

Greymouth Petroleum Limited
Ngatoro-E Wellsite
Monitoring Programme Report
2012-2014

Technical Report 2014–109

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Executive summary

Greymouth Petroleum Limited (GPL) re-entered an established wellsite located on Dudley Road, Inglewood, within the New Plymouth district, in the Waitara catchment. The site is called Ngatoro-E wellsite. This report for the period November 2012–December 2014 describes the monitoring of GPL's environmental performance during the period under review, and the results and environmental effects of the GPL's activities. During this period, the wellsite was re-entered with one well drilled, tested and hydraulically fractured (Ngatoro-17).

GPL holds six resource consents for the activities at the Ngatoro-E wellsite, which include a total of 97 consent conditions setting out the requirements that they must satisfy. GPL holds consent 7067-1 to take groundwater; consent 4069-4 to discharge emissions to air from hydrocarbon exploration; consent 4067-2 to discharge treated stormwater from hydrocarbon exploration and production activities on and into land where it may enter an unnamed tributary of the Ngatoroiti Stream; consent 9744-1 to discharge contaminants associated with hydraulic fracturing activities into land; consent 7068-1 to discharge waste drilling fluids and produced water into land by deepwell injection; and consent 7069-1 to discharge drilling muds, cuttings and wastes from hydrocarbon exploration via mix-bury cover (not exercised during the monitoring period under review).

During the monitoring period, Greymouth Petroleum Limited demonstrated an overall high level of environmental performance.

Taranaki Regional Council's (the Council) monitoring programme for the period under review included 28 inspections of the site and surrounding environment (at approximately fortnightly intervals), 14 stormwater samples, seven surface water samples, two groundwater samples, one hydraulic fracture fluid sample and one return fracture fluid sample were obtained for analysis. Furthermore, biomonitoring surveys were performed prior to the commencement of drilling activities, and following their completion at the Ngatoro-E wellsite.

The monitoring showed that the site was generally neat, tidy and well maintained, although silt and sediment controls were required during the drilling campaign to reduce the concentration of suspended solids. Site staff were cooperative with requests made by officers of the Council to install liners in the skimmer pits, improve sediment controls, and address the increased chloride concentrations in the discharge. These works were completed to a satisfactory standard.

GPL notified the Council of its intention to combust gas intermittently on 1 October 2014, 30 October 2014, and 26 November 2014. Following these dates, gas combustion occurred intermittently over the course of a few days in conjunction with well testing. No offensive or objectionable odours, smoke or dust associated with activities at the wellsite were observed. The mix bury cover consent was not exercised and the drilling fluids and cuttings were disposed of at a consented off site facility. There were no Unauthorised Incidents (UIs) recording non-compliance in respect of this consent holder during the period under review.

During the monitoring period under review, GPL demonstrated a high level of environmental and administrative performance with the resource consents. For reference, in the 2012-2013 year, 35% of consent holders in Taranaki monitored through tailored compliance monitoring programmes achieved a high level of environmental performance

and compliance with their consents, while another 59% demonstrated a good level of environmental performance and compliance with their consents. In the 2013-2014 year, 60% of consent holders achieved a high level of environmental performance and compliance with their consents, while another 29% demonstrated a good level of environmental performance and compliance.

This report includes recommendations for future drilling operations, including recommendations relating to optional reviews of consents 4069-4; 7067-1; 7068-1; 7069-1; and 9744-1.

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1. Introduction

1.1 Compliance monitoring programme reports and the Resource Management Act 1991

1.1.1 Introduction

This report covers the results and findings of the monitoring programme implemented by the Taranaki Regional Council (the Council) during the period from November 2012 to November 2014 in respect of the consents held by Greymouth Petroleum Ltd (GPL) that relate to exploration activities at the Ngatoro-E wellsite located along Dudley Road in the New Plymouth district, in the Waitara catchment. During this period, the wellsite was re-entered with one well drilled, tested and hydraulically fractured (Ngatoro-17).

One of the intents of the *Resource Management Act 1991* (RMA) is that environmental management should be integrated across all media, so that a consent holder's use of water, air, and land should be considered from a single comprehensive environmental perspective. Accordingly, the Council generally implements integrated environmental monitoring programmes and reports the results of the programmes jointly. This report discusses the environmental effects of GPL's use of water, land, and air, and is the first combined biennial report by the Council for the Ngatoro-E wellsite.

1.1.2 Structure of this report

Section 1 of this report is a background section. It sets out general information about compliance monitoring under the RMA and the Council's obligations and general approach to monitoring sites through annual programmes, the resource consent held by GPL in the Waitara catchment, the nature of the monitoring programme in place for the period under review, and a description of the activities and operations conducted at the Company's site during exploration activities.

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 during future drilling operations.

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 a discharger, and may include cultural and socio-economic effects;
- (b) physical effects on the locality, including landscape, amenity and visual effects;
- (c) ecosystems, including effects on plants, animals, or habitats, whether aquatic or terrestrial;
- (d) natural and physical resources having special significance (for example recreational, cultural, or aesthetic);
- (e) risks to the neighbourhood or environment.

In drafting and reviewing conditions on discharge permits, and in implementing monitoring programmes, the Council is recognising the comprehensive meaning of 'effects' in as much as is appropriate for each discharge source. 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. Compliance monitoring, including both activity and impact monitoring, enables the Council to continuously re-evaluate its approach and that of consent holders to resource management, and, ultimately, through the refinement of methods, 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/s during the period under review, this report also assigns a rating as to each Company's environmental and administrative performance.

Environmental performance is concerned with actual or likely effects on the receiving environment from the activities during the monitoring year.

Administrative performance is concerned with the Company's approach to demonstrating consent compliance in site operations and management including the timely provision of information to Council (such as contingency plans and water take data) in accordance with consent conditions.

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

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

Environmental Performance

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

significant environmental impacts and was not obliged to issue any abatement notices or infringement notices in relation to such impacts.

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

For example:

- High suspended solid values recorded in discharge samples, however the discharge was to land or to receiving waters that were in high flow at the time;
 - Strong odour beyond boundary but no residential properties or other recipient nearby.
- **Improvement required** Likely or actual adverse effects of activities on the receiving environment were more than minor, but not substantial. There were some issues noted during monitoring, from self reports, or in response to unauthorised incident reports. Cumulative adverse effects of a persistent minor non-compliant activity could elevate a minor issue to this level. Abatement notices and infringement notices may have been issued in respect of effects.
 - **Poor** Likely or actual adverse effects of activities on the receiving environment were significant. There were some items noted during monitoring, from self reports, or in response to unauthorised incident reports. Cumulative adverse effects of a persistent moderate non-compliant activity could elevate an 'improvement required' issue to this level. Typically there were grounds for either a prosecution or an infringement notice in respect of effects.

Administrative compliance

- **High** The administrative requirements of the resource consents were met, or any failure to do this had trivial consequences and 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 2012-2013 year, 35% of consent holders in Taranaki monitored through tailored compliance monitoring programmes achieved a high level of environmental performance and compliance with their consents, while another 59% demonstrated a good level of environmental performance and compliance with their consents. In the 2013-2014 year, 60% of consent holders achieved a high level of environmental performance and compliance with their consents, while another 29% demonstrated good level of environmental performance and compliance.

1.2 Process description

Site description

GPL holds a 40 year Petroleum Mining Permit No. 38148 to prospect, explore, and mine for condensate, gas, LPG, oil and petroleum within an area of 89.38 km². The Ngatoro-E wellsite is one of many sites within this area that have been established in order to explore, evaluate and produce hydrocarbons.

The Ngatoro-E wellsite is located approximately 3 km along Dudley Rd, approximately 3.16 km from Kaimiro, as per Figure 1. The Ngatoro-E wellsite was established in 1992 and involved the removal of topsoil to create a firm and level foundation on which to erect a drilling rig and house associated equipment. Site establishment also involved the installation of:

- Wastewater control, treatment and disposal facilities;
- A system to collect and control stormwater and contaminants;
- A gas combustion system; and
- Other on site facilities such as accommodation, parking and storage.

The nearest residence is approximately 890 m away from the wellsite. Bunding, earthworks and good site location helped minimise any potential for off site effects affecting neighbouring properties.



Figure 1 Aerial view depicting the locality of the Ngatoro-E wellsite, with approximate regional location (insert).

Well development

The process of drilling a well can take a few weeks to several months, depending on the depth of the well, the geology of the area, and whether the well is vertical or horizontal.

Drilling fluids, more commonly known as 'drilling muds', are required in the drilling process for a number of reasons, including:

- As a safety measure to ensure that any pressurized liquids encountered in the rock formation are contained;
- To transport drill cuttings to the surface;
- To cool and lubricate the drilling bit;
- To provide information to the drillers about what is happening down hole and the actual geology being drilled; and
- To maintain well pressure and lubricate the borehole wall to control cave-ins and wash-outs.

The well is drilled progressively using different sized drill bits. The width of the well is widest at the surface as smaller drill bits are used as the well gets deeper. Once each section of the well is drilled, a steel casing is installed. Cement is then pumped down the well to fill the annulus (the space between the steel casing and the surrounding country rock). This process is repeated until the target depth is reached, with each section of steel casing interlocked with the next.

Production tubing is then fitted within the steel casing to the target depth. A packer is fitted between the production tubing and casing to stop oil/gas/produced water from entering the annulus. The packer is pressure tested to ensure it is sealed.

The construction aspects that are most important for a leak-free well include the correct composition and quality of the cement used, the installation method, and the setting time. The aim is to ensure that the cement binds tightly to the steel casing and the rock, and leaves no cavities through which liquids and gases could travel.

Once the well is sealed and tested the casing is perforated at the target depth, allowing fluids and gas to flow freely between the formation and the well.

Management of stormwater, wastewater and solid drilling waste

The Ngatoro-E wellsite is located approximately 139 m to the west of the nearest waterbody which is an unnamed tributary of the Ngatoroiti Stream.

Management systems were put in place to avoid any adverse effects on the surrounding environment from exploration and production activities on the wellsite. There are several sources of potential contamination from water and solid waste material which require appropriate management. These include:

- Stormwater from 'clean' areas of the site (for example parking areas). There is potential that during rainfall runoff will pick up small amounts of hydrocarbons and silt due to the nature of the activities on site;
- Stormwater which collects in the area surrounding the drilling platform and ancillary drilling equipment. This stormwater has a higher likelihood of contact with potential contaminants, particularly drilling mud;
- Produced water which flows from the producing formation and is separated from the gas and liquid phase at the surface; and
- Drill cuttings, mud and residual fluid which are separated from the liquid waste generated during drilling.

An important requirement of the site establishment is to ensure that the site is contoured so that all stormwater and any runoff from 'clean' areas of the site flow into perimeter drains. The drains direct stormwater into a skimmer pit system on site consisting of two settling ponds. Any hydrocarbons present in the stormwater float to the surface and can be removed. The ponds also provide an opportunity for suspended sediment to settle. Treated stormwater is then discharged from the wellsite onto and into land, and consequently into an unnamed tributary of the Ngatoroiti Stream.

Drilling mud and cuttings brought to the surface during drilling operations are separated out using a shale shaker. The drilling mud and some of the water is then reused for the drilling process. Cuttings were collected in bins located at the base of the shaker and disposed of offsite at a consented facility.

Hydraulic fracturing

In late 2012 the Parliamentary Commissioner for the Environment released an interim report on hydraulic fracturing within New Zealand. The purpose of this report is firstly to assess the environmental risks with hydraulic fracturing, and secondly to assess whether the policies, laws, regulations and institutions in New Zealand are adequate for managing these risks. The following discussion has been based upon this report.

The first known hydraulic fracturing operation was in 1989 at Petrocorp's Kaimiro-2 gas well in Taranaki. Since then, almost all of the hydraulic fracturing that has taken place in New Zealand has been done within the Taranaki region.

By the early 2000's New Zealand started exploring options for more unconventional ways of getting access to natural gas, and especially oil. These are considered to be more expensive than conventional drilling, but as the price of oil has risen and new technologies have been developed, these unconventional methods are growing.

The most common unconventional source of oil and gas in the Taranaki region has been extracting natural gas and oil from 'tight sands'. The boundary between tight sands and conventional reservoirs is ill-defined and generally based on whether the reservoir will have an economic production flow without hydraulic fracturing.

The process of hydraulic fracturing involves using a fracturing fluid, which is primarily water (typically made up of around 95-97% treated water). This fluid also contains various chemicals, including the three main components, which are:

- An inert proppant which keeps the induced fracture open when pumping is stopped, such as medium grained sand, or small ceramic pellets;
- A gelling substance to carry the proppant into the cracks; and
- A de-gelling substance to thin the gel to allow the fracturing fluid to return to the surface while leaving the proppant in the fractures.

The chemicals associated with the fracturing fluid are trucked to the site, stored in concentrated form, and mixed immediately before the hydraulic fracturing commences.

After the casing is perforated at the desired depth, the fracturing fluid is injected under high pressure into the well and is forced through the small holes into the rocks, creating cracks. This high downhole pressure is maintained for a brief period of time (approximately 1 hour) in order to exceed the fracture strength of the reservoir rock and cause artificial fractures.

Once a fracture has been initiated, the fracturing fluid and proppant are carried into the fracture. The placement of proppant in the fractures is assisted by the use of cross-linked gels. These are solutions, which are liquid at the surface but, when mixed, form long-chain polymer bonds and thus become gels that transport the proppant into the formation.

Once in the formation these gels 'break' back with time and temperature to a liquid state and are flowed back to surface as back flow without disturbing the proppant wedge, trapped in the hydraulic fracture. With continued flow, formation hydrocarbon fluids should be drawn into the fracture, through the perforations into the wellbore and to the surface.

Flaring from exploration activities

It is possible that flaring may occur during the following activities:

- Well testing and clean-up;
- Production testing;
- Emergencies; and
- Maintenance and enhancement activities (well workovers).

1.3 Resource consents

1.3.1 Water abstraction permit (groundwater)

Section 14 of the RMA stipulates that no person may take, use, dam or divert any water, unless the activity is expressly allowed for by resource consent or a rule in a regional plan, or it falls within some particular categories set out in Section 14.

GPL holds water permit **7067-1** to take groundwater during hydrocarbon exploration and production operations from up to four new wells at the Ngatoro-E wellsite. This permit was issued by the Council on 5 March 2007 under Section 87(d) of the RMA. It is due to expire on 1 June 2021.

Condition 1 requires that the abstraction shall not cause more than 10% lowering of static water level by interference with any adjacent bore.

Condition 2 requires that the abstraction shall not cause saltwater intrusion into any fresh water aquifer.

Condition 3 requires the submission of a summary well log to the depth of 1000m including a geological log; depth to, and thickness of, any freshwater aquifers; and the TVD to the freshwater-saline water interface.

Condition 4 requires records of all abstractions including date and volumes.

Conditions 5 and 6 provided for review of the consent.

1.3.2 Water discharge permit (treated stormwater)

Section 15(1)(a) of the RMA stipulates that no person may discharge any contaminant into water, unless the activity is expressly allowed for by a resource consent or a rule in a regional plan, or by national regulations.

GPL holds water discharge permit **4067-2** to discharge treated stormwater from hydrocarbon exploration and production operations at the Ngatoro-E wellsite onto land and into the Ngatoroiti Stream. This permit was issued by the Council on 2 July 1999 under Section 87(e) of the RMA. It is due to expire on 1 June 2015.

Condition 1 requires the consent holder to adopt the best practicable option to prevent or minimise adverse effects of the discharge on the environment.

Condition 2 imposes a limit on the stormwater catchment size.

Condition 3 requires the consent holder to notification of (re)commencement of any site works or drilling operations.

Condition 4 requires site specific details relating to contingency planning for the site.

Condition 5 requires the design, management and maintenance of the stormwater system to be undertaken in accordance with information submitted in the application.

Conditions 6 to 10 detail requirements for the capture, storage, and application of the discharge, and the design and construction of skimmer pits, drains and other retention areas.

Conditions 11, 12 and 13 impose limits on contaminants in the discharge, and stipulate effects the discharge shall not give rise to in the receiving waters.

Condition 14 requires the Council to be advised of reinstatement of the site.

Condition 15 provides for review of the consent.

1.3.3 Air discharge permit (exploration and production activities)

Section 15(1)(c) of the RMA stipulates that no person may discharge any contaminant from any industrial or trade premises into air, unless the activity is expressly allowed for by a resource consent, a rule in a regional plan, or by national regulations.

GPL holds air discharge permit ~~4069-4~~ to discharge emissions to air from flaring during hydrocarbon exploration and production testing associated with up to four new wells, flaring from well workover activities and in emergency situations associated with production activities, and miscellaneous emissions at the Ngatoro-E wellsite. This permit was issued by the Council on 5 March 2007 under Section 87(e) of the RMA. It is due to expire on 1 June 2021.

Condition 1 limits the duration of flaring during well testing.

Conditions 2 to 7 specify the requirements for notification prior to flaring and before undertaking alterations to equipment or processes which may substantially alter the nature or quantity of the discharge.

Conditions 8 to 14 specify the required equipment and processes for undertaking flaring, and limit the substances which may be flared to gases from the well stream.

Conditions 15 to 21 stipulate limits on contaminants and effects from flaring, and any other emissions from the wellsite.

Conditions 22, 23, and 24 specify the requirements for the recording and reporting of information relating to flaring.

Condition 25 provides for review of the consent.

1.3.4 Land discharge permit (mix-bury-cover)

Sections 15(1)(b) and (d) of the RMA stipulates 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 holds discharge permit **7069-1** to discharge drilling muds, drilling cuttings and drilling wastes from hydrocarbon exploration activities at the Ngatoro-E wellsite onto and into land via mix bury cover. This permit was issued by the Council on 26 February 2007 under Section 87(e) of the RMA. It is due to expire on 1 June 2021.

Condition 1 imposes limits on the volume of the waste discharge.

Conditions 2 and 3 specify the requirements for documentation required prior to exercise of the consent, and the waste discharge process.

Conditions 4 and 5 specify the requirements for notification and reporting of information relating to the discharge.

Conditions 6 to 10 specify the requirements for the location, processing and management of the waste material.

Conditions 11 to 23 stipulate contaminant levels the discharge shall not exceed in soil, ground-, or surface water, as well as requirements for disposal of the waste material.

Conditions 24 to 27 provide for review of the consent.

1.3.5 Land discharge permit (hydraulic fracturing)

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 holds discharge permit **9744-1** to discharge water based hydraulic fracturing fluids into land at depths greater than 3,620 mTVD beneath Ngatoro-E wellsite. This permit was issued by the Council on 11 December 2013 under Section 87(e) of the RMA. It is due to expire on 1 June 2022.

Conditions 1, 2, and 3 impose limits on the discharge process and contamination of freshwaters.

Conditions 4 to 7 specify the requirements for the sampling and monitoring programmes, and cover bore suitability and water sampling protocols and analysis.

Conditions 8 to 12 specify the requirements for recording and reporting, including pre- and post-fracturing discharge reports, as well as notification of discharge.

Condition 13 requires the consent holder to provide access allowing the sampling of hydraulic fracture fluids and return fluids.

Condition 14 requires the consent holder to adopt the best practicable option to prevent or minimise adverse effects.

Condition 15 stipulates that the fracture fluid shall be no less than 91% water and proppant by volume.

Condition 16 allows for review of the consent.

1.3.6 Land discharge permit (deep well injection)

Section 15(1)(a) of the RMA stipulates that no person may discharge any contaminant into water, unless the activity is expressly allowed for by a resource consent or a rule in a regional plan, or by national regulations.

GPL holds discharge permit **7068-1** to discharge waste drilling fluids and/or produced water from hydrocarbon exploration and production operations by deepwell injection at Ngatoro-E wellsite. This permit was issued by the Council on 5 March 2007 under Section 87(e) of the RMA. It is due to expire on 1 June 2021.

Condition 1 requires a site specific injection well management plan and log of the injection well.

Condition 2 requires the prevention of contamination of any useable freshwater aquifer.

Conditions 3 to 6 relate to recording and reporting, and include daily monitoring of contaminants and injection pressures.

Conditions 7 and 8 allow for review of the consent.

1.4 Monitoring programme

1.4.1 Introduction

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

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

The monitoring programme for exploration well sites consists of seven primary components. They are:

- Programme liaison and management;
- Site inspections;
- Chemical sampling;
- Solid wastes monitoring;
- Air quality monitoring;

- Discharges to land (hydraulic fracturing and deep well injection); and
- Biomonitoring surveys.

All seven components are discussed below.

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 reviews;
- renewals;
- new consents;
- advice on the Council's environmental management strategies and content of regional plans and;
- consultation on associated matters.

1.4.3 Site inspections

The Ngatoro-E wellsite was visited 28 times during the monitoring period. With regard to consents for the abstraction of or discharge to water, the main points of interest were plant processes with potential or actual discharges to receiving watercourses, including contaminated stormwater and process wastewaters. Air inspections focused on plant processes with associated actual and potential emission sources and characteristics, including potential odour, dust, noxious or offensive emissions. Sources of data being collected by the consent holder were identified and accessed, so that performance in respect of operation, internal monitoring, and supervision could be reviewed by the Council. The neighbourhood was surveyed for environmental effects.

1.4.4 Chemical sampling

The Council undertook sampling of both the discharges from the site and the water quality upstream and downstream of the discharge point and mixing zone.

The Ngatoro-E stormwater discharge was sampled on six occasions, and the sample analysed for hydrocarbons, suspended solids, pH and chloride. When the stormwater system was not discharging, samples were obtained from the storage skimmer pits and analysed for the same parameters. The unnamed tributary of the Ngatoroiti Stream was sampled on seven occasions, and the sample analysed for hydrocarbons, suspended solids, pH and chloride.

1.4.5 Solid wastes

The Council monitors any disposal of drill cuttings on site via mix bury cover to ensure compliance with resource consent conditions and to determine whether site activities were or were likely causing any adverse effects within the receiving environment.

In recent times consent holders have opted to remove drilling waste from the site by contractor and dispose of it at licensed disposal areas (land farming), which are monitored separately.

1.4.6 Air quality monitoring

Air quality monitoring is carried out in association with the well testing and clean-up phase, where flaring can occur.

Assessments are made by Inspecting Officers of the Council during site inspections to ensure that operators undertake all practicable steps to mitigate any effects from flaring gas. Inspecting Officers check that that plant equipment is working effectively, that there is the provision of liquid and solid separation, and that on site staff have regard to wind direction and speed at the time of flaring.

It is also a requirement that the Council and immediate land owners are notified prior to any gas being flared when practicable. This requirement was checked to ensure compliance with consent conditions and to determine whether site activities were causing any adverse effects within the receiving environment.

1.4.7 Discharges to land (hydraulic fracturing)

Sampling and analysis of the hydraulic fracturing, return flow fluids and nearby bores were carried out during the period under review. In addition, inspections of the site and surrounding land and water were carried out to ensure that no observable effects had occurred as a result of the discharge to land. Pre and post hydraulic fracturing reports were submitted by the consent holder detailing among other things, the effectiveness of the mitigation measures put in place to protect the environment.

1.4.8 Biomonitoring surveys

A biological survey was performed on two occasions in an unnamed tributary of the Ngatoroiti Stream to determine whether or not the discharge treated stormwater from the site has had a detrimental effect upon the macroinvertebrate communities of the stream.

2. Results

2.1 Water

2.1.1 Inspections

The Ngatoro-E wellsite, adjacent land and streams were inspected 28 times during this monitoring period. Below is a copy of the comments that were noted on the day of each inspection.

29 November 2012

Equipment had been brought onto the site for a well workover. The ring drains had also been scraped. The skimmer pits were full of stormwater and spring water but were not discharging. Any discharge from the second skimmer pit was flowing underground towards the nearby stream. A container was going to be placed into the flare pit to contain any solid or liquid hydrocarbons should the need arise, and bunding had been placed around the bulk storage tanks.

11 December 2012

Drilling of a new well (a side track from the existing well) had been completed and the casing was being perforated at the time of inspection. It was observed that the skimmer pit was discoloured (milky grey) with a yellow substance floating on the surface. Samples and photos were taken at the time of inspection. Staff on site advised that a sucker truck would be called to pump the skimmer pit, as the level of water in the pit was just below the outlet pipe. The skimmer pit was not discharging into the stream. The stream appeared clear with no effects visible. GPL staff on site advised that the lease was to be relinquished following the completion of the well later that week.

4 February 2013

An in-stream inspection of stormwater discharge from the site was carried out to visually assess silt and sediment runoff after a prolonged dry spell, and during the first significant rainfall for some time. Discharge points were all off site and easily accessible in adjacent paddocks.

Skimmer pits were discharging at the time of inspection, and there was no evidence of increased turbidity or clarity in the receiving waters as a result of this discharge. No flaring or odours were noted at the site.

19 March 2013

An inspection found that the site was in a neat and tidy condition. No flaring was evident at the time of inspection. GPL staff on site said that the skimmer pits at the site were to be cleaned out to reduce the silt content as part of routine maintenance. No effects of any discharges were noted from the skimmer pits into the receiving waters in the adjacent stream.

26 April 2013

No activity was occurring on site. The site had been closed following the last inspection and was in a clean and tidy order. The skimmer pit was full and discharging at the time of the inspection and a sample of the discharge was taken to ensure that it complied with the consent conditions. The pit at this site was still unlined, although a new requirement that all skimmer pits had to be lined had

recently come into effect. GPL were to advise the inspecting officer of the expected time frame in which this would be occurring.

14 May 2013

The site was neat and tidy and ring drains and bunds were clear. The skimmer pits were clear of debris following high winds the preceding weekend, and the discharge from the pits did not give rise to any visual impact in the receiving water. There was no flaring at site during the time of inspection.

12 June 2013

The site was inspected and it was noted that all site stormwater was being directed through skimmer pits and API oil-water separators prior to any discharge. This discharge was occurring to the adjacent stream and no effects were noted. No flaring was being undertaken and no off site odours were noted.

25 June 2013

An inspection of the site with Allan Crawford from GPL showed that it was neat and tidy. The ring drains and bunds were in place to direct all site stormwater through API oil-water separators and skimmer pits for treatment prior to discharge to the nearby water body. No flaring was occurring at the time of inspection and no other issues were evident.

6 August 2013

The site was inspected following recent heavy rainfall. There was no flaring being carried out and no odours from production facilities were evident during a down wind (off site) odour survey. Storm water was discharging at the site, but this did not have any visual effect down stream.

12 August 2013

The site was inspected after a weekend of rainfall, no flaring had been undertaken and no odours or smoke were evident. The ring drains, API oil-water separators, and bunds were clear of all contaminants. The skimmer pits were full and discharging, and there was no evidence of effects to the receiving waters noted.

25 September 2013

The site was inspected following a weekend of torrential rain and high winds. The site was unmanned, and no flaring was being undertaken. The ring drains and bunds were clear and there were no visual effects of stormwater discharge on the receiving waters.

7 November 2013

The site was inspected and found to be neat and tidy. There was no flaring occurring at the time of inspection. The ring drains and bunds were clear of obstructions and contaminants. Skimmer pits were clear and no effects of any discharges to the adjacent stream were reported.

9 January 2014

An inspection was undertaken of the site during heavy rainfall, resulting in stormwater runoff to the skimmer pits and stormwater discharges from the site. All stormwater was directed via the ring drains for treatment before being discharged to

the adjacent stream. There were no visual effects from the discharge noted. No flaring was being undertaken and the site was neat and tidy.

23 January 2014

An inspection was undertaken with GPL Environmental Advisor Allan Crawford following heavy rainfall the day before. The site was inspected to ensure compliance with resource consents held for water and air discharges, reinjection wells, flaring etc. Overall, the site was neat and tidy and well maintained. The ring drains, bunds and stormwater systems were fit for purpose, and skimmer pits were clear of contaminants & most were not discharging. Some repair work and lining was possibly required, and this was addressed in Allan's report. The flare pits were well sited to minimise potential off site effects, including odour, noise and light issues. Most had not been used for long periods. Some minor plant pest infestations were noted, and this was programmed for spraying. In the main, the site was well managed and no environmental concerns or effects were noted.

27 May 2014

A site visit was conducted with staff from BTW. Drilling was occurring at the time of inspection. Chemical storage was bunded and covered, and storage tanks were also bunded to prevent spills entering the ring drain. The pad area was wet from recent rain, and heavy machinery had churned up parts of the site such that silt and sediment could have readily mobilised into the ring drains. Silt controls were required in the ring drain and at the entry to the skimmer pits to ensure compliance with suspended solids limit in the discharge. It was recommended that areas where silt and sediment could mobilise to the perimeter drain (such as gravel dumps and areas in pad where high volumes of silt sit) were to have silt cloth, bio sock, hay bails or other such measures put in place to filter surface water run off. Samples were retrieved from the skimmer pit as these were not discharging at the time of inspection.

6 June 2014

The site was engaged with drilling activities, having reached a depth of 1700m. Silt controls had been placed in the perimeter drains by way of hay bales and silt cloth at the skimmer pit entrance. The silt controls were proving very effective as the skimmer pits were now clear. The very small discharge from the pits was unable to be sampled, so samples were retrieved from the second skimmer pit near the outflow pipe. Large amounts of hydrocarbon sheen appeared to be present in the perimeter drains, however this was found to be naturally present iron oxide from an iron pan at the rear of the site.

1 July 2014

A site inspection found that drilling was continuing on site and the casing of the intermediate section of the hole was planned to occur in the following days. The inspection found that the skimmer pits were full and discharging. Samples were taken from the skimmer pit discharge as well as upstream and downstream samples. A visual inspection of the receiving environment found that no adverse effects were observed. The flare pit was inspected and found to contain some clean stormwater in the base. No flaring had taken place on site during the drilling phase of the operation. Silt and sediment controls were in place within the ring drain system and subsequently silt and sediment were not found to be an issue at the time of inspection. The dry non-hazardous chemical store was found to be well bunded with

no signs of spillage. Good earth bunding was also in place about the cementing facilities. Overall the site appeared to be in a good clean and tidy order. No spills or potential risk areas were identified at the time of inspection.

7 July 2014

A site inspection was undertaken following heavy rainfall. There was not much activity at this site, with no flaring and no evidence of any contaminants in the skimmer pits.

17 July 2014

An inspection was carried out on site as part of routine compliance monitoring. The Tiger Rig remained on site and the drilling process was continuing. Casing of the intermediate section of the hole was in process at the time of the inspection. No flaring had occurred on site during the drilling programme; however an inspection of the flare pit onsite found it to be clean and tidy and suitable for flaring should it be required. The pit was lined and the liner was covered with soil. A slight sheen was observed in the ring drain running near the flare pit. Some of this was a result of iron oxide being discharged into the ring drain at the top end of the site. The skimmer pits appeared to be working efficiently and no sheen was observed in the second pit or the discharge. The skimmer pits were discharging at the time of the inspection and samples were taken of the discharge and the receiving environment. No visual effects were noted on the receiving environment at the time of the inspection.

23 July 2014

An inspection was undertaken in conjunction with Sheridan Standen (BTW). The inspection found that well drilling operations were continuing on site. Casing of the intermediate section was completed and following the appropriate safety tests drilling was anticipated to re-commence later that day. Skimmer pit contents appeared to be of a reasonable quality with no sheens, foams and or scums observed within the pits. The pits were discharging at the time of the inspection with the majority of the discharge water appearing to originate from springs discharging into the ring drains at the uppermost portion of the site. Silt and sediment controls in place in the ring drains appeared to be working well. Sampling results indicated that suspended solids are no longer a significant issue on site. Staff were spoken to regarding their wish to remove some hay bales from the ring drains. The inspecting officer did not anticipate any issue with removing these.

The bunded areas on site were in reasonable condition. Some general housekeeping was outlined to the onsite HSE regarding bungs on empty drums etc., however no significant issues were identified. No flaring had yet taken place on site as part of the well drilling operation. Samples of skimmer pit discharge and the receiving waters were taken to ensure compliance with resource consent conditions. A visual inspection of the receiving waters found them to be running clear and clean with no adverse effects observed as a result of the skimmer pit discharge. Previous sampling results had shown increased chloride levels within the skimmer pit discharge. This was raised with the on site HSE staff, the rig manager and Sheridan. Staff were cautioned to be vigilant about areas of the site that may contribute to increased chloride levels. It was advised that ensuring that the area about the mud/ cuttings tanks was clean and free of spills may assist in controlling the increased chloride values.

1 August 2014

Recent work had been undertaken on site about the cuttings/mud tank areas to address the increased chloride readings in the discharge. Old metal and sawdust had been removed from site with new material replaced. Hay bales had been removed from the ring drains; however sand bags remained about the cuttings area to capture silt and sediment. The ring drains were found to be flowing clean and clear at the time of the inspection. A visual inspection of the skimmer pits found them to be free of any hydrocarbon sheen. They were discharging at the time of the inspection and samples were taken to ensure compliance with resource consent conditions. A visual inspection of the receiving waters found it to be running clean and clear.

12 August 2014

A site inspection found that drilling of the bottom hole was in progress with TD anticipated within the coming week. Cementing and well logging activities were scheduled to occur thereafter.

No flaring had been undertaken on site as part of the drilling operation. A sucker truck was onsite at the time of inspection, removing stormwater from bunded areas and cleaning portions of the ring drains that were identified as high risk areas (i.e. about the mud tank areas).

The non-hazardous chemical store was covered from the weather with no sign of spills or possible sources of contamination. The on site HSE staff member was managing the area to ensure that storm water captured within the bund was managed to prevent dry product from getting wet.

Ring drains were flowing well with all stormwater being directed to the skimmer pits for treatment prior to discharge. The discharge was slightly turbid, however no effect was observed within the receiving waters following appropriate mixing. Samples of the skimmer pit discharge and receiving waters were taken to ensure compliance with consent conditions. The site was clean and tidy and appeared to be well managed. The area about the mud/cuttings tank was greatly improved from previous inspections.

26 August 2014

Total depth of the well (TD) had been reached and Halliburton were on site to complete the bottom hole cement job. The site was clean and tidy with chemicals stored in a bunded area and under cover. Skimmer pit contents were clear with little to no apparent suspended solids; there was only a very small discharge after a long period without rain. Samples were retrieved from near the outfall of the second skimmer pit.

4 September 2014

An inspection of the site found that the Tiger Rig was still on site. TD had been reached and casing cemented in the bottom hole. Further cementing and casing was being undertaken in the following days with the well anticipated to be completed in a short time. The site was found to be clean and tidy with all non-hazardous chemicals stored in a bunded area protected from the weather. The area about the mud tanks was reasonably clean. Silt and sediments controls were in place about the ring drains and the storm water within the skimmer pits appeared to be of reasonable quality. The pits were not discharging at the time of the inspection;

however samples were obtained to ensure compliance with resource consent. No flaring had yet been undertaken on site. A visual examination of the receiving waters downstream from the well site found them to be flowing clean and clear with no adverse effects observed.

18 September 2014

Inspection was carried out during a period of reasonably heavy rain. Drilling on site had been completed and the Tiger Rig was being removed from the site and transported to the Urenui-1 wellsite. Approximately half of the rig and associated equipment had been removed at the time of inspection. Cleaning of equipment by water blaster was taking place on site with the washings being sucked up by sucker truck for disposal off site. The D tank remained on site to collect any contaminated material or water. The cellar about the well head had been sucked out. Although some stormwater remained in the cellar, there was plenty of free board remaining to ensure that any further stormwater collected within it could be contained. The cellar was to be sucked out again prior to the Tiger Rig Staff leaving site. The metal about the well head where the rig had been located was to be scraped down with new metal spread over the area in due course. No flaring had taken place on the site. The pipe from the original skimmer pits on site had been removed to ensure that there is no chance of stormwater entering it and discharging. Skimmer pits were inspected and were found to be full and flowing well. A large volume of storm water was observed discharging from the skimmer pits into the receiving waters which were also found to be flowing swiftly and higher than observed on previous inspections. Samples were taken of the discharge and receiving environment to ensure compliance with resource consent conditions.

8 October 2014

Site inspection was carried out in conjunction with zone 2 stimulation of the wellsite. Baker Hughes was onsite carrying out works. The site had a number of diesel spills on the pad, most likely originating from the heavy machinery required to carry out Hydraulic fracturing (HF). Staff on site were spoken to regarding clean up. All chemicals were stored within a bund and undercover.

Ring drains were flowing towards the skimmer pit system, and the system was discharging during inspection. Discharge, upstream, and downstream samples were collected. A visual inspection of the receiving environment indicated little impact from the discharge. The HF was abandoned due to the hydration unit, and the well was shut in.

17 October 2014

The third hydraulic fracture of the well had taken place the evening previous to the inspection. At the time the well was being flowed, however as this was in its initial stages the flow back material was mainly HF fluid and so no flaring was taking place on site in association with the activities.

Site inspection found that the site was in a good order with Baker Hughes adopting their usual practices in regards to bunding and chemical storage. No issues were identified with the Baker Hughes activities on site. The skimmer pits were inspected and a sample was taken from the second skimmer pit. No discharge was occurring from the pits at the time of inspection. Visually the pits appeared to be clean with no obvious suspended solid or hydrocarbon contamination within them. It was noted that the secondary lining about the discharge pipe from the second skimmer pit had

come away from the primary pit lining. Officers were confident that the integrity of the pit remained intact. An inspection of this was not carried out due to the location of the issue and the health and safety issues associated with such an inspection.

23 October 2014

Site inspection was carried out under fine weather conditions. At the time of the inspection the fourth HF of the well stimulation programme was in progress. The depth and zone targeted for the fracture was in accordance with resource consent conditions. The site in general was clean and tidy and the majority of the equipment from the drilling operation had been removed. The only chemicals on site were those directly associated with the fracture. Baker Hughes equipment was set up as per their usual operating procedure, with steel bunds in place to capture any spillage associated with the fracturing equipment. The flare pit was inspected and found to be clean and free of any staining or liquid materials. At the time of inspection a small pilot flare was in operation. Minimal flaring had occurred on site during the well stimulation programme that was currently being undertaken. Ring drains were flowing freely with water only present in the drain along the western edge of the site.

Skimmer pits were inspected and the issue regarding the integrity of the liner (as per previous inspection) had been addressed and rectified by GPL staff. The skimmer pits had been sucked out to allow for the repair to take place; the materials were then placed back into the pits in order to hold down the liner and maintain head and to prevent groundwater intrusion. The pits were approximately 20cm below discharge level, however samples were taken to ensure compliance with resource consent conditions should a discharge occur.

The receiving environment was visually inspected and the stream was running at a reasonably low level with water quality appearing clean and clear. Staff on site were spoken to regarding the repair work and advised that it was satisfactory.

Flow back samples from the third fracture on site were also retrieved. No samples were required on site for this fracture, but samples of both fracture fluid and flow back fluid were required for the last fracture in the well stimulation programme. Staff on site were advised of this.

2.1.2 Results of discharge monitoring

During the period under review a total of 14 stormwater samples were obtained. Stormwater was observed discharging from the wellsite skimmer pits on six occasions, and six samples were obtained in conjunction with this. The remaining eight stormwater samples were obtained from the second skimmer pit to ensure compliance with consent conditions in anticipation of potential discharges.

Analysis of the samples obtained showed that all but three of the samples would have been compliant with resource consent conditions should a discharge have occurred.

Results are detailed in Table 1 and sampling locations are shown in Figure 2.

Table 1 Results of stormwater samples obtained from the Ngatoro-E wellsite during the monitoring period

| Date | Chloride <i>g/m³</i> | Hydrocarbons <i>g/m³</i> | pH <i>pH</i> | Suspended Solids <i>g/m³</i> | Sampling location |
|-------------|------------------------------------|--|-----------------|--|--------------------|
| 27 May 2014 | 18.9 | 2.7 | 7.3 | 105 | Skimmer pit |
| 06 Jun 2014 | 23.7 | <0.5 | 7.0 | <2 | Skimmer pit |
| 01 Jul 2014 | 37.3 | 3.0 | 6.6 | 51 | Discharge |
| 17 Jul 2014 | 136 | <0.5 | 7.1 | 16 | Discharge |
| 23 Jul 2014 | 112 | <0.5 | 7.1 | 11 | Discharge |
| 01 Aug 2014 | 14.5 | 0.9 | 7.3 | 13 | Discharge |
| 12 Aug 2014 | 24.4 | 1.4 | 6.8 | 33 | Discharge |
| 26 Aug 2014 | 10.7 | <0.5 | 7.2 | <2 | Skimmer pit |
| 04 Sep 2014 | 10.3 | <0.5 | 7.8 | 2 | Second skimmer pit |
| 18 Sep 2014 | 35.2 | 1.9 | 7.2 | 59 | Skimmer pit |
| 08 Oct 2014 | 21.0 | <0.5 | 7.4 | 25 | Discharge |
| 17 Oct 2014 | 9.2 | <0.5 | 8.0 | 2 | Skimmer pit |
| 22 Oct 2014 | 7.7 | 13 | 7.1 | 56 | Skimmer pit |

Samples obtained on 27 May 2014 returned elevated levels of suspended solids. Although these values exceed the limits as specified by condition 11 of consent 4067-2, no actual non-compliances occurred as these samples were obtained from the skimmer pit to ensure compliance with consent conditions in anticipation of potential discharges. Therefore, no discharges containing elevated levels of suspended solids were released from the skimmer pits into the receiving environment in relation to these samples.

The discharge samples obtained on 17 July 2014 and 23 July 2014 returned an elevated level of chlorides (136 g/ m³ and 112 g/ m³ respectively), which contravened Section 15(1)(b) of the RMA and special condition 11 of resource consent 4067-2 (which limits chloride concentration to no greater than 50g/m³). This high count was most likely attributed to old metal and sawdust in the area around the cuttings/mud tank. Removing and replacing this material addressed this issue. In addition, no adverse effects were noted in the nearby stream. These events were not treated as a non-compliance due to a lack of adverse environmental effects and the timely response from GPL staff in removing and replacing the offending material.

All sewage was directed for treatment through a septic tank system and removed by contractor to a licensed disposal facility.

2.1.3 Results of receiving environment monitoring

During the period under review, seven samples were obtained in conjunction with the stormwater discharges on 1 July 2014, 17 July 2014, 23 July 2014, 1 August 2014, 12 August 2014, 18 September 2014 and 8 October 2014 from an unnamed tributary of the Ngatoroiti Stream to ensure that stormwater discharges were not having an adverse effect on the receiving stream environment. Of the stream samples obtained, no exceedances were recorded in relation to consent 4067-2. Results are detailed in Table 2 and sampling locations can be seen in Figure 2.

Table 2 Samples obtained from an unnamed tributary of the Ngatoroit Stream during the monitoring period under review

| Date | Chloride <i>g/m³</i> | Hydrocarbons <i>g/m³</i> | pH <i>pH</i> | Suspended Solids <i>g/m³</i> | Sampling location |
|-------------|------------------------------------|--|-----------------|--|-------------------------|
| 01 Jul 2014 | 8.3 | <0.5 | 6.2 | <2 | Upstream of discharge |
| | 12.6 | 0.7 | 6.4 | 9 | Downstream of discharge |
| 17 Jul 2014 | 7.9 | <0.5 | 6.6 | <2 | Upstream of discharge |
| | 31.2 | <0.5 | 6.8 | 8 | Downstream of discharge |
| 23 Jul 2014 | 8.3 | <0.5 | 6.9 | 35 | Upstream of discharge |
| | 25.3 | <0.5 | 7.0 | 32 | Downstream of discharge |
| 01 Aug 2014 | 8.2 | <0.5 | 7.0 | <2 | Upstream of discharge |
| | 8.9 | 0.8 | 7.1 | 5 | Downstream of discharge |
| 12 Aug 2014 | 7.8 | <0.5 | 6.3 | <2 | Upstream of discharge |
| | 16.0 | 1.8 | 6.6 | <18 | Downstream of discharge |
| 18 Sep 2014 | 30.5 | 0.8 | 7.1 | 45 | Downstream of discharge |
| | 7.8 | <0.5 | 6.8 | 9 | Upstream of discharge |
| 08 Oct 2014 | 8.5 | <0.5 | 6.8 | 2 | Upstream of discharge |
| | 11.8 | <0.5 | 6.9 | 6 | Downstream of discharge |



Figure 2 Stormwater and surface water sampling locations at the Ngatoro-E wellsite

The receiving surface water body was inspected regularly in conjunction with site inspections. No effects were observed and the stream appeared clear with no visual change in colour or clarity. In addition, no odour, oil, grease films, scum, foam or suspended solids were observed in the stream as a result of activities at the Ngatoro-E wellsite during the monitoring period.

2.2 Air

2.2.1 Inspections

Air quality monitoring inspections were carried out in conjunction with general compliance monitoring inspections. See Section 2.1.1 for comments concerning site inspections.

2.2.2 Results of discharge monitoring

GPL notified the Council of its intention to combust gas at the Ngatoro-E wellsite on 1 October 2014, 30 October 2014, and 26 November 2014. Following these dates, gas combustion occurred intermittently over the course of a few days in conjunction with well testing. During this time a flare pit was largely employed for the combustion of gas, to maintain a pilot flare and for emergency gas combustion / depressurisation.

During routine inspections, no offensive or objectionable odours, smoke or dust associated with activities at the Ngatoro-E wellsite were observed. From observations during site inspections, including the inspection of the flare log maintained by GPL, it appeared that special conditions relating to the control of emissions to air from the combustion of hydrocarbons were complied with.

2.2.3 Results of receiving environment monitoring

No chemical monitoring of air quality was undertaken during the testing phase of the Ngatoro-E wellsite as gas combustion activities were minimal and the controls implemented by GPL did not give rise to any concerns with regard to air quality.

2.2.4 Other ambient monitoring

No other ambient air sampling was undertaken, as the controls implemented by GPL appeared sufficient and council officers had no concerns with regard to air quality as a result of site operations.

2.3 Land

2.3.1 Inspections (hydraulic fracturing)

Land monitoring inspections were carried out in conjunction with general compliance monitoring inspections. See Section 2.1.1 for comments concerning site inspections.

2.3.2 Results of discharge and receiving environment monitoring (mix/bury/cover)

Consent 7069-1 to discharge drilling muds, drilling cuttings and drilling wastes from hydrocarbon exploration activities at the Ngatoro-E wellsite onto and into land via mix/bury/cover was not exercised throughout the monitoring period under review. Drilling muds, drilling cuttings and drilling wastes were disposed of at a consented off site facility.

2.3.3 Land status

The well site was constructed on a flat rural dairy farming area. Relatively minor earthworks were required to construct the site. The land had not been reinstated at the time of the last inspection (23 October 2014) as the site was still in use.

2.4 Biomonitoring surveys

Biomonitoring surveys were performed prior to the commencement of drilling on 16 May 2014, and following the completion of drilling and hydraulic fracturing activities on 14 November 2014, at the Ngatoro-E wellsite to determine whether or not consented discharges of treated stormwater, treated produced water and surplus drilling water from hydrocarbon exploration and production activities on and into land where it may enter an unnamed tributary of the Ngatoroiti Stream have had a detrimental effect upon the macroinvertebrate communities of this stream.

Both the pre and post drilling/hydraulic fracturing biomonitoring surveys were undertaken at three established sites; 30 m upstream of the discharge tributary confluence (site 1), 110 m downstream of the discharge tributary confluence (site 2) and 220 m downstream of the discharge tributary confluence (site 3), as seen in Figure #.

The Councils' 'vegetation sweep' sampling technique was used at the three sites to collect streambed macroinvertebrates from the unnamed tributary of the Ngatoroiti Stream. This has provided baseline data for any future assessment of consented discharge effects from the Ngatoro-E wellsite on the macroinvertebrate communities of this stream. Samples were processed to provide number of taxa (richness), MCI, and SQMCI_s scores for each site.

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

A summary of the biomonitoring surveys are as follows. A complete copy of the biomonitoring survey report can be found within Appendix II of this report.



Figure 3 Biomonitoring sites in the Ngatoroiti Stream in relation to the Ngatoro-E wellsite

Summary

The May 2014 pre-drill survey and the November 2014 post-drill survey of three sites, upstream and downstream of the skimmer pit discharge point to an unnamed tributary of the Ngatoroiti Stream, were undertaken because of drilling at the Ngatoro-E wellsite. Taxa richnesses were moderate for all three sites and were similar to other sites in similar streams in the Taranaki region within the same altitudinal band. MCI and SQMCI_s indices remained relatively constant at all three sites from the pre-drill survey to the post-drill survey. The only significant difference found was an increase in the MCI score of 15 units from the pre-drill survey to the post-drill survey at site 1 which would likely be due to site variability as no such trend occurred at sites 2 and 3. There were no significant decreases in health of the macroinvertebrate communities in the Ngatoroiti Stream shown by pre-drill and post-drill surveys and therefore there was no evidence that Ngatoro-E wellsite discharges to an unnamed tributary of the Ngatoroiti Stream had had any significant effects on macroinvertebrate communities in the Ngatoroiti Stream.

2.5 Contingency plan

GPL have provided a general contingency plan, as required by condition 4 of resource consent 4067-2 with site specific maps which cover all onshore sites that they operate. The contingency plan has been reviewed and approved by officers of the Council.

2.6 Investigations, interventions, and incidents

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

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

Complaints may be alleged to be associated with a particular site. If there is 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.

Any minor actual or potential non-compliance with consent conditions were addressed during site inspections. GPL staff would quickly take steps to ensure that requests made by Council Inspecting Officers were adhered to without delay.

3. Discussion

3.1 Discussion of consent exercise

Of the six resource consents relating to the Ngatoro-E wellsite, five were exercised and actively monitored; consents 7067-1 (to take groundwater during hydrocarbon exploration and production activities), 4069-4 (to discharge emissions to air from hydrocarbon exploration and production activities), 4067-2 (to discharge treated stormwater from hydrocarbon exploration and production activities on and into land where it may enter an unnamed tributary of the Ngatoroiti Stream), 9744-1 (to discharge contaminants associated with hydraulic fracturing activities into land), and 7068-1 (to discharge waste drilling fluids and produced water from hydrocarbon exploration and production activities by deepwell injection).

The discharge of drilling muds, cuttings and wastes from hydrocarbon exploration via mix-bury cover was not exercised during the monitoring period under review as permitted by resource consent 7069-1. Drilling waste was transported off site to a consented facility.

It is considered that all remaining resource consent conditions were complied with during the monitoring period, including the provision of various pieces of information (contingency plan, notifications etc.).

Monitoring has shown that the management on site ensured that no effects to the environment occurred during the monitoring period.

3.2 Environmental effects of exercise of consents

Stormwater

The discharge of stormwater from earthworks has the potential for sediment and other contaminants to enter surface water where it may detrimentally affect in-stream flora and fauna. To mitigate these effects, GPL established perimeter drains during the construction of the wellsite, and care was taken to ensure runoff from disturbed areas was directed into the drains or directed through adequate silt control structures.

Adverse effects on surface water quality can occur if contaminated water escapes through the stormwater system. API water-oil separator pits are designed to trap sediment and hydrocarbons through gravity separation. Any water that is unsuitable for release via the interceptor pits was directed to the drilling sumps, or removed for off-site disposal.

GPL also undertook the following mitigation measures in order to minimise off site adverse effects:

- All stormwater was directed via perimeter drains to the skimmer pits for treatment prior to discharge;
- Additional bunding was constructed around the bulk fuel tank, chemical storage area, and other areas where runoff from areas containing contaminants could occur;
- Regular inspections of the interceptor pits occurred; and

- Maintenance and repairs were carried out if required.

Interceptor pits do not discharge directly to surface water, instead they discharge onto and into land where the discharge usually soaks into the soil before reaching any surface water. However, if high rainfall had resulted in the discharge reaching the surface water, significant dilution would have occurred.

There are numerous on site procedures included in drilling and health and safety documentation that are aimed at preventing spills on site, and further procedures that address clean-up to remedy a spill situation before adverse environmental effects have the opportunity to occur (for example bunding of chemicals and bulk fuel).

Groundwater

Small amounts of groundwater may have been encountered as produced water during operations at the wellsite. It was anticipated that the abstraction of groundwater would not impact on any groundwater resource. Further the groundwater would not be affected from contamination by drilling or fracturing activities as it would be protected by the well casing.

Flaring

The environmental effects from flaring have been evaluated in monitoring reports prepared by the Council in relation to the flaring emissions from specific wells in the region.

The Council has previously undertaken field studies at two wells (one gas, and the other producing oil and heavier condensates); together with dispersion modelling at a third site¹. More recently two studies have focused on field investigations and modelling of emissions from flares involving fracturing fluids.²

In brief, the previous studies found that measurements of carbon monoxide, carbon dioxide, and methane concentrations to be safe at all points downwind, including within 50 m of the flare pit. Measurements of suspended particulate matter found concentrations typical of background levels, and measurements of PM₁₀ found compliance with national standards even in close proximity to the flare. Beyond 120 m from the flare pit, concentrations of polycyclic aromatic hydrocarbons (PAH) approached background levels, as did levels of dioxins beyond 250 m from the flare.

In summary, the studies established that under combustion conditions of high volume flaring of gases with some light entrained liquids etc., atmospheric concentrations of all contaminants had reduced by a distance of 250 m downwind to become essentially typical of or less than elsewhere in the Taranaki environment (for example urban areas). These levels are well below any concentrations at which there is any basis for concern over potential health effects.

¹ Taranaki Regional Council, *Fletcher Challenge Energy Taranaki Ltd, Mangahewa 2 Gas Well Air Quality Monitoring Programme Report 1997 - 98*, August 1998.

² Taranaki Regional Council: *Atmospheric Dispersion Modelling of Discharges to Air from the Flaring of Fracturing Fluid*, Backshall, March 2013; and *Investigation of air quality arising from flaring of fracturing fluids -emissions and ambient air quality*, Technical Report 2012- 03, Taranaki Regional Council May 2012.

The measures to be undertaken by GPL to avoid or mitigate actual or potential adverse environmental impacts on air quality included:

- The use of a test separator to separate solids and fluids from the gas during all well clean-ups, and workover activities where necessary, thus reducing emissions to air. In particular, this would reduce the potential for heavy smoke incidents associated with elevated PAH and dioxin emissions;
- Records of flaring events are kept by GPL and provided to the Council;
- Every endeavor was made by GPL to minimise the total volume of gas flared while ensuring that adequate flow and pressure data was gathered to inform their investment decision; and
- Every endeavor was made by GPL to minimise smoke emissions from the flare.

Odour and dust

Suppression of dust with water was to be implemented if it was apparent that dust may be travelling in such a direction to adversely affect off site parties. Odour may stem from the product, flare, or some of the chemicals used on site. Care was taken to minimize the potential for odour emissions (for example by keeping containers sealed, and ensuring the flare burnt cleanly).

Hazardous substances

The use and storage of hazardous substances on site has the potential to contaminate surface water and soils in the event of a spill. In the unlikely event of a serious spill or fire, the storage of flammable materials could have resulted in air, soil and water contamination.

GPL was required to implement the following mitigation measures:

- All potentially hazardous material were used and stored in accordance with the relevant Hazardous Substances and New Organisms regulations;
- All areas containing hazardous chemicals were bunded;
- Sufficient separation of chemicals from the flare pit were maintained for safety reasons;
- In the unlikely event of a spill escaping from bunded areas, the site perimeter drain and interceptor pit system was implemented to provide secondary containment on site; and
- A spill contingency plan was prepared that sets out emergency response procedures to be followed in the event of a spill.

Hydraulic fracturing

The process of hydraulic fracturing results in some chemicals (for example clay stabilisers) being absorbed into the rock, where some may be residually trapped near the fracture face. The chemicals used in the fracturing process are classified as hazardous substances. However, these additives used in the process make up less than 5% of the total volume of fluid, the remaining being water and proppant. In a concentrated form some of the chemicals used in the fluid are toxic, but prior to the activity they are highly diluted as part of the process. The majority of the fluid returns to the surface for controlled disposal at a consented facility.

Hence, there is a discharge of contaminants (energy, chemicals, water and inert sand/ small ceramic pellets) to land at considerable depth that has minor and temporary changes to the physical and chemical condition of the land (reservoir) in a way that does not affect other foreseeable users of the land and water resources.

The interval fractured is generally over 3 km below the surface. It is isolated by a considerable thickness of impermeable rock. The reservoir sands are known to contain hydrocarbons at pressures that exceed hydrostatic pressure, proving that the cap rock is relatively impermeable to the flow of water and hydrocarbons over very long time scales and high pressures.

The potential for the hydraulic fracturing activities to trigger seismic activity, particularly if located near faults within the formation has also been raised as a concern by some individuals. However, hydraulic fracturing is designed to create certain fractures in the rock and on a geological scale these are insignificant. The fissures created by the fracturing discharge are generally less than 400 m long, several mm wide and roughly 20 m thick into reservoir rock. These are very small features on a geological scale, and are not envisaged to create any increased risk of significant seismic activity.

The risk of the reservoir being fractured with a failure of the geological seal causing fracture fluids to migrate upwards and contaminate groundwater resources is considered extremely low. This is a result of numerous geological seals acting as natural barriers that stop any fracture fluids migrating upward.

Concern has also been raised that shallow groundwater may become contaminated from chemicals used in the hydraulic fracturing process. It is alleged that fluids may return to the surface via poorly sealed well casing or via cracks created through the fracturing process, rendering groundwater unsafe for human consumption. These hydro-geological risks of hydraulic fracturing affecting potable groundwater arise from two potential sources. The integrity of the well being used for the hydraulic fracturing, including the well casing and cement programme; and the geologic integrity of the reservoir seal and seals above this.

As a result of fracture design and modelling, coupled with extensive monitoring, the potential for groundwater to be impacted by hydraulic fracturing of a properly constructed well is extremely low and highly unlikely.

Summary

There were no significant adverse environmental effects observed to water, land or air as a result of the wellsite activities during the monitoring period.

3.4 Evaluation of performance

A tabular summary of GPL's compliance record for the period under review is set out in Tables 9 to 14.

Table 3 Summary of performance for consent 4067-2 to discharge treated stormwater.

| Condition requirement | Means of monitoring during period under review | Compliance achieved? |
|--|--|---|
| 1. Consent holder to adopt best practicable option at all times | Visually inspecting site, procedures and processes | Yes |
| 2. Maximum stormwater catchment area shall be no more than 1.3 ha | Plans, procedures and processes | Yes |
| 3. Five days working notice provided to the Council prior to site works and drilling | Notification received | Yes |
| 4. Council to approve prepared contingency plan in relation to the wellsite prior to exercise of the consent | Contingency plan approved | Yes |
| 5. The stormwater system shall be designed, managed, and maintained in accordance with information submitted | Comparative inspections in accordance with information submitted | Yes |
| 6. All discharges from the site shall flow to a perimeter drain and skimmer pit | Site inspection | Yes |
| 7. Discharge shall be applied so that it infiltrates the soil and does not pond or run off to water | Site inspection | Yes |
| 8. Skimmer pits shall have a combined capacity of no less than 260m ³ and retain hydrocarbons | Site inspection and physicochemical sampling | Yes |
| 9. All stormwater pits shall be lined with impervious material | Site inspection | Yes |
| 10. Perimeter drains and to be installed prior to commencement of any site works | Site inspection | Yes |
| 11. Constituents in the discharge shall meet the following standards: a) pH 6.0 - 9.0 b) Suspended solids <100 g/m ³ c) Hydrocarbon <15 g/m ³ d) Chloride <50 g/m ³ | Physicochemical sampling | No – the chloride limit was breached on two sampling occasions, however the likely environmental effect of this is minimal and all other samples of the discharge returned good results |
| 12. Following a mixing zone of 25 m, discharges shall not give rise to an increase in temperature of more than 2°C | Physicochemical sampling | Yes |

| Condition requirement | Means of monitoring during period under review | Compliance achieved? |
|--|--|----------------------|
| 13. Following the mixing zone, the discharge shall not give rise to adverse effects in/on the receiving waters | Site inspection | Yes |
| 14. The Council shall be advised in writing 48 hrs prior to reinstatement of the site | Notification | Yes |
| 15. Notice of Council to review consent | No provision for review during monitoring period | N/A |
| Overall assessment of consent compliance and environmental performance in respect of this consent | | High |
| Overall assessment of administrative performance in respect of this consent | | High |

Table 4 Summary of performance for consent 4069-4 to discharge emissions to air from flaring.

| Condition requirement | Means of monitoring during period under review | Compliance achieved? |
|---|---|----------------------|
| 1. Flaring shall not occur for more than 45 days per zone, for up to four zones per well, for up to four wells | Inspection of records | Yes |
| 2. Council must be notified at least 1 month before establishment of production operations at the wellsite | Notification received | Yes |
| 3. Consent holder shall supply the Council with a final layout plan | Plan received | Yes |
| 4. Council must be notified 24hrs prior to initial flaring of each zone. | Notification | Yes |
| 5. At least 24hrs notice prior to flaring required to notify neighbours within 1000m of the wellsite when practicable | Notification received | Yes |
| 6. Council notified of continuous flaring | Notification received | Yes |
| 7. Consultation prior to alteration to plant equipment or processes | Site inspection and liaison with consent holder | Yes |
| 8. Regard given to wind conditions during flaring | No complaints received from neighbours | Yes |
| 9. Gas treated by liquid and solid separation and recovery | Site inspection | Yes |
| 10. Notify Council and re-establish liquid separation and recovery within 3 hrs if separation cannot be implemented while well is flowing | Notification and site inspection | Yes |
| 11. No liquid or solid hydrocarbons through gas flare | Inspection of flare pit | Yes |

| Condition requirement | Means of monitoring during period under review | Compliance achieved? |
|--|--|----------------------|
| 12. After flow commences, separated gas shall be combusted through the gas flare system | Inspection of flare pit | Yes |
| 13. Best practicable option to prevent effects on the environment | Site inspection, procedures and processes | Yes |
| 14. Flare only used to dispose of substances from the well stream | Site inspection | Yes |
| 15. Consent holder shall not discharge any contaminant to air that is liable to be hazardous, toxic or noxious at or beyond the boundary of the wellsite | Site inspection | Yes |
| 16. No offensive odour or smoke beyond the boundary | Site inspection | Yes |
| 17. Opacity of smoke emissions shall not exceed level 1 on Ringelmann Scale | Site inspection | Yes |
| 18. Control of carbon monoxide | Ambient gas monitoring | Yes |
| 19. Control of nitrogen oxides | Ambient gas monitoring | Yes |
| 20. No discharge of contaminant that exceeds specific WES limits | Ambient gas monitoring | Yes |
| 21. Flaring limited to within 20 m of defined location | Site inspection | Yes |
| 22. Analysis of typical gas and crude oil streams from the field made available to Council | Available on request | Yes |
| 23. Record of smoke-emitting incidents | Available on request | Yes |
| 24. Log all flaring, including time, duration, zone, volumes flared and smoke events | Inspections of records | Yes |
| 25. Notice of Council to review consent | No provision for review during monitoring period | N/A |
| Overall assessment of consent compliance and environmental performance in respect of this consent | | High |
| Overall assessment of administrative performance in respect of this consent | | High |

Table 5 Summary of performance for consent 7067-1 to abstract groundwater

| Condition requirement | Means of monitoring during period under review | Compliance achieved? |
|---|--|----------------------|
| 1. Abstraction must not cause more than a 10% lowering of static water level by interference with any adjacent bore | Complaints and sampling | Yes |
| 2. Abstractions does not cause salt water intrusion into any freshwater aquifer | Water sampling in adjacent bores pre/post drilling | Yes |
| 3. Well log to 1000 m submitted to Council | Well log submitted | Yes |
| 4. Consent holder shall maintain records of abstraction and make available to Council | Available on request | Yes |
| 5. Consent shall lapse if not implemented by date specified | Notification received and confirmed by site inspection | Yes |
| 6. Notice of Council to review consent | No provision for review during the monitoring period | N/A |
| Overall assessment of consent compliance and environmental performance in respect of this consent | | High |
| Overall assessment of administrative performance in respect of this consent | | High |

Table 6 Summary of performance for consent 7068-1 to discharge waste drilling fluids and/or produced water by deepwell injection

| Condition requirement | Means of monitoring during period under review | Compliance achieved? |
|--|---|----------------------|
| 1. Prior to the exercise of consent, the consent holder shall submit an "Injection Operation Management Plan" | Consent not exercised during monitoring period under review | N/A |
| 2. Consent holder shall ensure that injection will not contaminate any freshwater aquifer | Consent not exercised during monitoring period under review | N/A |
| 3. Consent holder to keep daily record of nature and amount of injected material and make available to Council on 3-monthly basis | Consent not exercised during monitoring period under review | N/A |
| 4. Injected wastes monitored daily for: a) pH b) suspended solids c) total dissolved solids d) salinity e) chlorides f) total hydrocarbons | Consent not exercised during monitoring period under review | N/A |
| 5. Fluid injected at pressures below the pressure required to fracture the injection formation | Consent not exercised during monitoring period under review | N/A |

| Condition requirement | Means of monitoring during period under review | Compliance achieved? |
|---|---|----------------------|
| 6. Consent holder to provide a written report during May each year | Consent not exercised during monitoring period under review | N/A |
| 7. Consent shall lapse implemented by date specified | Consent not exercised during monitoring period under review | N/A |
| 8. Notice of Council to review consent | Consent not exercised during monitoring period under review | N/A |
| Overall assessment of consent compliance and environmental performance in respect of this consent | | N/A |
| Overall assessment of administrative performance in respect of this consent | | N/A |

Table 7 Summary of performance for consent 7069-1 to discharge drilling wastes on and into land via mix-bury-cover

| Condition requirement | Means of monitoring during period under review | Compliance achieved? |
|---|---|----------------------|
| 1. Volume of waste discharged shall not exceed 4000 m ³ | Consent not exercised during monitoring period under review | N/A |
| 2. Prior to exercise of consent, the consent holder to provide report for each discharge to Council | Consent not exercised during monitoring period under review | N/A |
| 3. Discharge to take place in accordance with information submitted in support of application | Consent not exercised during monitoring period under review | N/A |
| 4. Notification to Council 48 hrs prior to commencement and upon completion of discharge | Consent not exercised during monitoring period under review | N/A |
| 5. Records of composition, volumes, and quantities of waste to be discharged shall be kept | Consent not exercised during monitoring period under review | N/A |
| 6. Edge of mix-bury-cover zone to be at least 30 m from any water source | Consent not exercised during monitoring period under review | N/A |
| 7. All ponded water to be removed from drilling waste retention receptacle prior to mix-bury-cover operations | Consent not exercised during monitoring period under review | N/A |
| 8. All sumps to be permeable | Consent not exercised during monitoring period under review | N/A |
| 9. Solid drilling wastes to be incorporated with uncontaminated soils | Consent not exercised during monitoring period under review | N/A |
| 10. Placement of solid drilling wastes, where practicable, to be above water table | Consent not exercised during monitoring period under review | N/A |

| | | |
|--|---|-----|
| 11. Total loading of trace elements in waste shall not exceed Alberta Energy and Utilities Board, 1996, G-50 guidelines | Consent not exercised during monitoring period under review | N/A |
| 12. Chloride levels in each disposal area shall not exceed 1600 kg | Consent not exercised during monitoring period under review | N/A |
| 13. Nitrogen levels in each disposal area shall not exceed 400 kg | Consent not exercised during monitoring period under review | N/A |
| 14. Hydrocarbon levels in the soil waste mix shall not exceed 0.0015% [15 mg/kg] on a dry weight basis | Consent not exercised during monitoring period under review | N/A |
| 15. Level of total dissolved salts within surface or ground water shall not exceed 2500 gm ⁻³ | Consent not exercised during monitoring period under review | N/A |
| 16. Disposal of solid drilling wastes to comply with specified limits | Consent not exercised during monitoring period under review | N/A |
| 17. Solid drilling wastes to be covered by at least 1 m of uncontaminated soil and revegetated within 6 months of completion of activity | Consent not exercised during monitoring period under review | N/A |
| 18. Cover material to be compacted and contoured to direct stormwater away from disposal site | Consent not exercised during monitoring period under review | N/A |
| 19. Consent holder to adopt best practicable option at all times | Consent not exercised during monitoring period under review | N/A |
| 20. Exercise of consent shall not lead to direct discharge of contaminants to a surface water body | Consent not exercised during monitoring period under review | N/A |
| 21. Exercise of consent shall not result in adverse impacts on ground or surface water, or result in a change of suitability of use | Consent not exercised during monitoring period under review | N/A |
| 22. Hydrocarbon concentrations in the soil covering the disposal site to comply with agreed guideline values | Consent not exercised during monitoring period under review | N/A |
| 23. Soil levels shall not exceed the following parameters: a) conductivity 290 mS/m b) total dissolved salts 2500 g/m ³ c) sodium 460 g/m ³ d) chloride 700 g/m ³ | Consent not exercised during monitoring period under review | N/A |
| 24. Consent holder may apply to Council for change or cancellation to conditions | Consent not exercised during monitoring period under review | N/A |

| | | |
|---|---|-----|
| 25. Council may review any or all of consent conditions within two months of condition 2 | Consent not exercised during monitoring period under review | N/A |
| 26. Consent shall lapse if not implemented by date specified | Consent not exercised during monitoring period under review | N/A |
| 27. Notice of Council to review consent | Consent not exercised during monitoring period under review | N/A |
| Overall assessment of consent compliance and environmental performance in respect of this consent | | N/A |
| Overall assessment of administrative performance in respect of this consent | | N/A |

Table 8 Summary of performance for consent 9744-1 to discharge water-based hydraulic fracturing fluids

| Condition requirement | Means of monitoring during period under review | Compliance achieved? |
|--|--|----------------------|
| 1. Discharge to occur below 3,620 mTVD | Review of records | Yes |
| 2. No discharge into reservoir after 1 June 2017 | - | N/A |
| 3. Exercise of consent shall not contaminate or put at risk freshwater | Sampling bores pre/post discharge | Yes |
| 4. Consent holder shall undertake sampling programme | Inspection and sampling bores pre/post discharge | Yes |
| 5. Groundwater monitoring bores may be installed as required | Site assessment | Yes |
| 6. Sampling programme shall follow recognised field parameters | Inspection, procedures and processes | Yes |
| 7. Sampling and analysis shall follow recognised protocols | Inspection, procedures and processes | Yes |
| 8. Consent holder to undertake well and equipment pressure testing | Review of records | Yes |
| 9. Pre-fracturing report provided to Council 14 days prior to second and subsequent discharges | Report received | Yes |
| 10. Consent holder to notify prior to each hydraulic fracture discharge | Notification received | Yes |
| 11. Post-fracturing report provided to Council within 60 days after discharge has ceased | Report received | Yes |
| 12. Reports as per conditions 9 and 11 to be emailed to consents@trc.govt.nz | Reports received via email | Yes |

| | | |
|---|--|-------------|
| 13. Consent holder to provide access to location where hydraulic fracture fluids and return fluids can be collected by Council officers | Provided | Yes |
| 14. Consent holder to adopt best practicable option at all times | Inspection, sampling, procedures and processes | Yes |
| 15. Fracture fluid comprised of no less than 91% water and proppant | Sample of discharge and return fluids | Yes |
| 16. Notice of Council to review consent | No provision for review | N/A |
| Overall assessment of consent compliance and environmental performance in respect of this consent | | High |
| Overall assessment of administrative performance in respect of this consent | | High |

During the monitoring period, Greymouth Petroleum Limited demonstrated a high level of environmental performance and compliance with the resource consents. The site was generally neat, tidy, and well maintained.

3.5 Exercise of optional review of consents

Resource consents 4069-4, 7067-1, 7068-1 and 7069-1 provide for optional review in June 2015. Conditions 25, 6, 8 and 27, respectively, allow the Council to review the consents for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of these resource consents, which were either not foreseen at the time the applications were considered or which it was not appropriate to deal with at the time.

Resource consent 9744-1 also provides for an optional review in June 2015. In this case, condition 16 allows the Council to review the consent for any of the following purposes:

- a) ensuring that the conditions are adequate to deal with any significant adverse effects on the environment arising from the exercise of this consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time; and/or
- b) further specifying the best practicable option as required by condition 14; and/or
- c) ensuring hydraulic fracturing operations appropriately take into account any best practice guidance published by a recognised industry association or environmental regulator.

Based on the results of monitoring during the period under review, it is considered that there are no grounds that require a review to be pursued. A recommendation to this effect is presented in section 4.

3.6 Alterations to monitoring programmes

In designing and implementing the monitoring programmes for air and water discharges and water abstractions at wellsites in the region, the Council takes into account the extent of information made available by previous and other authorities, its relevance under the Act, the obligations of the Act in terms of monitoring emissions/discharges and effects, and of subsequently reporting to the regional community, the scope of assessments required at the time of renewal of permits, and the need to maintain a sound understanding of wellsite processes within Taranaki.

The Council has routinely monitored wellsite activities for more than 20 years in the region. This work has included multiple water samples and biomonitoring surveys in the vicinity of wellsites, and has demonstrated that a monitoring regime based on frequent and comprehensive inspections is rigorous and thorough, in terms of identifying any adverse effects from wellsite and associated activities. Furthermore, with regard to hydraulic fracturing activities, baseline groundwater monitoring samples have demonstrated that hydraulic fracturing discharges have not given rise to any significant adverse effects on groundwater aquifers within the region. However, the Council had for a time not routinely required the imposition of additional targeted physicochemical and biological monitoring unless a site-specific precautionary approach indicated this would be warranted for certainty and clarity around site effects.

In addition, the Council has also noted a desire by some community groups or individuals for a heightened level of information feedback and certainty around the results and outcomes of monitoring at wellsites. The Council has therefore moved to extend the previous regime, to make the sampling and extensive analysis of groundwater and surface waters in the general vicinity of a wellsite where hydraulic fracturing occurs, and biomonitoring of surface water ecosystems, an integral part of the basic monitoring programme for such activities.

Therefore, it is proposed that for any further work at the Ngatoro-E wellsite, the new standard programme will continue to be repeated, notwithstanding the lack of any effects or concerns previously found. A recommendation to this effect is attached to this report.

4. Recommendations

1. THAT this report be forwarded to the Company, and to any interested parties upon request;
2. THAT the monitoring of future consented activities at Ngatoro-E wellsite continues to include the sampling and extensive analysis of both groundwater and surface waters in the general vicinity of a wellsite where hydraulic fracturing occurs;
3. THAT the monitoring of future consented activities at Ngatoro-E wellsite continues to include biomonitoring surveys;
4. THAT, subject to the findings of monitoring of any further activities at the Ngatoro-E wellsite consents 4069-4, 7067-1, 7068-1, 7069-1 and 9744-1 shall not be reviewed in 2015.

Glossary of common terms and abbreviations

The following abbreviations and terms may have been used within this report:

| | |
|------------------|---|
| Al* | Aluminium. |
| As* | Arsenic. |
| Biomonitoring | Assessing the health of the environment using aquatic organisms. |
| BOD | Biochemical oxygen demand. A measure of the presence of degradable organic matter, taking into account the biological conversion of ammonia to nitrate. |
| BODF | Biochemical oxygen demand of a filtered sample. |
| Bund | A wall around a tank to contain its contents in the case of a leak. |
| CBOD | Carbonaceous biochemical oxygen demand. A measure of the presence of degradable organic matter, excluding the biological conversion of ammonia to nitrate . |
| COD | Chemical oxygen demand. A measure of the oxygen required to oxidise all matter in a sample by chemical reaction. |
| Conductivity | Conductivity, an indication of the level of dissolved salts in a sample, usually measured at 20°C and expressed in mS/m. |
| Cu* | Copper. |
| DO | Dissolved oxygen. |
| DRP | Dissolved reactive phosphorus. |
| F | Fluoride. |
| 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 what were the circumstances/events surrounding an incident including any allegations of an incident. |
| l/s | Litres per second. |
| 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. |
| Mixing zone | The zone below a discharge point where the discharge is not fully mixed with the receiving environment. For a stream, conventionally taken as a length equivalent to 7 times the width of the stream at the discharge point. |
| NH ₄ | Ammonium, normally expressed in terms of the mass of nitrogen (N). |

| | |
|------------------|---|
| NH ₃ | Unionised ammonia, normally expressed in terms of the mass of nitrogen (N). |
| NO ₃ | Nitrate, normally expressed in terms of the mass of nitrogen (N). |
| NTU | Nephelometric Turbidity Unit, a measure of the turbidity of water. |
| O&G | Oil and grease, defined as anything that will dissolve into a particular organic solvent (e.g. hexane). May include both animal material (fats) and mineral matter (hydrocarbons). |
| Pb* | Lead. |
| pH | A numerical system for measuring acidity in solutions, with 7 as neutral. Numbers lower than 7 are increasingly acidic and higher than 7 are increasingly alkaline. The scale is logarithmic i.e. a change of 1 represents a ten-fold change in strength. For example, a pH of 4 is ten times more acidic than a pH of 5. |
| Physicochemical | Measurement of both physical properties(e.g. temperature, clarity, density) and chemical determinants (e.g. metals and nutrients) to characterise the state of an environment. |
| PM ₁₀ | Relatively fine airborne particles (less than 10 micrometre diameter). |
| Resource consent | Refer Section 87 of the RMA. Resource consent 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 subsequent amendments. |
| SS | Suspended solids. |
| Temp | Temperature, measured in °C (degrees Celsius). |
| Turb | Turbidity, expressed in NTU. |
| UI | Unauthorised Incident. |
| UIR | Unauthorised Incident Register - contains a list of events recorded by the Council on the basis that they may have the potential or actual environmental consequences that may represent a breach of a consent or provision in a Regional Plan. |
| Zn* | Zinc. |

*an abbreviation for a metal or other analyte may be followed by the letters 'As', to denote the amount of metal recoverable in acidic conditions. This is taken as indicating the total amount of metal that might be solubilised under extreme environmental conditions. The abbreviation may alternatively be followed by the letter 'D', denoting the amount of the metal present in dissolved form rather than in particulate or solid form.

For further information on analytical methods, contact the Council's laboratory.

Appendix I

Resource consents

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

Name of
Consent Holder: Greymouth Petroleum Limited
P O Box 3394
NEW PLYMOUTH

Consent Granted
Date: 26 February 2007

Conditions of Consent

Consent Granted: To discharge drilling muds, drilling cuttings and drilling wastes from hydrocarbon exploration activities at the Ngatoro-E wellsite onto and into land via mix bury cover at or about GR: Q19:114-210

Expiry Date: 1 June 2021

Review Date(s): June 2009, June 2015

Site Location: Ngatoro-E wellsite, 561 Upper Dudley Road, Inglewood
[Owners: G & V Robinson]

Legal Description: Pt DP 2282 Sec 11 Pt Sec 17 Pt Sec 3 Blk VII Sec 12 Blk VIII Egmont SD

Catchment: Waitara

Tributary: Manganui
Ngatoro
Ngatoro-iti

General conditions

- a) On receipt of a requirement from the Chief Executive, Taranaki Regional Council the consent holder shall, within the time specified in the requirement, supply the information required relating to the exercise of this consent.
- b) Unless it is otherwise specified in the conditions of this consent, compliance with any monitoring requirement imposed by this consent must be at the consent holder's own expense.
- c) The consent holder shall pay to the Council all required administrative charges fixed by the Council pursuant to section 36 in relation to:
 - i) the administration, monitoring and supervision of this consent; and
 - ii) charges authorised by regulations.

Special conditions

1. This consent allows for the discharge of up to 4000 m³ of solid drilling wastes [including drill cuttings and residual fluids] by way of mix-bury-cover into land on the Ngatoro-E wellsite and surrounding land.
2. Prior to the exercise of this consent for each separate mix-bury-cover discharge the consent holder shall provide to the written satisfaction of the Chief Executive, Taranaki Regional Council, a report describing proposed mix-bury-cover, including area, location, nature of material, means of compliance with conditions, etc, and the results of any relevant monitoring of existing mix-bury-cover discharge sites under this consent. In any case additional mix-bury-cover discharges shall not take place under this consent within 12 months of any previous mix-bury-cover discharge, unless this requirement is waived in writing by the Chief Executive, Taranaki Regional Council.
3. The consent holder shall ensure that the discharge, licensed by this consent, takes place in general accordance with the information submitted in support of application 4539. In particular but without limitation, any amendment to the location of the mix-bury-cover site, pre-treatment of solids, changes to fluids/additives, method of mix-bury-cover, or post burial site management, shall be advised to the Chief Executive, Taranaki Regional Council, prior to any discharge to the mix-bury-cover site, and shall not provide or result in any less environmental protection than that set out or provided for in the information submitted in support of application 4539.
4. The consent holder shall notify the Taranaki Regional Council at least 48 hours prior to commencement, and upon completion of the discharge to the mix-bury-cover site[s].

Consent 7069-1

5. The consent holder shall keep records of the composition and volumes of the material to be discharged, including records of quantities and types of drilling fluids and additives used [materials and their composition], and shall forward the records to the Taranaki Regional Council prior to the discharge.
6. The edge of the mix-bury-cover zone shall be at least 30 metres from any surface water body, spring, or any pre-existing groundwater supply bore.
7. All ponded water shall be removed from the drilling waste holding receptacle prior to the recovery/mixing operation.
8. If sumps are used as drilling waste holding receptacles on the site, and the sump is to be used for a disposal area, the impermeable liner shall be perforated, and where possible removed, so that it no longer encloses the solid drilling wastes.
9. The solid drilling wastes [drill cuttings and residual fluids] shall be incorporated with uncontaminated soils with a mixing ratio of 1 part solid drilling wastes [drill cuttings, additives and residual fluids] to a minimum of 3 parts uncontaminated soil.
10. The placement of the solid drilling wastes [drill cuttings and residual fluids] shall, as far as practicable, be above the watertable.
11. The total loading of trace elements in the solid drilling wastes to be disposed of in the mix-bury-cover operation shall not exceed those listed in Table 3-1 of the Alberta Energy and Utilities Board, 1996, G-50 guidelines.
12. The loading of chloride must not exceed 1,600 kg for each distinct mix-bury-cover disposal area for wastes from an individual well.
13. The loading of nitrogen must not exceed 400 kg for each distinct mix-bury-cover disposal area for wastes from an individual well.
14. The hydrocarbon content of the soil waste mix shall not exceed 0.0015% [15 mg/kg] on a dry weight basis.
15. The exercise of this consent shall not result in a level of total dissolved salts within any surface water or ground water of more than 2500 gm⁻³.
16. The disposal of solid drilling wastes shall comply with the heavy metal receiving environment concentration limits specified in Table C, Section 9, Public Guidelines for the Safe Use of Sewage Effluent and Sewage Sludge on Land, Ministry of Health, 1992.

Consent 7069-1

17. The solid drilling wastes [drill cuttings and residual fluids] shall be covered by at least one metre of uncontaminated soil, and shall be revegetated and thereafter maintained with pasture cover within 6 months of the completion of any mix-bury-cover operation.
18. The consent holder shall compact and contour the cover material such that all surface stormwater is directed away from the mix-bury-cover site and shall maintain the cover layer of soil so as to ensure its integrity at all times to the satisfaction of the Chief Executive, Taranaki Regional Council.
19. The consent holder shall adopt the best practicable option [as defined in section 2 of the Resource Management Act 1991] to prevent or minimise any actual or potential adverse effects on the environment arising from the discharge, including but not limited to any water body or soil.
20. The exercise of this consent shall not lead, or be liable to lead, to a direct discharge of contaminants to a surface water body.
21. The exercise of this consent shall not result in any adverse impacts on groundwater as a result of leaching, or on surface water including aquatic ecosystems, and/or result in a change to the suitability of use of the receiving water as determined by the Chief Executive, Taranaki Regional Council.
22. At any time the levels of hydrocarbons in the soil shall comply with the guideline values for the designated soil type in the surface layer [less than 0.5 metre depth] set out in Tables 4.12 and 4.15 of the Guidelines for Assessing and Managing Petroleum Hydrocarbon Contaminated Sites in New Zealand [Ministry for the Environment, 1999].
23. At any time the upper [less than 0.5 metre depth] soil levels shall not exceed the following limits: conductivity 290 mSm⁻¹; total dissolved salts 2500 gm⁻³; sodium 460 gm⁻³; and chloride 700 gm⁻³.
24. The consent holder may apply to the Taranaki Regional Council for a change or cancellation of any of the conditions of this consent in accordance with section 127(1)(a) of the Resource Management Act 1991 to take account of operational requirements or the results of monitoring.
25. The Taranaki Regional Council may review any or all of the conditions of this consent within two months of receiving data on the volume and composition of the material under condition 5 for the purpose of assessing the adequacy of monitoring and mitigation measures.

Consent 7069-1

26. This consent shall lapse on the expiry of five years after the date of issue of this consent, 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.

27. In accordance with section 128 and section 129 of the Resource Management Act 1991, the Taranaki Regional Council may serve notice of its intention to review, amend, delete or add to the conditions of this resource consent by giving notice of review during the month of June 2009 and/or June 2015, for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of this resource consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time.

Signed at Stratford on 26 February 2007

For and on behalf of
Taranaki Regional Council

Director-Resource Management



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

Name of
Consent Holder: Greymouth Petroleum Limited
P O Box 3394
NEW PLYMOUTH

Consent Granted
Date: 5 March 2007

Conditions of Consent

Consent Granted: To take groundwater during hydrocarbon exploration and production operations from up to four new wells at the Ngatoro-E wellsite at or about GR: Q19:114-210

Expiry Date: 1 June 2021

Review Date(s): June 2009, June 2015

Site Location: Ngatoro-E wellsite, 561 Upper Dudley Road, Inglewood
[Owners: G & V Robinson]

Legal Description: Pt DP 2282 Sec 11 Pt Sec 17 Pt Sec 3 Blk VII Sec 12
Blk VIII Egmont SD

Catchment: Waitara

Tributary: Manganui
Ngatoro
Ngatoro-iti

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

General conditions

- a) On receipt of a requirement from the Chief Executive, Taranaki Regional Council the consent holder shall, within the time specified in the requirement, supply the information required relating to the exercise of this consent.
- b) Unless it is otherwise specified in the conditions of this consent, compliance with any monitoring requirement imposed by this consent must be at the consent holder's own expense.
- c) The consent holder shall pay to the Council all required administrative charges fixed by the Council pursuant to section 36 in relation to:
 - i) the administration, monitoring and supervision of this consent; and
 - ii) charges authorised by regulations.

Special conditions

1. The consent holder must ensure the abstraction shall cause not more than a 10% lowering of static water-level by interference with any adjacent bore.
2. The consent holder must ensure the abstraction shall not cause the intrusion of saltwater into any fresh water aquifer.
3. The consent holder shall submit, to the written satisfaction of the Chief Executive, Taranaki Regional Council, a summary well log to a depth of 1000 metres. The report shall:
 - a) provide a log to show the true vertical depth to all geological formation tops intersected within the freshwater zone;
 - b) identify the true vertical depth to, and thickness of, any freshwater aquifers intersected by the well;
 - c) identify the true vertical depth to the freshwater- saline water interface in the well.
4. The consent holder shall maintain records of abstraction including date, volume of groundwater abstracted per day, and shall make these records available to the Chief Executive, Taranaki Regional Council, upon request.
5. This consent shall lapse on 1 June 2021, unless the consent is given effect to before the end of that period or the Taranaki Regional Council fixes a longer period pursuant to section 125(1)(b) of the Resource Management Act 1991.

Consent 7067-1

6. In accordance with section 128 and section 129 of the Resource Management Act 1991, the Taranaki Regional Council may serve notice of its intention to review, amend, delete or add to the conditions of this resource consent by giving notice of review during the month of June 2009 and/or June 2015, for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of this resource consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time.

Signed at Stratford on 5 March 2007

For and on behalf of
Taranaki Regional Council

Director-Resource Management



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

Name of
Consent Holder: Greymouth Petroleum Limited
P O Box 3394
NEW PLYMOUTH

Consent Granted
Date: 5 March 2007

Conditions of Consent

Consent Granted: To discharge waste drilling fluids and/or produced water from hydrocarbon exploration and production operations by deepwell injection at or about GR: Q19:114-210

Expiry Date: 1 June 2021

Review Date(s): June 2009, June 2015

Site Location: Ngatoro-E wellsite, 561 Upper Dudley Road, Inglewood
[Owners: G & V Robinson]

Legal Description: Pt DP 2282 Sec 11 Pt Sec 17 Pt Sec 3 Blk VII Sec 12
Blk VIII Egmont SD

Catchment: Waitara

Tributary: Manganui
Ngatoro
Ngatoro-iti

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

General conditions

- a) On receipt of a requirement from the Chief Executive, Taranaki Regional Council the consent holder shall, within the time specified in the requirement, supply the information required relating to the exercise of this consent.
- b) Unless it is otherwise specified in the conditions of this consent, compliance with any monitoring requirement imposed by this consent must be at the consent holder's own expense.
- c) The consent holder shall pay to the Council all required administrative charges fixed by the Council pursuant to section 36 in relation to:
 - i) the administration, monitoring and supervision of this consent; and
 - ii) charges authorised by regulations.

Special conditions

1. Prior to the exercise of this consent for each individual well to be used for deepwell injection, the consent holder shall submit, to the written satisfaction of the Chief Executive, Taranaki Regional Council, a log of the injection well, and an injection well operation management plan, to demonstrate that special condition 2 of this consent can be met. The report shall:
 - a) identify the injection zone, including a validated bore log and geophysical log;
 - b) detail the results of fluid sampled from the injection zone, and the proposed wastes to be injected for maximum and mean concentrations for pH, suspended solids, total dissolved solids, salinity, chlorides, and total hydrocarbons;
 - c) demonstrate the integrity of well casing; and
 - d) outline design and operational procedure to isolate the zone.
2. The consent holder shall ensure that injection will not contaminate or endanger any actual or potential useable freshwater aquifer.
3. The consent holder shall keep daily records of the nature and amounts of all material injected, including injection pressure and rate, and shall make the records available to the Taranaki Regional Council on a 3 monthly basis, and when there has been a significant pressure change event.
4. The consent holder shall monitor the injected wastes daily for maximum and mean concentrations for pH, suspended solids, total dissolved solids, salinity, chlorides, and total hydrocarbons and shall make the records available to the Taranaki Regional Council every two months.
5. The consent holder shall inject fluids at pressures below the pressure that would be required to fracture the injection formation.
6. The consent holder shall provide to the Taranaki Regional Council during the month of May of each year, for the duration of the consent, a written report on all matters required under special conditions 1, 2, 3, 4 and 5 above.

Consent 7068-1

7. This consent shall lapse on the 1 June 2021, unless the consent is given effect to before the end of that period or the Taranaki Regional Council fixes a longer period pursuant to section 125(b) of the Resource Management Act 1991.
8. In accordance with section 128 and section 129 of the Resource Management Act 1991, the Taranaki Regional Council may serve notice of its intention to review, amend, delete or add to the conditions of this resource consent, by giving notice of review during the month following receipt of information required under special condition 6 above, and the month of June 2009 and/or June 2015 required for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of this resource consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time.

Signed at Stratford on 5 March 2007

For and on behalf of
Taranaki Regional Council

Director-Resource Management



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

Name of
Consent Holder: Greymouth Petroleum Limited
P O Box 3394
NEW PLYMOUTH 4341

Decision Date: 11 December 2013

Commencement Date: 11 December 2013

Conditions of Consent

Consent Granted: To discharge water based hydraulic fracturing fluids into land at depths greater than 3,620 mTVD beneath the Ngatoro-E wellsite

Expiry Date: 1 June 2022

Review Date(s): June annually

Site Location: Ngatoro-E wellsite, 615 Dudley Road, Inglewood

Legal Description: Sec 12 Blk VIII Egmont SD (Discharge source & site)

Grid Reference (NZTM) 1701339E-5659246N

Catchment: Waitara

Tributary: Manganui
Ngatoro
Ngatoro-iti

*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 3,620 mTVD.

Note: mTVD = metres true vertical depth, i.e. the true vertical depth in metres below ground level.

2. There shall be no discharge of hydraulic fracturing fluids into the reservoir after 1 June 2017.
3. The consent holder shall ensure that the exercise of this consent does not result in contaminants reaching any useable fresh water (groundwater or surface water). Usable fresh groundwater is defined as any groundwater having a Total Dissolved Solids concentration of less than 1000 mg/l.
4. The consent holder shall undertake a programme of sampling and testing that monitors the effects of the exercise of this consent on fresh water resources to assess compliance with condition 3 (the 'Monitoring Programme'). The Monitoring Programme shall be certified by the Chief Executive, Taranaki Regional Council ('the Chief Executive'), before this consent is exercised, and shall include:
 - (a) the location of the discharge point(s);
 - (b) the location of sampling sites; and
 - (c) sampling frequency with reference to a hydraulic fracturing programme.
5. 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, a monitoring bore. The bore 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 ($^{13}\text{C-CH}_4$).

Consent 9744-1.1

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. This plan shall specify the use of standard protocols recognised to constitute good professional practice including quality control and assurance. An International Accreditation New Zealand (IANZ) accredited laboratory shall be used for all sample analysis. Results shall be provided to the Chief Executive within 30 days of sampling and shall include supporting quality control and assurance information. These results will be used to assess compliance with condition 3.

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

8. The consent holder shall undertake well and equipment pressure testing prior to any hydraulic fracture programme on a given well to ensure any discharge will not affect the integrity of the well and hydraulic fracturing equipment.
9. Any hydraulic fracture discharge shall only occur after the consent holder has provided a comprehensive 'Pre-fracturing discharge report' to the Chief Executive. The report shall be provided at least 14 days before the discharge is proposed to commence and shall detail the hydraulic fracturing programme proposed, including as a minimum:
 - (a) the specific well in which each discharge is to occur, the intended fracture interval(s) ('fracture interval' is the discrete subsurface zone to receive a hydraulic fracture treatment), and the duration of the hydraulic fracturing programme;
 - (b) the number of discharges proposed and the geographical position (i.e. depth and lateral position) of each intended discharge point;
 - (c) the total volume of fracture fluid planned to be pumped down the well, including mini- fracture treatments, and their intended composition, including a list of all contaminants and Material Safety Data Sheets for all the chemicals to be used;
 - (d) the results of the reviews required by condition 14;
 - (e) results of modelling showing an assessment of the likely extent and dimensions of the fractures that will be generated by the discharge;
 - (f) the preventative and mitigation measures to be in place to ensure the discharge does not cause adverse environmental effects and complies with condition 3;
 - (g) the extent and permeability characteristics of the geology above the discharge point to the surface;
 - (h) any identified faults within the modeled fracture length plus a margin of 50%, and the potential for adverse environmental effects due to the presence of the identified faults;
 - (i) the burst pressure of the well and the anticipated maximum well and discharge pressures and the duration of the pressures; and
 - (j) details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal.

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

Consent 9744-1.1

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

Consent 9744-1.1

14. The consent holder shall at all times adopt the best practicable option, as defined in section 2 of the Resource Management Act 1991, to prevent or minimize any actual or likely adverse effect of the activity on the environment by, as a minimum, ensuring that:
 - (a) the discharge is contained within the fracture interval;
 - (b) regular reviews are undertaken of the preventative and mitigation measures adopted to ensure the discharge does not cause adverse environmental effects; and
 - (c) regular reviews of the chemicals used are undertaken with a view to reducing the toxicity of the chemicals used.
15. The fracture fluid shall be comprised of no less than 91% water and proppant by volume.
16. The Taranaki Regional Council may review any or all of the conditions of this consent by giving notice of review during the month of June each year, for the purposes of:
 - (a) ensuring that the conditions are adequate to deal with any significant adverse effects on the environment arising from the exercise of this consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time; and/or
 - (b) further specifying the best practicable option as required by condition 14; and/or
 - (c) ensuring hydraulic fracturing operations appropriately take into account any best practice guidance published by a recognised industry association or environmental regulator.

Signed at Stratford on 11 December 2013

For and on behalf of
Taranaki Regional Council

Director-Resource Management



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

Name of
Consent Holder: Greymouth Petroleum Acquisitions Company Limited
P O Box 3394
NEW PLYMOUTH 4341

Decision Date
(Change): 15 January 2014

Commencement Date
(Change): 15 January 2014 (Granted: 2 July 1999)

Conditions of Consent

Consent Granted: To discharge treated stormwater from hydrocarbon exploration and production operations at the Ngatoro-E wellsite onto land and into the Ngatoroitī Stream

Expiry Date: 1 June 2015

Site Location: Ngatoro-E wellsite, 615 Dudley Road, Inglewood

Legal Description: Sec 12 Blk VIII Egmont SD (Discharge source & site)

Grid Reference (NZTM) 1701491E-5659305N

Catchment: Waitara

Tributary: Manganui
Ngatoro
Ngatoroitī

*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 to section 36 of the Resource Management Act 1991.

Special conditions

1. 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 minimise any actual or likely adverse effect on the environment associated with the discharge of contaminants from the site.
2. Stormwater discharged shall be collected from a catchment area of no more than 1.3 ha.
3. At least 5 working days prior, the consent holder shall advise the Chief Executive, Taranaki Regional Council of the date of each of the following events:
 - a) commencement of any site works (site works includes the introduction of a drilling rig, drilling equipment or any other associated equipment or facilities to the site for any purpose other than for the construction of the site);
 - b) commencement of any well drilling operation; and
 - c) recommencement of any site works or drilling operations following a period of inactivity exceeding 30 days.

If any of these events is rescheduled or delayed, the consent holder shall immediately provide further notice advising of the new date.

Any advice given in accordance with this condition shall include the consent number and the wellsite name and be emailed to worknotification@trc.govt.nz.

4. The consent holder shall maintain a contingency plan that details measures and procedures to be undertaken to prevent spillage or accidental discharge of contaminants not authorised by this consent and measures to avoid, remedy or mitigate the environmental effects of such a spillage or discharge. The contingency plan shall be certified by the Chief Executive, Taranaki Regional Council prior to discharging from the site, and after any change to the plan.
5. Subject to the other conditions of this consent the design, management and maintenance of the stormwater system shall be undertaken in accordance with the information submitted in support of the consent application.

Consent 4067-2.1

6. All discharges from the site, including from any containment pit or hydrocarbon combustion facility (e.g. flare pit, thermal oxidiser), shall flow to a perimeter drain and skimmer pit. Perimeter drains shall be designed, including by having a positive grade and low permeability, to ensure that runoff flows directly to a skimmer pit without ponding.
7. The discharge shall be applied at such a rate and over such an area of land that it infiltrates the soil or runs off to surface water but does not pond.
8. Skimmer pits shall have a combined capacity of no less than 260 m³, and be designed to retain any hydrocarbons that enter them.
9. All skimmer pits and any other stormwater retention areas shall be lined with an impervious material to prevent seepage through the bed and sidewalls, and all skimmer pits shall have a valve that can be shut off to prevent any discharge from the site.
10. Perimeter drains and skimmer pits necessary to comply with the conditions of this consent shall be installed before any site works commences. Site works includes the introduction of a drilling rig, drilling equipment or any other associated equipment or facilities to the site for any purpose other than for the construction of the site.
11. Constituents in the discharge shall meet the standards shown in the following table.

| Constituent | Standard |
|--------------------------------|--|
| pH | Within the range 6.0 to 9.0 |
| suspended solids | Concentration not greater than 100 gm ⁻³ |
| total recoverable hydrocarbons | Concentration not greater than 15 gm ⁻³ [as determined by infrared spectroscopic technique] |
| chloride | Concentration not greater than 50 gm ⁻³ |

12. After allowing for a mixing zone of 25 metres, the discharge shall not give rise to an increase in the temperature of the receiving waters of more than 2 degrees Celsius.
13. After allowing for a mixing zone of 25 metres, the discharge shall not give rise to any of the following effects in the receiving water:
 - a) the production of any conspicuous oil or grease films, scums or foams, or floatable or suspended materials;
 - b) any conspicuous change in the colour or visual clarity;
 - c) any emission of objectionable odour;
 - d) the rendering of fresh water unsuitable for consumption by farm animals;
 - e) any significant adverse effects on aquatic life.
14. The consent holder shall advise the Chief Executive, Taranaki Regional Council, in writing at least 48 hours prior to the reinstatement of the site and the reinstatement shall be carried out so as to minimise adverse effects on stormwater quality. Notification shall include the consent number and a brief description of the activity consented and be emailed to worknotification@trc.govt.nz.

Consent 4067-2.1

15. In accordance with section 128 and section 129 of the Resource Management Act 1991, the Taranaki Regional Council may serve notice of its intention to review, amend, delete or add to the conditions of this resource consent by giving notice of review during the month of June 2003 and/or June 2009, for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of this resource consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time.

Signed at Stratford on 15 January 2014

For and on behalf of
Taranaki Regional Council

Director-Resource Management

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

Name of
Consent Holder: Greymouth Petroleum Limited
P O Box 3394
NEW PLYMOUTH 4341

Decision Date
(Change): 11 December 2013

Commencement Date
(Change): 11 December 2013 (Granted: 5 March 2007)

Conditions of Consent

Consent Granted: To discharge emissions to air from flaring during hydrocarbon exploration and production testing associated with up to 4 new wells, flaring from well workover activities and in emergency situations associated with production activities, and miscellaneous emissions at the Ngatoro-E wellsite

Expiry Date: 1 June 2021

Review Date(s): June 2015

Site Location: Ngatoro-E wellsite, 615 Dudley Road, Inglewood
(Property owener: G & V Robinson)

Legal Description: Sec 12 Blk VIII Egmont SD (Discharge source & site)

Grid Reference (NZTM) 1701350E-5659333N

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

General conditions

- a) On receipt of a requirement from the Chief Executive, Taranaki Regional Council the consent holder shall, within the time specified in the requirement, supply the information required relating to the exercise of this consent.
- b) Unless it is otherwise specified in the conditions of this consent, compliance with any monitoring requirement imposed by this consent must be at the consent holder's own expense.
- c) The consent holder shall pay to the Council all required administrative charges fixed by the Council pursuant to section 36 in relation to:
 - i) the administration, monitoring and supervision of this consent; and
 - ii) charges authorised by regulations.

Special conditions

Duration

1. This consent shall not be exercised for more than an accumulated duration of 45 days per zone, allowing four zones to be tested per well, from up to four wells. The time interval specified in this condition refers to that period during which this consent is exercised and is not regarded as continuous elapsed time from the first exercise of this consent.
2. The consent holder shall notify the Chief Executive, Taranaki Regional Council, in writing at least one month prior to the establishment of production operations at the Ngatoro-E wellsite.

Information and notification

3. Prior to the commencement of testing, the consent holder shall supply to the Chief Executive, Taranaki Regional Council, a final site layout plan, demonstrating configuration of the facilities and equipment so as to avoid or mitigate the potential effects of air emissions.
4. The Taranaki Regional Council shall be notified within 24 hours prior to the initial flaring of each zone being commenced.
5. At least 24 hours prior to any flaring, the consent holder shall undertake all practicable measures to notify residents within 1000 metres of the wellsite of the commencement of flaring. The consent holder shall include in the notification a 24-hour contact telephone number for a representative of the consent holder, and shall keep and make available to the Chief Executive, Taranaki Regional Council, a record of all queries and/or complaints received.
6. The consent holder shall, whenever practicable, notify the Chief Executive, Taranaki Regional Council, whenever the continuous flaring of hydrocarbons (other than purge gas) is expected to occur for more than five minutes in duration. Notification shall, as far as practicable, be no less than 24 hours prior to such flaring being commenced.

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7. No alteration shall be made to plant equipment or processes which may substantially alter the nature or quantity of flare emissions or other wellsite emissions, including but not limited to the recovery of produced gas, other than as notified in this consent application, without prior consultation with the Chief Executive, Taranaki Regional Council.

Flaring

8. Other than for the maintenance of a pilot flare flame, the consent holder shall have regard to the prevailing and predicted wind speed and direction at the time of initiation of any episode of flaring or other combustion of hydrocarbons.
9. All gas being flared, at any time during well clean-up, drill stem testing, initial testing, or production testing, or at any other time, must first be treated by effective liquid and solid separation and recovery, as far as is practicable to ensure that smoke emission during flaring is minimised.
10. If separation cannot be implemented and/or maintained at any time while there is a flow from the well, whether natural or induced, then the consent holder shall notify the Chief Executive, Taranaki Regional Council, and shall in any case re-establish liquid separation and recovery within three hours.
11. Subject to special conditions 9 and 10, no liquid or solid hydrocarbons shall be combusted through the gas flare system other than in an emergency.
12. As soon as is practicable after flow commences, the separated gas shall be combusted so that emissions of smoke are minimised.
13. The consent holder shall adopt the best practicable option, as defined in section 2 of the Resource Management Act 1991, to prevent or minimise any actual or potential effect on the environment arising from the flare emission, emissions from the flare pit, or any other emissions from the wellsite (including use of a separator during well clean-up). This requirement applies in addition to any of the specific requirements set out in conditions 1, 8, 9, 10, 11 and 12.
14. Only substances originating from the well stream and treated as outlined by conditions 9, 10, 11, 12 and 13 are to be combusted within the flare pit.
15. The consent holder shall not discharge any contaminant to air authorised by this consent at a rate or a quantity such that the contaminant, whether alone or in combination with other contaminants, is or is liable to be hazardous or toxic or noxious at or beyond the boundary of the wellsite, or beyond 100 metres of the flare, whichever distance is greater.
16. There shall not be any offensive odour or smoke, as determined by an enforcement officer of the Taranaki Regional Council, beyond the boundary of the wellsite or beyond 100 metres of the flare, whichever distance is greater, arising from the exercise of this consent.
17. The opacity of any smoke emissions shall not exceed a level of 1 as measured on the Ringelmann Scale for more than four minutes cumulative duration in any 60-minute period.

18. The consent holder shall control all emissions of carbon monoxide to the atmosphere from the flare, whether alone or in conjunction with any other emissions from the wellsite, in order that the maximum ground level concentration of carbon monoxide arising from the exercise of this consent measured under ambient conditions does not exceed 10 mg/m³ (eight-hour average exposure), or 30 mg/m³ one-hour average exposure) at or beyond the boundary of the wellsite or beyond 100 metres from the flare, whichever distance is greater.
19. The consent holder shall control all emissions of nitrogen oxides to the atmosphere from the flare, whether alone or in conjunction with any other emissions from the wellsite, in order that the maximum ground level concentration of nitrogen dioxide arising from the exercise of this consent measured under ambient conditions does not exceed 100 mg/m³ (24-hour average exposure), or 200 mg/m³ (1-hour average exposure) at or beyond the boundary of the wellsite, or beyond 100 metres from the flare, whichever distance is greater.
20. The consent holder shall control emissions to the atmosphere from the wellsite and flare of contaminants other than carbon dioxide, carbon monoxide, and nitrogen oxides, whether alone or in conjunction with any emissions from the flare, in order that the maximum ground level concentration for any particular contaminant arising from the exercise of this consent measured at or beyond the boundary of the wellsite or beyond 100 metres from the flare, whichever distance is greater, is not increased above background levels:
 - a) by more than 1/30th of the relevant Occupational Threshold Value-Time Weighted Average, or by more than the Short Term Exposure Limit at any time (all terms as defined in Workplace Exposure Standards, 2002, Department of Labour); or
 - b) if no Short Term Exposure Limit is set, by more than three times the Time Weighted Average at any time (all terms as defined in Workplace Exposure Standards, 2002, Department of Labour).
21. Flaring shall only occur within 20 metres of the location defined by NZTM 1701350E-565933N.

Recording and reporting information

22. The consent holder shall make available to the Chief Executive, Taranaki Regional Council, upon request, an analysis of a typical gas and crude oil stream from the field, covering sulphur compound content and the content of carbon compounds of structure C₆ or higher number of compounds.
23. The consent holder shall keep and make available to the Chief Executive, Taranaki Regional Council, upon request, a record of all smoke-emitting incidents noting time, duration and cause.
24. The consent holder shall keep and make available to the Chief Executive, Taranaki Regional Council, logs of all flaring, including time, duration and (as far as is practicable) volumes of substances flared.

Review

25. In accordance with section 128 and section 129 of the Resource Management Act 1991, the Taranaki Regional Council may serve notice of its intention to review, amend, delete or add to the conditions of this resource consent by giving notice of review during the month of June 2009 and/or June 2015, for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of this resource consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time.

Signed at Stratford on 11 December 2013

For and on behalf of
Taranaki Regional Council

Director-Resource Management

Appendix II
Biomonitoring Surveys

To Job Manager; Callum MacKenzie
From Freshwater Biologists; Darin Sutherland and Bart Jansma
Report No DS007
Document 1502247
Date 30 April 2015

Biomonitoring of the Ngatoroit Stream in relation to drilling at the Ngatoro-E wellsite, May and November 2014

Introduction

Pre-drill and a post-drill macroinvertebrate surveys were performed at the Ngatoro-E wellsite to determine whether drilling discharges of treated stormwater, uncontaminated site water, and production water into an unnamed tributary of the Ngatoroit Stream had had a detrimental effect upon macroinvertebrate communities of the Ngatoroit Stream. The pre-drill survey produced baseline results that allowed comparison with the post-drill survey enabling any changes in the condition of the macroinvertebrate communities to be determined. The Ngatoro-E wellsite stormwater and site production water was discharged from a skimmer pit into an unnamed tributary approximately 20 m upstream of its confluence with the Ngatoroit Stream (Figure 1).

Methods

The pre-drill survey was undertaken on 16 May 2014 at three sites (Table 1). Site 1 was the control site while site 2 was the primary impacted site and site 3 was the secondary impacted site. The subsequent post-drill survey was completed at the same three sites on 14 November 2014. The altitude of the three sites was approximately 330 m asl.

The Council's standard 'kick-sampling' technique was used to collect macroinvertebrates in the Ngatoroit Stream (Table 1). The 'kick-sampling' technique is very similar to Protocol C1 (hard-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark et al, 2001).

Table 1 Biomonitoring sites in the Ngatoroit Stream in relation to the Ngatoro-E wellsite.

| Site No. | Site code | Grid reference (NZTM) | Location |
|----------|-----------|-----------------------|---|
| 1 | NGI000174 | 1701506E-5659250N | Approx 30m upstream of the discharge tributary confluence |
| 2 | NGI000178 | 1701596E-5659355N | 110m downstream of the discharge tributary confluence |
| 3 | NGI000180 | 1701631E-5659464N | 220m downstream of the discharge tributary confluence |



Figure 1 Biomonitoring sites in the Ngatoroiti Stream in relation to the Ngatoro-E wellsite

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

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

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

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

A semi-quantitative MCI value (SQMCI_s) has also been calculated for the taxa present at each site by multiplying each taxon score by a loading factor (related to its abundance), totalling these products, and dividing by the sum of the loading factors (Stark, 1998 and 1999). The loading factors were 1 for rare (R), 5 for common (C), 20 for abundant (A), 100 for very

abundant (VA) and 500 for extremely abundant (XA). Unlike the MCI, the SQMCI_s is not multiplied by a scaling factor of 20, so that its corresponding range of values is 20x lower. A difference of 0.9 units or more in SQMCI_s is considered significantly different (Stark, 1998).

Results

Site habitat characteristics

The water temperatures were cool, with moderate water levels, swift flows, and clear water during the pre-drill and post drill sampling (Table 2). Substrate at site 1 during the pre-drill survey was comprised of a mixture of fine and coarse gravel, cobbles, and boulders while during the post-drill survey it was comprised of a mixture of fine gravel, cobbles, and boulders. Site 2 during the pre-drill survey was comprised of a mixture of cobbles and boulders while during the post-drill survey it was mainly comprised of cobble and boulder but with more fine and coarse gravel also evident. Site 3 during the pre-drill and post-drill survey had a predominantly coarse gravel, cobbles, and boulders substrate.

Slippery algal mats were present on hard substrates but no filamentous algae was present at the time of both the pre-drill survey and post-drill surveys for all sites except for the site 2 post-drill which had patchy algal mats and patchy filamentous algae present. All sites on both survey occasions had patchy moss present and the post-drill survey sites had patchy wood and leaves present. Only site 1 at the pre-drill survey had patchy leaves present. All sites were either partially or completely shaded with overhanging vegetation and undercut banks.

Table 2 Summary of time of sampling and some water variables collected at each site.

| | Time (NZST) | | Temperature (°C) | | Water Colour | | Water Clarity | | Flow Conditions | | Water Speed | |
|-----------|-------------|------|------------------|------|--------------|------------|---------------|-------|-----------------|----------|-------------|-------|
| | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post | Pre | Post |
| NGI000174 | 1400 | 0935 | 9.9 | 9.6 | Uncoloured | Uncoloured | Clear | Clear | Moderate | Moderate | Swift | Swift |
| NGI000178 | 1420 | 0905 | 10.0 | 9.5 | Uncoloured | Uncoloured | Clear | Clear | Moderate | Moderate | Swift | Swift |
| NGI000180 | 1435 | 0830 | 10.0 | 9.4 | Uncoloured | Uncoloured | Clear | Clear | Moderate | Moderate | Swift | Swift |

Macroinvertebrate communities

Comparative data for similar sites (TRC, 2015) are summarised in Table 3. Results of the pre-drill and post-drill survey macroinvertebrate faunal data are summarised in (Table 4).

Table 3 Range and median number of taxa, MCI values and SQMCI_s scores for 'control' sites (ring plain rivers/streams with sources in the National Park) at altitudes between 300 and 349 m asl (TRC, 2015).

| | No. of taxa | MCI value | SQMCI _s value |
|-------------|-------------|-----------|--------------------------|
| No. Samples | 187 | 187 | 129 |
| Range | 4-38 | 75-143 | 1.7-7.8 |
| Median | 23 | 118 | 7.0 |

Table 4 Macroinvertebrate fauna of the Ngatoroit Stream in relation to the Ngatoro-E wellsite surveys sampled 16 May 2014 (pre-drill) and 14 November, 2014 (post-drill).

| Taxa List | Site Code | MCI score | Pre-drill survey | | | Post-drill survey | | |
|-----------------------------|----------------------------------|-----------------------------|------------------|-------------------------|-----------|-------------------|-----------|-----------|
| | | | NGI000174 | NGI000178 | NGI000180 | NGI000174 | NGI000178 | NGI000180 |
| PLATYHELMINTHES (FLATWORMS) | <i>Neppia</i> | 6 | - | - | R | - | - | - |
| ANNELIDA (WORMS) | Oligochaeta | 1 | - | - | - | - | R | R |
| MOLLUSCA | <i>Gyraulus</i> | 3 | R | - | - | - | - | - |
| | <i>Potamopyrgus</i> | 4 | R | R | R | - | R | R |
| EPHEMEROPTERA (MAYFLIES) | <i>Ameletopsis</i> | 10 | - | - | - | R | R | - |
| | <i>Austroclima</i> | 7 | C | C | R | C | C | C |
| | <i>Coloburiscus</i> | 7 | VA | VA | XA | VA | VA | VA |
| | <i>Deleatidium</i> | 8 | VA | VA | VA | XA | XA | XA |
| | <i>Nesameletus</i> | 9 | A | VA | C | VA | A | A |
| | <i>Zephlebia group</i> | 7 | R | C | C | A | C | R |
| PLECOPTERA (STONEFLIES) | <i>Acroperla</i> | 5 | - | - | - | C | C | A |
| | <i>Austroperla</i> | 9 | - | R | R | - | - | R |
| | <i>Megaleptoperla</i> | 9 | - | R | R | - | - | - |
| | <i>Stenoperla</i> | 10 | - | R | - | - | - | - |
| | <i>Zelandobius</i> | 5 | R | R | - | R | - | - |
| | <i>Zelandoperla</i> | 8 | C | C | A | C | C | A |
| COLEOPTERA (BEETLES) | Elmidae | 6 | A | C | C | C | A | VA |
| | Dytiscidae | 5 | - | - | - | R | - | - |
| | Hydraenidae | 8 | R | R | R | R | R | R |
| MEGALOPTERA (DOBSONFLIES) | <i>Archichauliodes</i> | 7 | C | C | C | C | A | A |
| TRICHOPTERA (CADDISFLIES) | <i>Hydropsyche (Aoteapsyche)</i> | 4 | A | A | A | C | C | A |
| | <i>Costachorema</i> | 7 | - | - | R | R | - | R |
| | <i>Hydrobiosis</i> | 5 | C | R | C | - | - | C |
| | <i>Hydropsyche (Orthopsyche)</i> | 9 | - | - | - | - | R | - |
| | <i>Polypsectopus</i> | 6 | - | R | - | - | - | - |
| | <i>Psilochorema</i> | 6 | - | R | - | R | - | - |
| | <i>Beraeoptera</i> | 8 | C | C | C | A | VA | VA |
| | <i>Confluens</i> | 5 | - | - | R | - | - | - |
| | <i>Helicopsyche</i> | 10 | - | - | R | C | A | C |
| | <i>Olinga</i> | 9 | - | R | - | - | R | R |
| | <i>Pycnocentria</i> | 7 | - | C | R | R | - | - |
| DIPTERA (TRUE FLIES) | <i>Pycnocentroides</i> | 5 | - | - | - | R | C | C |
| | <i>Triplectides</i> | 5 | - | - | - | - | R | - |
| | <i>Zelolessica</i> | 7 | - | - | - | - | C | - |
| | <i>Aphrophila</i> | 5 | A | A | A | C | C | A |
| | Eriopterini | 5 | R | R | - | R | R | - |
| | Orthoclaadiinae | 2 | C | C | C | R | C | R |
| | <i>Polypedilum</i> | 3 | R | R | - | - | - | - |
| | Tanypodinae | 5 | - | - | - | - | - | R |
| | Empididae | 3 | R | R | R | R | R | C |
| | <i>Austrosimulium</i> | 3 | R | C | C | R | R | R |
| | Tanyderidae | 4 | - | R | - | - | - | - |
| No of taxa | | | 21 | 28 | 24 | 25 | 26 | 25 |
| MCI | | | 111 | 124 | 128 | 126 | 125 | 122 |
| SQMCIs | | | 6.9 | 7.4 | 7 | 7.9 | 7.7 | 7.4 |
| EPT (taxa) | | | 10 | 17 | 15 | 16 | 16 | 15 |
| %EPT (taxa) | | | 48 | 61 | 63 | 64 | 62 | 60 |
| 'Tolerant' taxa | | 'Moderately sensitive' taxa | | 'Highly sensitive' taxa | | | | |

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

Site 1. Approximately 30m upstream of discharge tributary confluence

A moderate macroinvertebrate community richness of 21 taxa was found at site 1 ('control' site) at the time of the pre-drill survey. A slightly higher richness of 25 taxa was found by the follow-up post-drill survey. Site 1 also had a similar taxa richness compared with numbers found at other sites in similar streams in the Taranaki region within the same altitudinal band (median taxa richness of 23 taxa; Table 3).

The pre-drill MCI score of 111 units indicated a community of 'good' biological health and this had increased significantly (Stark, 1998) to 126 units at the time of the post-drill survey indicating a community of 'very good' biological health. The pre-drill and post-drill survey MCI scores were similar to the median MCI score found at other sites in similar streams in the Taranaki region within the same altitudinal band (median MCI score of 118; Table 3).

The pre-drill SQMCI_s score of 6.9 units and the post-drill score of 7.9 units were relatively similar to each other and that of other sites in similar streams in the Taranaki region within the same altitudinal band (median SQMCI_s score of 7.0 units; Table 3).

The pre-drill survey community was characterised by one 'tolerant' taxon, caddisflies (*Aoteapsyche*), three 'moderately' sensitive taxa, mayflies (*Coloburiscus*), beetles (Elmidae), and craneflies (*Aphrophila*), and two 'highly' sensitive taxa, mayflies (*Deleatidium* and *Nesameletus*). The post-drill survey community was characterised by one 'moderately' sensitive taxon, mayflies (*Coloburiscus*) and three 'highly' sensitive taxa, mayflies (*Deleatidium*) and (*Nesameletus*), and caddisflies (*Beraeoptera*) (Table 4).

Site 2. 110m d/s of discharge tributary, under power lines

A moderate macroinvertebrate community richness of 28 taxa was found at site 2 ('primary impacted' site) at the time of the pre-drill survey. A slightly lower richness of 26 taxa was found by the follow-up post-drill survey. Site 2 also had a similar taxa richness compared with numbers found at other sites in similar streams in the Taranaki region within the same altitudinal band (median taxa richness of 23 taxa; Table 3).

The pre-drill MCI score of 124 units indicated a community of 'very good' biological health and this had increased to 125 units at the time of the post-drill survey which also indicated a community of 'very good' biological health. The pre-drill and post-drill survey MCI scores were similar to the median MCI score found at other sites in similar streams in the Taranaki region within the same altitudinal band (median MCI score of 118; Table 3).

The pre-drill SQMCI_s score of 7.4 units and the post-drill score of 7.7 units were similar to each other and that of other sites in similar streams in the Taranaki region within the same altitudinal band (median SQMCI_s score of 7.0 units; Table 3).

The pre-drill survey community was characterised by one 'tolerant' taxon, caddisflies (*Aoteapsyche*), two 'moderately' sensitive taxa, mayflies (*Coloburiscus*) and craneflies (*Aphrophila*) and two 'highly' sensitive taxa, mayflies (*Deleatidium* and *Nesameletus*). The post-drill survey community was characterised by three 'moderately' sensitive taxa, mayflies (*Coloburiscus*), beetles (Elmidae), and dobsonflies (*Archichauliodes*) and four 'highly' sensitive taxa, mayflies (*Deleatidium* and *Nesameletus*) and caddisflies (*Beraeoptera* and *Helicopsyche*) (Table 4).

Site 3. 220m downstream of the discharge tributary confluence

A moderate macroinvertebrate community richness of 24 taxa was found at site 3 ('secondary impacted' site) at the time of the pre-drill survey. A slightly higher richness of 25 taxa was found by the follow-up post-drill survey. Site 3 also had a similar taxa richness compared with numbers found at other sites in similar streams in the Taranaki region within the same altitudinal band (median taxa richness of 23 taxa; Table 3).

The pre-drill MCI score of 128 units indicated a community of 'very good' biological health but this had decreased to 122 units at the time of the post-drill survey but still indicated a community of 'very good' biological health. The pre-drill and post-drill survey MCI scores were similar to the median MCI score found at other sites in similar streams in the Taranaki region within the same altitudinal band (median MCI score of 118; Table 3).

The pre-drill SQMCI_s score of 7.0 units and the post-drill score of 7.4 units were similar to each other and that of other sites in similar streams in the Taranaki region within the same altitudinal band (median SQMCI_s score of 7.0 units; Table 3).

The pre-drill survey community was characterised by one 'tolerant' taxon, caddisflies (*Aoteapsyche*), two 'moderately' sensitive taxa, mayflies (*Coloburiscus*) and craneflies (*Aphrophila*), and two 'highly' sensitive taxa, mayflies (*Deleatidium*) and stoneflies (*Zelandoperla*). The post-drill survey community was characterised by one 'tolerant' taxon, caddisflies (*Aoteapsyche*), five 'moderately' sensitive taxa, mayflies (*Coloburiscus*), stoneflies (*Acroperla*), beetles (Elmidae), dobsonflies (*Archichauliodes*), and craneflies (*Aphrophila*), and four 'highly' sensitive taxa, mayflies (*Deleatidium* and *Nesameletus*), stoneflies (*Zelandoperla*), and caddisflies (*Beraeoptera*) (Table 4).

Discussion and Conclusions

The Council's 'kick-sampling' technique was used at three sites to collect streambed macroinvertebrates from the Ngatoroit Stream prior to and post drilling at the wellsite. This has provided data to assess any impacts of skimmer pit discharge effects from the Ngatoro-E wellsite on the macroinvertebrate communities of this stream. Samples were processed to provide number of taxa (richness), MCI, and SQMCI_s scores for each site.

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

The May 2014 pre-drill survey and the November 2014 post-drill survey of three sites, upstream and downstream of the skimmer pit discharge point to an unnamed tributary of the Ngatoroit Stream, were undertaken because of drilling at the Ngatoro-E wellsite. Taxa richnesses were moderate for all three sites and were similar to other sites in similar streams in the Taranaki region within the same altitudinal band. MCI and SQMCI_s indices remained relatively constant at all three sites from the pre-drill survey to the post-drill survey. The only significant difference found was an increase in the MCI score of 15 units from the pre-drill survey to the post-drill survey at site 1 which would likely be due to site variability as no such trend occurred at sites 2 and 3. There were no significant decreases in health of the macroinvertebrate communities in the Ngatoroit Stream shown by pre-drill and post-drill

surveys and therefore there was no evidence that Ngatoro-E wellsite discharges to an unnamed tributary of the Ngatoriti Stream had had any significant effects on macroinvertebrate communities in the Ngatoriti Stream.

Summary

- Taxa richnesses were moderate for all three sites and were similar to values found at other similar sites within the Taranaki Region.
- MCI scores for the pre-drill survey and post-drill survey were relatively similar to each other and indicated that the macroinvertebrate communities surveyed were mostly of 'very good' health and had slightly higher values than those found at similar sites within the Taranaki Region. SQMCI_s scores were largely congruent with MCI scores.
- There was no indication from any of the macroinvertebrate indices examined that Ngatoro-E wellsite discharges to an unnamed tributary of the Ngatoriti Stream had had any significant effects on the health of the macroinvertebrate communities in the Ngatoriti Stream.

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