	4
Nitrate*	Calculation from Nitrate-N.	0.010 g/m^3	4
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	4

Sample Type: Saline			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
Total Sulphate*	Calculation: from total sulphur.	2 g/m^3	4
C7 - C9	Head Space, GCMS analysis.	0.06 g/m^3	4
C10 - C14*	Solvent extraction, GC-FID analysis. US EPA 8015B/NZ OIEWG.	0.2 g/m^3	4
C15 - C36*	Solvent extraction, GC-FID analysis. US EPA 8015B/NZ OIEWG.	0.4 g/m^3	4
Total hydrocarbons (C7 - C36)	Solvent extraction, GC-FID analysis and Headspace, GC-MS FS analysis for C7-C9 carbon band.	0.7 g/m^3	4

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

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

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Ara Heron BSc (Tech)
Client Services Manager - Environmental

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

CERTIFICATE OF ANALYSIS

EnvSubGNS_Wairakei 12

Report No: 2017071802

Customer Ref:148414

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

GNS Lot No: **2017071802**

GNS Sample No.	2017004823
Collection Date	
Site ID	1808078.4
Field ID	SALINE

pH		6.95	-	-	-
Bicarbonate (Total)	mg/l	1068	-	-	-
HCO_3 Analysis Temperature	°C	23	-	-	-
HCO_3 Analysis Date		19/07/2017	-	-	-

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

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

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

M.K. Appleby
Moya Appleby
Senior Technician

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Tests marked with a † are not accredited and are outside the scope of the laboratory's accreditation

Hill Laboratories
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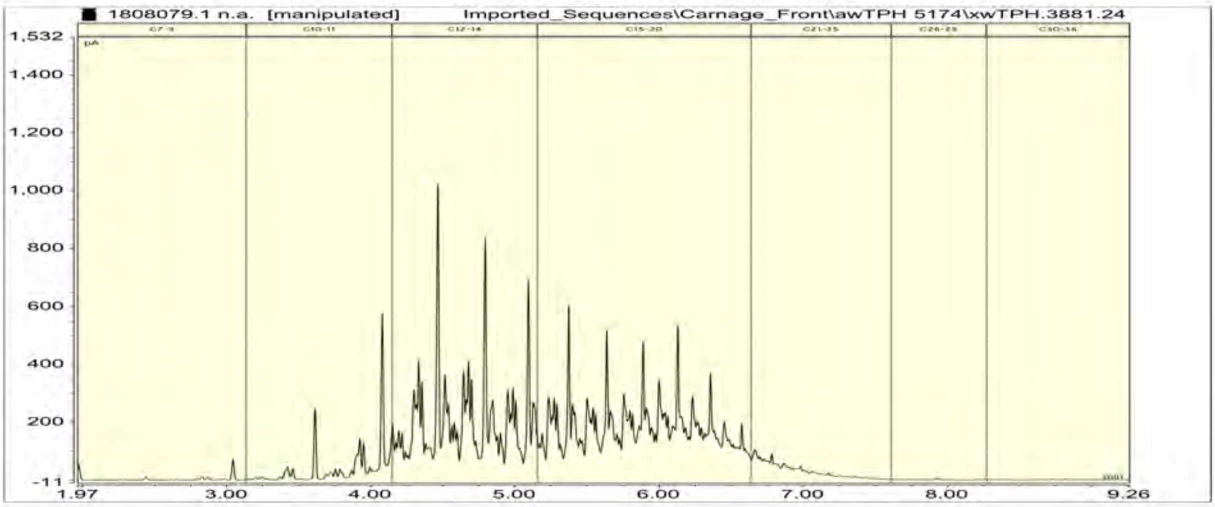
ANALYSIS REPORT

Client:	Greymouth Petroleum Limited	**Lab No:**	1808079 SPv1
Contact:	Skye Loveridge-Easther	**Date Received:**	13-Jul-2017
	C/- Greymouth Petroleum Limited	**Date Reported:**	26-Jul-2017
	14 Connett Road West	**Quote No:**	85159
	Bell Block	**Order No:**	12830
	New Plymouth 4312	**Client Reference:**	Hydraulic fracturing fluid testing
		Submitted By:	Skye Loveridge-Easther

Sample Type: Aqueous

Sample Name:		Kowhai 4 (Frac3) PrePumped HF Fluid 06-Jul-2017 9:20 am				
Lab Number:		1808079.1				
Ethylene Glycol in Water						
Ethylene glycol*	g/m³	< 20	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m³	< 20	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m³	< 20	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene	g/m³	< 0.010	-	-	-	-
Toluene	g/m³	0.020	-	-	-	-
Ethylbenzene	g/m³	< 0.010	-	-	-	-
m&p-Xylene	g/m³	0.03	-	-	-	-
o-Xylene	g/m³	0.011	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	10.4	-	-	-	-
C10 - C14	g/m³	750	-	-	-	-
C15 - C36	g/m³	1,020	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	1,770	-	-	-	-

1808079.1
Kowhai 4 (Frac3) PrePumped HF Fluid 06-Jul-2017 9:20 am
Client Chromatogram for TPH by FID



Analyst's Comments

Sample 1 Comment:
Please note that the TPH C7 - C9 band was analysed by the head space/GCMS method, with all other TPH bands analysed by hexane solvent extraction/GC/FID.

SUMMARY OF METHODS

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

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
Total Petroleum Hydrocarbons in Water*	Solvent Hexane extraction, GC-FID analysis, Headspace GC-MS FS analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734;26687,3629]	0.06 - 0.7 g/m^3	1
C7 - C9	Head Space, GCMS analysis.	0.06 g/m^3	1
C10 - C14	Solvent extraction, GC-FID analysis. US EPA 8015B/NZ OIEWG.	0.2 g/m^3	1
C15 - C36	Solvent extraction, GC-FID analysis. US EPA 8015B/NZ OIEWG.	0.4 g/m^3	1
Total hydrocarbons (C7 - C36)	Solvent extraction, GC-FID analysis and Headspace, GC-MS FS analysis for C7-C9 carbon band.	0.7 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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Carole Rodgers-Carroll BA, NZCS
Client Services Manager - Environmental

Appendix IV

Biomonitoring Reports

To	Job Managers, Callum MacKenzie and Jane Harvey
From	Environmental Scientist, Katie Blakemore
Report No	KB044
Document	2046748
Date	03 May 2018

Biomonitoring of an unnamed tributary of the Waitara River in relation to hydrocarbon exploration at Kowhai-D wellsite, February, April and November 2017

Introduction

Biological surveys were carried out in the vicinity of the newly established Kowhai-D on three occasions, to assess the impacts of wellsite activities on the macroinvertebrate fauna of this unnamed tributary of the Waitara River. Petrochem Ltd holds resource consent 10294-1 allowing the discharge of treated stormwater onto land and into an unnamed tributary of the Waitara River. A survey was carried out prior to the commencement of drilling to provide baseline data on the health of the macroinvertebrate communities. Further surveys were undertaken following the completion of drilling but prior to the commencement of hydraulic fracturing (HF), and again following the completion of HF, to determine whether stormwater discharges had caused any detrimental impacts to the macroinvertebrate communities of this unnamed tributary.

Methods

A pre-drill survey was carried out on 16 February 2017 at three sites which were established at the time of sampling (Table1, Figure 1). A post-drill (and pre-HF) survey was carried out at the same sites on 26 April 2017 and a post-HF survey was carried out on 29 November 2017. Samples were collected using a combination of the standard '400mL kick-sampling' and the 'vegetation sweep' techniques at all three in sites in the pre-drill survey and site 1 in the post-drill survey. The 'kick- sampling' technique was used at sites 2 and 3 in the post-drill and post-HF surveys, while the 'vegetation sweep' technique was used at site 1 in the post-drill and post-HF surveys. The 'kick-sampling' and 'vegetation sweep' techniques are respectively very similar to Protocol C1 (hard-bottomed, semi-quantitative) and Protocol C2 (soft-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate sampling in wadeable streams (Stark et al. 2001).

Table 1 Biomonitoring sites in an unnamed tributary of the Waitara River sampled in relation to the Kowhai-D wellsite

Site number	Site code	Grid reference (NZTM)	Location	Altitude (masl)
1	WTR000743	E1710423 N5674733	5m upstream of farm track	50
2	WTR000744	E1710095 N5675012	Downstream edge of wetland	50
3	WTR000745	E1710042 N5675020	50m downstream of wetland	50

Samples were preserved with Kahle's Fluid and ethanol for later sorting and identification under a stereomicroscope according to Taranaki Regional Council methodology using protocol P1 of NZMWG protocols for sampling macroinvertebrates in wadeable streams (Stark et al. 2001). Macroinvertebrate taxa found in each sample were recorded based on the abundance categories in Table 2.

Table 2 Macroinvertebrate abundance categories

Abundance category	Number of individuals
R (rare)	1-4
C (common)	5-19
A (abundant)	20-99
VA (very abundant)	100-499
XA (extremely abundant)	>499

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 or more MCI units is considered significantly different (Stark 1998). A gradation of biological water quality conditions based upon MCI ranges which has been adapted for Taranaki streams and rivers (TRC, 2013) from Stark’s classification (Stark, 1985; Boothroyd and Stark, 2000) (Table 3).

Table 3 Macroinvertebrate community health based on MCI ranges which has been adapted for Taranaki streams and rivers (TRC, 2013) from Stark’s classification (Stark, 1985 and Boothroyd and Stark, 2000)

Grading	MCI
Excellent	>140
Very Good	120-140
Good	100-119
Fair	80-99
Poor	60-79
Very Poor	<60

A semi-quantitative MCI value (SQMCIs) 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 SQMCIs is not multiplied by a scaling factor of 20, so that its corresponding range of values is 20x lower.

Figure 1 Biomonitoring sites in an unnamed tributary of the Waitara River sampled in relation to the Kowhai-D wellsite

Results

The pre-drill survey was carried out 11 days after a fresh of greater than 3x median flow and 13 days after a fresh of greater than 7x median flow. A steady, moderate, cloudy grey flow was recorded at all three sites. Substrate comprised predominantly hard clay and silt, with fine and coarse gravels also present at the three sites. Site 1 also had sand present, while site 2 had sand and wood/root and site 3 had cobble present. Water temperatures ranged from 15.4 °C- 15.9 °C at the three sites.

Macrophytes were present on the stream margins at all three sites, while leaves and wood were patchy at site 2 but absent at sites 1 and 3. Periphyton was absent at all three sites. Overhanging vegetation and undercut banks provided complete shading at site 1 and partial shading at sites 2 and 3.

The post-drill survey was carried out 8 days after a fresh of greater than 3x median flow and 20 days after a fresh of greater than 7x median flow. A steady, moderate, clear flow was recorded which was uncoloured at site 2, and tannin-stained brown at sites 1 and 3. Substrate at site 1 comprised a mixture of silt, sand, hard clay and wood/root. Site 2 had substrate dominated by cobble and wood/root with silt boulder, gravels and sand present in smaller amounts. Site 3 had substrate dominated by cobble with small amounts of silt, sand, gravels, boulder, hard clay and wood/root present. Water temperatures ranged from 14.2 °C -15.2 °C at the three sites.

Macrophytes were present on the streambed at site 1, absent at site 2 and present on the stream margins at site 3. Moss and leaves were patchy on the streambed at sites 2 and 3 but absent at site 1, and wood was patchy at site 2 only. Periphyton was absent at sites 1 and 2 while patchy filamentous periphyton was recorded at site 3. Overhanging vegetation and undercut banks provided partial shading at all three sites.

The post-HF survey was carried out 21 days after a fresh of greater than both 3x and 7x median flow. A very low, slow, cloudy brown flow was recorded at sites 1 and 3, while at site 2 flows were steady, low and clear brown. Substrate at sites 1 and 2 was dominated by silt and hard clay, with wood/root also present at site 1 and sand, gravels and cobble also present at site 2. Site 3 had substrate dominated by hard clay, sand and fine gravels, with silt, coarse gravel and cobble also present. Water temperatures ranged from 17.4 °C – 18.7 °C at the three sites.

Macrophytes were present on the streambed at site 1 and absent at sites 2 and 3. Moss and leaves were patchy on the streambed at sites 2 and 3 but absent at site 1, and wood was patchy at site 2 only. Periphyton was absent at sites 1 and 2, while slippery periphyton mats were recorded at site 3. Overhanging vegetation and undercut banks provided complete shading at site 1 and partial shading at sites 2 and 3.

Macroinvertebrate communities

Macroinvertebrate statistics for control sites between 50 and 79m altitude in small hill country streams are given in Table 4.

Table 4 Macroinvertebrate statistics for control sites in Taranaki small hill country streams at altitudes between 50 and 79 masl

Metric	Number of samples	Range	Median
Taxa richness	8	13-28	23
MCI	8	68-105	83
SQMCI$_s$	3	4.3-4.9	4.9

The full results of the pre-drill survey are given in Table 5, while the results of the post-drill survey are provided in Table 6 and the results of the post-HF survey are provided in Table 7.

Table 5 Macroinvertebrate fauna of the unnamed tributary of the Waitara River sampled in relation to the Kowhai-D wellsite on 16 February 2017

Taxa List	**Site Number**	**MCI score**	**1**	**2**	**3**
	Site Code		**WTR000743**	**WTR000744**	**WTR000745**
	Sample Number		**FWB17090**	**FWB17091**	**FWB17092**
PLATYHELMINTHES (FLATWORMS)	*Cura*	3	R	-	-
ANNELIDA (WORMS)	Oligochaeta	1	A	-	A
MOLLUSCA	Lymnaeidae	3	R	-	-
	Physa	3	R	-	-
	Potamopyrgus	4	-	C	A
CRUSTACEA	Ostracoda	1	C	-	A
	Paraleptamphopidae	5	-	R	A
	Paranephrops	5	-	-	R
EPHEMEROPTERA (MAYFLIES)	*Austroclima*	7	R	-	C
	Zephlebia group	7	C	C	A
HEMIPTERA (BUGS)	*Microvelia*	3	-	R	-
COLEOPTERA (BEETLES)	Dytiscidae	5	R	-	-
	Ptilodactylidae	8	-	-	R
TRICHOPTERA (CADDISFLIES)	*Hydrobiosis*	5	R	R	C
	Hydropsyche (Orthopsyche)	9	-	-	R
	Polyplectropus	6	C	R	-
	Psilochorema	6	-	C	C
	Oxyethira	2	R	C	-
	Triplectides	5	-	R	R
DIPTERA (TRUE FLIES)	*Paralimnophila*	6	R	-	-
	Zelandotipula	6	-	R	-
	Orthocladiinae	2	-	-	R
	Polypedilum	3	VA	C	R
	Tanypodinae	5	C	C	C
	Culicidae	3	-	R	-
	Paradixa	4	R	C	-
	Empididae	3	-	-	R
	Muscidae	3	-	-	R
	Austrosimulium	3	A	C	C
		No of taxa	16	15	18
		MCI	80	89	91
		SQMCIs	3.0	4.3	4.0
		EPT (taxa)	4	5	6
		%EPT (taxa)	25	33	33
'Tolerant' taxa	'Moderately sensitive' taxa	'Highly sensitive' taxa			

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

Table 6 Macroinvertebrate fauna of the unnamed tributary of the Waitara River sampled in relation to the Kowhai-D wellsite on 26 April 2017

Taxa List	**Site Number**	**MCI score**	**1**	**2**	**3**
	Site Code		**WTR000743**	**WTR000744**	**WTR000745**
	Sample Number		**FWB17223**	**FWB17224**	**FWB17225**
PLATYHELMINTHES (FLATWORMS)	*Cura*	3	C	-	R
NEMERTEA	Nemertea	3	C	-	-
NEMATODA	Nematoda	3	R	R	-
ANNELIDA (WORMS)	Oligochaeta	1	VA	C	C
HIRUDINEA (LEECHES)	Hirudinea	3	-	R	-
MOLLUSCA	Lymnaeidae	3	R	-	-
	Physa	3	C	-	-
	Potamopyrgus	4	C	R	A
CRUSTACEA	Copepoda	5	-	R	-
	Ostracoda	1	VA	R	R
	Paraleptamphopidae	5	-	C	C
	Paranephrops	5	-	R	R
EPHEMEROPTERA (MAYFLIES)	*Austroclima*	7	C	-	-
	Zephlebia group	7	C	-	C
PLECOPTERA (STONEFLIES)	*Acroperla*	5	-	-	R
ODONATA (DRAGONFLIES)	*Xanthocnemis*	4	R	-	-
COLEOPTERA (BEETLES)	Hydrophilidae	5	R	-	-
TRICHOPTERA (CADDISFLIES)	Ecnomidae/Psychomyiidae	6	-	R	-
	Hydrobiosis	5	-	-	R
	Polyplectropus	6	C	-	-
	Psilochorema	6	R	R	-
	Oxyethira	2	R	R	-
	Triplectides	5	R	-	-
DIPTERA (TRUE FLIES)	*Zelandotipula*	6	-	R	R
	Orthocladiinae	2	R	R	C
	Polypedilum	3	A	-	-
	Tanypodinae	5	R	R	R
	Austrosimulium	3	A	R	-
ACARINA (MITES)	Acarina	5	C	-	-
		No of taxa	21	15	12
		MCI	77	76	82
		SQMCIs	1.9	3.5	3.9
		EPT (taxa)	5	2	3
		%EPT (taxa)	24	13	25
'Tolerant' taxa	'Moderately sensitive' taxa	'Highly sensitive' taxa			

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

Table 7 Macroinvertebrate fauna of the unnamed tributary of the Waitara River sampled in relation to the Kowhai-D wellsite on 29 November 2017

Taxa List	**Site Number**	**MCI score**	**1**	**2**	**3**
	Site Code		**WTR000743**	**WTR000744**	**WTR000745**
	Sample Number		**FWB17223**	**FWB17224**	**FWB17225**
PLATYHELMINTHES (FLATWORMS)	*Cura*	3	C	-	R
NEMERTEA	Nemertea	3	C	-	-
NEMATODA	Nematoda	3	R	R	-
ANNELIDA (WORMS)	Oligochaeta	1	VA	C	C
HIRUDINEA (LEECHES)	Hirudinea	3	-	R	-
MOLLUSCA	Lymnaeidae	3	R	-	-
	Physa	3	C	-	-
	Potamopyrgus	4	C	R	A
CRUSTACEA	Copepoda	5	-	R	-
	Ostracoda	1	VA	R	R
	Paraleptamphopidae	5	-	C	C
	Paranephrops	5	-	R	R
EPHEMEROPTERA (MAYFLIES)	*Austroclima*	7	C	-	-
	Zephlebia group	7	C	-	C
PLECOPTERA (STONEFLIES)	*Acroperla*	5	-	-	R
ODONATA (DRAGONFLIES)	*Xanthocnemis*	4	R	-	-
COLEOPTERA (BEETLES)	Hydrophilidae	5	R	-	-
TRICHOPTERA (CADDISFLIES)	Ecnomidae/Psychomyiidae	6	-	R	-
	Hydrobiosis	5	-	-	R
	Polyplectropus	6	C	-	-
	Psilochorema	6	R	R	-
	Oxyethira	2	R	R	-
	Triplectides	5	R	-	-
DIPTERA (TRUE FLIES)	*Zelandotipula*	6	-	R	R
	Orthocladiinae	2	R	R	C
	Polypedilum	3	A	-	-
	Tanypodinae	5	R	R	R
	Austrosimulium	3	A	R	-
ACARINA (MITES)	Acarina	5	C	-	-
		No of taxa	21	15	12
		MCI	77	76	82
		SQMCIs	1.9	3.5	3.9
		EPT (taxa)	5	2	3
		%EPT (taxa)	24	13	25
'Tolerant' taxa	'Moderately sensitive' taxa	'Highly sensitive' taxa			

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

Site 1 - WTR000743

Moderate macroinvertebrate community richnesses of 16, 21 and 15 taxa were recorded in the pre-drill, post-drill and post-HF surveys respectively at this ‘control’ site, between two and eight taxa less than the median for small hill country streams at similar altitude (Table 4). The macroinvertebrate community in the pre-drill survey was characterised by three ‘tolerant’ taxa [oligochaete worm, midge larvae (*Polypedilum*) and sandfly larvae (*Austrosimulium*)] (Table 5). The post-drill macroinvertebrate community at this site was characterised by four ‘tolerant’ taxa, the same three as in the pre-drill survey and one additional taxon [seed shrimp (Ostracoda)] (Table 6). The macroinvertebrate community in the post-HF survey was characterised by one ‘tolerant’ taxon [midge larvae (*Polypedilum*)] and one ‘moderately sensitive’ taxon [caddisfly (*Polyplectropus*)] (Table 7).

Similar MCI scores of 80, 77 and 75 were recorded in the three surveys respectively, categorising the site as having ‘fair’ macroinvertebrate community health in the pre-drill survey and ‘poor’ macroinvertebrate community health in the post-drill and post-HF surveys (Table 3). These scores are not significantly different to the median MCI score for small hill country streams at similar altitude (Table 4).

Low $SQMCI_s$ scores of 3.0, 1.9 and 3.4 units were recorded in the three surveys respectively. The score recorded in the post-drill survey is significantly lower (Stark 1998) than that recorded by either the pre-drill or post-HF surveys (which are not significantly different from one another).

Site 2 – WTR000744

Moderate macroinvertebrate community richnesses of 15 taxa were recorded in both the pre-drill and post-drill surveys at this 'primary impact' site. The post-HF survey recorded a moderately low richness of 13 taxa, only two taxa less than the preceding surveys but a substantial ten taxa less than the median richness for small hill country streams at similar altitude (Table 4). In all three surveys, no taxa were recorded as 'abundant' or higher (Table 5, Table 6 and Table 7).

MCI scores of 89, 76 and 83 were recorded in the three surveys respectively, categorising the site as having 'fair' macroinvertebrate community health in the pre-drill and post-HF surveys, while the post-drill survey categorised the site as having 'poor' macroinvertebrate community health (Table 3). The score recorded in the pre-drill survey was significantly higher (Stark 1998) than the post-drill survey, while there were no other significant differences between surveys at this site. All scores were not significantly different (Stark 1998) from the median MCI score of 83 units for small hill country streams at similar altitude (Table 4).

$SQMCI_S$ scores of 4.3, 3.5 and 4.2 were recorded in the pre-drill, post-drill and post-HF surveys respectively. There are no significant differences (Stark 1998) between these scores.

Site 3 –WTR000745

A moderate macroinvertebrate community richness of 18 taxa was recorded at this 'secondary impact' site in the pre-drill survey. The post-drill survey recorded a moderate richness of 15 taxa, while the post-HF survey recorded a moderate richness of 17 taxa. The macroinvertebrate community in the pre-drill survey was characterised by three 'tolerant' taxa [oligochaete worms, mud snail (*Potamopyrgus*) and seed shrimp (Ostracoda)] and two 'moderately sensitive taxa [amphipod (Paraleptamphopidae) and mayfly (*Zephlebia* group)] (Table 5). The post-drill survey community was characterised by only one 'tolerant' taxon [mud snail (*Potamopyrgus*)] (Table 6). The post HF survey community was again characterised by only one taxon, this time the 'moderately sensitive' taxon [amphipod (Paraleptamphopidae)].

MCI scores of 91, 82 and 78 were recorded in the three surveys respectively, categorising the site as having 'fair' macroinvertebrate community health in the pre-drill and post-drill surveys and 'poor' macroinvertebrate community health in the post-HF survey (Table 3). The score recorded in the pre-drill survey was significantly higher (Stark 1998) than recorded in the post-HF survey, while there were no other significant differences between surveys at this site. All scores were also not significantly different (Stark 1998) from the median MCI score of 83 units for small hill country streams at similar altitude (Table 4).

$SQMCI_S$ scores of 4.0, 3.9 and 4.4 were recorded at this site in three surveys respectively. There are no significant differences (Stark 1998) between any of the three surveys at this site.

Discussion and conclusions

The Council's 'kick-sampling' and 'vegetation sweep' techniques were used at three sites on three occasions to collect benthic macroinvertebrates from an unnamed tributary of the Waitara River in relation to stormwater discharges to land and to this unnamed tributary of the Waitara River from the Kowhai-D wellsite. This has provided data to assess any potential impacts the consented discharges have had on the macroinvertebrate communities of the stream. Samples were processed to provide number of taxa (taxa richness), MCI and $SQMCI_s$ scores for each site.

Taxa richness is the most robust index when determining whether a macroinvertebrate community has been exposed to toxic discharges. Macroinvertebrates when exposed to toxic discharges may die and be swept downstream or may deliberately drift downstream as an avoidance mechanism (catastrophic drift). The MCI is a measure of the overall sensitivity of the macroinvertebrate community to organic pollution in stony streams. It is based on the presence/absence of taxa with varying degrees of sensitivity to environmental conditions. The $SQMCI_s$ takes into account relative abundances of taxa as well as sensitivity to pollution. Significant differences in taxa richness, MCI or $SQMCI_s$ between sites may indicate the degree of adverse effects (if any) of the discharge being monitored.

Taxa richnesses were moderate at all sites in the pre-drill survey, and were moderate to moderately low in the post-drill survey. The post-HF survey again recorded moderate to moderately low taxa richnesses. It is worth noting that taxa abundances at site 2 were low on all occasions, with only 'common' and 'rare' taxa recorded.

MCI scores categorised sites as having 'poor or 'fair' macroinvertebrate community health. In the pre-drill survey the score recorded at site 1 was significantly lower than at site 3. The post-drill and post-HF surveys found no significant differences between the three sites. Between surveys, site 1 remained similar, while site 2 recorded a significantly lower score in the post-drill survey than the pre-drill survey, and showed some improvement in the post-HF survey (which was not significantly different from either the pre-drill or post-drill surveys). Site 3 showed a decreasing MCI score over the three surveys, with the post-HF survey result being significantly lower than recorded in the pre-drill survey, and with post-drill score being similar to both the pre-drill and post-HF survey scores.

$SQMCI_S$ scores very low at all sites in all three surveys. Site 1 had had the lowest $SQMCI_S$ score in all three surveys, with difference being significant compared to sites 2 and 3 in the pre-drill and post-drill surveys, and also compared to site 3 in the post-HF survey. The score at site 1 was significantly lower in the post-drill survey compared to both the pre-drill survey and the post-HF survey. The scores at both site 2 and site 3 remained similar between all three surveys.

Overall, the three surveys showed no significant detrimental impacts from the treated stormwater discharges to land and to the unnamed tributary of the Waitara River. The observed results show lower or similar MCI and $SQMCI_S$ scores at site 1, upstream of wellsite discharges, compared to sites 2 and 3 which are downstream of the wellsite discharges. This is likely a result of habitat differences, however if stormwater discharges were causing adverse impacts on this unnamed tributary of the Waitara River, lower results would be expected at sites 2 and 3 compared to site 1 which is not the case in these three surveys. Although decreases in MCI score were noted at all three sites, at site 2 subsequent improvement was recorded, while at site 3 the decline was not significant between any two consecutive surveys.

Summary

Three macroinvertebrate surveys were carried out at three sites near the Kowhai-D wellsite in an unnamed tributary of the Waitara River, in relation to drilling and hydraulic fracturing activities at the wellsite. These surveys, undertaken in February, April and November 2017, recorded moderately low to moderate taxa richnesses. MCI scores ranged from 75-91 across the three surveys, characterising the macroinvertebrate community health as 'poor' or 'fair' on all occasions. Site 2 recorded a significant decrease between the pre-drill and post-drill surveys, but improved slightly in the post-HF survey. Site 3 declined slightly between the pre-drill and post-drill surveys, and again between the post-drill and post-HF survey, resulting in a significant decline between the pre-drill and post-HF surveys. The $SQMCI_S$ scores decreased significantly at site 1, but again subsequent improvement was noted. $SQMCI_S$ scores remained similar at sites 2 and 3 between the three surveys. Overall, these surveys provided no evidence that discharges from the Kowhai-D wellsite have caused any significant detrimental impacts on the macroinvertebrate communities of this unnamed tributary of the Waitara River.

References

Stark JD, 1985: A macroinvertebrate community index of water quality for stony streams. Water and Soil Miscellaneous Publication No. 87.

Stark JD, 1998: SQMCI: a biotic index for freshwater macroinvertebrate coded abundance data. New Zealand Journal of Marine and Freshwater Research 32(1): 55-66.

Stark JD, 1999: An evaluation of Taranaki Regional Council's SQMCI biomonitoring index. Cawthron Institute, Nelson. Cawthron Report No. 472.

Stark JD, Boothroyd IKG, Harding JS, Maxted JR, Scarsbrook MR, 2001: Protocols for sampling macroinvertebrates in wadeable streams. New Zealand Macroinvertebrate Working Group Report No. 1. Prepared for the Ministry for the Environment. Sustainable Management Fund Project No. 5103. 57p.

Stark JD and Fowles CR, 2009: Relationships between MCI, site altitude, and distance from source for Taranaki ring plain stream. Prepared for Taranaki Regional Council. Stark Environmental Report No. 2009-01. 47p.

TRC, 2016: Some statistics from the Taranaki Regional Council database (Esam) of freshwater macroinvertebrate surveys performed during the period from January 1980 to 30 September 2016.

Winterbourn MJ, Gregson KLD, Dolphin CH, 2006. Guide to the aquatic insects of New Zealand. [4th edition]. Bulletin of the Entomological Society of New Zealand 14, 108p.