Cheal Petroleum Limited
Deep Well Injection
Monitoring Programme
Annual Report
2012-2013

Technical Report 2013-34

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Executive summary

The following Annual Report by the Taranaki Regional Council (the Council) encompasses the monitoring period 1 July 2012 – 30 June 2013. The report provides details of the deep well injection (DWI) consents held by Cheal Petroleum Limited (the Company) during the period under review. The report also outlines the Company's DWI activities during this period, discusses the monitoring programme implemented by the Council and its results, and also provides an assessment of Company performance with regard to consent compliance.

During the period under review, the Company held two resource consents for the injection of fluids by DWI at their Cheal-A wellsite, Mountain Road, Ngaere. Consent 4728-2 permits the discharge of saline groundwater from the Mateamateaonga Formation into the Mount Messenger Formation. Consent 9545-1 permits the discharge of produced water from hydrocarbon exploration and production operations into the Urenui Formation. The consents include a number of special conditions which set out specific requirements with which the Company must comply.

The monitoring programme implemented by the Council in respect of the Company's DWI activities included inspections of injection operations, the review and assessment of injection data submitted by the Company, and groundwater monitoring in the vicinity of the Cheal-A wellsite.

During the period under review, the Council carried out two routine DWI inspection visits. Inspection visits included liaising with on-site staff, identification of the active injection well(s), viewing of the injection well monitoring equipment and injection logs, and the spot sampling of the injectate. In addition to the DWI inspection visits, the Cheal-A wellsite was visited by Council staff on 15 separate occasions in the 2012- 2013 monitoring period for inspections relating to other consents held by the Company for various activities at the site.

As required by the special conditions of the DWI consents held by the Company, process monitoring data and injection records were supplied to the Council during the 2012-2013 monitoring period. In total 11,577 cubic metres (m^3) of fluids were discharged under consent 4728-2, and 3,083 m^3 under consent 9545-1. An assessment of process data provided by the consent holder and data gathered during Council inspections does not indicate any potential issues with the integrity of the injection well or the injection zones.

Groundwater monitoring carried out by the Council in the vicinity of the Cheal-A wellsite does not indicate any contamination of shallow aquifers due to injection operations, further supporting the conclusion that the injection wells and injection zones remain secure.

The information gathered during inspection visits and the data supplied by the consent holder have been used in compiling this report.

During the 2012-2013 monitoring period, the Council was required to enter two unauthorised incidents against the Company for non-compliance with their DWI consents. One of the non compliances identified related to the non-submission of injection data and supporting information during the previous 2009 -2012 monitoring period. This non-compliance resulted in the Company's compliance rating being downgraded for 2009-2012

period. This non-compliance has therefore not been taken into account when assessing the Company's compliance rating for the period under review.

A second unauthorised incident was registered when the Council became aware that the Company was not complying with the purpose and conditions of DWI consent 4728-2. Consent 4728-2 was granted by the Council on 25 May 2012, following a consent renewal application by the Company. Consent 4728-1, the original DWI consent for the Cheal-A wellsite, permitted the discharge of drilling mud wastes, waste drill water and produced water into the Urenui and Mount Messenger Formations. Consent 4728-2 was granted with a revised purpose, and only permits the discharge of saline groundwater from the Mateamateaonga Formation into the Mount Messenger Formation. Following the granting of 4728-2, the Company continued to inject produced water into the Urenui Formation, as previously permitted under consent 4728-1. An Abatement Notice was issued by the Council on 4 April 2013, requireing the Company to cease the discharge of produced water to the Urenui Formation by 5 April 2013. The Company complied with the requirements of Abatement Notice. Following the issuing of the Abatement Notice, and the ceasing of injection operations at the Cheal-A wellsite, the Company submitted an application for consent to continue the discharge of produced water to the Urenui Formation. Following the consideration of this application, the Council granted consent 9545-1 on 17 April 2013.

These non-compliance issues, while identified during the period being reported, were also outlined and discussed in the Cheal DWI Monitoring Programme Report for the previous monitoring period (2009 – 2012). As the second non-compliance identified by the Council spanned the 2009-2012 and 2012 - 2013 monitoring periods, the Company's compliance rating in relation to consent 4728-2 will remain at **improvement desirable**.

The Company has demonstrated a **high** level of compliance in exercising consent 9545-1.

The Council did not receive any complaints or register any further unauthorised incidents associated with any of the Company's DWI activities during the 2012-2013 monitoring period. Overall, the Company has demonstrated significant improvement in the management of their DWI consents, and compliance requirements, over the course of the 2012-2013 monitoring period.

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

This report includes recommendations to be implemented during the 2013–2014 monitoring period.

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1. Introduction

1.1 Compliance monitoring programme reports and the Resource Management Act 1991

1.1.1 Introduction

The following Annual Report covers the monitoring period 1 July 2012 – 30 June 2013. During the period under review, the Cheal Petroleum Limited (the Company) held two resource consents for the injection of fluids by deep well injection (DWI) at their Cheal-A wellsite, Mountain Road, Ngaere. The consents held by the Company permitted the discharge of drilling mud wastes, waste drill water, produced water and saline groundwater into the Urenui and Mount Messenger Formations. Both consents held by the Company were exercised during the monitoring period. The consents include a number of special conditions which set out specific requirements with which the Company must comply.

The following report provides details of the DWI consents held by the Company during the period under review, outlines the Company's DWI activities during this period, and discusses the monitoring programme implemented by the Council and its results. The report also provides an assessment of Company performance with regard to consent compliance and makes recommendations regarding the future monitoring of the Company's DWI activities.

1.1.2 Structure of this report

The following report comprises five sections as follows:

- Section 1 of this report is a background section. It sets out general information about compliance monitoring under the relevant legislation and the Council's obligations and general approach to monitoring sites through dedicated monitoring programmes. Also covered in this section are the details of the individual resource consents held by the Company, the nature of the monitoring programme in place for the period under review, and a description of the activities and operations conducted on the Company's well sites;
- Section 2 presents the results of monitoring during the period under review, including technical data;
- Section 3 outlines any incidents, interventions and incidents that occurred during period under review;
- Section 4 discusses the results, their interpretation, and their significance for the environment; and
- Section 5 presents recommendations to be implemented in the 2013 - 2014 monitoring period.

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

1.1.3 The Resource Management Act (1991) and monitoring

The Resource Management Act (the Act) 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); and
(e) risks to the neighbourhood or environment.

In drafting and reviewing conditions on discharge permits, and in implementing monitoring programmes, the Council is recognising the comprehensive meaning of `effects' inasmuch as is appropriate for each discharge source. Monitoring programmes are not only based on existing permit conditions, but also on the obligations of the Act to assess the effects of the exercise of consents. In accordance with section 35 of the Act, 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, (covering both activity and impact), also enables the Council to continuously assess its own performance in resource management as well as that of resource users, particularly consent holders. It also enables the Council to continually re-evaluate its approach to resource management, and ultimately, through the refinement of methods, and considered responsible resource utilisation, to move closer to achieving sustainable development of the regions resources.

1.1.4 Evaluation of environmental performance

In addition to discussing the various details of the performance and extent of compliance by the Company during the period under review, this report also assigns an overall compliance 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 inconsequential non compliances with conditions were resolved positively, co-operatively, and quickly.

- **improvement desirable** indicates that the Council may have been obliged to record a verified unauthorised incident involving measurable environmental impacts, 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 end of the period under review, and/or abatement notices may have been issued.

- **poor performance** indicates that the Council may have been obliged to record a verified unauthorised incident involving significant environmental impacts, or, there were adverse environmental effects arising from activities and there were grounds for prosecution or an infringement notice.

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

1.2 Process description

1.2.1 Background

The Taranaki Basin occupies an area of approximately 100,000 square kilometres and is the most explored and commercially successful hydrocarbon producing area in New Zealand. Oil and gas exploration and development has been on-going in the region for nearly 150 years. Since the first well in 1865, over 600 exploration and production wells have been drilled. While the majority of the basin is offshore, the majority of the producing wells are onshore. The geology of the basin is derived from diverse episodes of tectonic activity. The Cretaceous to Quaternary basin fill is up to 9,000 m thick in places.

The modern era of exploration began in New Zealand in 1955 when a Shell-BP-Todd consortium explored a large part of the Taranaki region. The groups first well (Kapuni-1), discovered gas-condensate in Late Eocene Kapuni Group strata, and marked the beginning of New Zealand's natural gas industry. The Kapuni Field commenced commercial production in 1970. The next major discovery was the off-shore Maui field in 1969, which was in full production by 1979. Maui is New Zealand's largest hydrocarbon field to date. Many smaller fields were discovered between 1979 and 1999, including the McKee, Mangahewa, Ngatoro, Kaimiro, Rimu. More recent discoveries include the Pohokura gas field in 2001.

Overall, the Taranaki Basin remains relatively under-explored compared to many comparable rift complex basins of its size and potential.

1.2.2 Deep well injection (DWI)

DWI is often utilised as liquid waste disposal technology and provides an alternative to the surface disposal of such material. The DWI process utilises specially designed injection wells to pump liquid waste into deep geological formations, hydrocarbon reservoirs or confined saline aquifers. The receiving formations generally contain water that is too saline to be of any potential use. Impermeable geological seals overlying the injection intervals restrict any potential vertical migration of injected wastes into shallow freshwater aquifers.

A typical injection well consists of concentric pipes, cemented into the surrounding rock, which extend into permeable saline formations, at depths far below the base of potentially useable freshwater aquifers. Waste is then injected into the receiving

formation by pressure generated by surface pumps. International standards (adopted in the Taranaki Region) for the construction of disposal wells emphasise the importance of surface casing extending to depths below the base of the freshwater zones and being cemented back to surface. The standards also highlight the requirement for internal casing strings to be cemented back up the hole to seal off and isolate the disposal interval from the overlying fresh water zones, providing a multi-barrier approach to the protection of freshwater resources. As part of the resource consent application procedure for DWI activities, applicants are required to submit information that details both the design and construction specifications of the injection well(s) and illustrates well integrity and the isolation of the well bore from surrounding formations.

In Taranaki, contaminants disposed of by DWI are generally limited to produced water, saline groundwater, contaminated stormwater, waste drilling fluids, hydraulic fracturing (HF) fluids, and production sludges. The Council has approved, on specific occasions, the discharge of small volumes of other specified contaminants by DWI. Any application to discharge waste material not specifically licenced by the relevant resource consent is assessed by the Council on a case by case basis. The Council will assess the composition of the waste for consistency with those specifically approved for disposal. In some cases, a new consent may be required.

Produced water makes up the greatest volume of waste fluids generated by oil and gas exploration and production activities. Produced water is water that is present in a hydrocarbon bearing reservoir, brought to the surface as crude oil or natural gas is abstracted from it. When hydrocarbons are abstracted from a reservoir, they are brought to the surface as a produced fluid mixture. The composition of this produced fluid is dependent on whether crude oil or natural gas is being produced and generally includes a mixture of either liquid or gaseous hydrocarbons, formation water, dissolved or suspended solids, produced solids such as sand or silt, and injected fluids and additives that may have been placed in the formation as a result of exploration, hydraulic fracturing, and/or production activities. Produced waters may contain, in addition to salts, hydrocarbon residues and free oil, and traces of process additives including anti-scaling agents, anti-corrosion agents and biocides. Proportionally, higher quantities of water are produced from a hydrocarbon field as more oil or gas is abstracted, and the productive life of the field diminishes. The issue of produced water disposal is therefore expected to increase as many producing fields approach the end of their lives, and as more fields are discovered and developed.

Produced water and drilling fluid wastes are typically highly saline and contain hydrocarbon residues and system additives. Without treatment to an acceptable standard, the surface disposal of large volumes of produced water is not a suitable disposal option, particularly where the discharge can enter surface or groundwater systems. The salts and other contaminants contained within the discharge can adversely affect soil or freshwater biological systems and the quality of water resources used for supply purposes. Although there are methods to treat produced waters to a suitable standard for surface disposal, such as gas/steam stripping, biological and chemical adsorption, and activated carbon, they are generally not practical or economically viable. The injection of produced waters into deep geological formations by DWI is presently the most cost-effective option for the disposal of this type of waste, and more importantly, is an environmentally sound disposal option.

Produced waters have been disposed of by DWI in Taranaki since the development of the Kapuni Field in 1970. The collection, handling, treatment and disposal of produced water from a producing field are major undertakings and, if not appropriately managed, can have lasting adverse environmental effects. However, under appropriate geological and operational conditions, the disposal of produced waters by DWI should have no more than negligible environmental effects.

The injection of fluids into hydrocarbon bearing reservoirs is also an established oilfield technique for regulating reservoir pressure and/or as a means of enhancing the rate of oil recovery from a reservoir. This process is often referred to as water flooding. Water flooding is a secondary recovery process that is often implemented when natural reservoir pressures decline due to the removal of reservoir fluids during production. The injection of produced fluids back into the reservoir can increase reservoir pressure and stimulate production by driving reserves toward a production well. In certain cases, injected water is heated and injected through a well annulus to reduce oil viscosity, improving oil deliverability through the wellbore. Typically, either produced waters or fresh water, or a combination of the two, are used for water flooding.

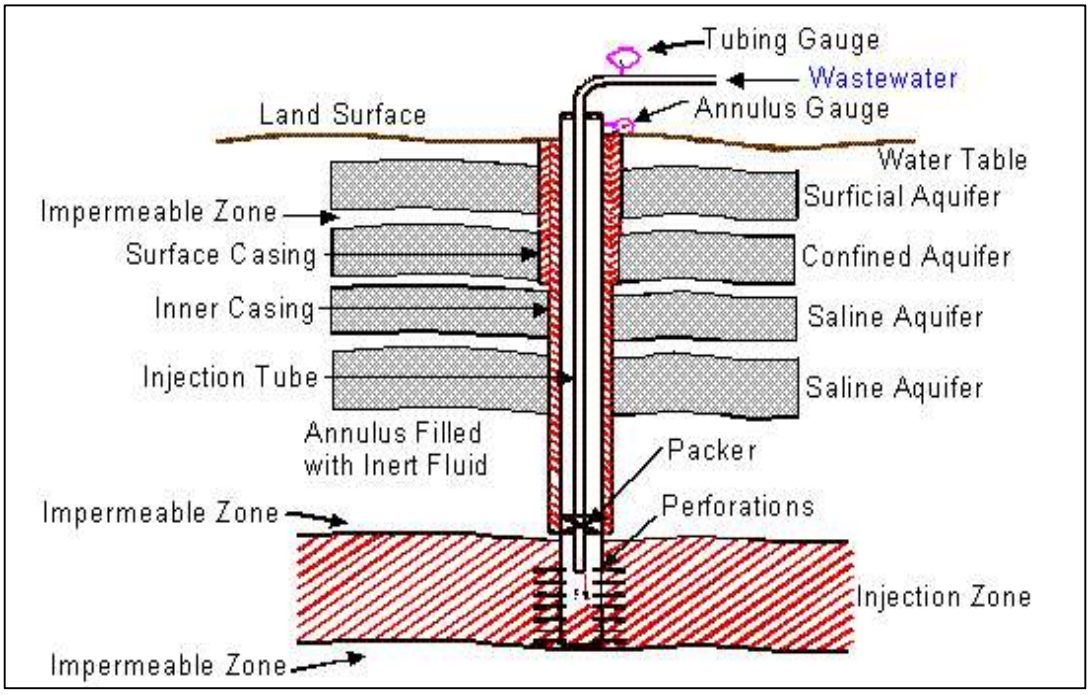

Figure 1 DWI schematic representative of Taranaki sites[1]

Regional councils are responsible for monitoring environmental effects from hydrocarbon exploration and development activities under the Act. Sections 15 and 30 of the Act give regional councils the responsibility for regulating the discharge of contaminants into the environment. The discharge of contaminants onto or into land that may result in water contamination may not take place unless expressly allowed by a rule in a regional plan, resource consent or other relevant regulations. The control of DWI activities through the resource consenting process and subsequent compliance monitoring is an appropriate regulatory regime. In the Taranaki region,

[1] http://web.deu.edu.tr/atiksu/ana58/deepwell.html

the discharge of contaminants by DWI requires resource consent from the Council. The activity falls under Rule 51 of the Regional Freshwater Plan for Taranaki and is classified as a discretionary activity. The application may be non-notified if no parties are deemed to be adversely affected by the proposed activity.

At the time of writing, there were a total of 18 current resource consents for DWI in Taranaki. However, several resource consents have been issued for relatively short-term activities during exploration phase drilling, and several others have not been, and may never be exercised.

1.3 Potential environmental effects of exercising a DWI consent

The main potential environment effect of discharging waste fluids by DWI is the contamination of freshwater aquifers during or following the discharge. Potential pathways for contamination of a freshwater aquifer can be created by the rupture of geological seal confining the injection zone, or failure of the grout seal in either the disposal well or any other well that penetrates the disposal interval. There is also potential for fluids to be forced upward from the injection zone through transmissive faults or fractures in the geological formations overlying the injection zone. Faults or fractures may have formed naturally prior to injection, or may be created by the waste dissolving the rocks of the confining zone. Artificial fractures may also be created by injecting wastewater at excessive pressures or by thermal processes.

There is also the potential for shallow groundwater to be contaminated by surface activities associated with DWI operations, particularly the handling, storage and transport of waste fluids. In all cases, the risk of contamination by spillage or unintended discharge of fluids being managed can be adequately mitigated by ensuring wastes are stored and transported in appropriately constructed and tested storage vessels and pipelines.

In each of the scenarios outlined above, the potential risk can be adequately mitigated by appropriate assessment, design, operation and monitoring of DWI activities. Appropriately engineered technology, regional and local geologic characterisation, and site specific modelling are typically combined at the planning stage of a disposal well to ensure that fluids discharged by DWI will be contained within the intended disposal interval. The assessment of resource consent applications and setting of appropriate conditions address these issues.

1.4 Resource consents

The protection of groundwater quality is of primary concern to the Council when processing resource consent applications for DWI activities. Section 15(1)(b) of the Act stipulates that no person may discharge any contaminant onto or into land in circumstances which may result in that contaminant (or any other contaminant originated as a result of natural processes from that contaminant) entering water, unless the activity is expressly allowed for by a resource consent, a rule in a regional plan, or national regulations.

Table 1 lists the consents held by the Company during the period under review, the wellsites to which the consents relate and the disposal wells in use at each site. All of the resource consents were issued by the Council under Section 87(e) of the Act.

Table 1 Summary of DWI consents held by the Company during the 2012-2013 period

Consent Number	Wellsite	Injection Well(s)	Formation	Status	Event Date
4728-2	Cheal-A	Cheal A2	Mount Messenger	Current	-
9545-1	Cheal-A	Cheal A4	Urenui	Current	

A summary of each consent held by the Company for DWI activities during the 2012-2013 monitoring period is included below.

Resource consent: 4728-2

"To discharge saline groundwater from the Mateamateaonga Formation into the Mount Messenger Formation by water flooding for enhanced oil recovery purposes"

Background

The Company lodged an application to renew consent 4728-1 on 26 November 2010. The application sought to change the purpose and conditions of the existing consent to reflect a change in the injection activities being carried out on-site. The application submitted by the Company proposed a reduction in scope with regard to the injection of power fluid into the Urenui Formation. Consent 4728-2 permits the applicant to inject fluids into the Mount Messenger Formation only, for enhanced oil recovery purposes. The point of discharge is approximately 400 m deeper than the previously carried out Urenui Formation water flood. The consent permits only the injection of saline groundwater abstracted from the lower section of the Mateamateaonga Formation. Saline groundwater is abstracted via the Cheal-A4 well, under water take consent 9211-1. The abstracted groundwater is injected into the Mount Messenger Formation via the previously suspended Cheal-A2 well, at a depth of approximately 1,800 m (below ground level). It is intended that the injection of fluids into the Cheal-A2 well will drive oil reserves within the Mt. Messenger Formation toward the Cheal-BH1 production well.

Consent 4728-2 was granted to Cheal Petroleum Limited on 25 May 2012. Consequential changes to the conditions of the revised consent included an increase in the maximum permitted daily injection volume from 200 m^3 to 800 m^3 and increased monitoring and reporting frequency requirements.

The current consent has twelve special conditions, as summarised below:

- Condition 1 requires the consent holder to submit a "Water Flooding Operation Management Plan" prior to exercising the consent;
- Condition 2 refers to injection well and subsurface information required for submission;
- Condition 3 limits the injection of fluids to the Mount Messenger Formation, below 1,600 m (below ground level);
- Condition 4 stipulates a maximum daily injection volume of 800 m^3;
- Condition 5 limits the injection pressure below which would be required to fracture the receiving formation;
- Condition 6 requires the best practicable option to be adopted for fluid injection;

- Conditions 7 and 8, refer to process monitoring and data submission requirements;
- Condition 9 stipulates the annual reporting requirements;
- Condition 10 is a notification requirement;
- Condition 11 prohibits the discharge from endangering or contaminating any freshwater resources; and
- Condition 12 is a review condition.

The consent conditions provide the Council with an option to review the conditions of the consent at specified intervals. Optional reviews are provided for on an annual basis. The consent is due to expire on 1 June 2017.

Consent 4728-2 was exercised during the period under review however the Company continued to inject produced water into the Urenui Formation as previously permitted under the original consent 4728-1. The Company was issued an Abatement Notice by the Council on 4 April 2013 requiring injection operations to cease until a revised consent application was processed. As outlined previously, this non-compliance issue was outlined and assessed against the Company in the previous period of reporting and resulted in the environmental performance rating of the Company being downgraded for the 2009-2012 period. The revised DWI consent was issued by the Council on 17 April 2013 (see below).

Resource consent: 9545-1

"To discharge produced water from hydrocarbon exploration and production operations into the Urenui Formation by deepwell injection at the Cheal-A wellsite"

Background
Consent 9545-1, which permits the discharge of waste fluids by DWI at the Cheal-A wellsite, Mountain Road, Ngaere, was granted on 17 April 2013.

Waste fluids are heated and injected through the Cheal-A4 well into the Urenui Formation below 1,300 m true vertical depth (TVD). The fluid is injected into the reservoir to improve oil flow and to physically push the oil toward an adjacent production well. The Company has utilised their Cheal-A4 well to inject fluids into the Urenui Formation since December 2009. The activity was permitted previously under consent 4728-1.

The consent was exercised on 22 April 2013.

The consent conditions provide the Council with an option to review the conditions of the consent at specified intervals. Optional reviews are provided for on an annual basis.

The current consent has twelve special conditions, as summarised below:

- Condition 1 requires the consent holder to submit a "Injection Operation Management Plan" prior to exercising the consent;
- Condition 2 refers to injection well and subsurface information required for submission;
- Condition 3 stipulates that there shall be no injection after 1 June 2016;

- Condition 4 requires the best practicable option to be adopted for fluid injection;
- Condition 5 limits the injection of fluids to the Urenui Formation, below 1,300 m TVD;
- Condition 6 stipulates a maximum daily injection volume of 200 m^3;
- Condition 7 limits the injection pressure to below 4,000 psi (276 bars);
- Condition 8 prohibits the discharge from resulting in any contaminants reaching any useable freshwater resources;
- Conditions 9, 10 and 11, refer to process monitoring and data submission requirements;
- Conditions 12, 13 and 14, refer to local groundwater quality monitoring requirements;
- Condition 15 stipulates the annual reporting requirements;
- Condition 16 is a notification requirement; and
- Condition 17 is a review condition.

The consent is due to expire on 01 June 2018.

The consent conditions provide the Council with an option to review the conditions of the consent at specified intervals. Optional reviews are provided for on an annual basis. The consent is due to expire on 1 June 2017.

Figure 2 shows the location of the DWI consents held by the Company during the period under review. Copies of the consent certificates are attached in Appendix I.

1.5 Monitoring programme

1.5.1 Introduction

Section 35 of the Act sets obligations upon the Council to gather information, monitor, and conduct research on the effects arising from consented activities within the Taranaki region and report upon these.

To perform its statutory obligations, the Council may be required to take and record measurements of physical and chemical parameters, take samples for analysis, carry out surveys and inspections, conduct investigations and seek information from consent holders. The monitoring programme implemented by the Council in relation to the Company's DWI activities consisted of four main components:

- Programme design, liaison and management;
- Site inspections and injectate sampling;
- Assessment of data submitted by the consent holder; and
- Groundwater quality monitoring.

Each component of the monitoring programme is discussed in further detail below.

1.5.2 Programme design, liaison and management

There is generally a significant investment of time and resources by the Council during annual reviews of existing monitoring programmes, and the scoping and design of future monitoring requirements. Significant time is spent managing compliance monitoring programmes throughout the monitoring year, and liaising with resource consent holders over consent conditions, their interpretation and

application. The Council also undertakes discussion during preparation for any consent reviews, renewals, or new consent applications, and provides advice on environmental management strategies, the content of regional plans and various other associated matters.

Figure 2 Aerial view of Cheal-A wellsite, Mountain Road, Ngaere

1.5.3 Site inspections and injectate sampling

The monitoring programme provides for physical inspections to be undertaken at all active DWI sites operated by the Company. The inspections include an examination of the injection wellhead, viewing the monitoring equipment and the spot sampling of the injectate for laboratory analysis. The sampling of injectate is carried out in order to characterise the general chemical nature of the discharge and also the variation in its chemical composition across the monitoring period. Samples of the injectate were obtained from storage tanks located at the Cheal-A wellsite. The tanks are identified by the Company as tank T-0504 and T-0505.

Table 2 Location of injectate sampling sites

Consent	Wellsite	Injection well	Site code	Sample point
4728-2	Cheal–A	Cheal-A4	GND2328	Tanks T-0504 & T-0505
9545-1	Cheal–A	Cheal-A4	GND2328	Tanks T-0504 & T-0505

Composite samples containing a 1:1 mix of fluid from each storage tank were submitted to the Council laboratory for analysis. Injectate samples were analysed for the following parameters:

- pH;
- Conductivity;
- Alkalinity;
- Chlorides; and
- Total petroleum hydrocarbons.

1.5.4 Assessment of data submitted by the consent holder

The resource consents held by the Company for DWI include conditions which require the Company to submit injection data and supporting information to the Council within specified timeframes. The injection data submitted by the consent holder forms the basis for assessing consent compliance. The major information requirements are as follows:

1. Information on the disposal well and injection zone

For each well used for DWI, the consent holder was required to provide an "Injection Operation Management Plan." The plans are required to include the operational details of the injection activities and to identify the conditions that would trigger concerns about the integrity of the injection well, the receiving formation or overlying geological seals. The plans are also required to detail the action(s) to be taken by the consent holder if trigger conditions are reached. The Company was also required to submit well construction details, an assessment of the local geological environment, results of well integrity testing and details of the proposed monitoring plan for the injection well. The information requested is required to demonstrate that the exercise of the consent will not contaminate or endanger any actual or potentially useable freshwater aquifer.

The Council holds a significant volume of information regarding Cheal wells and the underlying geology in the Cheal area. Data has been gathered where submitted as part of resource consent applications, during specific site investigations, and as part of various compliance monitoring programmes.

2. Discharge records

For each well used for DWI during the period under review, the consent holder was required to provide discharge records. The data required by the conditions of the consents exercised by the Company included the following:

- Injection hours;
- Injection volumes;
- Injection rate;
- Injection pressures; and
- Analytical results for injectate samples.

During the period under review the Company provided discharge records to the Council, detailing the injection, rates, pressure and volumes over the period 1 July 2012 to 30 June 2013. The consent holder also submitted results of injectate analysis during the period under review.

3. Annual reporting

The Company was required to submit annual written reports to the Council providing a summary of all injection data gathered over the previous 1 July to 30 June period. Annual reports also require the Company to detail how compliance has been achieved with the special conditions of consents exercised during the monitoring period. The Company's annual written report for the 2012-2013 period was received by the Council on 27 August 2013.

1.5.5 Groundwater quality monitoring

A programme of groundwater monitoring in the vicinity of the Cheal-A wellsite was initiated during 2012-2013 period. The programme provides for biannual sampling of groundwater from selected groundwater abstraction sites during each monitoring year. The programme follows on from the one-off groundwater monitoring investigation carried out by the Council in February 2012, to assess the potential environmental effects of exploration and production activities at the Company's Cheal wellsites on local water resources[2].

In order to select suitable sampling sites for inclusion in the monitoring programme, a survey of water abstraction sites within a 1 km radius of the Cheal-A wellsite was carried out. Initially, a desktop review of data held by the Council was conducted, including a search of the Council 'wells' database. The desktop review indicated that the Council held records for a number of groundwater abstractions in the area of investigation. Following the desktop review, a field survey was undertaken to confirm the location of known abstraction sites, to assess their suitability for sampling, and to identify any additional groundwater abstraction sites that may not have been registered with the Council.

Following the field survey, two private groundwater abstraction sites were selected for inclusion in the groundwater monitoring programme. The criteria used in assessing the suitability of each site for inclusion in the programme were the proximity of the site to the Cheal-A wellsite, the depth to which the bore has been drilled, the construction of the bore or well, and its susceptibility to contamination by surface runoff.

Details of the site selected for inclusion in the monitoring programme are listed below in Table 3.

Table 3 Location of groundwater sampling sites

Site Code	Classification	Distance from wellsite (m)	Casing depth (m)	Total depth (m)	High static water level (m)	Aquifer	Comment
GND0492	Bore	245	19.5	30.5	6.1	Volcanics	Downgradient of wellsite
GND1139	Bore	305	36	54	7.0	Volcanics	Downgradient of wellsite

[2] See bibliography

2. Results

2.1 Site inspections and injectate sampling

During the period under review, the Council carried out two routine DWI inspections at the Cheal-A wellsite. In addition, a total of 15 separate inspections were carried out by Council staff in relation to various activities at the Cheal-A wellsite during the 2012-2013 monitoring year.

Routine DWI inspections included undertaking a general visual assessment of the operational equipment, storage facilities and associated equipment. No operational issues were identified during the inspections and all equipment appeared in good condition. Company personal were able to assist by detailing the status of injection equipment, outlining the injection operations being carried out by the Company at that time, and also providing real-time monitoring data on request.

As part of the monitoring programme, spot samples of the injectate were obtained from active injection sites, typically during site inspection visits. The sampling of injectate was carried out on 11 September 2012 and 11 April 2013. The injectate samples were submitted to the IANZ accredited Council laboratory for physicochemical analysis. The results of the analysis are included below in Table 4. The concentrations of each analyte are within the expected range for produced water samples.

Table 4 Results of injectate sampling undertaken by the Council (2012-2013)

Parameter	Unit	Site GND1719	
		11/09/12	11/04/13
Time	NZST	12:50	10:30
TRC sample number	-	TRC122837	TRC135574
pH	pH Units	8	7
Conductivity @ 20°C	mS/m @ 20^{0}C	3,940	3,720
Alkalinity	g/m^3 $CaCO_3$	98	135
Chloride	g/m^3	16,400	16,300
Total petroleum hydrocarbons	g/m^3	31	100

2.2 Assessment of data provided by the consent holder

The Company provided full records of injection activities carried out during the 2012-2013 monitoring period, including injection hours, volumes, rate, and pressure data.

Table 5 outlines the Company's injection activities during the period under review. The injection data provided by the Company is summarised in Table 6.

Table 5 Summary of DWI activities during the period under review (2012-2013)

Consent	Wellsite	Injection wells	Total volume discharged (m^3) 01/07/12 – 30/06/13	Discharge period		TRC well ID
				From	To	
4728-2	Cheal-A	Cheal-A4	11,577	01/07/12	05/04/13	GND2328
9545-1	Cheal-A	Cheal-A4	3,083	22/04/13	30/06/13	GND2328
		Total	14,660	01/07/12	30/06/13	-

Table 6 Summary of the Company's 2012-2013 injection data

	4728-2		
	Volume injected (m^3)	**Injection pressure (psi)**	**Injection rate (m^3/hr)**
Total	11,577	-	-
Daily Maximum	123	1,827	5
Daily Average	49	1,195	2
	9545-1		
	Volume injected (m^3)	**Injection pressure (psi)**	**Injection rate (m^3/hr)**
Total	3,083	-	-
Daily Maximum	81	2,146	3
Daily Average	47	953	2

During the analysis of injection data provided by the Company in early 2013, it became apparent that there were instances where daily injection volume data was available, but no corresponding injection pressure data for a particular day. Similarly, there were instances where injection pressure data was available but no corresponding volume data. Clarification was sought from the Company with regard to gaps in the data submitted. A response was received from the Company, outlining how injection data is recorded and documented on-site and an explanation of how the recording procedure has contributed to gaps in the data provided. The injection data gathered at the Cheal-A site for submission the Council, is obtained by logging instantaneous injection volume and pressure readings each day at midnight. If the injection well is shut in at midnight when the readings are taken, the pressure will indicate a zero value, however if the Company has injected fluids during the day, the volume is recorded. Alternatively, if the well has been opened for injection just prior to midnight, there will be an injection pressure value recorded, but no volume data will have been entered, as no fluid has yet gone down the well. Also, depending on how soon a pressure measurement is logged after the opening or closing of the injection well, the pressure within the well may be still building or tapering off. A recommendation was made in the Company's 2009-2012 DWI monitoring report to alter the data recording procedure, to avoid any further data reporting gaps. The Company implemented the requested changes in the latter half of the 2012-2013 monitoring period. The changes made have improved the quality of the data now being received by the Council. It should be noted the Company constantly monitors injection pressures on-site in order to assess well performance, and to identify any potential issues with the injection well or subsurface environment.

The injection volume and pressure data provided by the Company for injection carried out under consent 4728-2 is presented graphically in Figures 3 and 4. The injection data for consent 9545-1 is presented in Figures 5 and 6.

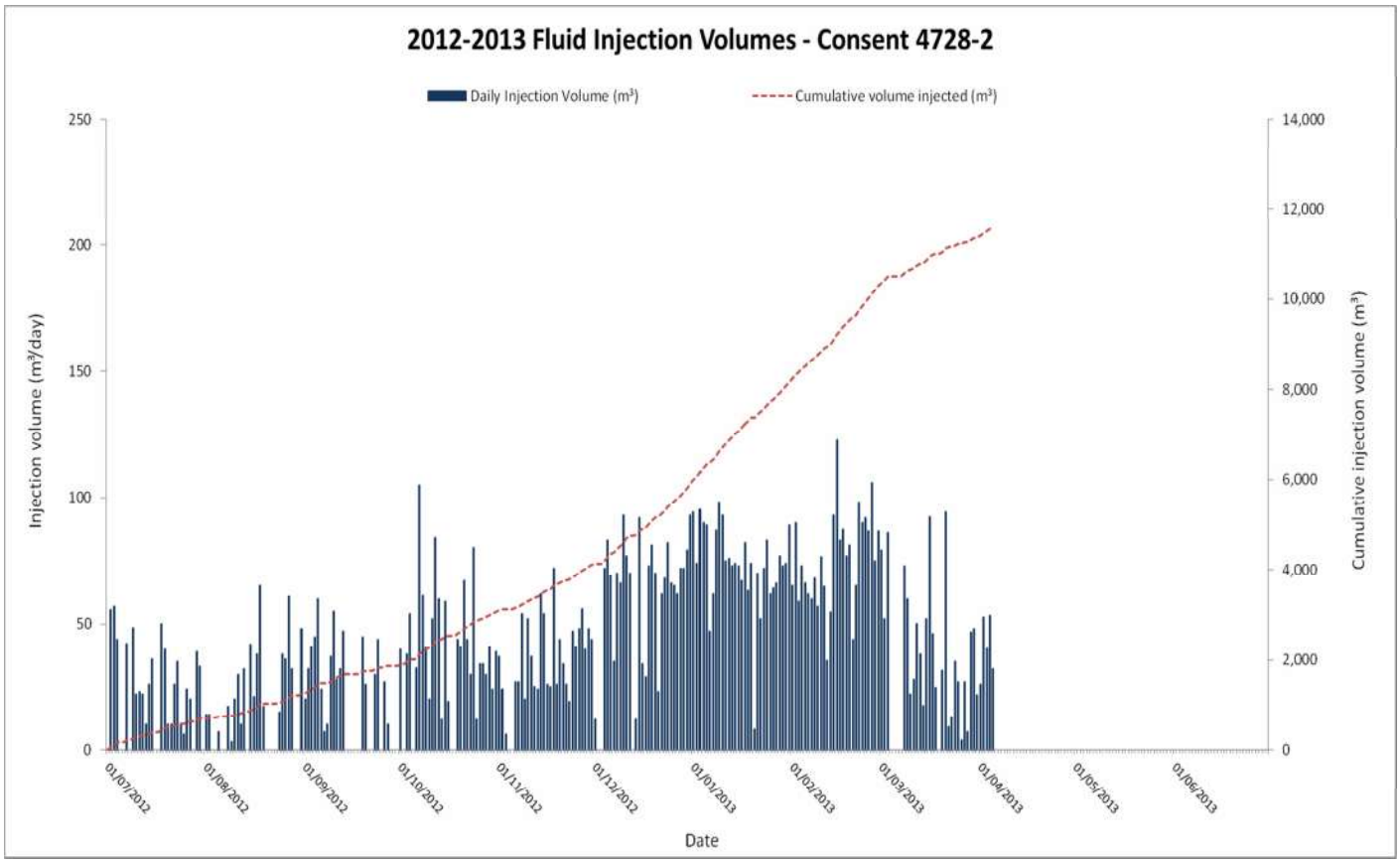

Figure 3 2012-2013 fluid injection volumes – consent 4728-2

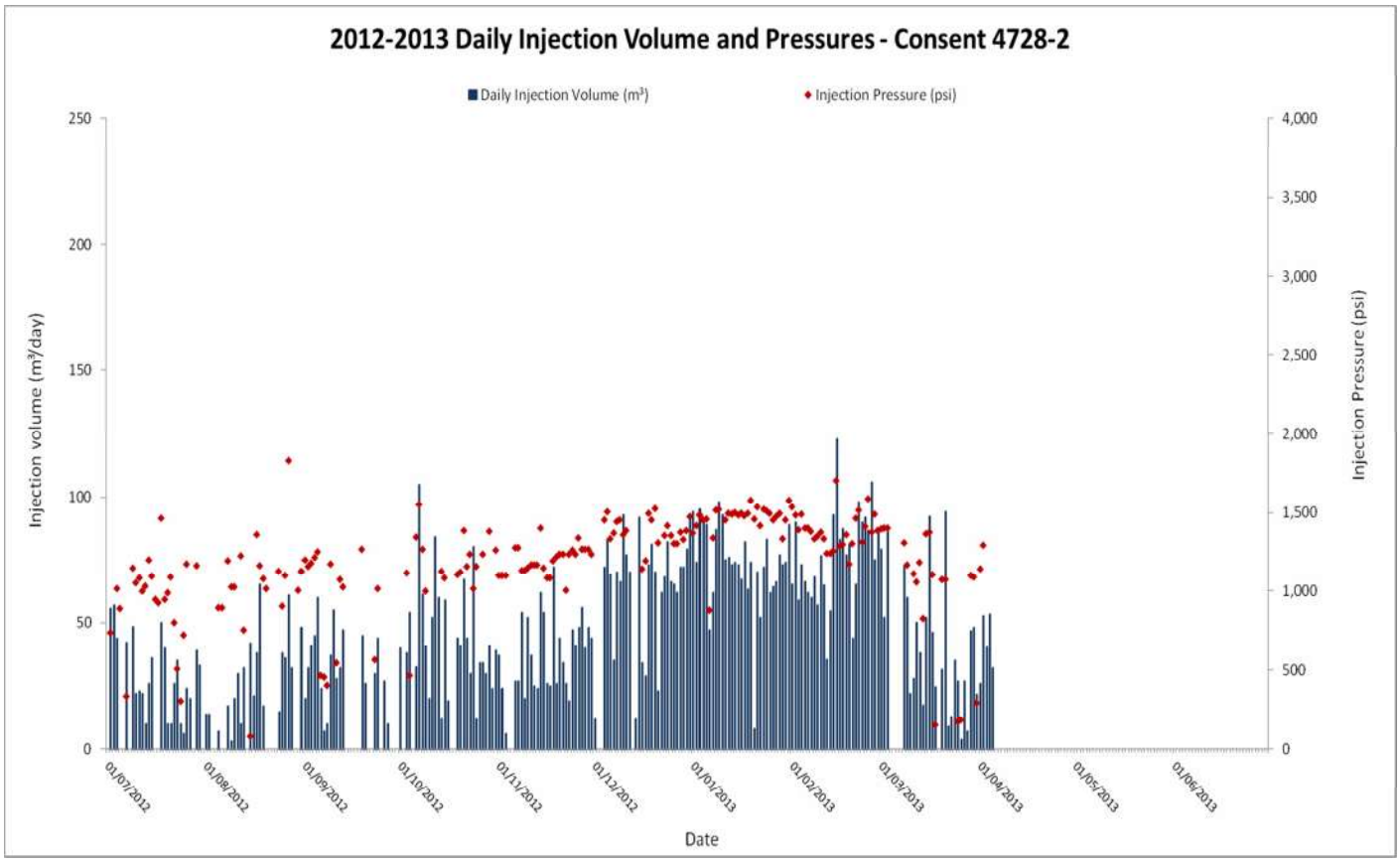

Figure 4 2012-2013 daily injection volumes and pressure – consent 4728-2

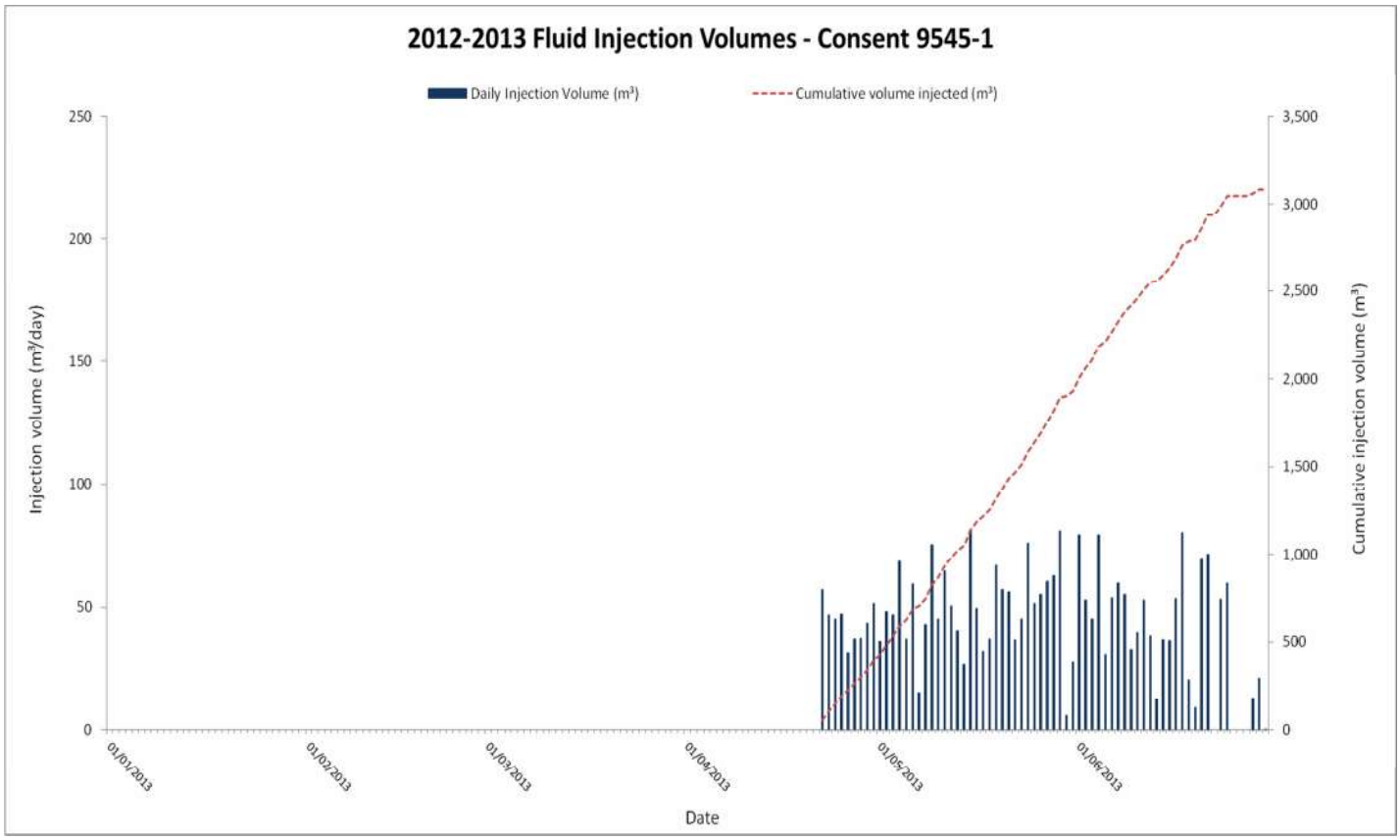

Figure 5 2012-2013 fluid injection volumes – consent 9545-1

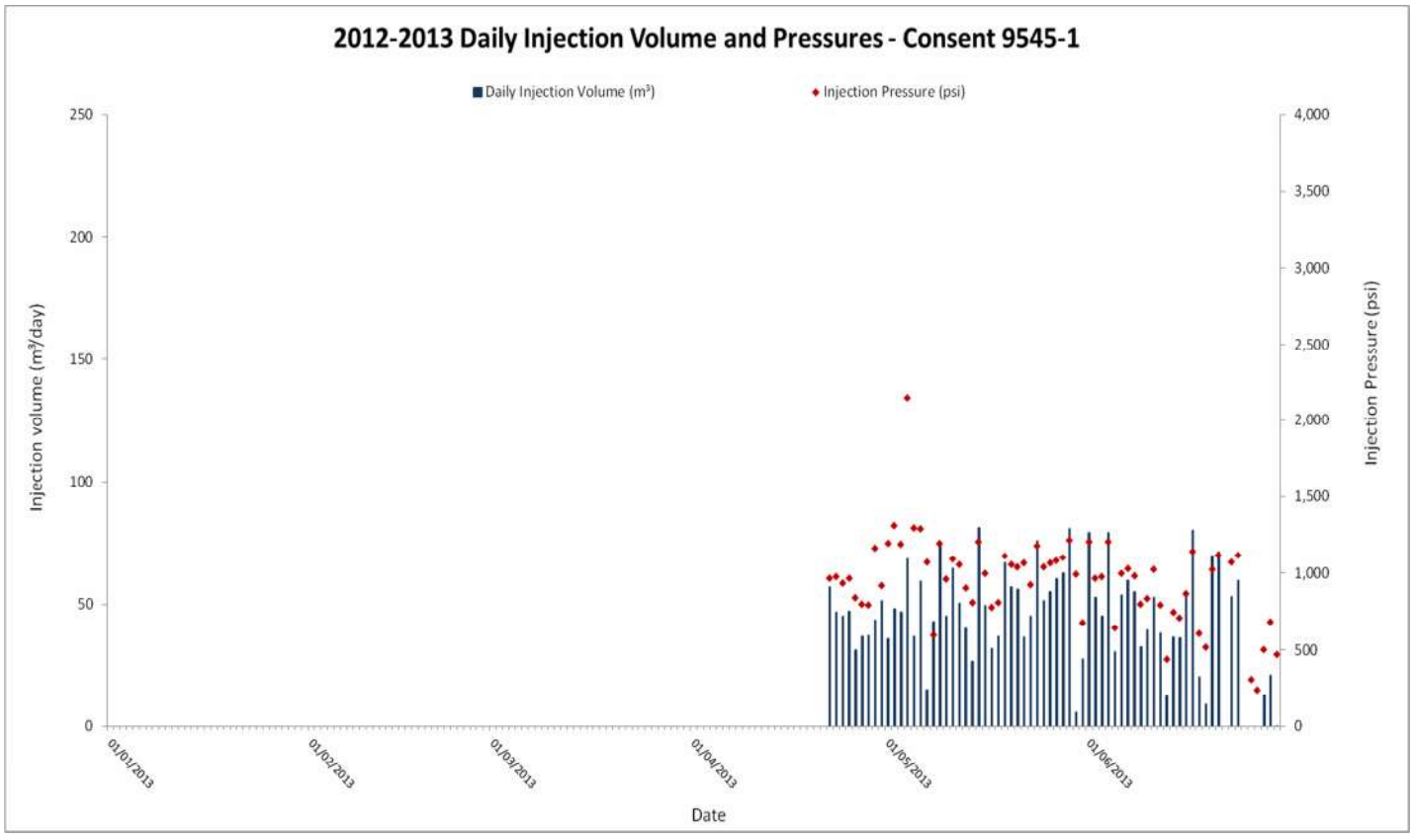

Figure 6 2012-2013 daily injection volumes and pressure – consent 9545-1

In addition to the Council's injectate sampling (Section 2.1), the Company also provided analytical results for samples of produced water injected via the Cheal-A4 well. As presented in Table 7, the maximum and mean values associated with the results of these analyses illustrate the variability in the composition of injectate across the monitoring period. The composition of the injectate varies depending on the origin and volume of fluids transferred from each individual source at the time of injection. The primary sources of produced water being injected at the Cheal-A wellsite are production wells at the Cheal-A, Cheal-B and Sidewinder wellsites.

Table 7 Range of contaminants in injectate sampled in 2012-2013

Parameter	Unit	Number of samples	Maximum value	Minimum value	Mean value
Temperature	^{0}C	7	64	64	64
pH	pH units	8	8.3	6.8	7.6
Conductivity	mg/l TDS	7	40,150	25,826	32,122
Salinity	mg/l	7	9,350	4,920	7,241
Chloride	mg/l	7	18,994	10,029	14,760
Suspended solids	mg/l	7	105	11	54
Total petroleum hydrocarbons	mg/l	7	25	4	13

2.3 Groundwater quality monitoring

As part of the groundwater monitoring programme implemented in the vicinity of the Cheal-A wellsite, groundwater samples were obtained from GND0492 on 24 May 2013 and GND1139 on 13 May 2013. The samples were collected following standard groundwater sampling methodologies and generally in accordance with the National Protocol for State of the Environment Groundwater Sampling in New Zealand (2006). The samples were analysed in the Council's IANZ accredited laboratory for a basic range of parameters, sufficient to characterise local groundwater quality, and to assess for potential contamination due to injection activities. The results of analyses carried out on samples obtained are set out below in Table 8. Also presented in Table 8 for comparison are the results of a previous sample taken from GND0492 on 13 February 2012. The results give no indication of any potential contamination by injected fluids. The results of previous sampling carried out in the vicinity of the Cheal wellsites was reported in the Cheal Petroleum DWI Monitoring Programme Report (2009-2012), and the TAG Oil Groundwater Monitoring Programme Compliance Report (Technical Report 2012-80).

Table 8 Results of groundwater sampling undertaken by the Council (2012-2013)

Sample Details	Units	GND0492		GND1139
TRC Sample Number	-	TRC120787	TRC135935	TRC135934
Sample Date	-	13/02/12	24/05/13	13/05/13
Sample Time	NZST	08:30	09:20	12:00
Analyte	**Units**			
Static Water Level	m	6.5	7.15	7.0
Temperature	ºC	17.5	12.4	12.9
pH	pH Units	8.1	6.6	6.8
Conductivity (EC)	mS/m@20ºC	21.5	13.7	18.3
Total Alkalinity	g/m^3 as $CaCO_3$	40	46	80
Chloride	g/m^3	21	10.5	14.2
Total Hydrocarbons	g/m^3	<0.7	<0.5	<0.5

3. Investigations, interventions, and incidents

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

The Council operates and maintains a register of all complaints and reported or discovered excursions from acceptable limits and practices, including non-compliance with consents, which may damage the environment. The Unauthorised Incident Register (UIR) includes events where the company concerned has itself notified the Council. The register contains details of any investigation and corrective action taken. Complaints may be alleged to be associated with a particular site. If there is potentially an issue of legal liability, the Council must be able to prove by investigation that the identified company is indeed the source of the incident (or that the allegation cannot be proven).

During the 2012-2013 monitoring period, the Council was required to enter two unauthorised incidents against the Company for DWI consent non-compliances. One of the non compliances identified related to the non-submission of injection data during the previous 2009-2012 monitoring period and contributed to the Company's compliance rating being downgraded for that period.

A second unauthorised incident was registered when the Council became aware that the Company was not complying with the purpose and conditions of DWI consent 4728-2. Consent 4728-2 was granted by the Council on 25 May 2012, following a consent renewal application by the Company. Consent 4728-1, the original DWI consent for the Cheal-A wellsite, permitted the discharge of drilling mud wastes, waste drill water and produced water into the Urenui and Mount Messenger Formations. Consent 4728-2 was granted with a revised purpose, and only permits the discharge of saline groundwater from the Mateamateaonga Formation into the Mount Messenger Formation. Following the granting of 4728-2, the Company continued to inject produced water into the Urenui Formation, as previously permitted under consent 4728-1. An Abatement Notice was issued by the Council on 4 April 2013, requiring the Company to cease the discharge of produced water to the Urenui Formation by 5 April 2013. The Company complied with the requirements of Abatement Notice.

Following the issuing of the Abatement Notice and the ceasing of injection operations at the Cheal-A wellsite, the Company submitted an application for consent to continue the diacharge of produced water to the Urenui Formation. Following the consideration of this application, the Council granted consent 9545-1 on 17 April 2013.

These non-compliance issues, while identified during the period being reported, were also outlined and discussed in the Cheal DWI Monitoring Programme Report (2009 – 2012), as the period over which the non-compliances occurred spanned the 2009-2012 and 2012 - 2013 monitoring periods. The Council did not receive any complaints or register any further unauthorised incidents associated with any of the Company's DWI activities during the 2012 - 2013 monitoring period.

4. Discussion

During the period under review, the Company exercised two DWI consents at its Cheal-A wellsite, 4728-2 and 9545-1. The Company utilised its DWI consents to dispose of produced water from its Cheal and Sidewinder wellsites. The injection of fluids was also used to maintain pressure within the underlying reservoir to improve oil production and deliverability.

Consent 4728-2 permits the discharge of saline groundwater from the Mateamateaonga Formation into the Mount Messenger Formation. During the 2012-2013 monitoring period, consent 4728-2 was exercised between 1 July 2012 and 5 April 2013. Injection was via the Cheal-A4 well into the Urenui Formation, at a depth of approximately 1,400 m (below ground level). The discharge of produced water to the Urenui Formation had previously been permitted under consent 4728-1. Consent 4728-1 expired on 25 May 2012, when 4728-2 was issued following the Company's consent renewal application. As the type of fluid being injected during the period under review, and the interval into which it was being discharged, were not expressly permitted by consent 4728-2, the Council was required to take enforcement action against the Company. An Abatement Notice was issued by the Council on 4 April 2013, requiring the Company to cease the discharge of produced water to the Urenui Formation until a consent which specifically permited the activity was processed by the Council. The Company complied with the requirements of Abatement Notice. A new consent, 9545-1, which permits the discharge of produced water from hydrocarbon exploration and production operations into the Urenui Formation, was granted by the Council on 17 April 2013. During the period that consent 4728-2 was exercised, 11,577 m^3 of produced water was discharged to the Urenui Formation at an average of 49 m^3/day. The average injection pressure was 1,195 psi, with a maximum pressure of 1,827 psi.

Consent 9545-1 was first exercised by the Company on 22 April 2013. Injection under this consent continued to the end of the 2012-2013 monitoring period (30 June 2013). During this period, 3,083 m^3 of produced water was discharged into the Urenui Formation, via the Cheal-A4 well, at an average of 47 m^3/day. The average injection pressure was 953 psi, with a maximum pressure of 2,146 psi.

During the 2012-2013 period, consent holder performance was assessed on compliance with consent conditions, with a particular emphasis on information provision, record keeping requirements and the analysis of the information and data provided. Compliance with the conditions of the consents exercised for DWI during the 2012-2013 period is summarised below in Section 4.1.

The consent holder is required to ensure that the discharge does not result in any contamination of actual or potential useable freshwater aquifer. Compliance with this condition is based on the assessment of consent holder submitted data, and the sampling and analysis of local groundwater abstractions. There is no evidence to suggest that the injection of fluids by DWI has resulted in the vertical migration of contaminants outside of the intended injection interval. The results of all analyses undertaken on groundwater samples obtained within the vicinity of the Cheal-A wellsite are within the expected ranges for shallow Taranaki groundwater. There was no evidence of any contaminates discharged from the wellsite by DWI in any of the samples obtained.

If deemed necessary, the Council may request further information from the consent holder that illustrates that the wells being used for the injection of waste and the receiving formation remain secure.

No complaints were received from the public with regard to any of the Company's DWI activities during the period under review, and no further incidents were recorded over and above those detailed in this report.

4.1 Discussion of site performance

During the period under review, the Company exercised DWI consents, 4728-2 and 9545-1. A summary of the Company's level of compliance with the special conditions attached to consent 4728-2 is provided in Table 9, and for consent 9545-1 in Table 10.

Table 9 Summary of Company performance with regard to consent 4728-2

Condition requirement	Means of monitoring during period under review	Compliance achieved?
Consent 4728-2: To discharge saline groundwater from the Mateamateaonga Formation into the Mount Messenger Formation by water flooding for enhanced oil recovery purposes.		
1. Before this consent is exercised, the consent holder shall submit a "Water Flooding Operation Management Plan."	Receipt of satisfactory "Water Flooding Operation Management Plan," prior to consent being exercised.	No*
2. Injection well, geological and operational data submission requirements. This information can be included in the "Water Flooding Operation Management Plan."	Receipt of satisfactory information prior to consent being exercised.	No*
3. The injection of fluids shall be confined to the Mt. Messenger Formation only, deeper than 1,600 metres below ground level.	Review of "Water Flooding Operation Management Plan," well construction log and injection data.	No
4. The volume of fluid injected shall not exceed 800 cubic metres per day.	Review and analysis of injection data.	Yes
5. The fluid injection pressure shall not exceed the fracture pressure of the receiving formation.	Review and analysis of injection data.	Yes
6. The consent holder shall at all times adopt the best practicable option.	Assessment of consent holder records and site inspection notices.	Yes
a) Maintain full discharge records and provide to the Council at the end of each month.	Receipt of satisfactory injection data at the end of each month.	Yes
7. Requirement for quarterly injectate analysis results to be submitted to Council.	Receipt of satisfactory injectate analysis data.	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
8. The consent holder shall provide to Council, during the month of May of every year, a summary of all data collected and a report detailing compliance with consent conditions. The report shall include water balance calculations, estimating the volume of injected fluids being returned to the surface and the volume remaining within the reservoir.	Receipt of satisfactory report in May each year of consent exercise.	Yes
9. 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 received by Council.	Yes
10. The consent holder shall ensure that the exercise of this consent does not result or be likely to result in contaminants reaching any water resources, including any usable fresh water aquifers.	Assessment of injection records and results of groundwater sampling and analysis programme.	Yes
11. Consent review provision.	N/A	N/A
Overall assessment of compliance and environmental performance in relation to groundwater monitoring conditions		**Improvement Desirable**

* An "Injection Well Operation Management Plan" was received for the preceding version of the consent (4728-1) which was for the same injection activity that occurred under consent 4728-2 during the period under review.

Table 10 Summary of Company performance with regard to consent 9545-1

Condition requirement	Means of monitoring during period under review	Compliance achieved?
Consent 9545-1: To discharge produced water from hydrocarbon exploration and production operations into the Urenui Formation by deep well injection at the Cheal-A wellsite.		
1. By 1 June 2013, the consent holder shall submit an "Injection Operation Management Plan."	Receipt of satisfactory "Injection Operation Management Plan," by 1 June 2013.	Yes
2. Injection well, geological and operational data submission requirements. This information can be included in the "Injection Operation Management Plan."	Receipt of satisfactory information by 1 June 2013.	Yes
3. No injection permitted after 1 June 2016.	Assessment of injection records and site inspection notices.	N/A
4. The consent holder shall at all times adopt the best practicable option.	Assessment of consent holder records and site inspection notices.	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
5. The injection of fluids shall be confined to the Urenui Formation only, deeper than 1,300 metres true vertical depth.	Review of "Water Flooding Operation Management Plan," well construction log and injection data.	Yes
6. The volume of fluid injected shall not exceed 200 cubic metres per day.	Review and analysis of injection data.	Yes
7. The injection pressure at the wellhead shall not exceed 4,000 psi (276 bars).	Review and analysis of injection data.	Yes
8. 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).	Assessment of injection records and results of groundwater sampling and analysis programme.	Yes
9. Maintain full records of injection data.	Receipt and assessment of injection data.	Yes
10. Maintain records an undertake analysis to characterise each type of waste arriving on-site for discharge.	Receipt and assessment of injection data.	Yes
11. The data required by conditions 9 & 10 above, for each calendar month, is required to be submitted by the 15th day of the following month.	Receipt of satisfactory data by the date specified.	Yes
12. 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.	Monitoring Programme submitted to the Chief Executive, Taranaki Regional Council, for certification before 1 June 2013,	Yes
13. All groundwater 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.	Implementation of Groundwater Monitoring Programme and assessment of results.	Yes
14. 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.	Receipt of Sampling and Analysis Plan prior to fist round of sampling being undertaken	Yes
15. The consent holder shall provide to the Council, before 31 August each year, a summary of all data collected and a report detailing compliance with consent conditions over the previous 1 July to 30 June period.	Receipt of satisfactory report by 31 August each year.	Yes

Condition requirement	Means of monitoring during period under review	Compliance achieved?
16. 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 received by Council.	Yes
17. Consent review provision.	N/A	N/A
Overall assessment of compliance and environmental performance in relation to groundwater monitoring conditions		**High**

Overall, in 2012-2013, the Company achieved an "**improvement desirable**" environmental compliance performance rating with respect to DWI 4728-1. The performance rating of the Company was downgraded due to the non-compliance matters outlined previously in this report and the subsequent enforcement actions carried out by the Council, which included the issuing of an Abatement Notice. The criteria associated with an "**improvement desirable**" level of environmental performance are outlined in Section 1.1.4 as follows:

> **"improvement desirable** indicates that the Council may have been obliged to record a verified unauthorised incident involving measureable environmental impacts, or, there were measureable 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 end of the period under review, and/or abatement notices may have been issued."

The Company achieved a "**high"** level of environmental compliance performance in relation to the exercising of DWI consent 9545-1. The Company complied with all special conditions attached to the consent, within the timeframes specified. The criteria associated with a "**high**" level of environmental performance are outlined in Section 1.1.4 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."

4.2 Environmental effects of exercise of consents

The most significant potential adverse environment effect arising as a result of fluid injection is the contamination of freshwater aquifers. The protection of groundwater is fundamental to the protection of surface water and consequently, groundwater should be protected to the greatest extent practicable from serious or irreversible damage arising from human activity.

Well engineering technology, regional and local geologic characterisation, and site specific mathematical modelling are typically combined at the planning stage of a injection well to ensure that injected fluids are contained within the intended

disposal interval. This information is typically supplied to the Council when an application for consent to discharge fluids by DWI is lodged, and used to assess the potential for adverse environmental effects resulting from the proposed activity.

The DWI consents exercised during the period under review permit the discharge of waste fluids into the Mount Messenger and Urenui Formations. Discharges to the Urenui Formation via the Cheal-A3 and Cheal-A4 wells occur at depths of approximately 1,400 m TVD (below ground level). The injection interval is overlain by thick layers of impermeable siltstones and mudstones, confining the injected waste material within the intended zone. In the case of the Cheal-A4 well, resistivity data indicates saline water occurring at depths as shallow as 300 m TVD (below ground level), thus providing up to 1,100 m of separation between the injection zone and the base of freshwater aquifers.

The results of the sampling and analysis of local groundwater and surface water systems in the vicinity of the wellsite location confirm that injection operations have not resulted in the migration of contaminates to shallow aquifers utilised for water supply in the area surrounding the site.

The natural geological characteristics of the strata overlying the injection intervals, the engineering of the injection wells, the planning and monitoring of injection activities, and their regulation, all contribute to minimise the potential for any adverse environmental effect resulting from DWI activities.

4.3 Recommendations from the previous report

In the 2009-2012 Triennial Report, it was recommended:

1. THAT the compliance monitoring and reporting period be reduced from a triennial to annual period.

   The recommendation was implemented in the 2012-2013 period. This report is the first annual report produced under the new reporting frequency adopted.

2. THAT all monitoring of the Company's DWI activities carried out during the 2009-2012 period be continued during the 2012-2013 monitoring period.

   The recommendation was implemented in the 2012-2013 period.

3. THAT biannual sampling of shallow groundwater in the vicinity of active injection wells is included in the monitoring programme for the forthcoming period.

   The groundwater monitoring recommendation was incorporated into the monitoring programme for the Company's DWI activities. Only one round of groundwater sampling was carried out during the period under review, but comparison with data collected during the previous monitoring period was possible and indicates no significant changes in groundwater quality in the vicinity of the Cheal-A wellsite.

4. THAT the Company maintain full records of all injection data, as required by the relevant resource consents, including injection hours, volumes, pressures and

rates and submits this data at the intervals specified by consent conditions or as requested by the Council. If not specified in the resource consent(s) exercised, average and maximum daily values for all parameters listed above shall be recorded.

The recommendation was implemented in the 2012-2013 period.

5. THAT the consent holder ensures they are familiar with, and meet, all of the recording and reporting requirements set out in the special conditions of their DWI consents.

   Significant improvement has been noted in relation to the Company's management of their DWI consents, and compliance requirements, over the course of the 2012-2013 monitoring period.

6. THAT the Council notes there is no requirement at this time for a consent review to be pursued or grounds to exercise the review options.

   There was no review of any DWI consent held by the Company during the 2012-2013 period.

4.4 Alterations to monitoring programme for 2013-2014

In designing and implementing the monitoring programmes for air/water discharges in the region, the Taranaki Regional Council has taken into account the extent of information made available by previous authorities, its relevance under the Resource Management Act, the obligations of the Act in terms of monitoring emissions/discharges and effects, and 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 industrial processes within Taranaki emitting to the atmosphere/discharging to the environment.

It is proposed that the range of monitoring carried out during the 2012-2013 period in relation to the Company's DWI activities be continued during the 2013-2014 monitoring period.

4.5 Exercise of optional review of consents

Consents 4728-2 and 9545-1 both have review conditions attached to them that allow the Council to review either consent on an annual basis. The Council may serve notice of its intention to review, amend, delete or add to the conditions of this resource consent. A review may be required for the purpose of ensuring that the conditions are adequate to deal with any adverse effects on the environment arising from the exercise of this resource consent, which were either not foreseen at the time the application was considered or which it was not appropriate to deal with at the time.

Based on the results of monitoring carried out in the period under review, and in previous years as set out in earlier annual compliance monitoring reports, it is considered that there are no grounds to require a consent review to be pursued or grounds to exercise the review options. A recommendation to this effect is presented in Section 5 of this report.

5. Recommendations

1. THAT the range of monitoring carried out during the 2012-2013 period in relation to the Company's DWI activities be continued during the 2013-2014 monitoring period.

2. THAT the Council notes there is no requirement at this time for a consent review to be pursued or grounds to exercise the review options.

Glossary of common terms and abbreviations

The following abbreviations and terms are used within this report:

Aquifer (freshwater)	A formation, or group or part of a formation that contains sufficient saturated permeable media to yield exploitable quantities of fresh water.
Bcf	Billion cubic feet.
Conductivity	A measure of the level of dissolved salts in a sample. Usually measured at 20°C and expressed as milli-siemens per metre (mS/m) or as Total Dissolved Solids (g/m^3).
Confining layer	A geological layer or rock unit that is impermeable to fluids.
Deep well injection (DWI)	Injection of fluids at depth for disposal or enhanced recovery.
Fracture gradient	A measure of how the pressure required to fracture rock in the earths crust changes with depth. It is usually measured in units of "pounds per square inch per foot" (psi/ft) and varies with the type of rock and the strain of the rock.
Freshwater-saline-water interface	The depth in a well at which fresh water becomes saline. The interface may be a gradational or sharp transition, depending on geology. The FW-SW transition is demonstrated by down-hole geophysical logging.
g/m^3	Grams per cubic metre. A measure of concentration which is equivalent to milligrams per litre (mg/l), or parts per million (ppm).
Hyraulic fracturing (HF)	The process of increasing reservoir permeability by injecting fluids at pressures sufficient to fracture rock within the reservoir ("fraccing").
Injectate	Fluid disposed of by deep well injection.
L/s	Litres per second.
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.
mbgl	Metres below ground level.
m^3	Cubic metre.
Packer	A downhole device used to isolate the annulus from the production conduit, enabling controlled production, injection or treatment.
pH	Numerical system for measuring acidity in solutions, with 7 as neutral. Values lower than 7 are acidic and higher than 7 are 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.

Power fluid	Pressurized fluids used to transmit and control energy into oil/gas wells. Cheal power fluid is a heated combination of fresh and produced water.
Produced water	Water associated with oil and gas reservoirs that is produced along with the oil and gas. Typically highly saline with salt concentrations similar to seawater and containing low levels of hydrocarbons.
Resource consent	Refer Section 87 of the RMA. Resource consents include land use consents (refer Sections 9 and 13 of the RMA), coastal permits (Sections 12, 14 and 15), water permits (Section 14) and discharge permits (Section 15).
The Act	Resource Management Act 1991 and subsequent amendments.
TRC	Taranaki Regional Council (the Council).
TVDSS	True vertical depth sub sea. Given as metres below sea level.
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.
Water flooding	A method of thermal recovery in which hot water is injected into a reservoir through specially distributed injection wells. Hot waterflooding reduces the viscosity of the crude oil, allowing it to move more easily toward production wells.

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Appendix I

DWI consents exercised in 2012-2013 period

Discharge Permit

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

Name of Consent Holder:	Cheal Petroleum Limited P O Box 402 NEW PLYMOUTH 4340
Decision Date:	25 May 2012
Commencement Date:	25 May 2012

Conditions of Consent

Consent Granted:	To discharge saline groundwater from the Mateamateaonga Formation into the Mount Messenger Formation by water flooding for enhanced oil recovery purposes at or about (NZTM) 1712361E-5639489N
Expiry Date:	1 June 2017
Review Date(s):	June 2013, June 2014, June 2015, June 2016
Site Location:	Cheal-A wellsite, 4273 Mountain Road, Ngaere (Property owners: JR & RP Lightoller)
Legal Description:	Pt Sec 24 Blk VI Ngaere SD (Discharge source & site)
Catchment:	Waingongoro
Tributary:	Mangawharawhara

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 "Water Flooding Operation Management Plan" which shall include the operational details of the flooding project and identify the conditions that would trigger concerns about the integrity of the injection well, the injection zone or confining geological layers. 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) Revised and up to date well completion logs for Cheal-A3 and Cheal-A4 wells including details of the plugging and cementing workovers carried out, and subsurface construction details;
   b) An up to date well completion log for Cheal-A2 well (proposed injection well) including subsurface construction details, design of the exterior surface casing, the intermediate protective casing, and the innermost casing, tubing, and packer;
   c) Well cementing details;
   d) Annular pressure testing which demonstrates well integrity;
   e) Well integrity monitoring and well maintenance procedures;
   f) Results of Formation Integrity Testing (FIT) for the receiving formation;
   g) A full chemical analysis of the injection fluid and receiving formation-water.

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

3. The injection of fluids shall be confined to the Mt. Messenger Formation only, deeper than 1,600 metres below ground level.

4. The volume of fluid injected shall not exceed 800 cubic metres per day .

5. The fluid injection pressure shall not exceed the fracture pressure of the receiving formation.

6. 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.

7. The consent holder shall keep daily records of:

   a) maximum injection pressure;
   b) maximum and average rate of injection;
   c) volume of fluid injected;
   d) volumes of produced water returned through the production wells.

   During the operation of the well, these records shall be provided to the Taranaki Regional Council at the end of each month.

8. The consent holder shall measure and record the following constituents of the discharge on a quarterly basis:

   a) pH;
   b) suspended solids concentration;
   c) temperature;
   d) salinity;
   e) chloride concentration.

9. The consent holder shall provide to Taranaki Regional Council, during the month of May of every year, a summary of all data collected and a report detailing compliance with consent conditions. The report shall include water balance calculations, estimating the volume of injected fluids being returned to the surface and the volume remaining within the reservoir.

10. 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.

11. The consent holder shall ensure that the exercise of this consent does not result or be likely to result in contaminants reaching any water resources, including any usable fresh water aquifers.

12. 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 25 May 2012

For and on behalf of
Taranaki Regional Council

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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:	Cheal Petroleum Limited P O Box 402 NEW PLYMOUTH 4340
Decision Date:	17 April 2013
Commencement Date:	17 April 2013

Conditions of Consent

Consent Granted:	To discharge produced water from hydrocarbon exploration and production operations into the Urenui Formation by deepwell injection at the Cheal-A wellsite
Expiry Date:	1 June 2018
Review Date(s):	June 2014, June 2015, June 2016, June 2017
Site Location:	Cheal-A wellsite, 4273 Mountain Road, Ngaere (Property owner: J & R Lightoller)
Legal Description:	Pt Sec 24 Blk VI Ngaere SD (Discharge source & site)
Grid Reference (NZTM)	1712361E-5639489N
Catchment:	Waingongoro
Tributary:	Mangawharawhara

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. By 1 June 2013, the consent holder shall submit an "Injection Operation Management Plan." The plan shall include the operational details of the injection activities and identify the conditions that would trigger concerns about the integrity of the injection well, the receiving formation or overlying geological seals. The plan shall also detail the action(s) to be taken by the consent holder if trigger conditions are reached.

2. By 1 June 2013, the consent holder shall provide to the Chief Executive, Taranaki Regional Council:

   (a) a geological assessment of the environment in which the well is located, including the injection zone, the geological seals confining the injection zone and any associated faulting;
   (b) details of the injection well design, construction its structural integrity, including an up to date well construction diagram;
   (c) an assessment of the suitability of the injection well for the proposed activity; and
   (d) details of how the integrity of the injection well will be monitored and maintained;

   (Note: The information required by condition 2 may be included within the "Injection Operation Management Plan" required by condition 1).

3. There shall be no injection of any fluids after 1 June 2016.

4. 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.

5. The injection of fluids shall be confined to the Urenui Formation, deeper than 1,300 metres true vertical depth.

6. The volume discharged shall not exceed 200 cubic metres per day.

7. The injection pressure at the wellhead shall not exceed 4,000 psi (276 bars). If exceeded, the injection operation shall be ceased immediately and the Chief Executive of the Taranaki Regional Council informed immediately.

8. 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 TDS concentration of less than 1,000 mg/l.

9. Once the consent is exercised, the consent holder shall keep daily records of the:

   (a) injection hours;
   (b) volume of fluid discharged; and
   (c) maximum and average injection pressure.

10. For each waste stream arriving on site for discharge, the consent holder shall characterise the fluids by recording the following information:

    (a) type of fluid;
    (b) source of fluid (site name and company);
    (c) an analysis of a representative sample of the fluid for:
        (i) pH;
        (ii) conductivity
        (iii) suspended solids concentration;
        (iv) temperature;
        (v) salinity;
        (vi) chloride concentration; and
        (vii) total hydrocarbon concentration.

    The analysis required by condition 10 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 undertake a programme of sampling and testing (the 'Monitoring Programme') that monitors the effects of the exercise of this consent on fresh water resources within an Area of Review (AoR), to assess compliance with condition 8. The Monitoring Programme shall be designed to characterise local groundwater quality, and be submitted to the Chief Executive, Taranaki Regional Council, for certification before 1 June 2013, and shall include:

    (a) the location of sampling sites;
    (b) well/bore construction details; and
    (c) sampling frequency.

    The AoR shall extend 1,000 metres radially from the point of injection. It is a requirement that at least one suitable monitoring bore be located within 500 metres of the well head. If no suitable existing bores are available, it will be necessary for the Monitoring Programme to include installation of, and sampling from, a suitable 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.

13. All groundwater 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 12 and 13, could be taken and analysed by the Council or other contracted party on behalf of the consent holder.

14. 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. This plan shall specify the use of standard protocols recognised to constitute good professional practice including quality control and assurance. An IANZ accredited laboratory shall be used for all sample analysis. Results shall be provided to the Chief Executive, Taranaki Regional Council within 30 days of sampling and shall include supporting quality control and assurance information. These results will be used to assess compliance with condition 8.

    Note: The Sampling and Analysis Plan may be combined with the Monitoring Programme required by condition 12.

15. The consent holder shall provide to the Chief Executive, Taranaki Regional Council, before 31 August each year, a summary of all data collected and a report detailing compliance with consent conditions over the previous 1 July to 30 June period. Based on the data provided, the report shall also provide:

    a) an assessment of injection well performance;
    b) an assessment of the on-going integrity and isolation of the wellbore;
    c) an assessment of the on-going integrity and isolation of the receiving formation; and
    d) an updated injection modeling report, demonstrating the ability of the receiving formation to continue to accept additional waste fluids.

16. 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.

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 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 17 April 2013

For and on behalf of
Taranaki Regional Council

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Chief Executive