

Greymouth Petroleum Limited
Kowhai-C Wellsite
Monitoring Programme Report
2013-2014

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Executive summary

Greymouth Petroleum Limited established a hydrocarbon exploration site located on Otaraoa Road, Tikorangi within the New Plymouth district in the Waiau catchment. The site is known as the Kowhai-C wellsite. This report covers the period from September 2013 to May 2014. During this period, the Kowhai-C wellsite was established with one well drilled, tested and hydraulically fractured. This well is now in production.

This report for Greymouth Petroleum Limited describes the monitoring programme implemented by the Taranaki Regional Council (the Council) to assess Greymouth Petroleum Limited's environmental performance in relation to exploratory operations at the Kowhai-C wellsite during the period under review, and the results and environmental effects of Greymouth Petroleum Limited's activities.

Greymouth Petroleum Limited holds a total of seven resource consents for the activities at the Kowhai-C wellsite, which include a total of 91 consent conditions setting out the requirements that Greymouth Petroleum Limited must satisfy. Greymouth Petroleum Limited holds consent 9474-1 to discharge emissions to air associated with hydrocarbon producing wells; consent 9475-1 to discharge contaminants to air from hydrocarbon exploration; consent 9476-1 to discharge produced water, well drilling fluids, well workover fluids including hydraulic fracturing fluids, and contaminated stormwater into land by deepwell injection (not exercised during monitoring period under review); consent 9477-1 to discharge stormwater and sediment, deriving from soil disturbance for the purpose of constructing the wellsite; consent 9478-1 to discharge treated stormwater, treated produced water and surplus drilling water onto and into land where it may enter an unnamed tributary of the Waiau Stream; consent 9479-1 to take groundwater; and consent 9480-1 to discharge contaminants associated with hydraulic fracturing activities into land.

The Council's monitoring programme for the period under review included 21 inspections of the site and surrounding environment, at approximately fortnightly intervals. Seven stormwater samples, one surface water sample, six groundwater samples, one hydraulic fracture fluid sample and one return fracture fluid sample were obtained for analysis. Furthermore, two biomonitoring surveys were performed (one in an unnamed tributary of the Waiau Stream and another in the Parahaki Stream) prior to the commencement of hydraulic fracturing activities, and another two following the completion of hydraulic fracturing activities at the Kowhai-C wellsite.

Greymouth Petroleum Limited notified the Council of its intention to test the well and combust gas intermittently at the Kowhai-C wellsite between 8 January 2014 and 9 February 2014. Although gas combustion was anticipated intermittently for approximately two weeks, gas combustion only occurred intermittently over the course of a few days in conjunction with well testing and pipeline installations. No offensive or objectionable odours, smoke or dust associated with activities at the wellsite were observed. The drilling fluids and cuttings were disposed of at a consented off-site facility.

The site was generally neat and tidy, yet significant maintenance was required regarding the ring-drains, as substantial ponding was observed within the ring-drains in two specific areas, which had the potential to discharge offsite untreated and unauthorised. This contravened Section 15(1)(b) of the Resource Management Act and special condition 6 of consent 9478-1. Subsequently, abatement notice 12164 was issued which required

Greymouth Petroleum Limited to undertake works to ensure that stormwater flowed directly to the skimmer pits without pooling or ponding within the ring-drain system, mitigating the potential for unauthorised discharges from the site to occur. Works were later completed within the required timeframe and with appropriate notification following the abatement notice.

Additional non-compliances were addressed during site inspections and are outlined as follows. Chemicals and equipment were found stored outside of the ring-drained area, the initial installation of certain components of the skimmer pits were substandard and did not reflect information submitted, an approximate 30 cm rip was identified in the lining of the first skimmer pit, and a small section of the flare pit liner had become exposed and melted due to heat exposure. All were rectified and repaired by Greymouth Petroleum Limited promptly, minimising any potential risk of unauthorised discharges or effects. No adverse effects were observed in any case.

Taking in account the matter noted above, during the monitoring period, Greymouth Petroleum Limited nevertheless demonstrated a good level of environmental performance and compliance with the resource consents overall. The site was generally neat, tidy and well maintained and site staff were cooperative with requests made by officers of the Council, with any required works completed to a satisfactory standard.

This report includes recommendations for future drilling operations at this site.

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1. Introduction

1.1. Compliance monitoring programme reports and the Resource Management Act 1991

1.1.1. Introduction

This report is for the period September 2013 to May 2014 by the Taranaki Regional Council (the Council) on the monitoring programme associated with resource consent held by Greymouth Petroleum Limited. During this period, the Kowhai-C wellsite was established with one well (Kowhai-3) drilled, tested and hydraulically fractured. This well is now in production.

This report covers the results and findings of the monitoring programme implemented by the Council in respect of the consents held by Greymouth Petroleum Limited that relate to exploration activities at Kowhai-C wellsite located off Otaraoa Road, Tikorangi.

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 Greymouth Petroleum Limited's use of water, land, and air.

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 Greymouth Petroleum Limited in the Waiau 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 Kowhai-C wellsite 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 interpretation, 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 (eg, recreational, cultural, or aesthetic);
- (e) risks to the neighbourhood or environment.

In drafting and reviewing conditions on discharge permits, and in implementing monitoring programmes, the Taranaki Regional 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 Resource Management Act 1991, the Council undertakes compliance monitoring for consents and rules in regional plans; and maintains an overview of performance of resource users against regional plans and consents. Compliance monitoring, including impact monitoring, also enables the Council to continuously assess its own performance in resource management as well as that of resource users particularly consent holders. It further enables the Council to continually 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 consent performance

Besides discussing the various details of the performance and extent of compliance by the consent holder during the period under review, this report also assigns an overall rating. The categories used by the Council, and their interpretation, are as follows:

- a **high** level of environmental performance and compliance indicates that essentially there were no adverse environmental effects to be concerned about, and no, or inconsequential (such as data supplied after a deadline) non-compliance with conditions.
- a **good** level of environmental performance and compliance indicates that adverse environmental effects of activities during the monitoring period were negligible or minor at most, or, 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, or, there were perhaps some items noted on inspection notices for attention but these items were not urgent nor critical, and follow-up inspections showed they have been dealt with, and any inconsequential non compliances with conditions were resolved positively, co-operatively, and quickly.

- **improvement required (environmental) or improvement required (administrative)** (as appropriate) indicates that the Council may have been obliged to record a verified unauthorised incident involving measurable environmental impacts, and/or, there were measurable environmental effects arising from activities and intervention by Council staff was required and there were matters that required urgent intervention, took some time to resolve, or remained unresolved at the end of the period under review, and/or, there were on-going issues around meeting resource consent conditions even in the absence of environmental effects. Abatement notices may have been issued.
- **poor performance (environmental) or poor performance (compliance)** indicates generally that the Council was obliged to record a verified unauthorised incident involving significant environmental impacts, or there were material failings to comply with resource consent conditions that required significant intervention by the Council even in the absence of environmental effects. Typically there were grounds for either a prosecution or an infringement notice.

For reference, in the 2013-2014 year, 60% 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 29% demonstrated a good level of environmental performance and compliance with their consents.

1.2. Process description

Site description

Greymouth Petroleum Limited holds a 15 year Petroleum Mining Permit No. 51378 to prospect, explore, and mine for condensate, gas, LPG, oil and petroleum within an area of 68.12 km². The Kowhai-C wellsite is one of many sites within this area that have been established in order to explore, evaluate and produce hydrocarbons.

The Kowhai-C wellsite is located approximately 0.61 km along Otaraoa Road, approximately 1 km from Tikorangi, as per Figure 1. The Kowhai-C wellsite was established in 2013 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 480 m away from the wellsite. Bunding, earthworks and site location helped minimise any potential for off site effects for the neighbours.



Figure 1 Aerial view displaying the locality of the Kowhai-C wellsite, with approximate regional location (inset)

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 Kowhai-C wellsite is located approximately 260 m to the south west of the nearest waterbody, which is an unnamed tributary of the Waiau 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 [e.g. parking areas] which run off during rainfall. There is potential that this 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 water 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 potentially into an unnamed tributary in the Waiau catchment.

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 off-site 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. Background

Greymouth Petroleum Limited holds seven resource consents related to activities at the Kowhai-C wellsite site, as follows:

- Discharge Permit 9474-1; granted 13 February 2013,
- Discharge Permit 9475-1; granted 13 February 2013,
- Discharge Permit 9476-1; granted 28 February 2013 (not exercised),
- Discharge Permit 9477-1; granted 13 February 2013,
- Discharge Permit 9478-1; granted 13 February 2013,
- Water Permit 9479-1; granted 13 February 2013 and
- Discharge Permit 9480-1; granted 22 February 2013.

Each of the consent applications were processed on a non-notified basis as Greymouth Petroleum Limited obtained the landowner approvals as an affected party, and the Council were satisfied that the environmental effects of the activity would be minor. The consents are discussed in further detail below.

Copies of the consents can be found within Appendix I of this report.

1.3.2. Air discharge permit (production activities)

Section 15(1)(c) of the *Resource Management Act 1991* (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.

The Council determined that the application to discharge emissions to air associated with the production activities at the Kowhai-C wellsite fell within Rule 11 of the RAQP.

The standard/term/condition of Rule 11 states that the:

- *Flare or incinerator point is a distance equal to or greater than 300 metres from any dwelling house.*

Greymouth Petroleum Limited holds air discharge permit 9474-1 to discharge emissions to air associated with hydrocarbon producing wells at the Kowhai-C wellsite.

This permit was issued by the Council on 13 February 2013 under Section 87(e) of the RMA. It is due to expire 1 June 2027.

Consent conditions were imposed on Greymouth Petroleum Limited to ensure that adverse effects are avoided in the first instance. A summary of conditions can be viewed in Table 8, Section 3.3.

1.3.3. Air discharge permit (exploration activities)

Section 15(1)(c) of the *Resource Management Act 1991* (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.

The Council determined that the application to discharge emissions to air associated with the exploration activities at the Kowhai-C wellsite fell within Rule 9 of the Regional Air Quality Plan (RAQP).

The standard/term/conditions associated with Rule 9 are as follows:

- *Flare or incinerator point is at least 300 metres from any dwelling house;*
- *The discharge to air from the flare must not last longer than 15 days cumulatively, including of testing, clean-up, and completion stages of well development or work-over, per zone to be appraised; and*
- *No material to be flared or incinerated, other than those derived from or entrained in the well stream.*

Provided the activities were conducted in accordance with the applications and in compliance with the recommended special conditions, then no significant effects were anticipated.

Greymouth Petroleum Limited holds air discharge permit 9475-1 to discharge contaminants to air from hydrocarbon exploration at the Kowhai-C wellsite, including combustion involving flaring or incineration of petroleum recovered from natural deposits, in association with well development or redevelopment and testing or enhancement of well production flows.

This permit was issued by the Council on 13 February 2013 under Section 87(e) of the RMA. It is due to expire on 1 June 2027.

Consent conditions were imposed on Greymouth Petroleum Limited to ensure that adverse effects are avoided in the first instance. A summary of conditions can be viewed in Table 9, Section 3.3.

1.3.4. Discharges to land (deep well injection)

Sections 15(1)(b) and (d) of the *Resource Management Act 1991* (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.

The discharge of contaminants to groundwater by deepwell injection or water flooding falls under Rule 51 of the RFWP. The application may be non-notified if no parties are deemed to be adversely affected by the proposed activity.

Greymouth Petroleum Limited holds discharge permit 9476-1 to discharge produced water, well drilling fluids, well workover fluids including hydraulic fracturing fluids, and contaminated stormwater from hydrocarbon exploration operations into the Mount Messenger Formation by deepwell injection via the Kowhai-C waste disposal well.

This permit was issued by the Council on 28 February 2013 under Section 87(e) of the RMA. It is due to expire on 1 June 2027.

Consent conditions were imposed on Greymouth Petroleum Limited to ensure that adverse effects are avoided in the first instance. A summary of conditions can be viewed in Table 10, Section 3.3.

1.3.5. Water discharge permit (stormwater and sediment – earthworks)

Section 15(1)(a) of the *Resource Management Act 1991* (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.

Council considered that the application fell under Rule 27 of the RFWP as a controlled activity (which may be non-notified without written approval), subject to one standard/term/condition to be met:

- *A site erosion and sediment control management plan shall be submitted to the Taranaki Regional Council.*

Greymouth Petroleum Limited supplied a site erosion and sediment control management plan in support of the application.

The Council was satisfied that the activity would meet all the standards for a controlled activity. It was therefore obliged to grant the consent but imposed conditions in respect of those matters over which it reserved control. Those matters over which the Council reserved its control were:

- Approval of a site erosion and sediment control management plan and the matters contained therein;
- Setting of conditions relating to adverse effects on water quality and the values of the waterbody;
- Timing of works;
- Any measures necessary to reinstate the land following the completion of the activity;
- Monitoring and information requirements;
- Duration of consent;
- Review of conditions of consent and the timing and purpose of the review; and
- Payment of administrative charges and financial contributions.

Greymouth Petroleum Limited holds water discharge permit 9477-1 to discharge stormwater and sediment, deriving from soil disturbance undertaken for the purpose of constructing the Kowhai-C wellsite, onto land.

This permit was issued by the Council on 13 February 2013 under Section 87(e) of the RMA. It is due to expire on 1 June 2018.

Consent conditions were imposed on Greymouth Petroleum Limited to ensure that adverse effects are avoided in the first instance. A summary of conditions can be viewed in Table 11, Section 3.3.

1.3.6. Water discharge permit (treated stormwater and treated produced water)

Section 15(1)(a) of the *Resource Management Act 1991* (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.

The Council determined that the application to discharge treated stormwater, treated produced water and surplus drill water fell within Rule 44 of the RFWP, which provides for a discharge as a discretionary activity.

The discharge of stormwater may result in contaminants (e.g. sediment, oil) entering surface water. These contaminants have the potential to smother or detrimentally affect in-stream flora and fauna. On-site management of stormwater, as discussed in 1.2 above, is necessary to avoid/remedy any adverse effects on water quality.

Greymouth Petroleum Limited holds water discharge permit 9478-1 to discharge treated stormwater, treated produced water and surplus drilling water from hydrocarbon exploration and production operations at the Kowhai-C wellsite onto and into land where it may enter an unnamed tributary of the Waiau Stream.

This permit was issued by the Council on 13 February 2013 under Section 87(e) of the RMA. It is due to expire on 1 June 2027.

Consent conditions were imposed on Greymouth Petroleum Limited to ensure that adverse effects were avoided in the first instance. A summary of conditions can be viewed in Table 12, Section 3.3.

1.3.7. Water abstraction permit (groundwater)

Section 14 of the *Resource Management Act 1991* (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.

The Council determined that the application to take groundwater fell within Rule 49 of the Regional Freshwater Plan for Taranaki (RFWP) as the rate and daily volume of the groundwater abstraction might exceed that of the permitted activity (Rule 48). Rule 49 provides for groundwater abstraction as a controlled activity, subject to two conditions:

- *The abstraction shall cause not more than a 10% lowering of static water-level by interference with any adjacent bore;*
- *The abstraction shall not cause the intrusion of saltwater into any fresh water aquifer.*

Greymouth Petroleum Limited holds water permit 9479-1 to take groundwater, as 'produced water', during hydrocarbon exploration and production activities at the Kowhai-C wellsite.

Any produced water will be from reserves far below that which is used for domestic or farm purposes. Shallow groundwater (which does not have any saltwater content) was protected by casing within the bore hole. Given these factors, the abstraction would not cause the above effects.

In granting the consent it was considered that the taking of groundwater was unlikely to have any adverse effect on the environment.

The Council was satisfied that the proposed activity would meet all the standards for a controlled activity. It was therefore obliged to grant the consent but imposed conditions in respect of those matters over which it reserved control. Those matters over which the Council reserved its control were:

- Volume and rate of abstraction;
- Daily timing of abstraction;
- Effects on adjacent bores, the aquifer, river levels, wetlands and sea water intrusion;
- Fitting of equipment to regulate flows and to monitor water volumes, levels, flows and pressures;
- Payment of administrative charges;
- Monitoring and report requirements;
- Duration of consent; and
- Review of the conditions of consent and the timing and purpose of the review.

This permit was issued by the Council on 13 February 2013 under Section 87(d) of the RMA. It is due to expire on 1 June 2027.

Consent conditions were imposed on Greymouth Petroleum Limited to ensure that adverse effects were avoided in the first instance. A summary of conditions can be viewed within Table 13, Section 3.3.

1.3.8. Discharges to land (hydraulic fracturing)

Sections 15(1)(b) and (d) of the *Resource Management Act 1991* (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.

The discharge of contaminants associated with hydraulic fracturing, onto and into land where contaminants may reach water, is a discretionary activity under Rule 44 of the RFWP.

The rule is a “catch all” rule as there is currently no specific rule for the discharge of hydraulic fracturing contaminants. The rule is set out below:

Discharge of contaminants onto or into land restricted by s15(1)(b) [where contaminants may reach water] and s15(1)(d) [where the discharge is from industrial or trade premises] of the Resource Management Act 1991 which is not expressly provided for in Rules 21-42 or which is provided for but does not meet the standards, terms or conditions and any other discharge of contaminants to land which is provided for in Rules 21-42 but which does not meet the standards, terms or conditions of those rules [irrespective of whether the discharges are from industrial or trade premises or are likely to reach water].

Provided the activities were to be conducted in accordance with the application and in compliance with the recommended special conditions, then no significant effects were anticipated.

Greymouth Petroleum Limited holds discharge permit 9480-1 to discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3,400 mTVD (true vertical depth) beneath the Kowhai-C wellsite.

This permit was issued by the Council on 22 February 2013 under Section 87(e) of the RMA. It is due to expire on 1 June 2020.

Consent conditions were imposed on Greymouth Petroleum Limited to ensure that adverse effects are avoided in the first instance. A summary of conditions can be viewed in Table 14, Section 3.3.

1.4. Monitoring programme

1.4.1. Introduction

Section 35 of the *Resource Management Act 1991* (RMA) sets out obligation/s upon the Council to: gather information, monitor, and conduct research on the exercise of resource consent 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 wellsites 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.

The monitoring programme for the Kowhai-C wellsite focused primarily on programme liaison and management, site inspections, physicochemical sampling, biomonitoring surveys and discharges to land. However, 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, or new consents, advice on the Council's environmental management strategies and the content of regional plans, and consultation on associated matters.

1.4.3. Site inspections

Inspection and examination of wellsites is a fundamental and effective means of monitoring and are undertaken to ensure that good environmental practices are adhered to and resource consent special conditions complied with.

The inspections are based on internationally recognised and endorsed wellsite monitoring best-practice checklists developed by the Alberta Energy Resources Conservation Board and the USEPA, adapted for local application.

The inspections also provide an opportunity for monitoring officers to liaise with staff about on-site operations, monitoring and supervision; discuss matters of concern; and resolve any issues in a quick and informal manner.

Inspections pay special attention to the ring-drains, mud sumps, treatment by skimmer pits and the final discharge point from the skimmer pit on to land and then any potential receiving waters.

During each inspection the following are checked:

- Weather;
- Flow rate of surface waters in the general vicinity;
- Flow rate of water take;
- Whether pumping of water was occurring;
- General tidiness of site;
- Site layout;
- Ring-drains;
- Hazardous substance bunds;
- Treatment by skimmer pits/sedimentation pits;
- Drilling mud;
- Drill cuttings;
- Mud pit capacity and quantity contained in pit;
- Sewage treatment and disposal;
- Cementing waste disposal;
- Surface works;

- Gas combustion systems, whether flaring was in progress, and if there was a likelihood of flaring, whether the Council had been advised;
- Discharges;
- Surface waters in the vicinity for effects on colour and clarity, aquatic life and odour;
- Site records;
- General observations; and
- Odour (a marker for any hydrocarbon and hazardous chemical contamination).

1.4.4. Chemical sampling

The Council may undertake sampling of discharges from site and from sites upstream and downstream of the discharge point to ensure that resource consent special conditions are complied with and to determine whether site activities were causing any adverse effects within the receiving environment.

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 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 return flow of hydraulic fracturing fluids and nearby bores were carried out during site inspections. These inspections of the site and surrounding land and water were carried out to ensure that no observable effects have 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

Biomonitoring surveys in any nearby streams may be carried out pre and post occupation of the wellsite to assess whether the activities carried out on-site, and associated discharges have had any effect on ecosystems.

2. Results

2.1. Water

2.1.1. Inspections

The Kowhai-C wellsite, adjacent land and streams were inspected 21 times during the monitoring period. Below is a copy of the comments that were noted on the day of each inspection.

5 September 2013

Earthworks were commencing on-site. Access track top soil was being stripped from the site and piled as earth bunds about the wellsite. Hay bales had been placed in the roadside drain to control any sediment run-off during periods of wet weather. No further silt and sediment controls were required during this stage due to the stripping area being flat land with plenty of grass filtration prior to any surface water bodies. Conditions were very windy at the time of inspection, however no dust was being generated from the site.

12 September 2013

Earthworks were continuing on-site with the pad area level nearing completion. Metal had been imported onto the site and placed on the access track. Further metal was anticipated to be brought on-site to further establish the pad area. Hay bales had been replaced by silt fencing after the bales were stolen on two separate occasions. Sediment settling pond had been dug on-site and was directing all site stormwater through it prior to discharge. No discharges had yet occurred from the settling pond. Skimmer pits were anticipated to be constructed later in the day with all stormwater to be treated via the skimmer pits. The settling pond was to remain in place and continue to receive site water (via the skimmer pits) for final treatment prior to discharging. Small 'v' drains were also to be constructed along the outside edge of the earth bunds to direct any rainwater collected on the outside edge of the bund to the settling pond. This was planned to be completed in the following days. At the time of inspection there was plenty of grass filtration available between the bunds and surface water, however the 'v' drains were expected to create a more efficient system.

17 September 2013

Earthworks were continuing on-site. The final cut and levels of the pad were nearing completion and metal had begun to be imported onto site. The access track and lay-down area were metaled with works. The sediment pond was still in place on-site and was empty at the time of the inspection. The sediment pond was to treat all stormwater from the lay-down area, pad area and the interior of the earth bunds surrounding the pad. Discussions were held with the on-site manager regarding the small 'v' drains which were to be constructed on the outer edge of the earth bunds to direct any stormwater from the outer edge of the exposed bunds back into the sediment pond prior to discharge. This was only required about the corner of the site nearest to the surface water. Surface waters were inspected and found to be flowing clean and clear. There was no sign that any sediment had reached the surface water as a result of on-site earthwork activities.

25 September 2013

Earthworks were continuing on-site. Work was being completed along the roadside near the access track entrance way to increase visibility. Earth banks were being scraped back by diggers in a tidy and orderly fashion. The earth bunds about the pad area were nearing completion and were to be planted in coming weeks to aid in stabilizing the earth bunds and prevent excess sediment runoff during periods of wet weather. Development of the pad area was continuing with further importation of gravel to the site. The application of gravel to the pad area was temporarily ceased due to a period of wet weather in the days preceding the inspection. The contour and ring-drains about the pad and lay down area continued to direct stormwater to the sediment pond. The sediment pond was inspected and found to be dry, however the large volume of sediment in the base of the pond was indicative it was functioning well in containing silt and sediment run-off from the site. There was no sign that the sediment pond had reached capacity during the recent rainfall events. Nearby surface waters were inspected and found to be flowing clean and clear. No evidence of sediment tracking overland towards any of the surface water locations in the vicinity of the site was apparent.

8 October 2013

Earthworks were continuing on-site. The drilling pad had been established and the first conductor was being installed. Earth bunds about the site had been contoured and planted out. The water reservoir had been lined and was full at the time of inspection. The original settling pond had been filled in and the two skimmer pit treatment system had been installed. The skimmer pits had replaced the settling ponds and all stormwater was directed to these pits. The pits were anticipated to be lined within coming days. The nearby stream was inspected and found to be free of any silt and sediment. Drainage had been placed through the bund to allow for drainage of the lay down area. It was outlined to site staff that if stormwater from the lay down area was not directed for treatment through skimmer pits then the area could not be used to store drilling or associated equipment.

21 October 2013

Earthworks were nearing completion with only minor works occurring on-site. Silt and sediment treatment on-site appeared appropriate with settling ponds collecting stormwater off the pad site as well as a second settling pond collecting stormwater off the lay down area. Sediment cloth at the roadside appeared to be working well capturing sediment, however were due for a clean out, which was discussed further with on-site staff. The laydown area was bunded, however the stormwater captured in this area was being discharged via a pipe through the bund onto the nearby farmland and not being directed to the skimmer pit treatment system. At the time of the inspection drill casing and chemicals were found to be stored on the lay down area rather than within the ring-drain drill pad area. The casing appeared clean and caps were in place on the ends of all the pipes and it was considered that storage on the laydown area was appropriate in this case. Drilling fluid, barite and lime was also observed to be stored in the laydown area. Any subsequent spill would result in a discharge to land rather than the spills being directed to a ring-drain and subsequent skimmer pits. No bunding was on-site about the chemicals. The storage of such chemicals on the lay down area was in breach of consent 9478-1, specifically special conditions 1 & 7. Discussions were held with on-site staff regarding issues surrounding the storage of chemicals on-site. It was arranged that the chemicals

would be moved onto the well site pad area and appropriate bunding placed about the store.

23 October 2013

Site inspection was completed in relation to the recent non-compliance observed with the storage of chemicals on-site on 21 October 2013. Site inspection found that a majority of the chemicals had been re-located onto the drill pad area and stored within a gravel bund on-site within the ring-drain system. The final chemicals were being transported onto the drill pad area at the time of the inspection. There was no evidence of spills on the lay down area and at the time of inspection it appeared that the movement of chemicals on-site had taken place without incident. At the time of inspection Resource Consent 9478-1 was being complied with so no abatement notice was to be issued in relation to this matter.

8 November 2013

Wellsite construction was complete and the Tiger Rig had been imported onto the site with drilling anticipated to commence within the day. Chemical store had been re-located onto the lay down area and appeared to be well bunded at the time of the inspection. The previously installed pipe draining stormwater from the lay down area through the bund had not been removed as was the agreement. The pipe had been blocked via a piece of timber being placed against its opening. This was found to be insufficient and did not provide a reasonable seal. Ponding within the ring-drain at this location was also observed. Ponding was also observed in the ring-drain next to the skimmer pits. Skimmer pits were partially full at the time of the inspection and were not discharging. Inspection of the skimmer pits found that the pipe connecting the two pits was positioned higher than the discharge pipe. This would effectively work as a decanter of surface water from the first pond to the second and hence would not retain any hydrocarbons in the first pond. A shut off valve had been placed at the discharge point of the skimmer pits; however this was located approximately 2 metres down a concrete riser below a solid manhole cover. The location of the shut off valve was inaccessible for immediate activation should a spill occur. The lining about the discharge pipe and pipe connecting the skimmer pits was to be examined to ensure that they were water tight and impermeable as the sealant 'boot' had come away from the lining membrane. This was not necessarily an issue, however was to be checked to confirm the water tight requirement. While on-site the following action was taken:

- Drainage pipe running through the bunding on the laydown area was completely removed.
- Engineer called to site to complete works to ensure the shut off valve from the skimmer pits is accessible during an emergency situation.
- Metal and a digger were being arranged to be brought to site to address the ponding issues within the ring-drain system.
- BTW attended site and it was agreed between Council, BTW and Greymouth Petroleum Limited that a goose neck pipe would be installed between the two skimmer pits to ensure that hydrocarbons are retained within both the first and second pits.

Site staff agreed to keep the Council informed of the progress of works on-site and that these remaining matters would be addressed with a level of urgency.

13 November 2013

The Tiger Rig had commenced drilling on-site. At time of inspection drilling had reached an approximate depth of 780m towards an approximate TVD of 4200m. Casing of the top hole was scheduled to commence over the coming days. Chemical stores on-site appeared to be well bunded and well managed with no signs of any spills or possible sources of contamination. The area about the mud/cuttings tanks also appeared to be clean and tidy at the time of inspection. The issues identified in the previous inspection had been addressed with the shut off valve for the skimmer pits having had an extension added to make it accessible. A 'goose neck' had been installed on the pipe between the two skimmer pits in order to address the retention issue of surface materials within the first pond. Gravel had been placed in the ring-drains at the previously identified low points in order to ensure that there was no ponding or pooling within these areas. These areas were to be reassessed following a period of wet weather to ensure the drains were working appropriately. Skimmer pits were only partially full. Overall the site appeared to be well managed and in a good condition.

25 November 2013

Drilling activities were continuing on-site. Drilling was at approximately 3,400 metres at the time of inspection. The installation of casing of the intermediate section was to be undertaken within coming hours. Ring-drains and skimmer pits were inspected and found to be in a good working order. No samples were taken from the skimmer pits as the water level was only just covering the base on the pits. Area about the mud and cuttings tanks was in a clean and tidy order. Non hazardous chemicals were stored on-site within a metal bund. Some salt was observed to have been spilt on the ground with further bags torn open and salt exposed. This issue was raised with the on-site manager who was arranging the clean up of the area. Rain was expected soon following an extended dry period. It was outlined to site staff to ensure the site was clean and tidy prior to any rainfall events in an effort to prevent any contaminants tracking to the skimmer pits.

5 December 2013

Site inspection was completed following a period of wet weather. Drilling was continuing on-site with the Tiger Rig. The intermediate section had been cased and drilling was continuing at an approximate depth of 3,500 metres. Inspection found that the chemical store was well bunded and in a clean and tidy order. The area about the drilling rig was found to be well managed and in a clean and tidy condition at the time of inspection. Cuttings tanks were low with no sign of any significant spills about the cutting handling areas. No flaring had occurred on-site during this phase of exploration. Skimmer pits were full, however were not yet discharging. A sample was obtained from the skimmer pit to ensure compliance with resource consent conditions should a discharge occur. Significant ponding was observed in the ring-drains at two specific areas. Ponding in the ring-drain at the base of the flare pit running along behind the drilling rig was found to be approximately 15 - 20 cm deep. Significant ponding was also observed in the ring-drain area about the lay down pad. This ponding was concentrated about the corner where the previous overflow pipe had been removed following the earth work stage of the site development. This ponding was measured to be approximately 30cm deep and no flow was observed leading towards the main ring-drain system. There was an indication that the ponding had resulted in stormwater flowing out of the rear of the ring-drain towards the outside of the bund and off-site. This was not occurring at the

time of the inspection however further rain without immediate remediation would result in an unauthorised discharge from site. This issue was raised with on-site health and safety and management staff and immediate attention was to be given to this at the conclusion of the inspection. The rear portion of the ring-drain was to be blocked off with metal in order to prevent an unauthorised discharge until such time as the ponding issue could be adequately dealt with. Section 15(1)(b) of the Resource Management Act and special condition 6 of consent 9478-1 were contravened. Subsequently, abatement notice 12164 was issued to Greymouth Petroleum Limited.

16 December 2013

Site inspection was carried out in relation to abatement notice issued in conjunction with previous inspection. Site inspection found that drilling was continuing on-site. Non hazardous chemical store was clean and tidy. The dry chemicals had been covered with tarpaulins to protect them from the weather. Work had been undertaken on the ring-drains on-site to address the pooling issue. Metal had been imported to site in order to increase the level of the ring-drain about the laydown area to ensure that stormwater was directed to the skimmer pits. Ringdrains about the drilling pad had also been re-defined. Dry weather at the time of the inspection meant that there was no water within the ring-drain system. Attention was to be given to the ringdrains during a period of wet weather to ensure that they were working efficiently and complying with resource consent conditions. It was highlighted that silt and sediment may be an issue following the next period of wet weather due to the works undertaken on-site. It was outlined to site staff to ensure that the skimmer pits were operating as per their design. Primary discharge from the pits was via the goose neck discharge pipe. The spillway was to be used in emergencies only (i.e: periods of extreme wet weather). Skimmer pits were not discharging at the time of the inspection, however a sample was obtained from the skimmer pits to ensure compliance with resource consent conditions should a discharge occur. A visual inspection was undertaken at the point of discharge and the receiving environment. No adverse environmental effects were noted at the time of the inspection. No flaring had been carried out on site.

7 January 2014

Drilling on-site was complete, however the Tiger Rig remained on-site. Wire lining activities were in progress. The area about the drilling rig appeared to be clean and tidy. The non-hazardous chemical store was clean and tidy with all liquid materials stored in sealed covered containers. Dry material on-site was stored under cover to protect it from the weather. Site was dry at the time of inspection, however there was found to be no material within the ring-drains that would prevent site water from flowing directly to the skimmer pits, provided the gradient within the drains were correct. The flare pit was inspected and found to be clean. Cranrock services were on-site preparing for well testing. There was no sign of exposed lining within the flare pit, however site staff were advised to re-check this prior to flaring to ensure that no lining was melted by the flare. Skimmer pits were inspected and found not to be discharging at the time of the inspection. The first skimmer pit was empty and dry while the second skimmer pit was full. A sample was obtained from the second skimmer pit to ensure compliance with consent conditions should a discharge occur. An approximate 30 cm rip was identified in the lining of the first skimmer pit. This was located on the wall of the pit slightly below the level of the discharge pipe. This issue was raised with staff on-site and requested that it be repaired. It was also suggested that the pit lining was examined for any further rips at this time. As the rip

was located below the 'full' level of the skimmer pits this may have resulted in contaminants entering groundwater should the first skimmer pit be allowed to fill to a level that would discharge into the second skimmer pit. It was outlined to site staff to ensure that the rip was repaired as soon as practicable and prior to the pending hydraulic fracturing activities that were scheduled to occur on site.

15 January 2014

Inspection was carried out to assess the skimmer pit liner repairs. Activities occurring on site were concerned with the demobilisation of the Tiger Rig to lay down area so hydraulic fracturing operations could commence later in the week. Ian Roebuck Cranes were on-site assisting with the rig break down. Inspection of the skimmer pits showed areas of liner where repairs had been carried out, main repairs on floor of pond liner were not sighted as water was being used to check the seal was obstructing views. Water levels in the pond indicated repairs had been successful. A small section of liner was observed around the pond 1 outflow pipe to be open and not joined to the main pit liner, it was suggested that this area may needed to be double skinned. However, upon further discussion with the on-site manager, it was decided that a telescopic cherry picker was to be used to get into the skimmer pit to seal the open section. Skimmer pits were not discharging at time of inspection. Consent 9478-1 was compliant at the time of inspection.

17 January 2014

Site inspection was conducted during the hydraulic fracturing of well Kowhai-3. The Tiger Rig had been completely demobilised to the lay down area. The site was clean and tidy, and strong wind gusts were generating large volumes of dust, site staff were advised to ensure that this was not having an effect beyond the site boundary. Both skimmer pits were holding only a small volume of water due to the pit liner repairs, and were unlikely to discharge in the near future. An area of exposed liner in the flare pit was to be recovered and stabilised with soil prior to flaring commencing. An inspection of the receiving waters found clear flowing water pooling at a farm crossing / ford. The pool was also clear and no visual signs of hydrocarbons were present. Consent 9480-1 was compliant at the time of inspection.

22 January 2014

Site inspection was completed following the hydraulic fracturing operation at the Kowhai-C wellsite. The fracture was completed on 21 January 2014 below the minimum depth required by the resource consent of 3400 mTVD. Inspection found that the Tiger rig had been dismantled and was stored on-site within the ring-drained pad area. The Baker Hughes fracturing equipment was set up on-site as well as associated well testing equipment. The site was found to be in a reasonable condition with all non-hazardous chemicals stored in an appropriate manner. Ring-drains were found to be free of debris. A small silt fence placed in the ring-drain prior to entry into the first skimmer pit appeared to be retaining some sediment. Skimmer pits were inspected and the tear previously identified in the lining had been repaired. The pits were not discharging, however samples were taken from the second skimmer pit to ensure compliance with resource consent conditions should a discharge occur. Flaring was occurring on-site at the time of the inspection. A small flame could be observed exiting the top of the flare pit. No smoke was observed at the point of flare. It was outlined to site staff to continue monitoring the skimmer pits to ensure that the repairs to the lining were holding, and to continue monitoring the

flare pit to ensure that no lining became exposed. As the banks of the flare pit are steep there was a chance that the lining may have become exposed.

28 January 2014

Hydraulic fracturing equipment remained on-site. The site was in a reasonable condition with all chemicals stored in a safe manner. Skimmer pits were inspected and found to be approximately 0.5 m below the level required for discharging. A sample was obtained from the second skimmer pit to ensure compliance with resource consent conditions should a discharge have occurred. A sample of surface water was also taken downstream of the wellsite as part of routine hydraulic fracturing monitoring activities. Flaring was not occurring on-site at the time of the inspection; however flaring had been undertaken intermittently at the site in days preceding the inspection. The flare pit was inspected and found to be clean and tidy. No lining was exposed within the flare pit at the time of the inspection.

13 February 2014

Site inspection found that hydraulic fracturing activities on-site had been completed and the associated Baker Hughes equipment had been removed from site. The Tiger drilling rig had been dismantled, however still remained stored on-site. Testing was on-going. At the time of inspection the well was flowing with all gas being directed off-site via a recently installed pipeline. Only a pilot flare was in operation on-site. Storage tanks were adequately bunded with earth bunds. Inspection found no signs of spills about these storage areas. Some chemicals remained on-site, however they were stored within sealed containers and stored within an earth bund. In general the site was in a clean and tidy order. Skimmer pits were inspected and found to be relatively empty. Approximately 3 inches of water was visible in the base of each pit meaning that a reasonable amount of stormwater would be required before the pits discharged. No samples were taken during the inspection.

6 March 2014

The Tiger drilling rig remained stored within the lay down area on-site. Chemicals had been removed from site. The site was being run by Cranrock who were carrying out well testing of the single well. The well was shut in hence no flaring was occurring on-site at the time of inspection. Minor works were taking place on-site to tie the well into the pipeline to Kowhai-B. Skimmer pits were inspected and found to be empty. The flare pit was also inspected and found to be clean and free of any obvious contaminants. Ring-drains about the site remained in place with equipment clear of the drains as not to obstruct stormwater flow during periods of wet weather.

15 April 2014

The well was shut in and works were continuing towards pipeline installation and production facilities to tie the site in with Kowhai-B, where all condensate and natural gas was to be directed. At the time of inspection condensate was being stored and removed via heavy transport. Skimmer pits were approximately one third full and not discharging; a sample was retrieved from the second skimmer pit. An inspection of the receiving waters showed no visible impacts. Evidence that the skimmer pits had discharged to land was apparent. It was outlined to site staff that the dark stains on the pad area from the rig required scraping and removal, and the large area on the pad towards the well head required gravel to stop ponding. In addition, the ring-drain in the lower corner of the site next to the skimmer pits required some attention, as loose material removed from the drain would help

reduce suspended solids entering the skimmer pits. A section of the flare liner was also exposed and appeared to have melted during flaring, this section was required to be replaced prior to any future well entry activities where flaring was likely to occur.

22 May 2014

Production activities were continuing on-site. A pilot flare was operating as a safety precaution. The flare was small but visible, yet this discharge readily dissipated into the atmosphere. The area where prior flare liner repair was undertaken had become exposed, at the time of inspection the liner had not suffered any damage from the pilot flare. Once works to the production line had been completed and the pilot flare no longer required (which was anticipated the following week) the liner was required to be covered and any repairs made. Silt controls in the perimeter drains appeared to be working and stormwater contained within the skimmer pits appeared cleaner than previous inspection. A sample was retrieved from second skimmer pit as no discharge was occurring at the time of inspection. It was outlined to site staff that as mentioned in the previous inspection, works were required to ensure no ponding on the pad occurred; these works were anticipated to be undertaken once production equipment installation was complete.

2.1.2. Results of discharge monitoring

During the period under review a total of seven stormwater samples were obtained. As stormwater was not observed discharging during any of the inspections conducted, all seven 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 of the samples would have been compliant with resource consent conditions should a discharge have occurred. Results are detailed in Table 1.

Table 1 Results of stormwater samples obtained from the Kowhai-C wellsite during the monitoring period

Date	Chloride <i>g/m³</i>	Hydrocarbon <i>g/m³</i>	pH <i>pH</i>	Suspended solids <i>g/m³</i>	Sampling location
05 Dec 2013	7.7	0.7	6.9	40	Second skimmer pit
16 Dec 2013	14.1	<0.5	7.6	15	Second skimmer pit
07 Jan 2014	19.0	0.5	7.0	10	Second skimmer pit
22 Jan 2014	15.4	<0.5	7.4	2	Second skimmer pit
28 Jan 2014	17.0	<0.5	7.6	7	Second skimmer pit
15 Apr 2014	4.6	<0.5	7.4	17.2	Second skimmer pit
22 May 2014	5.3	<0.5	7.7	11	Second skimmer pit

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, one sample was obtained on 28 January 2014 from an unnamed tributary of the Waiau Stream, post initial hydraulic fracturing activities

of the Kowhai-3 well. No exceedences were recorded in relation to consent 9478-1. Results are detailed in Table 2.

Table 2 Sample obtained on 28 January 2014 from an unnamed tributary of the Waiau Stream post initial hydraulic fracturing activities

Parameter	Unit	Sample 1
Chloride	g/m ³	26.4
Conductivity	mS/m@20C	15.8
Hydrocarbons	g/m ³	<0.5
pH	pH	6.6
Suspended solids	g/m ³	4
Turbidity	NTU	4.1

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 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

Greymouth Petroleum Limited notified the Council of its intention to flare gas intermittently at the Kowhai-C wellsite between 8 January 2014 and 9 February 2014. Although gas combustion was anticipated intermittently for approximately three to four weeks, gas combustion only occurred intermittently over the course of a few days in conjunction with well testing. The flare pit was utilised to maintain a pilot flare and for emergency gas combustion / depressurisation largely during pipeline installations.

During routine inspections, no offensive or objectionable odours, smoke or dust associated with activities at the Kowhai-C wellsite were observed. The flare pit was inspected to ensure that solid and liquid hydrocarbons were not combusted through the gas combustion system and there was no evidence to support or suggest this was occurring.

From observations during site inspections, including the inspection of the flare log maintained by Greymouth Petroleum Limited, 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 Kowhai-C wellsite as gas combustion activities were minimal and the controls

implemented by Greymouth Petroleum Limited 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 Greymouth Petroleum Limited did not give rise to any concerns with regard to air quality.

2.3. Land

2.3.1. Inspections

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 receiving environment monitoring (hydraulic fracturing)

Greymouth Petroleum Limited notified the Council of the proposed hydraulic fracturing discharge operations for well Kowhai-3. The Council developed the Kowhai-C wellsite groundwater monitoring programme in consultation with Greymouth Petroleum Limited. This monitoring programme included three sampling locations which were selected based on their proximity to the Kowhai-C wellsite and their individual construction and usage characteristics. The site selection is designed to provide a sample set representative of groundwater abstractions in the area surrounding the site. Table 3 outlines the details of the sites selected for inclusion in the programme. Figure 2 shows the sampling sites in relation to the wellsite.

Table 3 Kowhai-C wellsite associated groundwater monitoring bore details

Site No.	Easting (m)	Northing (m)
GND2432	1711476	5678976
GND2433	1711343	5678851
GND2434	1711499	5678670



Figure 2 Aerial photo depicting the locality of the Kowhai-C wellsite and associated groundwater monitoring bores

The monitoring programme requires an initial 12 months of groundwater monitoring. Groundwater samples will be obtained from the sampling sites recorded in Table 3 at the following specified intervals:

- Pre-hydraulic fracturing (baseline sample); and
- Three months after initial hydraulic fracturing event.

The original wellsite groundwater monitoring programmes involved the analysis for certain parameters. However, the range of parameters being analysed for has evolved since the first consent for hydraulic fracturing was issued. Therefore, the groundwater monitoring programme was subsequently revised and approved by the Chief Executive of the Council. As such, the Council decided the Kowhai-C wellsite groundwater monitoring programme should follow the latest range. The revised parameters that were analysed are as follows:

- pH;
- Conductivity;
- Major ions (Ca, Mg, K, Na, total alkalinity, bromide, chloride, nitrate-nitrogen, and sulphate);
- Trace metals (barium, copper, iron, manganese, nickel and zinc);
- Total petroleum hydrocarbons;
- Formaldehyde;
- Dissolved methane and ethane gas;
- Methanol;
- Glycols;
- Benzene, toluene, ethylbenzene, and xylenes (BTEX); and
- Carbon-13 composition of any dissolved methane gas discovered ($^{13}\text{C-CH}_4$).

In order to assess whether the discharge of fracturing fluids had contaminated or put at risk usable freshwater aquifers above the stated point of discharge, groundwater samples were taken as per the monitoring programme outlined above.

The results of the groundwater monitoring programme are detailed in Tables 4 to 6.

Table 4 Pre and post hydraulic fracturing results obtained from groundwater monitoring bore GND2432

Parameter	Unit	Pre-frac 7 January 2014	Post-frac 23 April 2014
Alkalinity (total)	g/m ³ CaCO ₃	540	580
Barium	mg/kg	0.044	0.021
Benzene	g/m ³	<0.0010	<0.0010
Bicarbonate	g/m ³ HCO ₃	650	707
Bromine (dissolved)	g/m ³	0.12	0.12
Calcium	g/m ³	82	50
Chloride	g/m ³	13.3	12.3
Conductivity	mS/m@20C	94.1	102.6
Copper (dissolved)	g/m ³	<0.0005	<0.0005
Ethane	g/m ³	<0.003	<0.003
Ethylbenzene	g/m ³	<0.0010	<0.0010
Ethylene	g/m ³	<0.003	<0.003
Ethylene glycol	g/m ³	<4	<4
Formaldehyde	g/m ³	0.03	<0.02
Hardness (total)	g/m ³ CaCO ₃	350	220
Hydrocarbons	g/m ³	<0.7	<0.7
Iron (dissolved)	g/m ³	14.8	4.0
Manganese (dissolved)	g/m ³	0.128	0.065
Magnesium	g/m ³	35	24
Mercury (dissolved)	g/m ³	<0.00008	<0.00008
Methane	g/m ³	18.2	34
Methanol	g/m ³	<2	<2
Nickel	mg/kg	0.0051	0.0019
Nitrate nitrogen	g/m ³ N	<0.002	<0.002
Nitrite/nitrate nitrogen	g/m ³ N	<0.002	<0.002
Nitrite nitrogen	g/m ³ N	<0.002	<0.002
pH	pH	7.3	7.6
Potassium	g/m ³	12.9	8.5
Propylene glycol	g/m ³	<4	<4
Sodium	g/m ³	49	138
Sulphate	g/m ³	<0.5	1.1
Sum of Anions	meq/l	11.1	12.0
Sum of Cations	meq/l	10.0	10.9
Temperature	Deg.C	18.2	11.7
Toluene	g/m ³	<0.0010	<0.0010
Total dissolved solids	g/m ³	540	640
meta-Xylene	g/m ³	<0.002	<0.002
ortho-Xylene	g/m ³	<0.0010	<0.0010
Zinc	g/m ³	0.66	0.27

Table 5 Pre and post hydraulic fracturing results obtained from groundwater monitoring bore GND2433

Parameter	Unit	Pre-frac 7 January 2014	Post-frac 22 April 2014
Alkalinity (total)	g/m ³ CaCO ₃	24	24
Barium	mg/kg	0.0158	0.0162
Benzene	g/m ³	<0.0010	<0.0010
Bicarbonate	g/m ³ HCO ₃	30	29
Bromine (dissolved)	g/m ³	0.045	0.056
Calcium	g/m ³	9.3	9.2
Chloride	g/m ³	8.4	8.1
Conductivity	mS/m@20C	10.6	10.8
Copper (dissolved)	g/m ³	<0.0005	<0.0005
Ethane	g/m ³	<0.003	<0.003
Ethylbenzene	g/m ³	<0.0010	<0.0010
Ethylene	g/m ³	<0.003	<0.003
Ethylene glycol	g/m ³	<4	<4
Formaldehyde	g/m ³	<0.02	<0.02
Hardness (total)	g/m ³ CaCO ₃	31	32
Hydrocarbons	g/m ³	<0.7	<0.7
Iron (dissolved)	g/m ³	<0.02	<0.02
Manganese (dissolved)	g/m ³	0.0023	0.0033
Magnesium	g/m ³	1.92	2.1
Mercury (dissolved)	g/m ³	<0.00008	<0.00008
Methane	g/m ³	0.017	<0.002
Methanol	g/m ³	<2	<2
Nickel	mg/kg	<0.0005	<0.0005
Nitrate nitrogen	g/m ³ N	0.36	0.55
Nitrite/nitrate nitrogen	g/m ³ N	0.36	0.55
Nitrite nitrogen	g/m ³ N	<0.002	<0.002
pH	pH	6.3	6.4
Potassium	g/m ³	1.08	1.29
Propylene glycol	g/m ³	<4	<4
Sodium	g/m ³	6.8	6.9
Sulphate	g/m ³	10.3	10.1
Sum of Anions	meq/l	0.96	0.96
Sum of Cations	meq/l	0.94	0.97
Temperature	Deg.C	15.3	15.6
Toluene	g/m ³	<0.0010	<0.0010
Total dissolved solids	g/m ³	74	84
meta-Xylene	g/m ³	<0.002	<0.002
ortho-Xylene	g/m ³	<0.0010	<0.0010
Zinc	g/m ³	0.0044	0.0082

Table 6 Pre and post hydraulic fracturing results obtained from groundwater monitoring bore GND2434

Parameter	Unit	Pre-frac 7 January 2014	Post-frac 23 April 2014
Alkalinity (total)	g/m ³ CaCO ₃	28	19.6
Barium	mg/kg	0.030	0.030
Benzene	g/m ³	<0.0010	<0.0010
Bicarbonate	g/m ³ HCO ₃	34.2	23
Bromine (dissolved)	g/m ³	0.063	0.062
Calcium	g/m ³	10.8	-
Chloride	g/m ³	19.4	19.0
Conductivity	mS/m@20C	15.7	16.4
Copper (dissolved)	g/m ³	0.0009	0.0029
Ethane	g/m ³	<0.003	<0.003
Ethylbenzene	g/m ³	<0.0010	<0.0010
Ethylene	g/m ³	<0.003	<0.003
Ethylene glycol	g/m ³	<4	<4
Formaldehyde	g/m ³	<0.02	<0.02
Hardness (total)	g/m ³ CaCO ₃	40	38
Hydrocarbons	g/m ³	<0.7	<0.7
Iron (dissolved)	g/m ³	0.04	0.10
Manganese (dissolved)	g/m ³	0.0191	0.062
Magnesium	g/m ³	3.2	3.4
Mercury (dissolved)	g/m ³	<0.00008	<0.00008
Methane	g/m ³	<0.002	<0.002
Methanol	g/m ³	<2	<2
Nickel	mg/kg	<0.0005	<0.0005
Nitrate nitrogen	g/m ³ N	0.56	0.27
Nitrite/nitrate nitrogen	g/m ³ N	0.56	0.28
Nitrite nitrogen	g/m ³ N	<0.002	0.004
pH	pH	5.8	5.9
Potassium	g/m ³	2.6	6.5
Propylene glycol	g/m ³	<4	<4
Sodium	g/m ³	10.2	9.3
Sulphate	g/m ³	12.4	25
Sum of Anions	meq/l	1.40	1.46
Sum of Cations	meq/l	1.31	1.33
Temperature	Deg.C	15.6	13.1
Toluene	g/m ³	<0.0010	<0.0010
Total dissolved solids	g/m ³	111	125
meta-Xylene	g/m ³	<0.002	<0.002
ortho-Xylene	g/m ³	<0.0010	<0.0010
Zinc	g/m ³	0.0151	0.0136

The results in Tables 4 to 6 show parameters that are all within the typical range for background Taranaki shallow groundwater. It is considered that the slight variations seen between samples are not a result of hydraulic fracturing operations, but are natural variances in groundwater between sites and as seasons change. No levels are of any environmental significance.

In conjunction with the groundwater monitoring programme, prior to the initial hydraulic fracturing process of the Kowhai-3 well, a sample of the fracture fluids was

obtained. Once hydraulic fracturing had commenced, fracture fluids returning to the well head (known as return or 'flowback' fluids) were also sampled and analysed for the same parameters as the groundwater samples. A site inspection undertaken during the hydraulic fracturing operation on 17 January 2014 found that there were no observed effects from the discharge. The results of the hydraulic fracturing campaign at the Kowhai-C wellsite returned levels that are of no environmental significance. Results are detailed in Table 7.

Table 7 Hydraulic fracture fluid and return hydraulic fracture fluid obtained from the Kowhai-C well

Parameter	Unit	Fracture Fluid 17 January 2014	Return Fluid 22 January 2014
Alkalinity (total)	g/m ³ CaCO ₃	-	49
Barium	mg/kg	-	17.1
Benzene	g/m ³	<0.0010	137
Bicarbonate	g/m ³ HCO ₃	-	2530
Bromine (dissolved)	g/m ³	-	16.5
Calcium	g/m ³	-	68
Chloride	g/m ³	-	5000
Conductivity	mS/m@20C	-	1951
Copper (dissolved)	g/m ³	-	0.028
Ethane	g/m ³	-	2.3
Ethylbenzene	g/m ³	0.0013	89
Ethylene	g/m ³	-	<0.005
Ethylene glycol	g/m ³	8	<20
Formaldehyde	g/m ³	-	0.39
Hardness (total)	g/m ³ CaCO ₃	-	250
Hydrocarbons	g/m ³	69	-
Iron (dissolved)	g/m ³	-	3.4
Manganese (dissolved)	g/m ³	-	2.8
Magnesium	g/m ³	-	20
Methane	g/m ³	-	0.85
Methanol	g/m ³	3	<20
Nickel	mg/kg	-	0.26
Nitrate nitrogen	g/m ³ N	-	<0.002
Nitrite/nitrate nitrogen	g/m ³ N	-	<0.002
Nitrite nitrogen	g/m ³ N	-	<0.002
pH	pH	-	7.3
Potassium	g/m ³	-	990
Propylene glycol	g/m ³	<4	<20
Sodium	g/m ³	-	4000
Sulphate	g/m ³	-	68
Sulphur (dissolved)	g/m ³	-	23
Toluene	g/m ³	0.0057	570
Total dissolved solids	g/m ³	-	17000
meta-Xylene	g/m ³	0.005	600
ortho-Xylene	g/m ³	0.0033	185
Zinc (dissolved)	g/m ³	-	0.13

2.3.3. Results of receiving environment monitoring (deepwell injection)

Consent 9476-1 to discharge produced water, well drilling fluids, well workover fluids including hydraulic fracturing fluids, and contaminated stormwater from hydrocarbon exploration operations into the Mount Messenger Formation by deepwell injection via the Kowhai-C waste disposal well, was not exercised during the monitoring period under review.

2.3.4. Land status

The wellsite was constructed on relatively 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 (22 May 2014) as the site was still in use.

2.4. Biomonitoring surveys

Two biomonitoring surveys were performed (one in an unnamed tributary of the Waiau Stream and another in the Parahaki Stream) prior to the commencement of hydraulic fracturing activities on 6 September 2013 and 17 December 2013. Another two biomonitoring surveys were performed at the same stream sites following the completion of hydraulic fracturing activities at the Kowhai-C wellsite on 20 February 2014. Biomonitoring surveys were conducted to determine whether or not consented discharges and activities from the Kowhai-C wellsite have had a detrimental effect upon the macroinvertebrate communities of these streams.

Both the pre and post hydraulic fracturing biomonitoring surveys were undertaken at two sites; 10 m downstream of an access culvert and pond of the unnamed tributary of the Waiau Stream (site 1) and 20 m upstream of Inland North Road of the Parahaki Stream (site 2), as seen in Figure 3.

The Councils' 'vegetation sweep' sampling technique was used at the three sites to collect streambed macroinvertebrates from the unnamed tributary of the Mangawharawhara Stream. This has provided baseline data for any future assessment of consented discharge effects from the Kowhai-C 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.

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



Figure 3 Biomonitoring sites in an unnamed tributary of the Waiiau Stream and the Parahaki Stream in relation to the Kowhai-C wellsite

6 September 2013 / 17 December 2013

The September 2013 survey of the unnamed tributary of the Waiiau Stream, downstream of the intended skimmer pit discharge point to land near the stream, was undertaken prior to drilling and hydraulic fracturing at the Kowhai-C wellsite. Taxa richness was moderate and included a similar number of 'tolerant' and 'sensitive' species. A numerical abundance of 'tolerant' taxa resulted in a SQMCI_s significantly lower than the median score for 'control' sites in streams at a similar altitude. The MCI score indicated that the stream communities were of fair 'health' (TRC, 2013), and were better than the biological health recorded at 'control' sites in similar streams at a comparative altitude elsewhere in the region.

The December 2013 survey of the Parahaki Stream was undertaken after drilling but prior to hydraulic fracturing of the Kowhai-C wellsite. Taxa richness was moderate and similar to 'control' sites in similar streams at a comparative altitude elsewhere in the region. The MCI score indicated that the stream communities were of poor 'health' (TRC, 2013), however results were close to the biological health recorded at 'control' sites in similar streams at a comparative altitude elsewhere in the region. It is important to note that the 'vegetation sweep' sampling method targets habitat favoured by more 'tolerant' taxa, and that typically results in reduced MCI scores when using this sampling method.

20 February 2014

This February 2014 survey of the unnamed tributary of the Waiiau Stream and of the Parahaki Stream was undertaken following drilling and hydraulic fracturing at the Kowhai C wellsite. Taxa richnesses were low to moderate. The macroinvertebrate communities of both streams contained more 'tolerant' than 'sensitive' taxa. A comparison of the surveys carried out prior to and after drilling and/or hydraulic fracturing showed a significant decrease in MCI and SQMCI_s scores at site 1 and a significant decrease in SQMCI_s score at site 2. It is important to note that the

'vegetation sweep' sampling method targets habitat favoured by more 'tolerant' taxa, and that typically results in reduced MCI scores when using this sampling method. The significant decrease in MCI and SQMCI_s scores at site 1 and significant decrease in SQMCI_s score at site 2 can be attributed to the very low and slow flows recorded during the late summer period, and the consequent reduction in habitat available for 'sensitive' taxa at the time of this survey.

The MCI scores recorded in this survey indicated that the stream communities were of poor 'health' (TRC, 2014), similar to the biological health recorded at 'control' sites in similar streams at a comparative altitude elsewhere in the region. This, in part, can be attributed to the habitat which was limited by very low and slow flows. There was no indication from the results of the two surveys that the activities at the Kowhai-C wellsite have impacted on the biological communities of the unnamed tributary of the Waiiau Stream or Parahaki Stream.

2.5. Contingency plan

Greymouth Petroleum Limited has provided a general contingency plan, as required by Condition 4 of resource consent 9478-1 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 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.

Incidents 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).

In the period under review, there were a number of non-compliances observed by the inspecting officers; one abatement notice was issued to Greymouth Petroleum Limited in relation to one of these non-compliances.

An inspecting officer visited the site on 5 December 2013, when significant ponding was observed within the ring-drains (as per Photo 1) in two specific areas which had potential to discharge offsite without treatment via the stormwater treatment system/ skimmer pits. This contravened Section 15(1)(b) of the Resource Management Act and special condition 6 of consent 9478-1. Subsequently, abatement notice 12164 was issued which required Greymouth Petroleum Limited to undertake works to ensure that stormwater flowed directly to the skimmer pits without pooling or ponding within the ring-drain system, mitigating the potential for unauthorised discharges from the site to occur. Works were completed within the required timeframe and with appropriate notification following the abatement notice.



Photo 1 Substantial ponding seen overflowing the ring-drain at the Kowhai-C wellsite on 5 December 2013

Additional non-compliances were addressed during site inspections and are outlined as follows. Chemicals and equipment were observed stored outside of the ring-drained area (21 October 2013), the initial installation of certain components of the skimmer pits were substandard and did not reflect information submitted (8 November 2013), an approximate 30 cm rip was identified in the lining of the first skimmer pit (7 January 2014), and a small section of the flare pit liner had become exposed and melted due to heat exposure (15 April 2014). All were rectified and repaired by Greymouth Petroleum Limited promptly, minimising any potential risk of unauthorised discharges or effects. No adverse effects were observed on any occasion.

The Council was not required to undertake significant additional investigations and interventions, or record incidents, in association with Greymouth Petroleum Limited's conditions in resource consents or provisions in Regional Plans.

3. Discussion

3.1. Discussion of consent exercise

Of the seven resource consents relating to the Kowhai-C wellsite, consents 9474-1 (to discharge emissions to air associated with hydrocarbon producing wells), 9475-1 (to discharge contaminants to air from hydrocarbon exploration), 9477-1 (to discharge stormwater and sediment, deriving from soil disturbance undertaken for the purpose of constructing the site onto land), 9478-1 (to discharge treated stormwater, treated produced water and surplus drilling water from hydrocarbon exploration and production operation onto and into land where it may enter an unnamed tributary of the Waiau Stream), 9479-1 (to take groundwater, as 'produced water', during hydrocarbon exploration), and 9480-1 (to discharge contaminants associated with hydraulic fracturing activities into land) were exercised and actively monitored.

The discharge of produced water, well drilling fluids, well workover fluids including hydraulic fracturing fluids, and contaminated stormwater from hydrocarbon exploration operations into the Mount Messenger Formation by deepwell injection was not exercised during the monitoring period under review, as permitted by resource consent 9476-1.

Other than as noted in section 2.6, 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 significant adverse 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, Greymouth Petroleum Limited 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. Interceptor 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.

Greymouth Petroleum Limited also undertook the following mitigation measures in order to minimize 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 (noting that on one occasion an abatement notice was issued, to direct that modifications were made to the ring-drain system).

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 (e.g. bunding of chemicals and bulk fuel).

Groundwater

Small amounts of groundwater may have been encountered as produced water during operations at the wellsite due to the occasional nature of the groundwater abstraction. It is anticipated that the abstraction would not impact on any groundwater resource. Furthermore, the wells were designed to case out groundwater, thus isolating it from the well operation.

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, nitrogen 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 polyaromatic 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

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.

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 (e.g. urban areas). These levels are well below any concentrations at which there is any basis for concern over potential health effects.

The measures to be undertaken by Greymouth Petroleum Limited 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 Greymouth Petroleum Limited and provided to the Council;
- Every endeavor was made by Greymouth Petroleum Limited 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 Greymouth Petroleum Limited 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 (e.g. 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.

Greymouth Petroleum Limited 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 (although on one occasion drums were found outside the bunded area);
- 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 (e.g. 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. Comprehensive monitoring of ground and surface water found no evidence of fracturing causing any effects.

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.

3.3. Evaluation of performance

A tabular summary of Greymouth Petroleum Limited's compliance record for the period under review is set out in Tables 8 to 14.

Table 8 Summary of performance for consent 9474-1 to discharge emissions to air associated with hydrocarbon producing wells at the Kowhai-C wellsite

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Council must be notified 24hrs prior to flaring when practicable	Notification	Yes
2. Occupants of dwellings within 300 m of the wellsite shall be provided with notification at least 24 hrs prior to flaring, when practicable	Notification	Yes
3. Location of flare shall be NZTM: 1711713E – 5678466N	Inspection	Yes
4. No material to be flared or incinerated, other than those derived from or entrained in the well stream	Inspection of flare pit	Yes
5. All gas flared must first be treated by effective liquid and solid separation and recovery	Inspection of flare pit	Yes
6. Best practicable option to be adopted	Inspections, procedures and processes	Yes
7. No offensive or objectionable odour or smoke at or beyond the boundary	Inspection	Yes
8. All permanent tanks used as hydrocarbon storage vessels fitted with vapour recovery systems	Inspection	Yes
9. Control of carbon monoxide, nitrogen dioxide, sulphur dioxide and fine particles	Inspection of Company records	Yes
10. Control of other emissions	Inspection of Company records	Yes
11. Analysis of typical gas and condensate stream from field to be made available to the Council	Available upon request	Yes
12. Consent holder shall make available to the Council a flaring log detailing all flaring events including time, duration, zone, volumes flared and smoke events	Inspection of Company records	Yes
13. Consent shall lapse if not implemented	Consent exercised	N/A

Condition requirement	Means of monitoring during period under review	Compliance achieved?
14. Notice of Council to review consent	No provision for review during period	N/A
Overall assessment of consent compliance and environmental performance in respect of this consent		High

Table 9 Summary of performance for consent 9475-1 to discharge contaminants to air from hydrocarbon exploration at the Kowhai-C wellsite, including combustion involving flaring or incineration of petroleum recovered from natural deposits, in association with well development or redevelopment and testing or enhancement of well production flows

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Consent shall not be exercised for more than an accumulated duration of 15 days per zone for up to 8 wells	Inspection of records	Yes
2. Location of flare shall be NZTM: 1711713E – 5678466N	Inspection	Yes
3. Council must be notified 24hrs prior to initial flaring of each zone	Notification received	Yes
4. Occupants of dwellings within 300 m of the wellsite shall be provided with notification at least 24 hrs prior to flaring, when practicable	Notification	Yes
5. No material to be flared or incinerated, other than those derived from or entrained in the well stream	Inspection of flare pit	Yes
6. All gas flared must first be treated by effective liquid and solid separation and recovery	Inspection of flare pit	Yes
7. If effective separation could not be achieved as per condition 6, the consent holder shall reinstate effective separation as soon as possible; if separation could not be achieved within 3 hours, combustion must cease	Inspection of flare pit and Company records	Yes
8. If effective liquid and solid separation could not be achieved as per conditions 6 and 7, the consent holder shall provide to the Council a report	Inspection of flare pit and Company records	Yes
9. Best practicable option to be adopted	Inspections, procedures and processes	Yes
10. No offensive or objectionable odour or smoke at or beyond the boundary	Inspection	Yes
11. Control of carbon monoxide, nitrogen dioxide, sulphur dioxide and fine particles	Inspection of Company records	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
12. Control of other emissions	Inspection of Company records	Yes
13. Analysis of typical gas and condensate stream from field to be made available to the Council	Available upon request	N/A
14. All permanent tanks used as hydrocarbon storage vessels fitted with vapour recovery systems	Inspection	Yes
15. Consent holder shall make available to the Council a flaring log detailing all flaring events including time, duration, zone, volumes flared and smoke events	Inspection of Company records	Yes
16. Consent shall lapse if not implemented	Consent exercised	N/A
17. Notice of Council to review consent	No provision for review during period	N/A
Overall assessment of consent compliance and environmental performance in respect of this consent		High

Table 10 Summary of performance for consent 9476-1 to discharge produced water, well drilling fluids, well workover fluids including hydraulic fracturing fluids, and contaminated stormwater from hydrocarbon exploration operations into the Mount Messenger Formation by deepwell injection via the Kowhai-C waste disposal well

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. Injection well, geological and operational data submission requirements. This information can be included in the "Injection Operation Management Plan."	Consent not exercised during monitoring period under review.	N/A
3. The injection pressure at the wellhead shall not exceed 1,685 psi (115 bars)	Consent not exercised during monitoring period under review.	N/A
4. The rate of injection shall not exceed 0.48 m ³ /minute	Consent not exercised during monitoring period under review.	N/A
5. The volume of fluid injected shall not exceed 687 m ³ /day	Consent not exercised during monitoring period under review.	N/A
6. The injection of fluids shall be confined to the Mt. Messenger Formation, deeper than 1,350 metres true vertical depth	Consent not exercised during monitoring period under review.	N/A
7. The consent holder shall at all times adopt the best practicable option.	Consent not exercised during monitoring period under review.	N/A

Condition requirement	Means of monitoring during period under review	Compliance achieved?
8. Only the following fluids originating from the consent holders operation may be discharged: <ul style="list-style-type: none"> a. Produced water; b. Well drilling fluids; c. Well workover fluids (including hydraulic fracturing return fluids); and d. Contaminated stormwater 	Consent not exercised during monitoring period under review.	N/A
9. Maintain full records of injection data.	Consent not exercised during monitoring period under review.	N/A
10. Maintain records and undertake analysis to characterise each type of waste arriving on-site for discharge.	Consent not exercised during monitoring period under review.	N/A
11. The data required by conditions 9 & 10 above, for each calendar month, is required to be submitted by the 15 th day of the following month.	Consent not exercised during monitoring period under review.	N/A
12. 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).	Consent not exercised during monitoring period under review.	N/A
13. The consent holder shall undertake a programme of sampling and testing (the 'Monitoring Programme') that monitors the effects of the exercise of this consent on fresh water resources	Consent not exercised during monitoring period under review.	N/A
14. All groundwater samples taken for monitoring purposes shall be taken in accordance with recognised field procedures and analysed for: <ul style="list-style-type: none"> a. pH; b. Conductivity; c. Chloride; and d. Total petroleum hydrocarbons 	Consent not exercised during monitoring period under review.	N/A
15. All groundwater sampling and analysis shall be undertaken in accordance with a Sampling and Analysis Plan, which shall be submitted to the Chief Executive, Taranaki Regional Council for review and certification before the first sampling is undertaken	Consent not exercised during monitoring period under review.	N/A
16. The consent holder shall provide to the Council each year, a summary of all data collected and a report detailing compliance with consent conditions over the previous 1 July to	Consent not exercised during monitoring period under review.	N/A

Condition requirement	Means of monitoring during period under review	Compliance achieved?
30 June period.		
17. The consent holder shall notify the Chief Executive, Taranaki Regional Council, in writing at least 5 days prior to the first exercise of this consent.	Consent not exercised during monitoring period under review.	N/A
18. No injection permitted after 1 June 2022	Consent not exercised during monitoring period under review.	N/A
19. Consent review provision.	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

Table 11 Summary of performance for consent 9477-1 to discharge stormwater and sediment, deriving from soil disturbance undertaken for the purpose of constructing the Kowhai-C wellsite, onto land

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. The discharge of stormwater from land shall not exceed more than 1.86 ha	Inspections and plans	Yes
2. Consent holder to adopt best practicable option at all times	Inspections, procedures and processes	Yes
3. 7 days written notice prior to site earthworks commencing	Notification received	Yes
4. All run off from any exposed soil shall pass through settlement ponds or sediment traps or other sediment control measure of equal standard	Inspections	Yes
5. Condition 4 shall cease to apply, and sediment control measures removed when the area is stabilised	Inspections	Yes
6. All earth worked areas shall be stabilised as soon as practicable	Inspection	Yes
Overall assessment of consent compliance and environmental performance in respect of this consent		High

Table 12 Summary of performance for consent 9478-1 to discharge treated stormwater, treated produced water and surplus drilling water from hydrocarbon exploration and production operations at the Kowhai-C wellsite onto and into land where it may enter an unnamed tributary of the Waiau Stream

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Consent holder to adopt best practicable option at all times	Inspections, procedures & processes	Mostly – issues with in-drain ponding, initial installation of skimmer pit components and initial storage of chemicals and equipment outside of bunded areas
2. Maximum stormwater catchment area shall be no more than 1.86 ha	Plans, procedures and processes	Yes
3. 5 days written 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 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	Mostly – Initial installation of certain components of skimmer pits were not satisfactory / did not reflect information submitted.
6. All discharges from the site shall flow to a perimeter drain and skimmer pit without ponding	Inspection	No – significant issues with ponding at / on-site. One abatement notice issued.
7. All stormwater pits shall be lined with impervious material	Inspection	Mostly - rip was identified in the lining of the first skimmer pit on one occasion
8. Skimmer pits shall have a combined capacity of no less than 310 m ³ before being discharged	Inspection	Yes
9. Constituents in discharges shall meet the following standards: a) pH 6.0 – 8.0 b) Suspended solids <100 g/m ³ c) Hydrocarbon <15 g/m ³ d) Chloride 50 g/m ³	Physicochemical sampling	Yes
10. Following a mixing zone of 20 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?
11. Following the mixing zone, the discharge shall not give rise to adverse effects in/on the receiving waters	Inspection	Yes
12. The Council shall be advised in writing 48 hrs prior to reinstatement of the site	Notification not received – site not reinstated	N/A
13. Consent shall lapse if not implemented	Exercise of consent confirmed by inspection	N/A
14. Notice of Council to review consent	No provision for review during period	N/A
Overall assessment of consent compliance and environmental performance in respect of this consent		Improvement Required

Table 13 Summary of performance for consent 9479-1 to take groundwater, as 'produced water', during hydrocarbon exploration and production activities at the Kowhai-C wellsite

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. The abstraction must not cause more than a 10% lowering of static water level by interference with any adjacent bore	Sampling adjacent bores pre/post drilling	Yes
2. The abstraction does not cause the intrusion of salt water into any freshwater aquifer	Sampling adjacent bores pre/post drilling	Yes
3. A well log to 1,000 m must be submitted to the Council	Well log to 1,000 m submitted	Acceptable
4. Consent shall lapse if not implemented by date specified	Consent exercised	N/A
5. Notice of Council to review consent	Notice of intention not served	N/A
Overall assessment of consent compliance and environmental performance in respect of this consent		High

Table 14 Summary of performance for consent 9480-1 to discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3400 mTVD beneath the Kowhai-C wellsite

Condition requirement	Means of monitoring during period under review	Compliance achieved?
1. Any discharge shall occur below 3,400 mTVD	Inspection of Company records	Yes
2. There shall be no discharge of hydraulic fracturing fluids into the reservoir after 1 June 2015	-	N/A
3. Exercise of consent shall not contaminate or put at risk freshwater	Sampling fresh water bores pre/post discharge	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
4. Consent holder shall undertake a sampling programme	Inspection and sampling fresh water 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 programme shall follow recognised field procedures	Inspection, procedures and processes	Yes
8. Consent holder to undertake well and equipment pressure testing	Inspection of company records	Yes
9. A pre-fracturing discharge report is to be provided to the Council 14 days prior to the second and subsequent discharges	Pre-fracturing discharge report received	Yes
10. Consent holder shall provide notification prior to each hydraulic fracture discharge	Notification received	Yes
11. A post-fracturing discharge report is to be provided to the Council within 60 days after the discharge has ceased	Post-fracturing discharge report received	Yes
12. The reports outlined in conditions 9 and 11 must be emailed to consents@trc.govt.nz	Reports received via email	Yes
13. The consent holder shall provide access to a location where samples of hydraulic fracturing fluids and return fluids can be obtained by the Council officers	Provided	Yes
14. Consent holder to adopt best practicable option at all times	Inspection, Physicochemical sampling, procedures and processes	Yes
15. The fracture fluid shall be comprised of no less than 95% water	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

Taking all matters into account, during the monitoring period, Greymouth Petroleum Limited demonstrated a good level of environmental performance and compliance with the resource consents. The incidents that occurred in respect of resource consent 9478-1 have been discussed in Section 2.6. The site was generally neat, tidy, and well maintained. No adverse effects were observed.

3.4. Exercise of optional review of consents

Each resource consent includes a condition which allows the Council to review the consent, for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of the resource consent, which were not foreseen at the time the application was considered or which it was not appropriate to deal with at the time. The next provisions for review are in 2015 and 2018.

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.

3.5. 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 in the order of hundreds of water samples and biomonitoring surveys in the vicinity of wellsites, and has demonstrated robustly 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 areas 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 Kowhai-C 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 presented in section 4.

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 Kowhai-C wellsite continue 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 Kowhai-C wellsite continue to include biomonitoring surveys;
4. THAT, subject to the findings of monitoring of any further activities at the Kowhai-C wellsite consents 9474-1, 9475-1, 9476-1, 9478-1, 9479-1 and 9480-1 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 .
cfu	Colony forming units. A measure of the concentration of bacteria usually expressed as per 100 millilitre sample.
COD	Chemical oxygen demand. A measure of the oxygen required to oxidise all matter in a sample by chemical reaction.
Condy	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.
E.coli	Escherichia coli, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre sample.
Ent	Enterococci, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre of sample.
F	Fluoride.
FC	Faecal coliforms, an indicator of the possible presence of faecal material and pathological micro-organisms. Usually expressed as colony forming units per 100 millilitre sample.
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 4341

Decision Date: 22 February 2013

Commencement Date: 22 February 2013

Conditions of Consent

Consent Granted: To discharge contaminants associated with hydraulic fracturing activities into land at depths greater than 3400 mTVD beneath the Kowhai-C wellsite

Expiry Date: 1 June 2020

Review Date(s): June annually

Site Location: Kowhai-C wellsite, 492 Otaraoa Road, Tikorangi
[Property owner: K & L Hunter]

Legal Description: Lot 2 DP 6166 Blk VI Waitara SD

Grid Reference (NZTM) 1711761E-5678397N

Catchment: Waiau

*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 discharge point shall be deeper than 3400 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 2015.
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). Useable 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 dedicated 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 ($^{13}\text{C-CH}_4$).

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

7. All sampling and analysis shall be undertaken in accordance with a *Sampling and Analysis Plan*, which shall be submitted to the Chief Executive for review and certification before the first sampling is undertaken. This plan shall specify the use of standard protocols recognised to constitute good professional practice including quality control and assurance. An International Accreditation New Zealand (IANZ) accredited laboratory shall be used for all sample analysis. Results shall be provided to the Chief Executive within 30 days of sampling and shall include supporting quality control and assurance information. These results will be used to assess compliance with condition 3.

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

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

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

- (a) the specific well in which each discharge is to occur and 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 and its intended composition, including a list of all contaminants and Material Safety Data Sheets for all the chemicals to be used;
- (d) the results of the reviews required by condition 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 2;
- (g) the extent and permeability characteristics of the geology above the discharge point to the surface;
- (h) any identified faults within the modeled fracture length plus a margin of 50%, and the potential for adverse environmental effects due to the presence of the identified faults;
- (i) the burst pressure of the well and the anticipated maximum well and discharge pressures and the duration of the pressures; and
- (j) details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal.

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

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;
 - (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 bottomhole pressure (psi), as well as predicted values for each of these parameters; prior to, during and after each hydraulic fracture treatment;
 - (i) details of the disposal of any returned fluids, including any consents that are relied on to authorise the disposal;
 - (j) details of any incidents where hydraulic fracture fluid is unable to pass through the well perforations (screen outs) that occurred, their likely cause and implications for compliance with conditions 1 and 2; and
 - (k) an assessment of the effectiveness of the mitigation measures in place with specific reference to those described in the application for this consent.
12. The reports described in conditions 9 and 11 shall be emailed to consents@trc.govt.nz with a reference to the number of this consent.

Consent 9480-1

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

Signed at Stratford on 22 February 2013

For and on behalf of
Taranaki Regional Council

Chief Executive

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 4341

Decision Date: 13 February 2013

Commencement
Date: 13 February 2013

Conditions of Consent

Consent Granted: To take groundwater, as 'produced water', during hydrocarbon exploration and production activities at the Kowhai-C wellsite at or about (NZTM) 1711761E-5678397N

Expiry Date: 1 June 2027

Review Date(s): June 2015, June 2021

Site Location: Kowhai-C wellsite, 492 Otaraoa Road, Tikorangi
(Property owner: K & L Hunter)

Legal Description: Lot 2 DP 6166 (Site of take)

Catchment: Waiau

*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 consent holder shall ensure the abstraction does not cause more than a 10% lowering of static water-level by interference with any adjacent bore.
2. The consent holder shall ensure the abstraction does not cause the intrusion of salt water into any freshwater aquifer.
3. The consent holder shall submit a summary well log to a depth of 1000 metres, within three months of the completion of drilling. The report shall:
 - a) include confirmation of the datum from which measurements are referenced;
 - b) provide a log to show the true vertical depth to all geological formation tops intersected within the freshwater zone;
 - c) identify the true vertical depth to, and thickness of, any freshwater aquifers intersected by the well; and
 - d) identify the true vertical depth to the freshwater-saline water interface in the well.
4. This consent shall lapse on 31 March 2018, 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.
5. 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 2015 and/or June 2021, 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 13 February 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 Limited
P O Box 3394
NEW PLYMOUTH 4341

Decision Date
(Change): 29 October 2013

Commencement Date
(Change): 29 October 2013 (Granted: 13 February 2013)

Conditions of Consent

Consent Granted: To discharge treated stormwater, treated produced water and surplus drilling water from hydrocarbon exploration and production operations at the Kowhai-C wellsite onto and into land where it may enter an unnamed tributary of the Waiau Stream

Expiry Date: 1 June 2027

Review Date(s): June 2015, June 2021

Site Location: Kowhai-C wellsite, 492 Otaraoa Road, Tikorangi

Legal Description: Lot 2 DP 6166 Blk VI Waitara SD

Grid Reference (NZTM) 1711878E-5678538N

Catchment: Waiau

*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 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 1.86 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; and
 - b) commencement of any well drilling operation.

If either 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 a brief description of the activity consented and be emailed to worknotification@trc.govt.nz.

4. The consent holder shall maintain a contingency plan that, to the satisfaction of the Chief Executive, Taranaki Regional Council, 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 provided to the Council prior to discharging from the site.
5. Subject 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 7312 and in particular, the:
 - a) Assessment of environmental effects submitted with the application;
 - b) Stormwater management design report for Kowhai-C wellsite provided in Appendix E of the assessment of environmental effects, dated 13 November 2012.

Consent 9478-1

6. All discharges from the site, including from any containment pit or flare pit, 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. 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 skimmer pits shall have a valve that can be shut off to prevent any discharge from the site.
8. Skimmer pits shall have a combined capacity of no less than 310 m³ before being discharged.
9. 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

10. After allowing for a mixing zone of 20 metres, the discharge shall not give rise to an increase in the temperature of the receiving waters of more than 2 degrees Celsius.
11. After allowing for a mixing zone of 20 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.
12. 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.
13. This consent shall lapse on 31 March 2018, 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 9478-1

14. 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 2015 and/or June 2021, 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 29 October 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 Limited
P O Box 3394
NEW PLYMOUTH 4341

Decision Date: 13 February 2013

Commencement
Date: 13 February 2013

Conditions of Consent

Consent Granted: To discharge stormwater and sediment, deriving from soil disturbance undertaken for the purpose of constructing the Kowhai-C wellsite, onto land at or about (NZTM) 1711878E-5678538N

Expiry Date: 1 June 2018

Site Location: Kowhai-C wellsite, 492 Otaraoa Road, Tikorangi
(Property owner: K & L Hunter)

Legal Description: Lot 2 DP 6166 (Discharge source & site)

Catchment: Waiau

*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. This consent authorises the discharge of stormwater from no more than 1.86 ha of land where earthworks is being undertaken for the purpose of establishing the Kowhai-C wellsite.
2. 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.
3. At least 7 working days before the commencement of earthworks for the purpose of wellsite construction and establishment, the consent holder shall notify the Taranaki Regional Council of the proposed start date for the earthworks. Notification shall include the consent number and a brief description of the activity consented and shall be emailed to worknotification@trc.govt.nz.
4. All run off from any area of exposed soil shall pass through settlement ponds or sediment traps with a minimum total capacity of:
 - a) 100 cubic metres for every hectare of exposed soil between 1 November to 30 April; and
 - b) 200 cubic metres for every hectare of exposed soil between 1 May to 31 October;unless other sediment control measures that achieve an equivalent standard are agreed to by the Chief Executive of the Taranaki Regional Council.
5. The obligation described in condition 4 above shall cease to apply, and accordingly the erosion and sediment control measures may be removed, in respect of any particular area, only when the area is stabilised

Note: For the purpose of conditions 4 and 5, "stabilised" in relation to any site or area means inherently resistant to erosion or rendered resistant, such as by using rock or by the application of basecourse, colluvium, grassing, mulch, or another method to the reasonable satisfaction of the Chief Executive, Taranaki Regional Council and as specified in the Taranaki Regional Council's Guidelines for Earthworks in the Taranaki Region, 2006. Where seeding or grassing is used on a surface that is not otherwise resistant to erosion, the surface is considered stabilised once, on reasonable visual inspection by an officer of the Taranaki Regional Council, an 80% vegetative cover has been established.

Consent 9477-1

6. All earthworked areas shall be stabilised vegetatively or otherwise as soon as is practicable and no longer than 6 months after the completion of soil disturbance activities.

Note: For the purposes of this condition "stabilised" has the same definition as that set out in condition 5.

Signed at Stratford on 13 February 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 Limited
P O Box 3394
NEW PLYMOUTH 4341

Decision Date: 28 February 2013

Commencement Date: 28 February 2013

Conditions of Consent

Consent Granted: To discharge produced water, well drilling fluids, well workover fluids including hydraulic fracturing fluids, and contaminated stormwater from hydrocarbon exploration operations into the Mount Messenger Formation by deepwell injection via the Kowhai-C waste disposal well

Expiry Date: 1 June 2027

Review Date(s): June annually

Site Location: Kowhai-C wellsite, 492 Otaraoa Road, Tikorangi
[Property owner: K & L Hunter]

Legal Description: Lot 2 DP 6166 Blk VI Waitara SD [discharge site]

Grid Reference (NZTM) 1711746E-5678303N

Catchment: Waiau

*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. Before this consent is exercised, the consent holder shall submit an "Injection Operation Management Plan" which shall include the operational details of the injection activities and identify the conditions that would trigger concerns about the integrity of the injection well, injection zone or overlying geological formations. The plan will also detail the action(s) to be taken by the consent holder if trigger conditions are reached.
2. Before this consent is exercised the consent holder shall provide to the Chief Executive of the Taranaki Regional Council:
 - (a) A final well completion log for the injection well including subsurface construction details, design of the exterior surface casing, the intermediate protective casing, and the innermost casing, tubing, and/or packer(s);
 - (b) Well cementing details, cement bond log and results of annular pressure testing which demonstrates well integrity;
 - (c) Details of on-going well integrity monitoring, well maintenance procedures and safe operating limits for the well;
 - (d) A detailed geological log of the well;
 - (e) Details and results of the Formation Integrity Testing carried out on the receiving formation and confining layers and an assessment of the results against the estimated modelled values submitted in the consent application;
 - (f) Results of an electrical resistivity survey, clearly showing the confirmed depth of freshwater as defined in condition 11; and
 - (g) A full chemical analysis of the receiving formation-water.

(Note: These details can be included within the "Injection Operation Management Plan.")

3. The injection pressure at the wellhead shall not exceed 1685 psi (115 bars). If exceeded, the injection operation shall be ceased immediately and the Chief Executive of the Taranaki Regional Council informed immediately.
4. The rate of injection shall not exceed 0.48 m³/min (3.0 bpm).
5. The volume of fluid injected shall not exceed 687 m³/day (or 4320 bpd).
6. The injection of fluids shall be confined to the Mt. Messenger Formation, deeper than -1,350 metres Total Vertical Depth.

7. 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; in particular, ensuring that the injection material is contained within the injection zone.
8. Only the fluids listed below and originating from the consent holder's operations may be discharged:
 - (a) Produced water;
 - (b) Well drilling fluids;
 - (c) Well workover fluids, including hydraulic fracturing return fluids; and
 - (d) Contaminated stormwater.
9. Once the consent is exercised, the consent holder shall keep daily records of the:
 - (a) total injection hours;
 - (b) volume of fluid injected;
 - (c) maximum and average rate of injection; and
 - (d) maximum and average injection pressure.
10. For each waste stream arriving on site for discharge, the consent holder shall record the following information:
 - (a) type of fluid;
 - (b) source of fluid (site name and location);
 - (c) an analysis of the fluid for:
 - (i) pH;
 - (ii) suspended solids concentration;
 - (iii) temperature;
 - (iv) salinity;
 - (v) chloride concentration; and
 - (vi) total hydrocarbon concentration

The analysis required by condition 10(c) above is not necessary if a sample of the same type of fluid, from the same source, has been taken, analysed and provided to the Chief Executive, Taranaki Regional Council within the previous 6 months.

11. The information required by conditions 9 and 10 above, for each calendar month, shall be provided to the Chief Executive, Taranaki Regional Council before the 15th day of the following month.
12. 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). Useable fresh groundwater is defined as any groundwater having a Total Dissolved Solids concentration of less than 1000 mg/l.

Consent 9476-1

13. 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 12 (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 sampling sites;
 - (b) well/bore construction details; and
 - (c) sampling frequency.

14. All water samples taken for monitoring purposes shall be taken in accordance with recognised field procedures and analysed for:
- (a) pH;
 - (b) conductivity;
 - (c) chloride; and
 - (d) total petroleum hydrocarbons.

Note: The samples required, under conditions 13 and 14, could be taken and analysed by the Council or other contracted party on behalf of the consent holder.

15. 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 12.

Note: The Sampling and Analysis Plan may be combined with the Monitoring Programme required by condition 13.

16. The consent holder shall provide to Taranaki Regional Council, during the month of July of every year, a summary of all data collected and a report detailing compliance with consent conditions over the previous 1 July to 30 June period. The report shall also provide and assess data which illustrates the on-going integrity and isolation of the wellbore, well performance and condition. The consent holder shall also provide an updated injection modeling report, illustrating the ability of the receiving formation to continue to accept additional waste fluids and estimating its remaining storage capacity.
17. The consent holder shall notify the Chief Executive, Taranaki Regional Council, in writing at least 5 days prior to the first exercise of this consent. Notification shall include the consent number and a brief description of the activity consented and be emailed to worknotification@trc.govt.nz.
18. There shall be no fluids discharged under this consent after 1 June 2022.

Consent 9476-1

19. 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 each year, 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 28 February 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 Limited
P O Box 3394
NEW PLYMOUTH 4341

Decision Date: 13 February 2013

Commencement
Date: 13 February 2013

Conditions of Consent

Consent Granted: To discharge contaminants to air from hydrocarbon exploration at the Kowhai-C wellsite, including combustion involving flaring or incineration of petroleum recovered from natural deposits, in association with well development or redevelopment and testing or enhancement of well production flows at or about (NZTM) 1711713E-5678466N

Expiry Date: 1 June 2027

Review Date(s): June 2015, June 2021 and in accordance with special condition 8

Site Location: Kowhai-C wellsite, 492 Otaraoa Road, Tikorangi
(Property owner: K & L Hunter)

Legal Description: Lot 2 DP 6166 Blk VI Waitara SD (Discharge source & site)

*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. Flaring shall not occur on more than 15 days, cumulatively, per zone for each well (with a maximum of 4 zones per well), for up to 8 wells.
2. Flaring shall only occur in a flare pit that is located at or about NZTM 1711713E-5678466N and lined with impermeable material that prevents any liquid from leaking through its base or sidewalls.
3. The consent holder shall notify the Chief Executive, Taranaki Regional Council, at least 24 hours before the initial flaring of each zone being commenced. Notification shall include the consent number and a brief description of the activity consented and be emailed to worknotification@trc.govt.nz.
4. At least 24 hours before any flaring, other than in emergencies, the consent holder shall provide notification to the occupants of all dwellings within 300 m 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 complaints received in respect of any flaring activity.
5. No material shall be flared or incinerated, other than those derived from or entrained in the well stream.
6. To the greatest extent possible, all gas that is flared must first be treated by effective liquid and solid separation and recovery.
7. Only gaseous hydrocarbons originating from the well stream shall be combusted, except that if, for reasons beyond the control of the consent holder, effective separation can not be achieved and combustion of liquid hydrocarbon is unavoidable, the consent holder shall reinstate effective separation as soon as possible and if separation can not be achieved within 3 hours combustion must cease.
8. If liquid hydrocarbon is combusted in accordance with the exception provided for in condition 7, the consent holder shall prepare a report that details:
 - a) the reasons that separation could not be achieved;
 - b) the date and time that separation was lost and reinstated;
 - c) what was done to attempt to reinstate separation and, if the attempt was unsuccessful the reasons why.

The report shall be provided to the Chief Executive, Taranaki Regional Council within 5 working days from the date of combustion of liquid hydrocarbon.

Consent 9475-1

9. 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 any emission to air from the flare, including, but not limited to, having regard to the prevailing and predicted wind speed and direction at the time of initiation of, and throughout, any episode of flaring so as to minimise offsite effects (other than for the maintenance of a pilot flare flame).
10. The discharge shall not cause any objectionable or offensive odour or objectionable or offensive smoke at or beyond the boundary of the property where the wellsite is located.
11. The consent holder shall control all emissions of carbon monoxide, nitrogen dioxide, fine particles (PM₁₀) and sulphur dioxide to the atmosphere from the site, in order that the maximum ground level concentration of any of these contaminants arising from the exercise of this consent measured under ambient conditions does not exceed the relevant ambient air quality standard as set out in the Resource Management (National Environmental Standards for Air Quality Regulations, 2004) at or beyond the boundary of the property on which the wellsite is located.
12. The consent holder shall control all emissions to the atmosphere from the site of contaminants other than those expressly provided for under special condition 11, in order that they do not individually or in combination with other contaminants cause a hazardous, noxious, dangerous, offensive or objectionable effect at or beyond the boundary of the property on which the wellsite is located.
13. The consent holder shall make available to the Chief Executive, Taranaki Regional Council, upon request, an analysis of a typical gas and condensate stream from the field, covering sulphur compound content and the content of carbon compounds of structure C₆ or higher number of compounds.
14. All permanent tanks used as hydrocarbon storage vessels, shall be fitted with vapour recovery systems.
15. The consent holder shall record and make available to the Chief Executive, Taranaki Regional Council upon request, a 'flaring log' that includes:
 - a) the date, time and duration of all flaring episodes;
 - b) the zone from which flaring occurred;
 - c) the volume of substances flared;
 - d) whether there was smoke at any time during the flaring episode and if there was, the time, duration and cause of each 'smoke event'.
16. This consent shall lapse on 31 March 2018, 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 9475-1

17. 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:

- a) during the month of June 2015 and/or June 2021; and/or
- b) within 1 month of receiving a report provided in accordance with condition 8;

for any of the following purposes:

- i. dealing with any significant adverse effect on the environment arising from the exercise of the consent which was not foreseen at the time the application was considered or which it was not appropriate to deal with at the time; and/or
- ii. requiring the consent holder to adopt specific practices in order to achieve the best practicable option to remove or reduce any adverse effect on the environment caused by the discharge; and/or
- iii. to alter, add or delete limits on mass discharge quantities or ambient concentrations of any contaminant; and
- iv. reducing emissions or environmental effects that may arise from any loss of separation.

Signed at Stratford on 13 February 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 Limited
P O Box 3394
NEW PLYMOUTH 4341

Decision Date: 13 February 2013

Commencement
Date: 13 February 2013

Conditions of Consent

Consent Granted: To discharge emissions to air associated with hydrocarbon producing wells at the Kowhai-C wellsite at or about (NZTM) 1711713E-5678466N

Expiry Date: 1 June 2027

Review Date(s): June 2015, June 2021

Site Location: Kowhai-C wellsite, 492 Otaraoa Road, Tikorangi
(Property owner: K & L Hunter)

Legal Description: Lot 2 DP 6166 (Discharge source & site)

*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. Other than in emergencies, the consent holder shall 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 be no less than 24 hours before the flaring commences. Notification shall include the consent number and be emailed to worknotification@trc.govt.nz.
2. At least 24 hours before any flaring, other than in emergencies, the consent holder shall provide notification to the occupants of all dwellings within 300 m 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 complaints received in respect of any flaring activity.
3. Flaring shall only occur in a flare pit that is located at or about NZTM 1711713E-5678466N and lined with impermeable material that prevents any liquid from leaking through its base or sidewalls.
4. No material shall be flared or incinerated, other than those derived from or entrained in the well stream.
5. To the greatest extent possible, all gas that is flared must first be treated by effective liquid and solid separation and recovery.
6. 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 any emission to air from the flare, including, but not limited to, having regard to the prevailing and predicted wind speed and direction at the time of initiation of, and throughout, any episode of flaring so as to minimise offsite effects (other than for the maintenance of a pilot flare flame).
7. The discharge shall not cause any objectionable or offensive odour or objectionable or offensive smoke at or beyond the boundary of the property where the wellsite is located.
8. All permanent tanks used as hydrocarbon storage vessels, shall be fitted with vapour recovery systems.
9. The consent holder shall control all emissions of carbon monoxide, nitrogen dioxide, fine particles (PM₁₀) and sulphur dioxide to the atmosphere from the site, in order that the maximum ground level concentration of any of these contaminants arising from the exercise of this consent measured under ambient conditions does not exceed the relevant ambient air quality standard as set out in the Resource Management (National Environmental Standards for Air Quality Regulations, 2004) at or beyond the boundary of the property on which the wellsite is located.

Consent 9474-1

10. The consent holder shall control all emissions to the atmosphere from the site of contaminants other than those expressly provided for under special condition 9, in order that they do not individually or in combination with other contaminants cause a hazardous, noxious, dangerous, offensive or objectionable effect at or beyond the boundary of the property on which the wellsite is located.
11. The consent holder shall make available to the Chief Executive, Taranaki Regional Council, upon request, an analysis of a typical gas and condensate stream from the field, covering sulphur compound content and the content of carbon compounds of structure C₆ or higher number of compounds.
12. The consent holder shall record and make available to the Chief Executive, Taranaki Regional Council, a 'flaring log' that includes:
 - a) the date, time and duration of all flaring episodes;
 - b) the zone from which flaring occurred;
 - c) the volume of substances flared;
 - d) whether there was smoke at any time during the flaring episode and if there was, the time, duration and cause of each 'smoke event'.
13. This consent shall lapse on 31 March 2018, 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.
14. 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 2015 and/or June 2021, for any of the following purposes:
 - a) dealing with any significant adverse effect on the environment arising from the exercise of the consent which was not foreseen at the time the application was considered or which it was not appropriate to deal with at the time; and/or
 - b) requiring the consent holder to adopt specific practices in order to achieve the best practicable option to remove or reduce any adverse effect on the environment caused by the discharge; and/or
 - c) to alter, add or delete limits on mass discharge quantities or ambient concentrations of any contaminant.

Signed at Stratford on 13 February 2013

For and on behalf of
Taranaki Regional Council

Director-Resource Management

Appendix II

Biomonitoring surveys

To Job Manager: Callum MacKenzie
From Freshwater Biologist: Brooke Thomas
Report No BT017
Document 1373250
Date 14 July 2014

Biomonitoring of an unnamed tributary of the Waiau Stream and of the Parahaki Stream following production at the Kowhai-C wellsite, February 2014

Introduction

These two biological surveys were performed following production at the Kowhai-C well, to determine whether or not treated stormwater and uncontaminated site and production water discharges, in the vicinity of the Waiau Stream and Parahaki Stream had any effects upon the macroinvertebrate communities of these streams. A biological survey of the Waiau Stream was conducted prior to drilling and hydraulic fracturing activities at the Kowhai-C well, to provide baseline data on the macroinvertebrate community of the stream (Thomas, 2014). A biological survey of the Parahaki Stream was carried out after drilling activities of the Kowhai-C wellsite but prior to hydraulic fracturing; also to provide baseline data on the macroinvertebrate community of the stream (Thomas, 2014).

Methods

Kowhai-C wellsite treated stormwater and site production water was discharged on to land within the vicinity of the unnamed tributary of the Waiau Stream (Figure 1). This survey of the unnamed tributary of the Waiau Stream was undertaken on 20 February 2014 at one established site (Table 1); 10 metres downstream of an access culvert and pond (site 1). No upstream site was established as the position of the Kowhai-C discharge was directly above the headwaters of the unnamed tributary of the Waiau Stream. Only one site was sampled below the discharge point due to limited accessibility.

A survey of the Parahaki Stream was also carried out on 20 February 2014 at one established site (Table 1); 20 metres upstream of Inland North Road (site 2). The Parahaki Stream is valued by the local community for its watercress. Although not in the direct vicinity of the Kowhai-C discharge, this biological survey was deemed necessary to determine whether or not hydraulic fracturing activities of the Kowhai-C wellsite had any detrimental effect upon macroinvertebrate communities of this valued stream.

The council's 'vegetation sweep' technique was used to collect streambed macroinvertebrates in both the unnamed tributary of the Waiau Stream, and in the Parahaki Stream. The 'vegetation sweep' technique is very similar to Protocol C2 (soft-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark *et al*, 2001).

Table 1 Biomonitoring site details of sites monitored in relation to the Kowhai C wellsite including the unnamed tributary of the Waiau Stream and the Parahaki Stream

Site No.	Site code	Grid reference (NZTM)	Location	Altitude (m asl)
1	WAI000070	1172016E-5678534N	10m d/s of pond	79
2	PRH000010	1711471E-5678890N	20m u/s Inland North Road	79



Figure 1 Biomonitoring sites in the unnamed tributary of the Waiau Stream and the Parahaki Stream in relation to the Kowhai-C 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 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.

Results and discussion

At the time of the early afternoon survey of the unnamed tributary of the Waiau Stream a brown, dirty and very low flow was recorded. The stream temperature was 22.1 °C. Macrophytes were recorded on both the stream bed and at the edges of the stream. Substrate was comprised of silt only. It was noted that a thick iron oxide coating was visible across the stream surface. Filaments of periphyton were widespread and there was partial shading at this site.

At the time of the midday survey of the Parahaki Stream, the water temperature was 18.4°C. A very low flow of dirty, brown water was recorded. Substrate was comprised of silt only. Macrophytes (mainly watercress) were recorded on both the stream bed and at the edges of the bank. The stream was not shaded and no periphyton was recorded.

Macroinvertebrate communities

Table 2 summarises the results of the current macroinvertebrate surveys following production activities at the Kowhai-C wellsite, along with results from the surveys carried out 6 September 2013 and 17 December 2013. Comparative data for sites in similar streams are presented in Table 2. The macroinvertebrate fauna recorded by the current surveys are presented in Table 4 (site 1) and Table 5 (site 2).

Table 2: Number of taxa, MCI and SQMCI_s in the unnamed tributary of the Waiau Stream (site 1) and Parahaki Stream (site 2) prior to and after production at the Kowhai-C wellsite.

Site No.	Site Code	No of taxa		MCI value		SQMCI _s value	
		Pre-production (06 Sept & 17 Dec 2013)	Post-drill/HF (20 Feb 2014)	Pre-production (06 Sept & 17 Dec 2013)	Post-drill/HF (20 Feb 2014)	Pre-production (06 Sept & 17 Dec 2013)	Post-drill/HF (20 Feb 2014)
1	WAI000070	25	10	83	70	2.7	1.7
2	PRH000010	22	15	76	72	4.1	3.2

Table 3: Range and median number of taxa, MCI values and SQMCI_s scores for control sites at altitudes between 50 and 79 m asl ((TRC, 1999 (updated 2013)).

	No. of taxa	MCI value	SQMCI _s value
No. Samples	61	61	33
Range	0-27	60-90	1.4-5.0
Median	17	73	4

Table 4: Macroinvertebrate fauna of the unnamed tributary of the Waiiau Stream in relation to the Kowhai-C wellsite sampled 20 February 2014.

Taxa List	Site Number	MCI score	1
	Site Code		WAI000070
	Sample Number		FWB14139
NEMERTEA	Nemertea	3	R
ANNELIDA (WORMS)	Oligochaeta	1	VA
MOLLUSCA	<i>Potamopyrgus</i>	4	VA
CRUSTACEA	Copepoda	5	R
	Ostracoda	1	XA
ODONATA (DRAGONFLIES)	<i>Xanthocnemis</i>	4	R
TRICHOPTERA (CADDISFLIES)	<i>Aoteapsyche</i>	4	R
	<i>Polypsectopus</i>	6	A
	<i>Oxyethira</i>	2	R
DIPTERA (TRUE FLIES)	Tanypodinae	5	A
No of taxa			10
MCI			70
SQMCI _s			1.7
EPT (taxa)			2
%EPT (taxa)			20
'Tolerant' taxa		'Moderately sensitive' taxa	'Highly sensitive' taxa

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

Table 5: Macroinvertebrate fauna of the Parahaki Stream in relation to the Kowhai-C wellsite sampled 20 February 2014.

Taxa List	Site Number	MCI score	2
	Site Code		PRH000010
	Sample Number		FWB14140
PLATYHELMINTHES (FLATWORMS)	<i>Cura</i>	3	A
NEMERTEA	Nemertea	3	C
ANNELIDA (WORMS)	Oligochaeta	1	VA
	Lumbricidae	5	A
MOLLUSCA	Lymnaeidae	3	C
	<i>Potamopyrgus</i>	4	XA
	Sphaeriidae	3	R
CRUSTACEA	Ostracoda	1	XA
	<i>Paracalliope</i>	5	XA
HEMIPTERA (BUGS)	<i>Microvelia</i>	3	R
TRICHOPTERA (CADDISFLIES)	<i>Polyplectropus</i>	6	R
DIPTERA (TRUE FLIES)	Tanypodinae	5	A
	Empididae	3	C
	Ephydriidae	4	R
ACARINA (MITES)	Acarina	5	R
		No of taxa	15
		MCI	72
		SQMCI _s	3.2
		EPT (taxa)	1
		%EPT (taxa)	7
'Tolerant' taxa		'Moderately sensitive' taxa	'Highly sensitive' taxa

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

Site 1- 10 metres downstream of pond

A moderately low community richness of 10 taxa was found at site 1 (Table 2 and Table 4), 15 taxa fewer than what was recorded in the pre-drill survey and seven taxa less than the median richness found at similar sites elsewhere in the region Table 3. The macroinvertebrate community contained a significant proportion of 'tolerant' taxa (70%), which was reflected in the MCI score of 70 units. This result represented a significant decrease from that recorded in the pre-drill survey (of 13 MCI units) but was not significantly different (Stark, 1998) to the median MCI score for 'control' sites in similar streams at comparative altitudes (Table 3). The decrease in MCI score can be attributed to a reduction in the number of 'sensitive' taxa recorded, which was nine fewer than what was recorded in the pre-drill survey. This drop in sensitive taxa can be attributed to a decrease in suitable habitat for such taxa, the result of very low and slow flows; a consequence of natural seasonal change. For example sensitive taxa, including mayflies (*Deleatidium* and *Zephlebia*) were present in the pre-drill survey but absent in the current survey; a reflection of the low and very slow flows recorded.

The community was characterised by three 'tolerant' taxa; (oligochaete worms, snails (*Potamopyrgus*), and seed shrimp (Ostracoda)) and two 'sensitive' taxa, (caddisfly (*Polyplectropus*) and chironomid midge larvae (Tanypodinae)).

The numerical dominance of 'tolerant' taxa resulted in a SQMCI_s score of 1.7 units, which was significantly lower (by 1.0 unit) than what was recorded in the pre-drill survey, and was significantly lower (by 2.3 units) than the median score for 'control' sites in similar streams

at this altitude (Stark, 1998) (Table 3). This can mainly be attributed to an increased abundance (from very abundant to extremely abundant) of the 'tolerant' seed shrimp (Ostracoda) which are generally found in slow flowing or stagnant waters.

Site 2- 20 metres upstream of Inland North Road

A moderate community richness of fifteen taxa was found at site 2 (Table 2 and Table 5), seven taxa less than what was recorded in the pre-HF survey and two taxa less than the median richness found at similar sites (Table 3). The macroinvertebrate community contained a large proportion of 'tolerant' taxa (67%), which was reflected in the MCI score of 72 units; four units less than what was recorded during the pre-HF survey and an insignificant (Stark, 1998) one unit less than the median MCI score for 'control' sites in similar streams at comparative altitudes (Table 3).

This community was characterised by four 'tolerant' taxa; (flatworms (*Cura*), snails (*Potamopyrgus*), seed shrimp (Ostracoda) and oligochaete worms), and three 'sensitive' taxa, (worms (Lumbricidae), amphipod (*Paracalliope*) and chironomid midge larvae (Tanypodinae).

The numerical dominance of several 'tolerant' taxa resulted in a SQMCI_s score of 3.2 units, which was significantly lower (by 0.9 unit) than what was recorded in the pre-HF survey, but not significantly different to the median score for 'control' sites in similar streams at this altitude (Table 3). The significant decrease in SQMCI_s score can be attributed to slow and low flows and consequent increases in abundances of 'tolerant' taxa, including; Oligochaete worms, seed shrimp (Ostracoda) and snail (*Potamopyrgus*) (the former two both 'extremely abundant'). Ostracod seed shrimps are usually found in abundance in very slow flowing streams and *Potamopyrgus* snails are often found in high densities after long periods since significant flood events. Water skater (*Microvelia*) was also present, a taxon usually found in highest abundance on the water surface of ponds, wetlands, or the margins of slow flowing streams.

Summary and Conclusions

The Councils 'vegetation sweep' technique was used to collect streambed macroinvertebrates from an unnamed tributary of the Waiau Stream and from the Parahaki Stream. This has provided data to compare with baseline data for the assessment of hydraulic fracturing and skimmer pit discharge effects from the Kowhai-C wellsite on the macroinvertebrate communities of these streams. 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.

This February 2014 survey of the unnamed tributary of the Waiau Stream and of the Parahaki Stream was undertaken following drilling and hydraulic fracturing at the Kowhai C wellsite. Taxa richness's were low to moderate. The macroinvertebrate communities of both streams contained more 'tolerant' than 'sensitive' taxa. A comparison of the surveys

carried out prior to and after drilling and/or hydraulic fracturing showed a significant decrease in MCI and SQMCI_s scores at site 1 and a significant decrease in SQMCI_s score at site 2. It is important to note that the 'vegetation sweep' sampling method targets habitat favoured by more 'tolerant' taxa, and that typically results in reduced MCI scores when using this sampling method. The significant decrease in MCI and SQMCI_s scores at site 1 and significant decrease in SQMCI_s score at site 2 can be attributed to the very low and slow flows recorded, and the consequent reduction in habitat available for 'sensitive' taxa at the time of this survey.

The MCI scores recorded in this survey indicated that the stream communities were of poor 'health' (TRC, 2014), similar to the biological health recorded at 'control' sites in similar streams at a comparative altitude elsewhere in the region. This, in part, can be attributed to the habitat which was limited by very low and slow flows. There was no indication from the results of the two surveys that the discharge from the Kowhai-C wellsite has impacted on the biological communities of the unnamed tributary of the Waiau Stream or Parahaki Stream.

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To Job Manager: Callum MacKenzie
From Freshwater Biologist: Brooke Thomas
Report No BT008
Document 1289187
Date 20 January 2014

Biomonitoring of an unnamed tributary of the Waiau Stream and of the Parahaki Stream prior to production at the Kowhai-C wellsite, 2013

Introduction

These two biological surveys were performed prior to production at the Kowhai-C well, to provide baseline data on the macroinvertebrate communities of an unnamed tributary of the Waiau Stream and of the Parahaki Stream.

The position of the Kowhai-C discharge is directly above the headwaters of the unnamed tributary of the Waiau Stream and consequently no suitable upstream control site was established. Only one site was found to be suitable for sampling below the discharge point due to limited accessibility. A second survey of the unnamed tributary of the Waiau Stream will be carried out following production activities at the well, to determine whether or not the discharge of treated stormwater, site water and production water onto land (in the vicinity of the stream) have had a detrimental effect upon macroinvertebrate communities of this stream.

The biological survey of the Parahaki Stream was carried out after drilling activities of the Kowhai-C wellsite but prior to hydraulic fracturing. The Parahaki Stream is valued by the local community for its watercress. A second biological survey of the Parahaki Stream will be performed to determine whether or not hydraulic fracturing activities of the Kowhai-C wellsite have had any detrimental effect upon macroinvertebrate communities of this stream.

Methods

Kowhai-C wellsite treated stormwater and site production water is to be discharged on to land within the vicinity of the unnamed tributary of the Waiau Stream (Figure 1). The survey of the unnamed tributary of the Waiau Stream was undertaken on 6 September 2013 at a newly established site (Table 1); 10 metres downstream of an access culvert and pond (site 1).

The biological survey of the Parahaki Stream was carried out on 17 December 2013 at a newly established site (Table 1); 20 metres upstream of Inland North Road (site 2).

The council's 'vegetation sweep' technique was used to collect streambed macroinvertebrates in both the unnamed tributary of the Waiau Stream, and in the Parahaki Stream. The 'vegetation sweep' technique is very similar to Protocol C2 (soft-bottomed, semi-quantitative) of the New Zealand Macroinvertebrate Working Group (NZMWG) protocols for macroinvertebrate samples in wadeable streams (Stark *et al*, 2001).

Table 1 Biomonitoring site details of sites monitored in relation to the Kowhai C wellsite including the unnamed tributary of the Waiau Stream and the Parahaki Stream

Site No.	Site code	Grid reference (NZTM)	Location	Altitude (m asl)
1	WAI000070	1172016E-5678534N	10m d/s of pond	79
2	PRH000010	1711471E-5678890N	20m u/s Inland North Road	79



Figure 1 Biomonitoring sites in the unnamed tributary of the Waiau Stream and the Parahaki Stream in relation to the Kowhai-C 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 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.

Results and discussion

At the time of the late afternoon survey of the unnamed tributary of the Waiau Stream an uncoloured, clear and moderate flow was recorded. Macrophytes were recorded on both the stream bed and at the edges of the stream. Substrate comprised fully of silt. It was noted that some macrophytes were covered in a fine layer of silt and that iron oxide was visible in shallow areas at the edge of the stream. No periphyton or shading was recorded at this site.

At the time of the late morning survey of the Parahaki Stream, the water temperature was 16.2°C. A low flow of dirty, brown water was recorded. Substrate was comprised of silt only. Macrophytes (mainly watercress) were recorded on both the stream bed and at the edges of the bank. The stream was partially shaded and no periphyton was recorded.

Macroinvertebrate communities

Table 2 summarises the results of the two macroinvertebrate surveys performed prior to production at the Kowhai-C wellsite. Comparative data for sites in similar streams are presented in Table 3. The macroinvertebrate fauna recorded by the current surveys are presented in Table 4 (site 1) and Table 5 (site 2).

Table 2: Number of taxa, MCI and SQMCI_s in the unnamed tributary of the Waiau Stream (site 1) and Parahaki Stream (site 2) prior to production of the Kowhai-C wellsite.

Site No.	No taxa	MCI value	SQMCI _s value
1	25	83	2.7
2	22	76	4.1

Table 3: Range and median number of taxa, MCI values and SQMCI_s scores for control sites at altitudes between 50 and 79 m asl ((TRC, 1999 (updated 2013)).

	No. of taxa	MCI value	SQMCI _s value
No. Samples	61	61	33
Range	0-27	60-90	1.4-5.0
Median	17	73	4

Table 4 : Macroinvertebrate fauna of the unnamed tributary of the Waiiau Stream in relation to the Kowhai-C pre-drill survey sampled 6 June 2013.

Taxa List	Site Number	MCI score	1
	Site Code		WAI000070
	Sample Number		FWB13240
NEMERTEA	Nemertea	3	R
ANNELIDA (WORMS)	Oligochaeta	1	VA
	Lumbricidae	5	R
MOLLUSCA	<i>Potamopyrgus</i>	4	A
CRUSTACEA	Copepoda	5	C
	Ostracoda	1	A
EPHEMEROPTERA (MAYFLIES)	<i>Deleatidium</i>	8	C
	<i>Zephlebia group</i>	7	C
PLECOPTERA (STONEFLIES)	<i>Acroperla</i>	5	R
ODONATA (DRAGONFLIES)	<i>Austrolestes</i>	4	A
COLEOPTERA (BEETLES)	Elmidae	6	R
	Dytiscidae	5	R
	Hydrophilidae	5	R
	TRICHOPTERA (CADDISFLIES)	<i>Aoteapsyche</i>	4
DIPTERA (TRUE FLIES)	<i>Polypsectropus</i>	6	C
	<i>Oxyethira</i>	2	R
	Hexatomini	5	R
	Orthoclaadiinae	2	C
ACARINA (MITES)	<i>Polypedilum</i>	3	C
	Tanypodinae	5	C
	Tanytarsini	3	VA
	<i>Paradixa</i>	4	C
	Empididae	3	R
	<i>Austrosimulium</i>	3	VA
	Acarina	5	R
		No of taxa	25
		MCI	83
		SQMCI	2.7
		EPT (taxa)	5
		%EPT (taxa)	20
'Tolerant' taxa		'Moderately sensitive' taxa	'Highly sensitive' taxa

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

Table 5: Macroinvertebrate fauna of the Parahaki Stream in relation to the Kowhai-C wellsite sampled 17 December 2013.

Taxa List	Site Number	MCI score	2	
	Site Code		PRH000010	
	Sample Number		FWB13394	
PLATYHELMINTHES (FLATWORMS)	<i>Cura</i>	3	C	
NEMATODA	Nematoda	3	R	
ANNELIDA (WORMS)	Oligochaeta	1	A	
MOLLUSCA	Lymnaeidae	3	C	
	<i>Potamopyrgus</i>	4	VA	
CRUSTACEA	Copepoda	5	R	
	Ostracoda	1	VA	
	<i>Paracalliope</i>	5	XA	
ODONATA (DRAGONFLIES)	<i>Procordulia</i>	5	R	
COLEOPTERA (BEETLES)	Dytiscidae	5	R	
TRICHOPTERA (CADDISFLIES)	<i>Polypectropus</i>	6	R	
	<i>Psilochorema</i>	6	R	
	<i>Oxyethira</i>	2	R	
DIPTERA (TRUE FLIES)	<i>Zelandotipula</i>	6	R	
	<i>Corynoneura</i>	3	C	
	Orthocladiinae	2	A	
	Tanypodinae	5	R	
	<i>Paradixa</i>	4	A	
	Empididae	3	C	
	Ephydriidae	4	C	
	<i>Austrosimulium</i>	3	C	
	ACARINA (MITES)	Acarina	5	C
			No of taxa	22
		MCI	76	
		SQMCI _s	4.1	
		EPT (taxa)	2	
		%EPT (taxa)	9	
'Tolerant' taxa		'Moderately sensitive' taxa	'Highly sensitive' taxa	

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

Site 1- 10 metres downstream of pond

A moderate community richness of twenty five taxa was found at site 1 (Table 2 and Table 4), eight taxa more than the median richness found at similar sites elsewhere in the region (Table 3). The macroinvertebrate community included similar proportions of 'tolerant' taxa (52%) and 'sensitive' taxa (48%), which was reflected in the MCI score of 83 units. This MCI score was statistically insignificant (Stark, 1998) 10 units higher than the median MCI score for 'control' sites in similar streams at comparative altitudes (Table 3).

The community was characterised by six 'tolerant' taxa; oligochaete worms, sandfly larvae (*Austrosimulium*), midge larvae (Tanytarsini), snails (*Potamopyrgus*), seed shrimp (Ostracoda) and damselfly larvae (*Austrolestes*) (Table 4).

The numerical dominance of 'tolerant' taxa resulted in a SQMCI_s score of 2.7 units, which was significantly lower (by 1.3 units) than the median score for 'control' sites in similar streams at this altitude (Table 3) (Stark, 1998).

Site 2- 20 metres upstream of Inland North Road

A moderate community richness of twenty two taxa was found at site 2 (Table 2 and Table 5), five taxa more than the median richness found at similar sites (Table 3). The macroinvertebrate community comprised a significant proportion of 'tolerant' taxa (59%), which was reflected in the MCI score of 76 units. This MCI score was similar to the median MCI score for 'control' sites in similar streams at comparative altitudes (Table 3).

This community was characterised by five 'tolerant' taxa; (snails (*Potamopyrgus*), seed shrimp (Ostracoda), oligochaete worms, orthoclad midges and midge larvae (*Paradixa*)); and one extremely abundant 'moderately sensitive' taxon, (amphipod (*Paracalliope*)).

The numerical dominance of this 'moderately sensitive' taxon resulted in a SQMCI₅ score of 4.1 units, which was 0.1 unit higher than the median score for 'control' sites in similar streams at this altitude (Table 3).

Summary and Conclusions

The Councils 'vegetation sweep' technique was used to collect streambed macroinvertebrates from an unnamed tributary of the Waiau Stream and from the Parahaki Stream. This has provided baseline data for any future assessment of hydraulic fracturing and skimmer pit discharge effects from the Kowhai-C wellsite on the macroinvertebrate communities of these streams. Samples were processed to provide number of taxa (richness), MCI, and SQMCI₅ 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 SQMCI₅ 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 SQMCI₅ between sites may indicate the degree of adverse effects (if any) of the discharge being monitored.

The September 2013 survey of the unnamed tributary of the Waiau Stream, downstream of the intended skimmer pit discharge point to land near the stream, was undertaken prior to drilling and hydraulic fracturing at the Kowhai-C wellsite. Taxa richness was moderate and included a similar number of 'tolerant' and 'sensitive' species. A numerical abundance of 'tolerant' taxa resulted in a SQMCI₅ significantly lower than the median score for 'control' sites in streams at a similar altitude. The MCI score indicated that the stream communities were of fair 'health' (TRC, 2013), and were better than the biological health recorded at 'control' sites in similar streams at a comparative altitude elsewhere in the region.

The December 2013 survey of the Parahaki Stream was undertaken after drilling but prior to hydraulic fracturing of the Kowhai-C wellsite. Taxa richness was moderate and similar to 'control' sites in similar streams at a comparative altitude elsewhere in the region. The MCI score indicated that the stream communities were of poor 'health' (TRC, 2013), however results were close to the biological health recorded at 'control' sites in similar streams at a comparative altitude elsewhere in the region. It is important to note that the 'vegetation sweep' sampling method targets habitat favoured by more 'tolerant' taxa, and that typically results in reduced MCI scores when using this sampling method.

A further survey will be conducted following the completion of all drilling activities at the Kowhai-C wellsite, to determine whether any discharges to land, and in the vicinity of the unnamed tributary of the Waiiau Stream, have had effects on the macroinvertebrate communities of this stream.

A further survey will also be conducted following hydraulic fracturing activities at the Kowhai-C wellsite, to determine whether or not this activity has had any effects of the macroinvertebrate communities of the Parahaki Stream.

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