Greymouth Petroleum Ltd
Turangi-A Hydraulic Fracturing
Monitoring Programme
2017-2018

Technical Report 19-03

Taranaki Regional Council
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Executive summary

Greymouth Petroleum Ltd (GPL) operates the Turangi-A hydrocarbon exploration site located on Turangi Road, Motunui. The wellsite lies within the Parahaki Catchment and contains hydrocarbon producing wells and associated infrastructure. 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 Council in relation to the hydraulic fracturing activities conducted by GPL at the Turangi-A wellsite over the period 30 June 2017 to 14 August 2017.

The programme of hydraulic fracturing undertaken by GPL at the Turangi-A wellsite included the hydraulic fracturing of one well. The well targeted for stimulation was the Turangi-3 well.

During the monitoring period, GPL 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 and biomonitoring surveys carried out to assess the impact of any site discharges during the fracturing programme on an unnamed tributary of the Parahaki Catchment. 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 Turangi-A wellsite.

The monitoring carried out by the Council indicates that the hydraulic fracturing activities undertaken by GPL 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 GPL in relation to these activities or provisions in regional plans, during the period under review.

GPL 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 Turangi-A wellsite.

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1 Introduction

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 Greymouth Petroleum Ltd (GPL) at the Turangi-A wellsite, over the period 30 June 2017 to 14 August 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 GPL at the Turangi-A wellsite included the hydraulic fracturing of one well. The well targeted for stimulation was the Turangi-3 well.

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 Turangi-A 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 Turangi-A.

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 Turangi-A 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 Turangi-A wellsite and hydraulic fracturing activities

The Turangi-A wellsite is located on Turangi Road, Motunui and lies within the Parahaki Catchment. An unnamed tributary of the Parahaki Stream is located approximately 80 m to the east of the wellsite and the main channel of the Parahaki Stream is located approximately 50 m to the west 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. One well (Turangi-3) was stimulated on two occasions during the hydraulic fracturing programme undertaken at the Turangi-A wellsite. A summary of the hydraulic fracturing activities is provided below in Table 1.

Table 1 Summary of hydraulic fracturing activities

Well	Bore id.	Fracturing date		Injection zone (m TVDss)	Formation
		Start	End		
Turangi-3	GND2106	30/06/17	30/06/17	3,957 to 3,995 3,961 to 3,963	Mangahewa
		14/08/17	14/08/17	3,657 to 3,660	Mangahewa

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

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

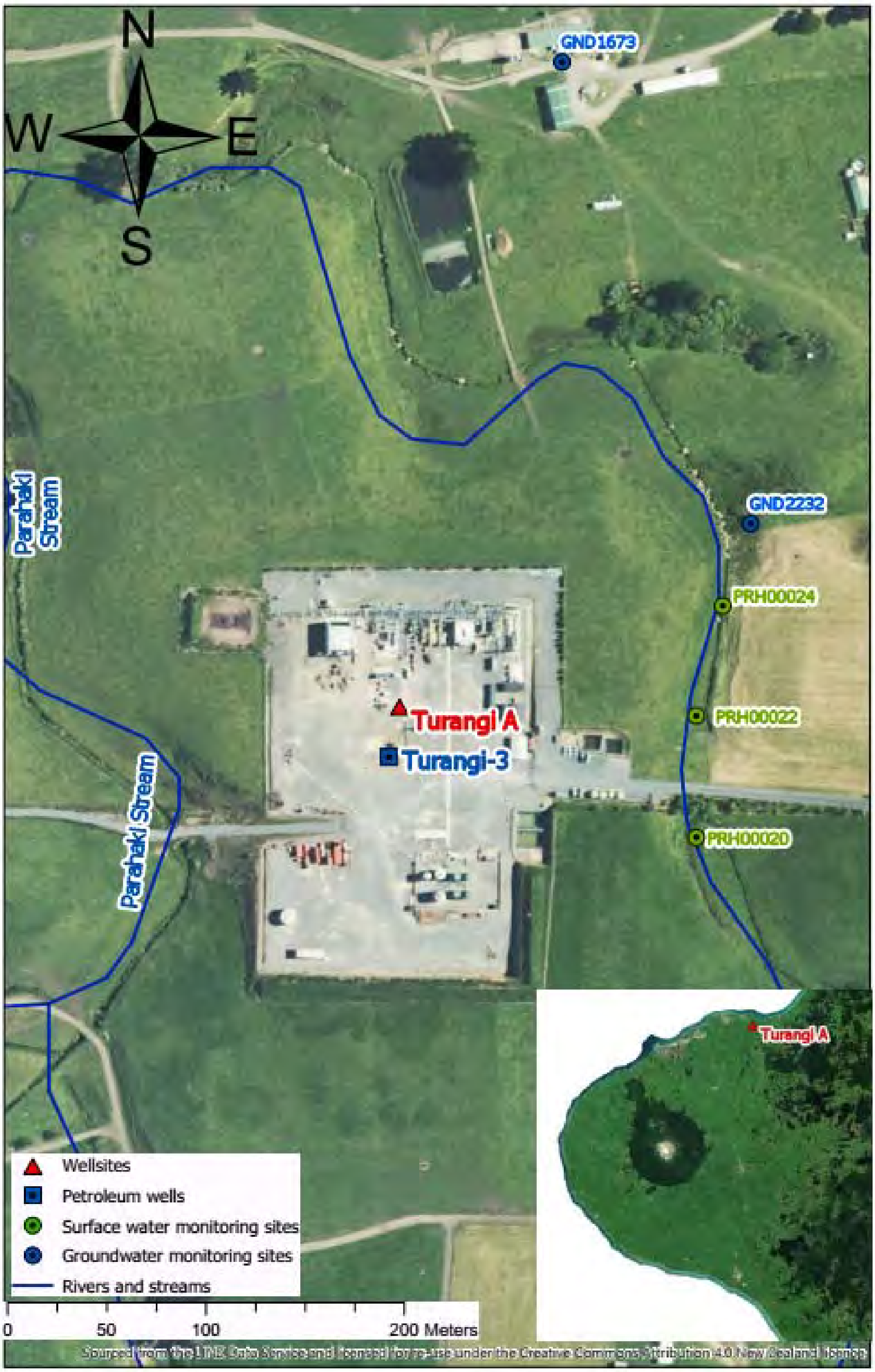

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Figure 1 Location map

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.

GPL was granted resource consent **10000-1** on 30 October 2014. The consent permits the discharge of contaminants in association with hydraulic fracturing activities at the Turangi-A wellsite. The consent was issued by the Council under Section 87(e) of RMA and requires the injection of fracturing fluids to occur below a depth of 3,350 m TVDss. The consent is due to expire 1 June 2028.

Consent 10000-1 has 18 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 2022;
- Condition 3 requires the consent holder to ensure that the exercising of the consent does not result in any contaminants reaching any useable freshwater (ground or surface water);
- Conditions 4, 5, 6 and 7 relate to freshwater monitoring requirements, to allow compliance with condition 3 to be assessed;
- Condition 8 requires the consent holder to carry out pressure testing of equipment prior to discharging;
- Condition 9 requires the consent holder to submit a pre-fracturing discharge report prior to any discharge occurring;
- Condition 10 is a notification requirement;
- Condition 11 requires the consent holder to submit a post-fracturing discharge report after the completion of the hydraulic fracturing programme for each well;
- Condition 12 stipulates the requirements for interim post fracturing reports;
- Condition 13 stipulates how the reports required by conditions 9, 11 and 12 are to be submitted;
- Condition 14 requires the consent holder to allow the Council access to a location where samples of hydraulic fracturing and return fluids can be obtained;
- Condition 15 requires the consent holder to adopt best practicable options;
- Condition 16 relates to the composition of the fracturing fluid;
- Condition 17 is a lapse clause; and
- Condition 18 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 Turangi-A 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 10000-1, GPL 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

As a generally accepted rule, all existing bores or wells within a 1 km radius of the proposed hydraulic fracturing activity are assessed for their suitability for sampling (or otherwise) in the monitoring programme. Two groundwater monitoring sites (GND2232 and GND1673) were found within 1 km of the wellsite. One of the sites identified (GND1673) was deemed suitable for inclusion in the groundwater monitoring programme. The other (GND2232) was excluded from the programme as the well is very shallow (~2.5 m deep) and up-gradient of the surface water drainage from the site. Groundwater quality at this site is also already regularly monitored by the Council as part of GPL’s deep well injection monitoring programme. The location of the both groundwater monitoring sites is displayed in Figure 1.

Bore details for GND1673, the only groundwater monitoring site included in the Turangi-A Hydraulic Fracturing monitoring programme, are summarised in Table 2.

Table 2 Details of groundwater sites included in the monitoring programme

Monitoring site	Easting	Northing	Distance from wellsite (m)	Total depth (m)	Screened/open interval (m)	Aquifer
GND1673	5681723	1713925	285	42	26-42	Marine terraces

Samples of groundwater were obtained pre-fracturing to provide a baseline reference of groundwater composition, with further rounds of sampling carried out three months and one year after commencement 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 GPL or a third party on behalf of GPL during the activity and were sent to Hill Laboratories Ltd for analysis.

1.4.4.3 Surface water quality monitoring

An unnamed tributary of the Parahaki Stream is located 80 m east of the site and the main channel of the Parahaki Stream is located 50 m to the west of the site (Figure 1).

Monitoring 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	Easting	Northing
PRH00020	Unnamed tributary of the Parahaki Stream	188 m downstream of GND2106	1714011	5681322
PRH00022	Unnamed tributary of the Parahaki Stream	30 m downstream of PRH00020	1714002	5681392
PRH00024	Unnamed tributary of the Parahaki Stream	37 m downstream of PRH00022	1714012	5681446

1.4.5 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 Parahaki Stream. 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 biological survey was carried out following hydraulic fracturing (HF) activities at the Turangi-A wellsite. A pre-HF survey was not carried out as the regular biomonitoring of Turangi Production Station (which is undertaken at the same sites) had been undertaken less than three months prior and was therefore used to provide baseline data for the activity.

2 Results

2.1 Consent holder submitted data

2.1.1 Turangi-3 post-fracturing discharge report

The conclusions from the Turangi-3 post-fracturing discharge report are summarised as follows:

- Interval one was fractured on 30 June 2017 at a depth of 3,957-3,995 and 3,961-3,963 m TVDss.
- Interval two was fractured on 14 August 2017 at a depth of 3,657-3,660 m TVDss.
- A total of 2,929 bbls (466 m^3) of liquid was discharged across the two fractured zones (Interval one 1,408 bbls and Interval two 1,521 bbls)
- The Turangi-3 well zones were opened for flow-back following the completion of each fracture with 1,279 bbls returned from Interval one and 1,521 bbls from Interval two.
- A slightly lower volume of fluid than that injected was returned during the initial flow back of Interval one and all fluid injected was returned during the initial flow back of Interval two. Any fluid remaining within the formation after the initial flowback will be brought to the surface during production of the well.
- A total of 47,198 lbs (21.4 tonnes) and 77,164 lbs (35 tonnes) of proppant was pumped into Interval one and interval two respectively.
- All proppant injected remained within the formation.
- There were no screen outs reported and all proppant pumped into the zones remained.
- All return fluid from the Turangi-3 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 GPL 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 were undertaken at the Turangi-A wellsite on 30 June 2017 and 14 August 2017. A pre-fracturing baseline sample was collected on 24 April 2017. Post-fracturing samples were collected three months and one year following commencement of the hydraulic fracturing activities on 5 October 2017 and 3 July 2018 respectively.

Methane concentrations >1 gm^3 were reported in the post hydraulic fracturing samples. The presence of methane alone is of little or no concern when not accompanied by additional hydrocarbons and/or increased chloride concentrations. Nonetheless to determine whether the source of the methane is biogenic or thermogenic samples were sent to Geological and Nuclear Sciences (GNS) for carbon 13 isotope analysis. The presence of carbon 13 isotopes at concentrations less than -50‰ indicate the methane is from a thermogenic deep gas source and concentrations greater than -50‰ a shallow biogenic gas source. Carbon 13 concentrations in both samples analysed indicated that the source of methane in the groundwater was biogenic and within the expected ranges for shallow groundwater resources across Taranaki.

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 Turangi-3 fracturing event

Parameter	**Bore id**	**GND1673**		
	Unit	**Pre-frac (baseline)**	**3 mth post frac**	**1 year post frac**
Sample date	**-**	**24/04/2017**	**05/10/2017**	**3/07/2018**
Lab number (Hill)	**-**	**1763761**	**1856042**	**2009942**
pH	pH	7.5	7.2	7.4
Total alkalinity	g/m^3 CaCO$_3$	142	144	150
Bicarbonate	g/m^3 HCO$_3$	173	175	182
Total hardness	g/m^3 CaCO$_3$	89	92	89
Electrical conductivity	mS/m	31.5	31.9	33.3
Total dissolved solids	g/m^3	210	220	196
Dissolved calcium	g/m^3	19.2	19.4	19.6
Chloride	g/m^3	15.4	15.4	15.1
Dissolved magnesium	g/m^3	9.9	10.6	9.8
Dissolved potassium	g/m^3	5.1	5.4	5.5
Dissolved sodium	g/m^3	29	32	30
Nitrite nitrogen	g/m^3 N	<0.002	<0.002	<0.002
Nitrate nitrogen	g/m^3 N	<0.002	<0.002	<0.002
Nitrate & nitrite nitrogen	g/m^3 N	<0.002	<0.002	<0.002
Sulphate	g/m^3	<0.5	<0.5	<0.5
Dissolved barium	mg/kg	0.022	0.023	0.023
Dissolved bromine	g/m^3	0.056	-	-
Bromide	g/m^3	-	0.06	0.08
Dissolved copper	g/m^3	<0.0005	0.0011	<0.0005
Dissolved iron	g/m^3	8.1	7.8	7
Dissolved manganese	g/m^3	0.186	0.194	0.189
Dissolved mercury	g/m^3	<0.00008	<0.00008	<0.00008
Dissolved Nickel	mg/kg	<0.0005	0.0008	0.0009
Dissolved zinc	g/m^3	0.0048	0.038	0.026
Ethylene glycol	g/m^3	<4	<4	<4
Propylene glycol	g/m^3	<4	<4	<4
Methanol	g/m^3	<2	<2	<2
Benzene	g/m^3	<0.0010	<0.0010	<0.0010
Toluene	g/m^3	<0.0010	<0.0010	<0.0010
Ethylbenzene	g/m^3	<0.0010	<0.0010	<0.0010
m-Xylene	g/m^3	<0.002	<0.002	<0.002
o-Xylene	g/m^3	<0.0010	<0.0010	<0.0010
Formaldehyde	g/m^3	<0.02	<0.02	<0.02
Ethane	g/m^3	<0.003	<0.003	<0.003

Parameter	Bore id	GND1673		
	Unit	Pre-frac (baseline)	3 mth post frac	1 year post frac
Sample date	-	**24/04/2017**	**05/10/2017**	**3/07/2018**
Lab number (Hill)	-	**1763761**	**1856042**	**2009942**
Ethylene	g/m^3	<0.004	<0.003	<0.004
Methane	g/m^3	0.66	5.3	7.5
C7-C9	g/m^3	<0.06	<0.06	<0.06
C10-C14	g/m^3	<0.2	<0.2	<0.2
C15-C36	g/m^3	<0.4	<0.4	<0.4
Total hydrocarbons	g/m^3	<0.7	<0.7	<0.7
δ13C value*	‰ (-)	-	68	70.7

*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 Turangi-3 well are shown below in Table 5. The certificates of analysis are included in Appendix III.

The results of the analyses carried out on the return fluid samples obtained following the hydraulic fracturing of the Turangi-3 well are summarised below in Table 6 and certificates of analysis are included in Appendix III. Return fluids were collected during flow back of each interval. 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	Turangi-3 (GND2106)	
Reference	-	Zone 1	Zone 2
Sample date	Unit	30/06/2017	14/08/2017
Lab number	Hill	1803488	1829055
Ethylene glycol	g/m^3	<20	<20
Propylene glycol	g/m^3	<20	<20
Methanol	g/m^3	<20	<20
Benzene	g/m^3	0.026	0.0028
Toluene	g/m^3	0.046	0.0068
Ethylbenzene	g/m^3	0.0033	0.0012
m-Xylene	g/m^3	0.016	0.003
o-Xylene	g/m^3	0.0053	0.0018
C7-C9	g/m^3	1.17	0.48
C10-C14	g/m^3	740	320
C15-C36	g/m^3	1,080	530
Total hydrocarbons	g/m^3	1,820	850

Table 6 Results of hydraulic fracturing return fluid sampling

Parameter	Bore id	Turangi-3 (GND2106)	
Reference	Unit	Zone 1	Zone 2
Lab number	Hill	1806605	1829056
pH	pH	6.9	6.9
Total alkalinity	g/m^3 $CaCO_3$	530	3,100
Bicarbonate	g/m^3 HCO_3	530	3,310
Total hardness	g/m^3 $CaCO_3$	250	90
Electrical conductivity	mS/m	912	1,240
Total dissolved solids	g/m^3	6,400	10,400
Dissolved barium	mg/kg	9	34
Dissolved bromine	g/m^3	6.4	5.4
Dissolved calcium	g/m^3	84	26
Dissolved copper	g/m^3	0.0061	0.01
Dissolved iron	g/m^3	4.3	3.6
Dissolved magnesium	g/m^3	10.4	6
Dissolved manganese	g/m^3	2.3	1.62
Total Nickel	mg/kg	0.052	<0.03
Total potassium	g/m^3	76	420
Total sodium	g/m^3	1,750	2,800
Total sulphur	g/m^3	7.8	41
Total zinc	g/m^3	0.091	0.08
Chloride	g/m^3	2,900	2,400
Nitrite nitrogen	g/m^3 N	<0.2	0.27
Nitrate nitrogen	g/m^3 N	<0.2	0.11
Nitrate & nitrite nitrogen	g/m^3 N	<0.2	0.38
Sulphate	g/m^3	23	124
Ethylene glycol	g/m^3	<20	<20

Parameter	Bore id	Turangi-3 (GND2106)	
Reference	**Unit**	**Zone 1**	**Zone 2**
Lab number	**Hill**	**1806605**	**1829056**
Propylene glycol	g/m^3	<20	<20
Methanol	g/m^3	180	51
Benzene	g/m^3	13.3	35
Toluene	g/m^3	15.3	106
Ethylbenzene	g/m^3	1.39	17.9
m-Xylene	g/m^3	7.9	117
o-Xylene	g/m^3	2.5	33
Formaldehyde	g/m^3	0.17	0.26
C7-C9	g/m^3	76	1,050
C10-C14	g/m^3	440	800
C15-C36	g/m^3	670	1,040
Total hydrocarbons	g/m^3	1,190	2,900

2.3 Biomonitoring surveys

A macroinvertebrate survey was carried out at three sites in an unnamed tributary of the Parahaki Stream near the Turangi-A wellsite (Figure 2) to determine if discharges from the Production Station had detrimental effects on the stream macroinvertebrate communities.

The unnamed tributary of the Parahaki Stream recorded moderately low taxa richnesses and low $SQMCI_s$ scores. MCI scores categorised all sites as having 'poor' macroinvertebrate community health, but the MCI scores were generally similar to those recorded in Taranaki lowland coastal streams. Observed minor differences in invertebrate metrics between sites are likely related to minor habitat variation between sites. Overall, the results of this survey provide no evidence that discharges from the Turangi-A wellsite have had any significant detrimental impacts on the stream macroinvertebrate communities.

The biomonitoring full report is included in 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 GPL. 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 GPL's conditions in resource consents or provisions in Regional Plans.

Figure 2 Location of biomonitoring sites in relation to the Production Station

3 Discussion

3.1 Environmental effects of exercise of consents

One well (Turangi-3) was stimulated by hydraulic fracturing at the Turangi-A wellsite during the period 30 June to 14 August 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 260 m north of the Turangi-A wellsite. The results of post fracturing groundwater sampling carried out showed only very minor variations in water composition in comparison to baseline results. Methane was reported in all the groundwater samples collected. Further analysis indicated the source of the methane was biogenic. 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 two biomonitoring surveys of an unnamed tributary of the Parahaki Catchment pre and post-fracturing of the Turangi-3 well. The results of the biomonitoring surveys undertaken in relation to the fracturing event indicate that the site activities had no adverse effects on the 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 GPL at the Turangi-A 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 10000-1

Purpose ***To discharge water based hydraulic fracturing fluids into land at depths greater than 3,350 mTVDss beneath the Turangi-A wellsite at or about (NZTM) 1713843E-5681398N***		
Condition requirement	**Means of monitoring during period under review**	**Compliance achieved?**
1. Any discharge shall occur below 3,350 mTVDss	Assessment of consent holder submitted data	Yes
2. No discharge shall occur after 1 June 2022	Assessment of consent holder submitted data	N/A
3. Exercise of consent shall not result in any contaminants reaching any useable freshwater	Results of groundwater monitoring	Yes
4. Consent holder shall undertake sampling programme	Development and certification of a monitoring programme	Yes
5. 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 3,350 mTVDss beneath the Turangi-A wellsite at or about (NZTM) 1713843E-5681398N*		
Condition requirement	**Means of monitoring during period under review**	**Compliance achieved?**
6. Sampling programme shall follow recognised field procedures and be analysed for a specified range of chemical parameters	Development and certification of a monitoring programme and assessment of results	Yes
7. All sampling to be carried out in accordance with a certified Sampling and Analysis Plan	Development and certification of a Sampling and Analysis Plan	Yes
8. Well and equipment pressure testing to be carried out prior to any hydraulic fracturing programme commencing	Assessment of consent holder submitted data	Yes
9. A pre-fracturing discharge report is to be provided to the Council 14 days prior to discharge	Pre-fracturing discharge report received	Yes
10. Consent holder shall notify the Council of hydraulic fracturing discharge	Notification received	Yes
11. A post-fracturing discharge report is to be provided to the Council within 90 days of any commencement	Post-fracturing discharge report received	Yes
12. 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 11	Interim post-fracturing report received	NR
13. The reports outlined in conditions 9 and 11 must be emailed to consents@trc.govt.nz	Reports received via email	Yes
14. 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	NR (GPL undertake sampling)
15. Consent holder to adopt best practicable option at all times	Site inspections, sampling and assessment of consent holder submitted data	Yes
16. Fracture fluid composition no less than 95 % water and proppant by volume	Assessment of consent holder submitted data and sampling of fracturing fluid	Yes
17. Lapse clause	Receive notice of exercise of consent	Yes

Purpose *To discharge water based hydraulic fracturing fluids into land at depths greater than 3,350 mTVDss beneath the Turangi-A wellsite at or about (NZTM) 1713843E-5681398N*		
Condition requirement	**Means of monitoring during period under review**	**Compliance achieved?**
18. 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; NR = not required

During the year, GPL 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 GPL be replicated for any future fracturing events at the Turangi-A 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 10000-1 provides for an optional review of the consent in June 2019. Condition 18 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 15; 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 GPL’s hydraulic fracturing activities be replicated for any future fracturing events at the Turangi-A 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 18 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

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

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

Greymouth Petroleum Ltd (2014) Turangi-3 Pre-Fracturing Discharge Report November 2014 Frodo Number #1851695

Greymouth Petroleum Ltd (2017) Turangi-A Water Quality Monitoring Programme Frodo November 2017 Number #1431396

Greymouth Petroleum Ltd (2017) Turangi-3 Post-Fracturing Discharge Report September 2017 Frodo Number #1937071

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 Limited

(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:	Greymouth Petroleum Limited PO Box 3394 New Plymouth 4341
Decision Date:	30 October 2014
Commencement Date:	30 October 2014

Conditions of Consent

Consent Granted:	To discharge water based hydraulic fracturing fluids into land at depths greater than 3,350 mTVDss beneath the Turangi-A wellsite
Expiry Date:	01 June 2028
Review Date(s):	June annually
Site Location:	Turangi-A wellsite, 126 Turangi Road, Motunui (Property owners: BA & JM McKenzie)
Legal Description:	Sec 21 Blk VI Waitara SD (Discharge source & site)
Grid Reference (NZTM)	1713843E-5681398N
Catchment:	Parahaki

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

General condition

a. The consent holder shall pay to the Taranaki Regional Council 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 3,350 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 2022.

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

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

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

5. 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.

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

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

Note: *The samples required, under conditions 4 and 6 could be taken and analysed by the Taranaki Regional Council or other contracted party on behalf of the consent holder.*

7. All sampling and analysis shall be undertaken in accordance with a *Sampling and Analysis Plan*, which shall be submitted to the Chief Executive for review and certification before the first sampling is undertaken. 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 3.

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

8. The consent holder shall undertake well and equipment pressure testing prior to any hydraulic fracture programme on a given well to ensure any discharge will not affect the integrity of the well and hydraulic fracturing equipment.

9. Any hydraulic fracture discharge shall only occur after the consent holder has provided a comprehensive 'Pre-fracturing Discharge Report' to the Chief Executive. The report shall be provided at least 14 days before the discharge is proposed to commence and shall detail the hydraulic fracturing programme proposed, including as a minimum:

   (a) the specific well in which each discharge is to occur, the intended fracture interval(s) ('fracture interval' is the discrete subsurface zone to receive a hydraulic fracture treatment), and the duration of the hydraulic fracturing programme;
   (b) the number of discharges proposed and the geographical position (i.e. depth and lateral position) of each intended discharge point;
   (c) the total volume of fracture fluid planned to be pumped down the well, including mini-fracture treatments, and their intended composition, including a list of all contaminants and Material Safety Data Sheets for all the chemicals to be used;
   (d) the monitoring techniques to be used to determine the fate of discharged material;
   (e) the results of the reviews required by condition 15;
   (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 3;
   (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 15.

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

10. The consent holder shall notify the Taranaki Regional Council of 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 9, 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.

11. Subject to condition 12, within 90 days of any commencement date as advised under condition 10, 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 6(a) to 6(k), in a return fluid sample taken within the first two hours of flow back, for each fracture interval if flowed back individually, or for the well if flowed back with all intervals comingled;
    (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 8 and the top-hole pressure (psi), slurry rate (bpm), surface proppant concentration (lb/gal), bottom hole proppant concentration (lb/gal), and calculated bottom hole pressure (psi), as well as predicted values for each of these parameters; prior to, during and after each hydraulic fracture treatment;
    (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 3; and
    (l) results of the monitoring referred to in condition 9(d);
    (m) an assessment of the effectiveness of the mitigation measures in place with specific reference to those described in the application for this consent.

12. For programs including multiple hydraulic fracturing discharges, more than one 'Post-fracturing discharge report' may be required in order to meet the specified 90 day deadline from each commencement date. In these situations the consent holder shall submit a subsequent 'Post-fracturing Discharge Report' to the Chief Executive within 90 days of the previous report submitted.

13. The reports described in conditions 9 and 11 shall be emailed to consents@trc.govt.nz with a reference to the number of this consent.

14. 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.

15. 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.

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

17. This consent shall lapse on 1 June 2022, 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.

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

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

    (b) further specifying the best practicable option as required by condition 15; 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 30 October 2014

For and on behalf of
Taranaki Regional Council

A D McLay
Director - Resource Management

Appendix II

Certificates of analysis (groundwater)

Hill Laboratories
TRIED, TESTED **AND TRUSTED**

R J Hill Laboratories Limited
1 Clyde Street Hamilton 3216
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

ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1763761 SPv1
Contact:	Regan Phipps	**Date Received:**	26-Apr-2017
	C/- Taranaki Regional Council	**Date Reported:**	08-May-2017
	Private Bag 713	**Quote No:**	47915
	Stratford 4352	**Order No:**	
		Client Reference:	GPL Turangi A Pre Frak
		Submitted By:	David Olson

Sample Type: Aqueous

Sample Name:		GND 1673 24-Apr-2017 2:50 pm				
Lab Number:		1763761.1				
Individual Tests						
Sum of Anions	meq/L	3.3	-	-	-	-
Sum of Cations	meq/L	3.5	-	-	-	-
pH	pH Units	7.5	-	-	-	-
Total Alkalinity	g/m^3 as $CaCO_3$	142	-	-	-	-
Bicarbonate	g/m^3 at 25°C	173	-	-	-	-
Total Hardness	g/m^3 as $CaCO_3$	89	-	-	-	-
Electrical Conductivity (EC)	mS/m	31.5	-	-	-	-
Total Dissolved Solids (TDS)	g/m^3	210	-	-	-	-
Dissolved Barium	g/m^3	0.022	-	-	-	-
Dissolved Bromine*	g/m^3	0.056	-	-	-	-
Dissolved Calcium	g/m^3	19.2	-	-	-	-
Dissolved Copper	g/m^3	< 0.0005	-	-	-	-
Dissolved Iron	g/m^3	8.1	-	-	-	-
Dissolved Magnesium	g/m^3	9.9	-	-	-	-
Dissolved Manganese	g/m^3	0.186	-	-	-	-
Dissolved Mercury	g/m^3	< 0.00008	-	-	-	-
Dissolved Nickel	g/m^3	< 0.0005	-	-	-	-
Dissolved Potassium	g/m^3	5.1	-	-	-	-
Dissolved Sodium	g/m^3	29	-	-	-	-
Dissolved Zinc	g/m^3	0.0048	-	-	-	-
Chloride	g/m^3	15.4	-	-	-	-
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	-	-	-	-

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 1673 24-Apr-2017 2:50 pm				
Lab Number:		1763761.1				
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m^3	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m^3	< 0.003	-	-	-	-
Ethylene	g/m^3	< 0.004	-	-	-	-
Methane	g/m^3	0.66	-	-	-	-
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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Peter Robinson MSc (Hons), PhD, FNZIC
Client Services Manager - Environmental

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Certificate of Analysis

Client:	Taranaki Regional Council	**Lab No:**	2009942 SPv1
Contact:	Jane Harvey	**Date Received:**	04-Jul-2018
	C/- Taranaki Regional Council	**Date Reported:**	11-Jul-2018
	Private Bag 713	**Quote No:**	47915
	Stratford 4352	**Order No:**	72793
		Client Reference:	Turangi A 1yr GW
		Submitted By:	Sarah Larkin

Sample Type: Aqueous

Sample Name:		GND 1673 182803 03-Jul-2018 10:35 am				
Lab Number:		2009942.1				
Individual Tests						
Sum of Anions	meq/L	3.4	-	-	-	-
Sum of Cations	meq/L	3.5	-	-	-	-
pH	pH Units	7.4	-	-	-	-
Total Alkalinity	g/m^3 as $CaCO_3$	150	-	-	-	-
Bicarbonate	g/m^3 at 25°C	182	-	-	-	-
Total Hardness	g/m^3 as $CaCO_3$	89	-	-	-	-
Electrical Conductivity (EC)	mS/m	33.3	-	-	-	-
Total Dissolved Solids (TDS)	g/m^3	196	-	-	-	-
Sample Temperature*	°C	15.8	-	-	-	-
Dissolved Barium	g/m^3	0.023	-	-	-	-
Dissolved Calcium	g/m^3	19.6	-	-	-	-
Dissolved Copper	g/m^3	< 0.0005	-	-	-	-
Dissolved Iron	g/m^3	7.0	-	-	-	-
Dissolved Magnesium	g/m^3	9.8	-	-	-	-
Dissolved Manganese	g/m^3	0.189	-	-	-	-
Dissolved Mercury	g/m^3	< 0.00008	-	-	-	-
Dissolved Nickel	g/m^3	0.0009	-	-	-	-
Dissolved Potassium	g/m^3	5.5	-	-	-	-
Dissolved Sodium	g/m^3	30	-	-	-	-
Dissolved Zinc	g/m^3	0.026	-	-	-	-
Bromide	g/m^3	0.08	-	-	-	-
Chloride	g/m^3	15.1	-	-	-	-
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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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 1673 182803 03-Jul-2018 10:35 am				
Lab Number:		2009942.1				
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	< 0.003	-	-	-	-
Ethylene	g/m^3	< 0.004	-	-	-	-
Methane	g/m^3	7.5	-	-	-	-
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	-	-	-	-

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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ANALYSIS REPORT

Client:	Taranaki Regional Council	**Lab No:**	1856042 SPv1
Contact:	David Olson	**Date Received:**	06-Oct-2017
	C/- Taranaki Regional Council	**Date Reported:**	19-Oct-2017
	Private Bag 713	**Quote No:**	47915
	Stratford 4352	**Order No:**	67235
		Client Reference:	GPL Turangi A 3 Month Post Frac
		Submitted By:	David Olson

Sample Type: Aqueous

	Sample Name:	GND1673 05-Oct-2017 12:00 pm				
	Lab Number:	1856042.1				
Individual Tests						
Sum of Anions	meq/L	3.3	-	-	-	-
Sum of Cations	meq/L	3.7	-	-	-	-
pH	pH Units	7.2	-	-	-	-
Total Alkalinity	g/m^3 as $CaCO_3$	144	-	-	-	-
Bicarbonate	g/m^3 at 25°C	175	-	-	-	-
Total Hardness	g/m^3 as $CaCO_3$	92	-	-	-	-
Electrical Conductivity (EC)	mS/m	31.9	-	-	-	-
Total Dissolved Solids (TDS)	g/m^3	220	-	-	-	-
Dissolved Barium	g/m^3	0.023	-	-	-	-
Dissolved Calcium	g/m^3	19.4	-	-	-	-
Dissolved Copper	g/m^3	0.0011	-	-	-	-
Dissolved Iron	g/m^3	7.8	-	-	-	-
Dissolved Magnesium	g/m^3	10.6	-	-	-	-
Dissolved Manganese	g/m^3	0.194	-	-	-	-
Dissolved Mercury	g/m^3	< 0.00008	-	-	-	-
Dissolved Nickel	g/m^3	0.0008	-	-	-	-
Dissolved Potassium	g/m^3	5.4	-	-	-	-
Dissolved Sodium	g/m^3	32	-	-	-	-
Dissolved Zinc	g/m^3	0.038	-	-	-	-
Bromide	g/m^3	0.06	-	-	-	-
Chloride	g/m^3	15.4	-	-	-	-
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:		GND1673 05-Oct-2017 12:00 pm				
Lab Number:		1856042.1				
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde	g/m^3	< 0.02	-	-	-	-
Gases in groundwater						
Ethane	g/m^3	< 0.003	-	-	-	-
Ethylene	g/m^3	< 0.003	-	-	-	-
Methane	g/m^3	5.3	-	-	-	-
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.	-	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

Sample Type: Aqueous			
Test	**Method Description**	**Default Detection Limit**	**Sample No**
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
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 22nd ed. 2012.	0.05 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. 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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Ara Heron BSc (Tech)
Client Services Manager - Environmental

Appendix III

Certificates of analysis (hydraulic fracturing fluids)

Hill Laboratories
TRIED, TESTED **AND TRUSTED**

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W www.hill-laboratories.com

ANALYSIS REPORT

Client:	Greymouth Petroleum Limited	**Lab No:**	1829056 SPv2
Contact:	Skye Loveridge-Easther	**Date Received:**	22-Aug-2017
	C/- Greymouth Petroleum Limited	**Date Reported:**	14-Sep-2017
	14 Connett Road West	**Quote No:**	81870
	Bell Block	**Order No:**	239877
	New Plymouth 4312	**Client Reference:**	Return Fluid Composite
		Submitted By:	Skye Loveridge-Easther

Sample Type: Saline

	Sample Name:	Composite of Tur - 3 - FRAC 2 Start, Tur - 3 - FRAC 2 Middle and Tur - 3 - FRAC 2 End				
	Lab Number:	1829056.4				
Individual Tests						
pH*	pH Units	6.9	-	-	-	-
Total Alkalinity*	g/m^3 as $CaCO_3$	3,100	-	-	-	-
Analysis Temperature for Bicarbonate	°C	23	-	-	-	-
Bicarbonate	g/m^3 at Analysis Temperature	3,310	-	-	-	-
Total Hardness*	g/m^3 as $CaCO_3$	90	-	-	-	-
Electrical Conductivity (EC)*	mS/m	1,240	-	-	-	-
Total Dissolved Solids (TDS)*	g/m^3	10,400	-	-	-	-
Dissolved Barium*	g/m^3	34	-	-	-	-
Dissolved Bromine*	g/m^3	5.4	-	-	-	-
Dissolved Calcium*	g/m^3	26	-	-	-	-
Dissolved Copper*	g/m^3	0.010	-	-	-	-
Dissolved Iron*	g/m^3	3.6	-	-	-	-
Dissolved Magnesium*	g/m^3	6	-	-	-	-
Dissolved Manganese*	g/m^3	1.62	-	-	-	-
Total Nickel*	g/m^3	< 0.03	-	-	-	-
Total Potassium*	g/m^3	420	-	-	-	-
Total Sodium*	g/m^3	2,800	-	-	-	-
Total Sulphur*	g/m^3	41	-	-	-	-
Total Zinc*	g/m^3	0.080	-	-	-	-
Chloride*	g/m^3	2,400	-	-	-	-
Nitrite-N	g/m^3	0.27	-	-	-	-
Nitrate-N	g/m^3	0.11	-	-	-	-
Nitrate*	g/m^3	0.49	-	-	-	-
Nitrate-N + Nitrite-N	g/m^3	0.38	-	-	-	-
Sulphate*	g/m^3	124	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 20	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	< 20	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	51	-	-	-	-

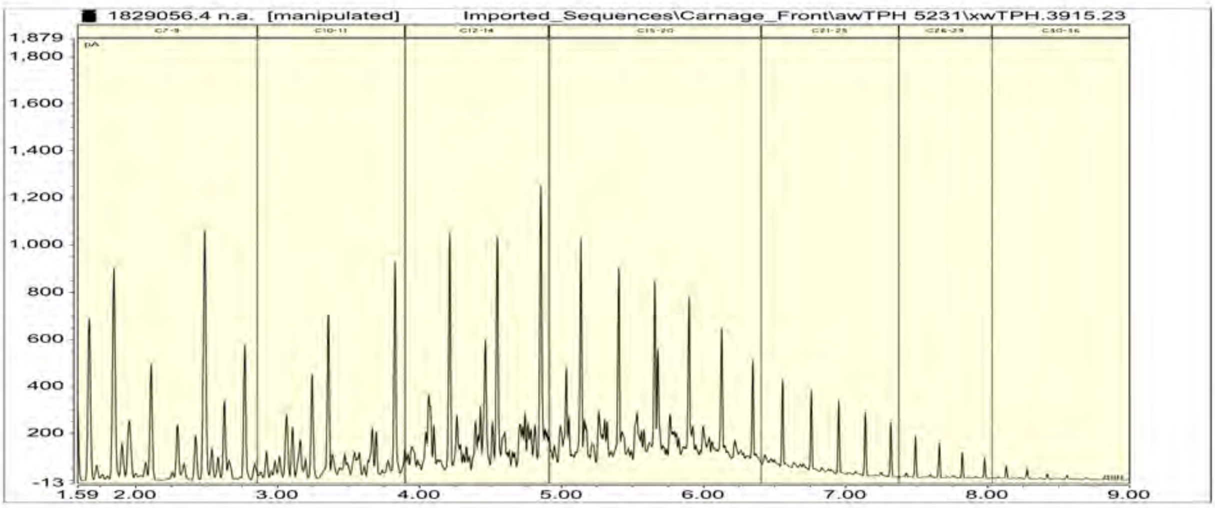
ilac-MRA
IANZ
ACCREDITED LABORATORY

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: Saline

Sample Name:	Composite of Tur - 3 - FRAC 2 Start, Tur - 3 - FRAC 2 Middle and Tur - 3 - FRAC 2 End				
Lab Number:	1829056.4				
BTEX in Water by Headspace GC-MS					
Benzene* g/m³	35	-	-	-	-
Toluene* g/m³	106	-	-	-	-
Ethylbenzene* g/m³	17.9	-	-	-	-
m&p-Xylene* g/m³	117	-	-	-	-
o-Xylene* g/m³	33	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS					
Formaldehyde* g/m³	0.26	-	-	-	-
Total Petroleum Hydrocarbons in Water					
C7 - C9 g/m³	1,050	-	-	-	-
C10 - C14* g/m³	800	-	-	-	-
C15 - C36* g/m³	1,040	-	-	-	-
Total hydrocarbons (C7 - C36) g/m³	2,900	-	-	-	-

1829056.4
Composite of Tur - 3 - FRAC 2 Start, Tur - 3 - FRAC 2 Middle and Tur - 3 - FRAC 2 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.

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. 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
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

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

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W www.hill-laboratories.com

ANALYSIS REPORT

Client:	Greymouth Petroleum Limited	**Lab No:**	1806605 SPv1
Contact:	Skye Loveridge-Easther	**Date Received:**	11-Jul-2017
	C/- Greymouth Petroleum Limited	**Date Reported:**	25-Jul-2017
	14 Connett Road West	**Quote No:**	81870
	Bell Block	**Order No:**	239436
	New Plymouth 4312	**Client Reference:**	Return Fluid Composite
		Submitted By:	Skye Loveridge-Easther

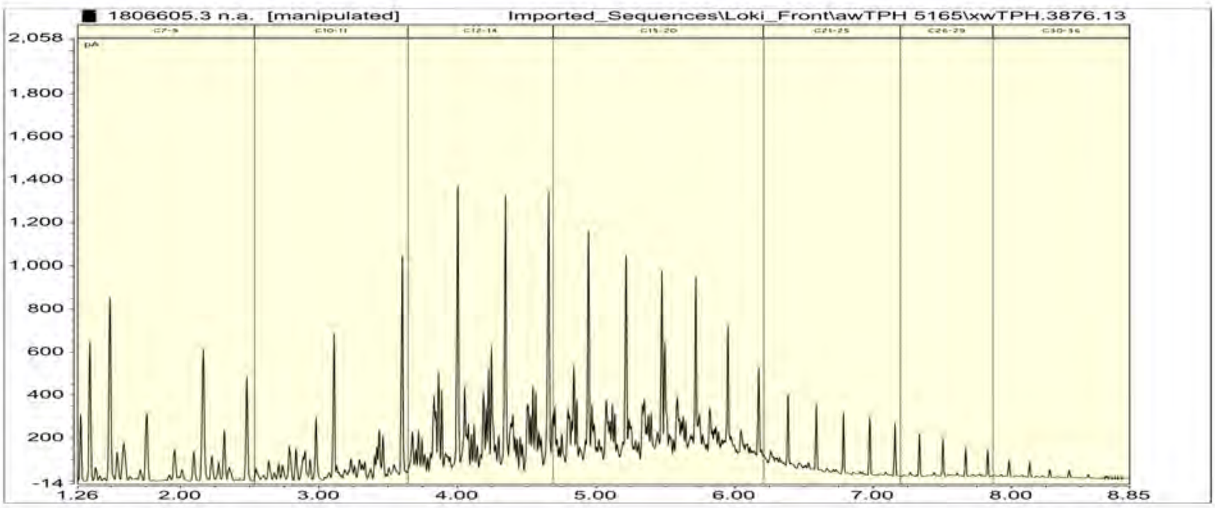
Sample Type: Saline

	Sample Name:	composite of HF return fluid middle and HF return fluid start				
	Lab Number:	1806605.3				
Individual Tests						
pH*	pH Units	6.9	-	-	-	-
Total Alkalinity*	g/m^3 as $CaCO_3$	530	-	-	-	-
Analysis Temperature for Bicarbonate	°C	23	-	-	-	-
Bicarbonate	g/m^3 at Analysis Temperature	530	-	-	-	-
Total Hardness*	g/m^3 as $CaCO_3$	250	-	-	-	-
Electrical Conductivity (EC)*	mS/m	912	-	-	-	-
Total Dissolved Solids (TDS)*	g/m^3	6,400	-	-	-	-
Dissolved Barium*	g/m^3	9.0	-	-	-	-
Dissolved Bromine*	g/m^3	6.4	-	-	-	-
Dissolved Calcium*	g/m^3	84	-	-	-	-
Dissolved Copper*	g/m^3	0.0061	-	-	-	-
Dissolved Iron*	g/m^3	4.3	-	-	-	-
Dissolved Magnesium*	g/m^3	10.4	-	-	-	-
Dissolved Manganese*	g/m^3	2.3	-	-	-	-
Total Nickel*	g/m^3	0.052	-	-	-	-
Total Potassium*	g/m^3	76	-	-	-	-
Total Sodium*	g/m^3	1,750	-	-	-	-
Total Sulphur*	g/m^3	7.8	-	-	-	-
Total Zinc*	g/m^3	0.091 [#1]	-	-	-	-
Chloride*	g/m^3	2,900	-	-	-	-
Nitrite-N	g/m^3	< 0.2 [#2]	-	-	-	-
Nitrate-N	g/m^3	< 0.2	-	-	-	-
Nitrate*	g/m^3	< 0.9	-	-	-	-
Nitrate-N + Nitrite-N	g/m^3	< 0.2 [#2]	-	-	-	-
Sulphate*	g/m^3	23	-	-	-	-
Ethylene Glycol in Water						
Ethylene glycol*	g/m^3	< 20	-	-	-	-
Propylene Glycol in Water						
Propylene glycol*	g/m^3	< 20	-	-	-	-
Methanol in Water - Aqueous Solvents						
Methanol*	g/m^3	1,080	-	-	-	-
BTEX in Water by Headspace GC-MS						
Benzene*	g/m^3	13.3	-	-	-	-
Toluene*	g/m^3	15.3	-	-	-	-
Ethylbenzene*	g/m^3	1.39	-	-	-	-
m&p-Xylene*	g/m^3	7.9	-	-	-	-

Sample Type: Saline

Sample Name:		composite of HF return fluid middle and HF return fluid start				
Lab Number:		1806605.3				
BTEX in Water by Headspace GC-MS						
o-Xylene*	g/m³	2.5	-	-	-	-
Formaldehyde in Water by DNPH & LCMSMS						
Formaldehyde*	g/m³	0.17	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	76	-	-	-	-
C10 - C14*	g/m³	440	-	-	-	-
C15 - C36*	g/m³	670	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	1,190	-	-	-	-

1806605.3
composite of HF return fluid middle and HF return fluid start
Client Chromatogram for TPH by FID



Analyst's Comments

Following a client query and QOWQ# 66752, a registration error was noted. Sample TRC HF Return Fluid End Turangi 3 Zone 1 5/7/17 had not been included in the composite.There was insufficient sample left to remake the composite.

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

#2 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 NO2N, NO3N and NOxN analysis.

Sample 3 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	4 g/m³	3
Propylene Glycol in Water*	Direct injection, dual column GC-FID	4 g/m³	3
Methanol in Water - Aqueous Solvents*	Direct injection, dual column GC-FID	1.0 g/m³	3
BTEX in Water by Headspace GC-MS*	Headspace GC-MS analysis, US EPA 8260B [KBIs:26687,3629]	0.0010 - 0.002 g/m³	3
Formaldehyde in Water by DNPH & LCMSMS*	DNPH derivatisation, extraction, LCMSMS	0.02 g/m³	3

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	3
Filtration, Unpreserved*	Sample filtration through 0.45µm membrane filter.	-	3
Total Digestion*	Boiling nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	3
Total Digestion of Saline Samples*	Nitric acid digestion. APHA 3030 E 22nd ed. 2012 (modified).	-	3
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	3
Total Alkalinity*	Saline water, Titration to pH 4.5.	1.0 g/m^3 as $CaCO_3$	3
Analysis Temperature for Bicarbonate	Temperature at which Bicarbonate titration was conducted as reported by Geological & Nuclear Sciences, Wairakei.	1.0 °C	3
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	3
Total Hardness*	Calculation from Calcium and Magnesium. APHA 2340 B 22nd ed. 2012.	1.0 g/m^3 as $CaCO_3$	3
Electrical Conductivity (EC)*	Conductivity meter, 25°C. APHA 2510 B 22nd ed. 2012.	0.1 mS/m	3
Total Dissolved Solids (TDS)*	Filtration through GF/C (1.2 µm), gravimetric. APHA 2540 C (modified; drying temperature of 103 - 105°C used rather than 180 ± 2°C) 22nd ed. 2012.	50 g/m^3	3
Filtration for dissolved metals analysis*	Sample filtration through 0.45µm membrane filter and preservation with nitric acid. APHA 3030 B 22nd ed. 2012.	-	3
Dissolved Barium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.0006 g/m^3	3
Dissolved Bromine*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.10 g/m^3	3
Dissolved Calcium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.0 g/m^3	3
Dissolved Copper*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	3
Dissolved Iron*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.004 g/m^3	3
Dissolved Magnesium*	Filtered sample, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.4 g/m^3	3
Dissolved Manganese*	Filtered sample, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0010 g/m^3	3
Total Nickel*	Nitric acid digestion, ICP-MS with universal cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.007 g/m^3	3
Total Potassium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	1.1 g/m^3	3
Total Sodium*	Nitric acid digestion, ICP-MS, ultratrace level. APHA 3125 B 22nd ed. 2012.	0.42 g/m^3	3
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	3
Total Zinc*	Nitric acid digestion, ICP-MS with dynamic reaction cell, ultratrace. APHA 3125 B 22nd ed. 2012.	0.0042 g/m^3	3
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	3
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	3
Nitrate-N	Calculation: (Nitrate-N + Nitrite-N) - NO2N. In-House.	0.0010 g/m^3	3
Nitrate*	Calculation from Nitrate-N.	0.010 g/m^3	3
Nitrate-N + Nitrite-N	Saline sample. Total oxidised nitrogen. Automated cadmium reduction, Flow injection analyser. APHA 4500-NO_3^- I 22nd ed. 2012 (modified).	0.002 g/m^3	3
Total Sulphate*	Calculation: from total sulphur.	2 g/m^3	3
C7 - C9	Head Space, GCMS analysis.	0.06 g/m^3	3
C10 - C14*	Solvent extraction, GC-FID analysis. US EPA 8015B/NZ OIEWG.	0.2 g/m^3	3
C15 - C36*	Solvent extraction, GC-FID analysis. US EPA 8015B/NZ OIEWG.	0.4 g/m^3	3

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	3

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

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

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Ara Heron BSc (Tech)
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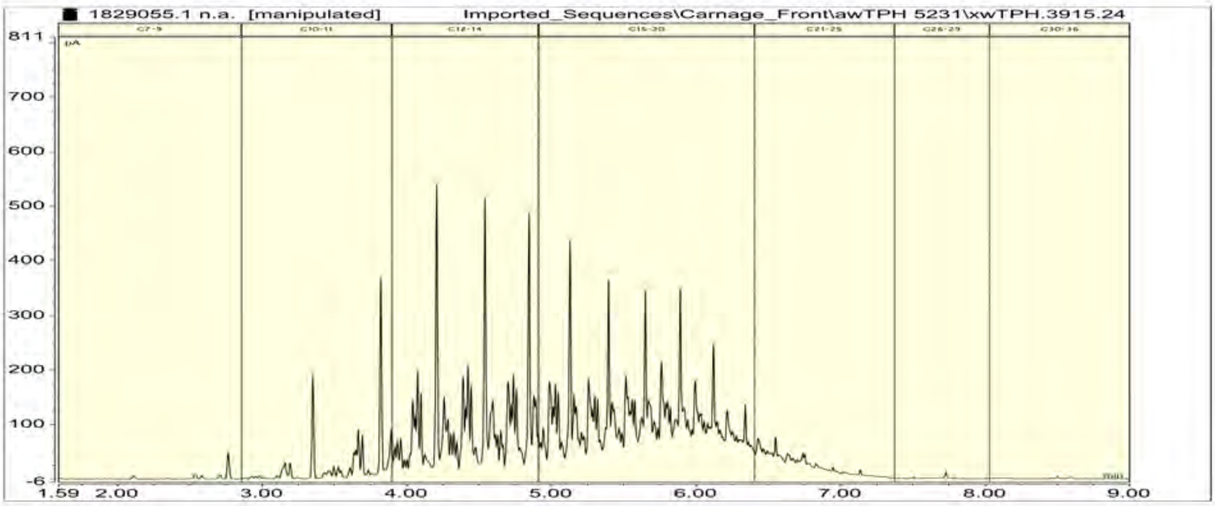
ANALYSIS REPORT

Client:	Greymouth Petroleum Limited	**Lab No:**	1829055 SPv1
Contact:	Skye Loveridge-Easther	**Date Received:**	22-Aug-2017
	C/- Greymouth Petroleum Limited	**Date Reported:**	11-Sep-2017
	14 Connett Road West	**Quote No:**	85159
	Bell Block	**Order No:**	239876
	New Plymouth 4312	**Client Reference:**	Hydraulic fracturing fluid testing
		Submitted By:	Skye Loveridge-Easther

Sample Type: Aqueous

Sample Name:		TUR 3 - FRAC 2 Prepumped HF Fluid 14-Aug-2017 2:03 pm				
Lab Number:		1829055.1				
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	0.0028	-	-	-	-
Toluene	g/m³	0.0068	-	-	-	-
Ethylbenzene	g/m³	0.0012	-	-	-	-
m&p-Xylene	g/m³	0.003	-	-	-	-
o-Xylene	g/m³	0.0018	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	0.48	-	-	-	-
C10 - C14	g/m³	320	-	-	-	-
C15 - C36	g/m³	530	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	850	-	-	-	-

1829055.1
TUR 3 - FRAC 2 Prepumped HF Fluid 14-Aug-2017 2:03 pm
Client Chromatogram for TPH by FID



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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.

Analyst's Comments

The sample was received on the 22/8/17, but it had not liquefied sufficiently to enable pour-offs to be completed until the 25/8/17.

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	Hexane extraction, GC-FID analysis US EPA 8015B/MfE Petroleum Industry Guidelines [KBIs:2803,10734] Analysis performed at 1 Clyde Street, Hamilton	0.06 - 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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Carole Rodgers-Carroll

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

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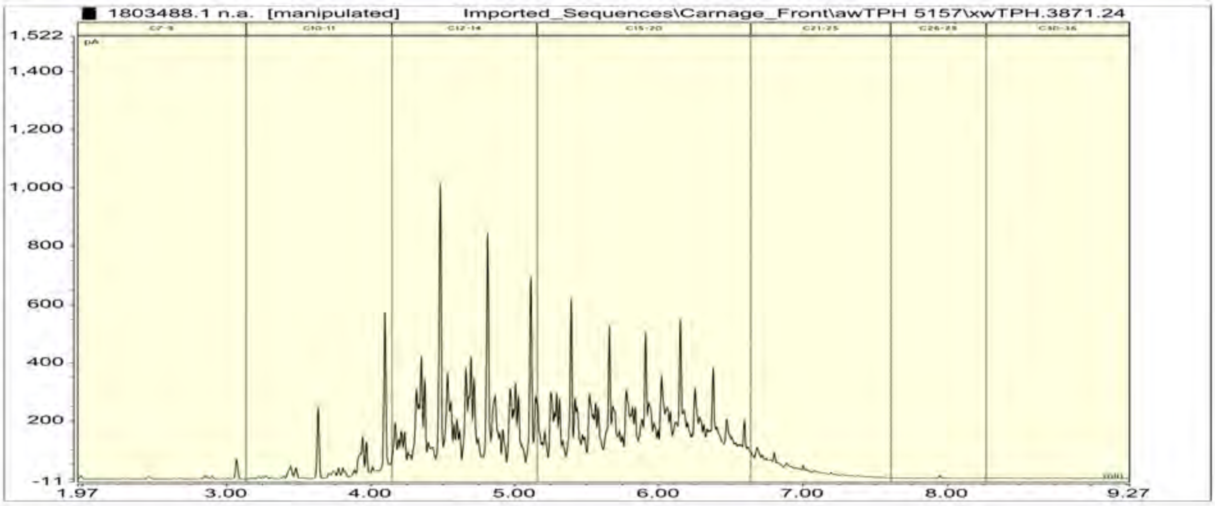
ANALYSIS REPORT

Client:	Greymouth Petroleum Limited	**Lab No:**	1803488 SPv2
Contact:	Skye Loveridge-Easther C/- Greymouth Petroleum Limited 14 Connett Road West Bell Block New Plymouth 4312	**Date Received:**	05-Jul-2017
		Date Reported:	26-Jul-2017
		Quote No:	85159
		Order No:	239436
		Client Reference:	Hydraulic fracturing fluid testing
		Submitted By:	Skye Loveridge-Easther

Sample Type: Aqueous

Sample Name:		Tur-3 Zone 1 Pre-Pumped HF Fluid 30-Jun-2017 5:14 pm				
Lab Number:		1803488.1				
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	0.026	-	-	-	-
Toluene	g/m³	0.046	-	-	-	-
Ethylbenzene	g/m³	0.0033	-	-	-	-
m&p-Xylene	g/m³	0.016	-	-	-	-
o-Xylene	g/m³	0.0053	-	-	-	-
Total Petroleum Hydrocarbons in Water						
C7 - C9	g/m³	1.17	-	-	-	-
C10 - C14	g/m³	740	-	-	-	-
C15 - C36	g/m³	1,080	-	-	-	-
Total hydrocarbons (C7 - C36)	g/m³	1,820	-	-	-	-

1803488.1
Tur-3 Zone 1 Pre-Pumped HF Fluid 30-Jun-2017 5:14 pm
Client Chromatogram for TPH by FID



Analyst's Comments

Supplement to test report 1803488 v1 issued on 24-Jul-2017.

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 Manager, Callum MacKenzie
From	Technical Officer, Katie Blakemore
Document	2008023
Report No	KB030
Date	13 February 2018

Biomonitoring of an unnamed tributary of the Parahaki Stream in relation to hydraulic fracturing at the Turangi-A wellsite, Greymouth Petroleum Ltd, August 2017

Introduction

A biological survey was carried out following hydraulic fracturing (HF) activities at the Turangi-A wellsite, to determine whether stormwater discharges to land near an unnamed tributary of the Parahaki Stream had caused any detrimental effects on the macroinvertebrate communities of this unnamed tributary. A pre-HF survey was not carried out as the regular biomonitoring of Turangi Production Station (which is undertaken at the same sites) had been undertaken less than three months prior to the commencement of HF at this wellsite, and was used to provide baseline data for this HF activity.

Methods

The survey was undertaken on 24 August 2017 at three established sites (Table1, Figure 1). Site 1 was the control site, while site 2 was the primary impact site and site 3 was the secondary impact site.

Table 1 Biomonitoring sites in an unnamed tributary of the Parahaki Stream in relation to the Turangi-A wellsite (which is located on the Turangi Production Station site)

Site number	Site code	Grid reference (NZTM)	Location	Altitude (masl)
1	PRH000020	E1714011 N5681332	Upstream of Turangi Production Station discharge	40
2	PRH000022	E1713999 N5681410	25m downstream of Turangi Production Station discharge	40
3	PRH000024	E1714012 N5681446	100m downstream of Turangi Production Station discharge	40

A combination of 'vegetation sweep' sampling and 'kick-sampling' was to collect streambed macroinvertebrates at three sites in the unnamed tributary of the Parahaki Stream. The 'kick-sampling' and 'vegetation sweep' techniques are very similar to Protocol C1 (hard-bottomed, semi-quantitative) and C2 (soft-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark *et al*, 2001).

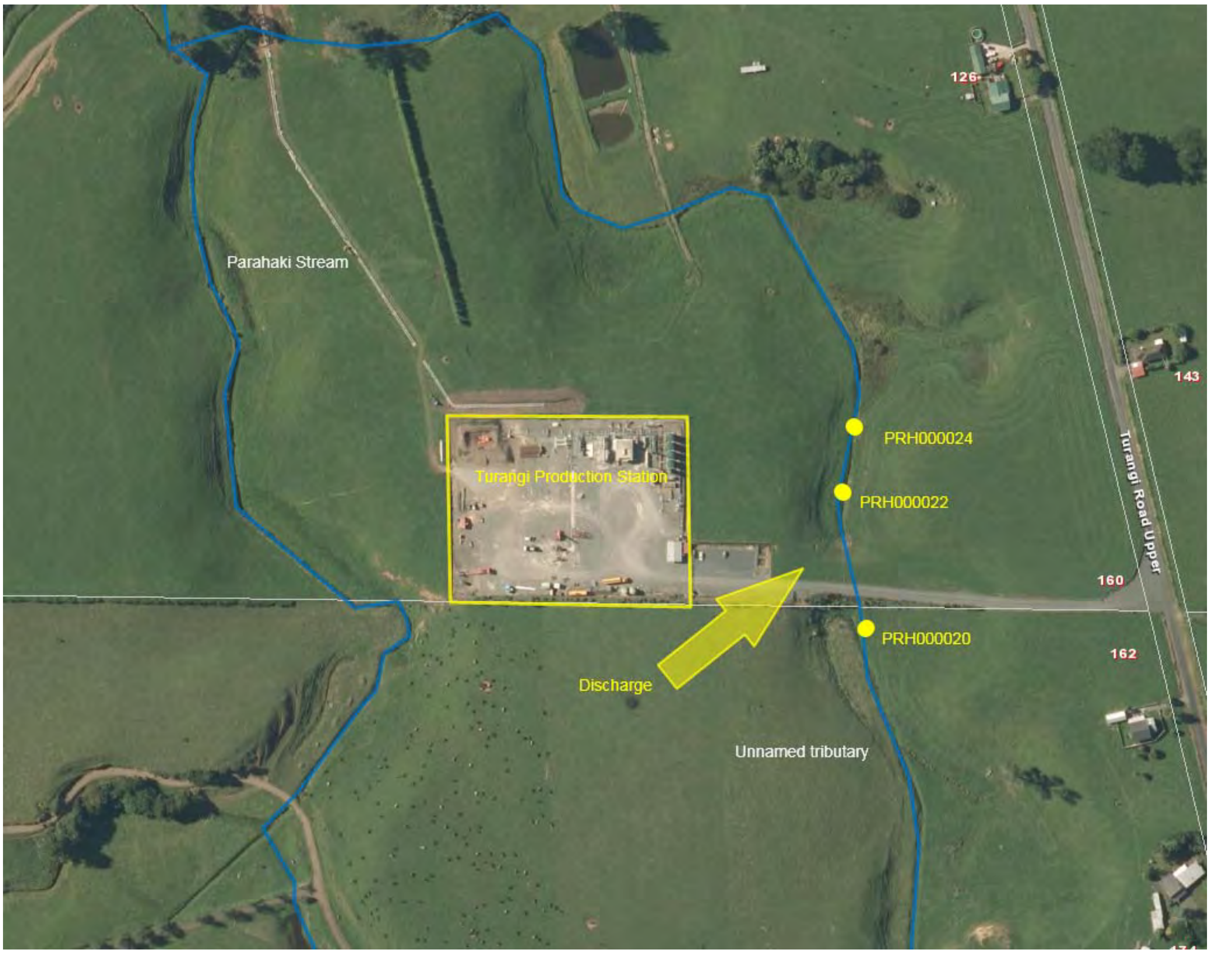

Figure 1 Biomonitoring sites in an unnamed tributary of the Parahaki Stream in relation to the Turangi-A wellsite (located on the Turangi Production Station site)

Samples were preserved with Kahle's Fluid for later sorting and identification under a stereomicroscope according to Taranaki Regional Council methodology using protocol P1 of 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.

Results

The survey was carried out 2 days following a fresh of 3x median flow and 4 days following a fresh of 7x median flow. At the time of the survey, all three sites had a clear and uncoloured, steady moderate flow. The water temperature at the three sites ranged between 14.1 – 14.9°C at the time of this survey.

Macrophytes were present on the stream margins at sites 1 and 2, and on the streambed at site 3. Moss, leaves or wood was absent from the streambed at all three sites. Periphyton mats were absent at all three sites, while filamentous periphyton was patchy (and epiphytic on macrophytes only) at site 1 and absent at sites 2 and 3. Overhanging vegetation and undercut banks were present at all three sites.

Substrate at site 1 was dominated by silt, with sand, fine and coarse gravels, cobble and hard clay also present. At site 2, substrate was dominated by fine and coarse gravels, and hard clay, with smaller amounts of silt, sand cobble and wood/root present. Site 3 had substrate dominated by sand, coarse gravel and hard clay, with smaller amounts of silt and fine gravel also present. Site 1 was observed to have both a silt coating and embedded gravel substrate, both of which were absent from sites 2 and 3.

Macroinvertebrate communities

Seven previous surveys have been undertaken at these sites in relation to petrochemical activities, three in relation to the Turangi-1 wellsite (two in 2005 and one in 2014), as well as four previous surveys in relation to the Turangi Production Station (spring 2015, summer 2016, summer 2017 and autumn 2017). Data from these surveys is summarised in Table 4 for comparative purposes. The results of the current survey are provided in Table 5 and are summarised in Table 4 together with the past results.

Table 4 Summary of previously recorded number of taxa, MCI values and SQMCI$_s$ values together with results from the preceding survey and the current (post-HF) survey

Site	N	Numbers of taxa				MCI values				SQMCI$_s$ values			
		Median	Range	Apr 2017	Current Survey	Median	Range	Apr 2017	Current Survey	Median	Range	Apr 2017	Current Survey
1	7	15	9-25	12	14	68	58-78	58	70	1.4	1.1-2.6	1.5	1.2
2	7	17	14-25	17	14	71	59-79	71	74	1.6	1.1-2.5	1.6	2.1
3	7	20	9-21	15	17	67	55-75	67	65	1.3	1.1-3.3	1.1	1.5

Table 5 Macroinvertebrate fauna of an unnamed tributary of the Parahaki Stream in relation to the Turangi-A wellsite, sampled on 24 August 2017

Taxa List	Site Number	MCI score	1	2	3
	Site Code		PRH000020	PRH000022	PRH000024
	Sample Number		FWB17278	FWB17279	FWB17280
COELENTERATA	Coelenterata	3	R	-	-
PLATYHELMINTHES (FLATWORMS)	*Cura*	3	-	-	R
NEMERTEA	Nemertea	3	R	R	R
NEMATODA	Nematoda	3	-	-	R
ANNELIDA (WORMS)	Oligochaeta	1	XA	VA	VA
	Lumbricidae	5	-	C	R
HIRUDINEA (LEECHES)	Hirudinea	3	R	R	R
MOLLUSCA	Lymnaeidae	3	R	R	R
	Physa	3	-	-	R
	Potamopyrgus	4	-	A	C
CRUSTACEA	Ostracoda	1	A	-	C
	Talitridae	5	R	R	-
EPHEMEROPTERA (MAYFLIES)	*Austroclima*	7	C	C	R
ODONATA (DRAGONFLIES)	*Xanthocnemis*	4	R	-	R
COLEOPTERA (BEETLES)	Elmidae	6	R	-	-
TRICHOPTERA (CADDISFLIES)	*Hydrobiosis*	5	-	R	R
	Polyplectropus	6	R	-	-
	Oxyethira	2	A	R	R
DIPTERA (TRUE FLIES)	*Zelandotipula*	6	-	R	-
	Orthocladiinae	2	C	C	R
	Polypedilum	3	-	R	R
	Austrosimulium	3	A	A	C
		No of taxa	14	14	17
		MCI	70	74	65
		SQMCIs	1.2	2.1	1.5
		EPT (taxa)	2	2	2
		%EPT (taxa)	14	14	12

'Tolerant' taxa	'Moderately sensitive' taxa	'Highly sensitive' taxa

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

Site 1 – upstream of Production Station discharge

A moderately low taxa richness of 14 taxa was recorded by this survey (Table 5). This is two taxa more than recorded in the previous survey, and one taxon less than the median richness for this site (15 taxa; Table 4). The macroinvertebrate community at the time of the current survey was characterised by four 'tolerant' taxa [seed shrimp (Ostracoda), axehead caddis (*Oxyethira*), sandfly (*Austrosimulium*) and worm (Oligochaeta)].

A MCI score of 70 units was recorded (Table 5), categorising the site as having 'poor' macroinvertebrate community health (Table 3). This score is significantly higher (Stark 1998) than the previously recorded score of 58 units but is not significantly different to the median score for this site (median MCI score 68 units; Table 4). A very low SQMCI$_s$ score of 1.2 units was recorded (Table 5). This is not significantly different (Stark 1998) to either the previously recorded score of 1.5 units or to the median score for this site (1.4 units; Table 4).

Site 2 – 25m downstream of Production Station discharge

A moderately low taxa richness of 14 units was recorded (Table 5). This is not substantially different from either the previously recorded richness of 17 taxa or to the median taxa richness for this site (17 taxa; Table 4). The macroinvertebrate community at the time of the current survey was characterised by three 'tolerant' taxa [worm (Oligochaeta), sandfly (*Austrosimulium*) and mud snail *(Potamopyrgus*)].

The recorded MCI score of 74 units (Table 5) categorised the site as having 'poor' macroinvertebrate community health (Table 3). This score is insignificantly higher (Stark 1998) than both the median score for this site (71 units; Table 4) and the previously recorded score of 71 units. A SQMCI$_s$ score of 2.1 units was recorded, insignificantly higher than both the median score for this site (1.6 units, Table 4), and the previously recorded score of 1.6 units.

Site 3 – 100m downstream of Production Station discharge

A moderately low taxa richness of 17 taxa was recorded at this site (Table 5). This is two taxa more than the previously recorded richness of 15 taxa but three taxa fewer the median richness for this site (20 taxa; Table 4). The macroinvertebrate community at the time of the current survey was characterised by one 'tolerant' taxon [worm (Oligochaeta)].

A MCI score of 65 units was recorded (Table 5), characterising the site as having 'poor' macroinvertebrate community health (Table 3). This is insignificantly lower (Stark 1998) than the previously recorded score of 67 units and the median score for this site (67 units; Table 4). A SQMCI$_s$ score of 1.5 units was recorded. This is insignificantly higher (Stark 1998) than both the score of 1.1 units recorded by the previous survey and the median score for this site (1.3 units; Table 4).

Discussion and conclusions

A combination of the Councils 'kick-sampling' and 'vegetation sweep' techniques were used at three sites to collect macroinvertebrates from an unnamed tributary of the Parahaki Stream in relation to HF at the Turangi-A wellsite. This has provided data to assess whether discharges to nearby land had had any effect on the macroinvertebrate communities of the unnamed tributary. Samples were processed to provide number of taxa (richness), MCI, and SQMCI$_S$ scores for each site.

MCI scores categorised all three sites as having 'poor' macroinvertebrate community health. There were no significant differences between sites in the current survey. Scores at sites 2 and 3 were similar to those recorded in the previous survey, while a significant improvement was recorded at site 1 the 'upstream control' site. The MCI scores recorded in the current survey were typical of those recorded in lowland coastal streams in the Taranaki region (TRC 2016). SQMCI$_s$ scores were very low, but were similar to median scores and to those recorded in the preceding survey for each site respectively. The recorded score at site 2 was significantly higher than that recorded at site 1, while the score at site 3 was not significantly different to either site 1 or site 2. $SQMCI_s$ scores were generally lower than is typical for lowland coastal streams in the Taranaki region (TRC 2016), reflecting the dominance of tolerant taxa found at these sites. Moderately low taxa richnesses were recorded at all three sites, and were similar to richnesses recorded in the preceding survey at all sites. These richnesses were similar to median scores for each site respectively, and were typical of those recorded for lowland coastal streams in the Taranaki region (TRC 2016).

Taken together, the moderately low taxa richnesses, low MCI scores, low $SQMCI_s$ scores and high proportions of tolerant taxa found indicate that the macroinvertebrate communities of this small stream were influenced primarily by habitat conditions at the three sites, with observed differences resulting from minor variation in habitat between sites. Taxa richnesses and MCI scores were similar between all three sites, and $SQMCI_s$ scores were significantly different only between sites 1 and 2. All invertebrate metrics recorded in this survey were similar to or significantly improved from those recorded in the preceding survey. Finally, the $SQMCI_S$ scores was lowest at site 1, the upstream 'control' site which is upstream of all discharges from the Turangi-A wellsite. Overall, these results provide no evidence that discharges of stormwater and treated production water have had any recent significant detrimental effects on the macroinvertebrate communities of this unnamed tributary of the Parahaki Stream.

Summary

A macroinvertebrate survey was carried out at three sites in an unnamed tributary of the Parahaki Stream near the Turangi-A wellsite, to determine if discharges from the Production Station had detrimental effects on the stream macroinvertebrate communities.

The unnamed tributary of the Parahaki Stream recorded moderately low taxa richnesses and low $SQMCI_s$ scores. MCI scores categorised all sites as having 'poor' macroinvertebrate community health, but the MCI scores were generally similar to those recorded in Taranaki lowland coastal streams. Observed minor differences in invertebrate metrics between sites are likely related to minor habitat variation between sites. Overall, the results of this survey provide no evidence that discharges from the Turangi-A wellsite have had any significant detrimental impacts on the stream macroinvertebrate communities.

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