GEOTHERMAL: THE NEXT GENERATION

DEEP GEOTHERMAL EXPLORATORY DRILLING AND TESTING IN THE TAUPŌ VOLCANIC ZONE

WELL DRILLING CONSENTING SCENARIOS REPORT

MAY 2023

traverse
ENVIRONMENTAL

Table of Contents

List of Figures

List of Tables

Report Information

Report Status	Final
Authors	Deborah Kissick, Traverse Environmental Brian Carey, GNS Samantha Alcaraz, GNS
Review By	Simon Bendall, Traverse Environmental Ralph Winmill, Contact Energy Penny Doorman and Mary Pappon, Bay of Plenty Regional Council Mark Brocklesby, Waikato Regional Council
ISBN	978-0-473-66734-4

Executive Summary

This report has been developed to identify the resource consents likely required by the planning framework established under Resource Management Act 1991 for the drilling and testing of a ~6km deep geothermal well in the Taupō Volcanic Zone. Such a well could encounter supercritical conditions with temperatures greater than 400 °C and pressures greater than 30 MPa.

To understand the nature of these consenting requirements, we have identified four "test" locations within the Taupō Volcanic Zone and have identified the applicable regulatory planning framework at each location. We have also identified two sites where there may be the potential to utilise or modify existing resource consents associated with a geothermal production operation for the purpose of drilling and testing a deep geothermal well.

The unique characteristics of each site have been considered to inform an analysis of the likely resource consent requirements for exploration activity. High-level consideration has also been given to the likely resource consent requirements for future production activity at each site.

The resource consent analysis in this report is focussed at Regional Plan level and in relation to the take, use and discharges of natural resources such as freshwater and geothermal fluids.

Freshwater use varies over the course of the well drilling and testing operations. Quantities of up to 6,000 tonnes/day, are required to support the drilling operation with a similar volume required for well testing with much of this water lost underground. A sustainable source of water will need to be identified and resource consent secured to enable this level of water take and use for durations of at least four months.

Discharges from the well drilling will largely be a mix of freshwater, drilling muds and chemicals with suspended rock materials. These will be discharged to site drill ponds, to land and underground at a rate of up to 100m^3/day increasing to 300m^3/day during well cementing operations. Four or five cementing operations are anticipated as being required to drill a 6km well. Flow testing of the well is likely to result in the surface discharge of ~7,000 tonnes/day of geothermal fluid, which will enter holding ponds before being discharged underground through injection or soakage. Discharges to air will also occur during flow testing, including the discharge of the greenhouse gases, carbon dioxide and methane. All discharges will require resource consent approval.

Overall, we have identified that while the planning frameworks covering the Taupō Volcanic Zone (i.e., the Waikato and Bay of Plenty regions) for establishing an exploratory well are similar, the likely challenges to the success of any resource consent application lies in the specific characteristics of the site location. Utilising and modifying an existing suite of consents is likely to be the most straight forward option for establishing a 6km deep well, provided additional sustainable resources such as freshwater are available, and the works can be considered within the scope of the original consent application.

1 Introduction

This report has been developed to describe the activities required for the drilling and testing of a ~6km deep geothermal well in the Taupō Volcanic Zone (presented in Part A) and the likely resource consent requirements for such activities (presented in Part B).

A well drilled to these depths could encounter supercritical conditions with temperatures greater than 400 °C and pressures greater than 30 MPa.

Part A of this report provides a summary of the anticipated well drilling requirements to establish and test a 6km deep well. In this section, we have focussed on the drilling and testing of the deep geothermal well for the purpose of understanding its capacity and chemical characterisation of the fluids. We have provided a high-level consideration of the consenting requirements of a long-term production operation that could follow from a successful exploration campaign, but only as far as noting where existing planning frameworks may expressly prevent such an activity.

Part A includes a brief description of the following components associated with drilling a deep exploratory well:

- Drill site and supporting infrastructure construction, and establishment of the facilities and equipment required for the drilling operation,
- Well Drilling, and
- Well Testing.

There are a number of pre-drilling surface activities required to enable a geothermal well to be established including:

- Site establishment and preparation including earthworks,
- Establishment of site access / roading / water supply,
- Well pad construction,
- Provision for worker accommodation and associated discharges of effluent,
- Need for sediment, dust and erosion and sediment control,
- Need to manage noise and
- Need to manage traffic effects.

These activities are typically managed at a local level through the relevant District Plan or Regional Plans for discharges or large-scale earthworks. As these activities are likely to be similar in nature to the requirements of current geothermal drilling operations undertaken in the Taupō, Rotorua Lakes and Kawerau Districts and are not expected to present a consenting barrier at any of the locations considered

in this report, they have not been addressed in detail in the well drilling activities or the consenting analysis. For the drilling site scenarios, relevant specific planning provisions which could add challenges to establishing a drill site and drilling in that location are identified, such as areas identified for their heritage or landscape values.

Part B of the report seeks to identify the requirements of the rule framework in the relevant Regional Plans as well as a high-level consideration of District Plan and reserve management requirements (where applicable).

In Part B, we have used the information provided in Part A to test and determine:

- Anticipated resource consent requirements at each site,
- Anticipated technical information requirements to inform the resource consent application(s),
- Recommendations regarding engagement with Council planning staff for such a project,
- Anticipated consultation requirements, and
- Indicative activity timelines.

We have focussed our attention on the resource consent requirements associated with drilling and testing a deep geothermal well. This includes activities such as water takes and use of both freshwater and geothermal water/fluid, and discharges including discharge of drilling fluids, geothermal water, steam, wastewater and stormwater.

2 Deep Geothermal Resources

Renewable geothermal resources are fundamental to New Zealand achieving both our net zero-carbon 2050 aspirations and the 100% renewable electricity target set by the New Zealand government for 2035.

To significantly grow the contribution from geothermal resources, the challenge is to better understand what resources may be available beneath the depths of the geothermal systems (conventional) that are currently used and to tap into deeper and hotter geothermal heat sources. Are there deep geothermal resources that New Zealand may be able to utilise as an energy source for our future?

The Geothermal the Next Generation research programme is looking at supercritical geothermal fluids (>4 km, >400°C) in the Taupō Volcanic Zone, New Zealand, which includes the Bay of Plenty and Waikato Regions (Figure 1 and Figure 2 below). This is geothermal water at a combination of high enough temperature and pressure to exist in a different state, the supercritical state. A number of researchers in other nations have postulated that geothermal fluid in this state offers more energy potential than is available from conventional sub-critical (steam and water) geothermal resources.

The Geothermal the Next Generation work is seeking to determine the contribution these hotter geothermal resources might be able to contribute to the transformation of New Zealand's energy sector to low carbon, net-zero.

This report, prepared as part of the Geothermal: the Next Generation research programme, seeks to provide an overview of the likely physical processes and activities involved in drilling a 6km exploratory well into supercritical geothermal conditions in order to determine the parts of the existing planning frameworks that will need to be considered.

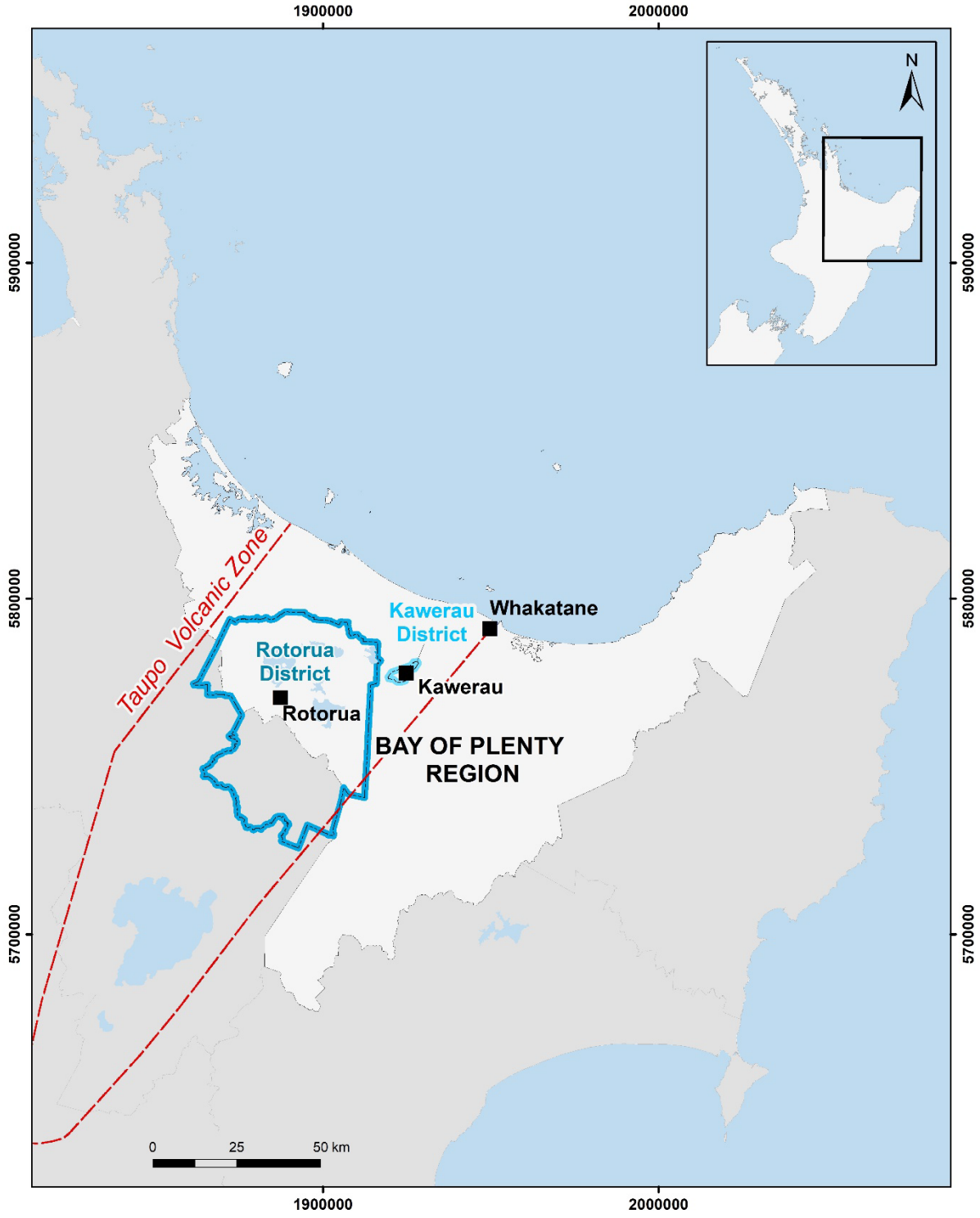

Figure 1 Bay of Plenty Region (white) and outlines of the Taupō Volcanic Zone (red hashed line), Rotorua District (dark blue line) and the Kawerau District (light blue line)

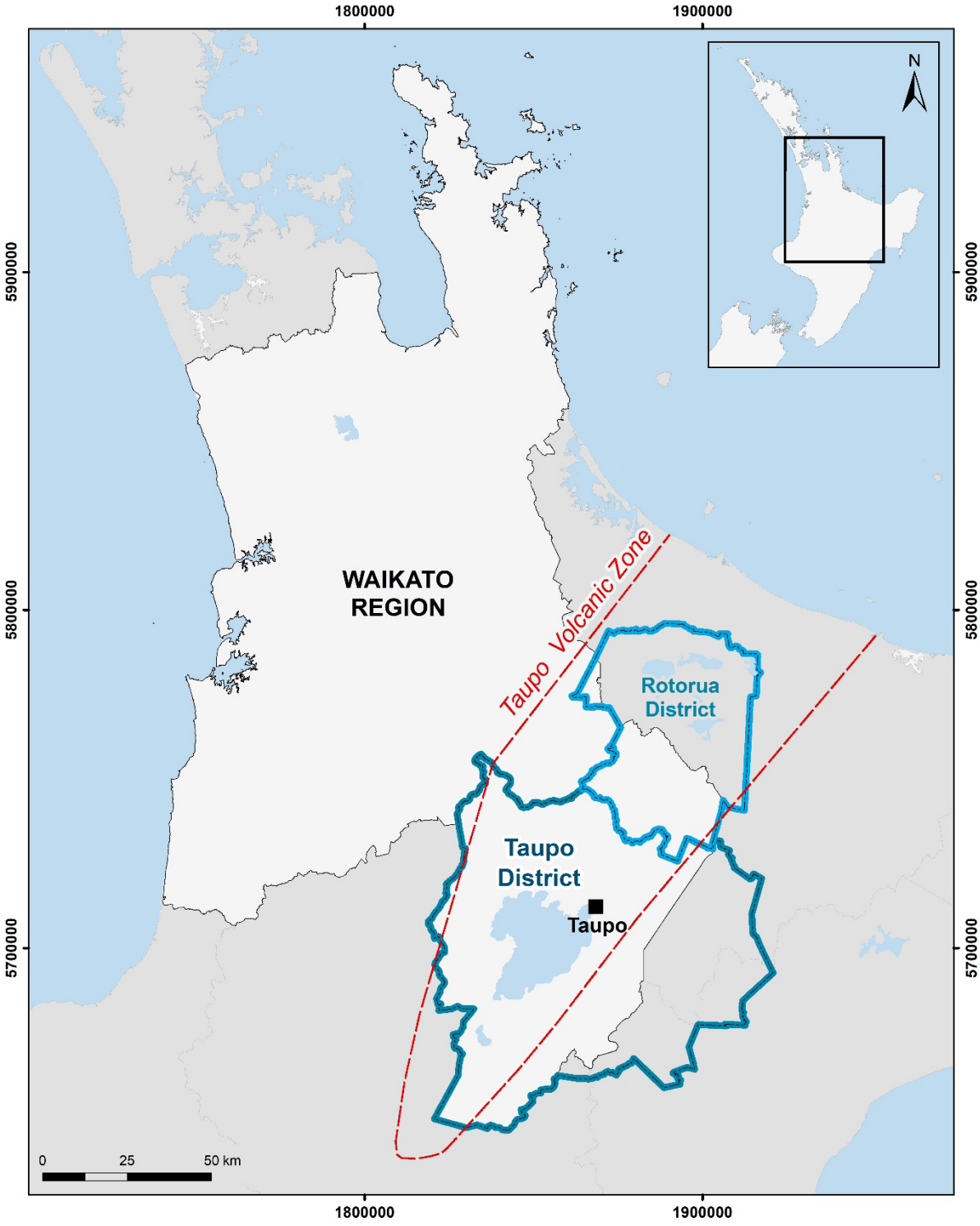

Figure 2 Waikato Region (white area) and outlines of the Taupō Volcanic Zone (red hashed line), Rotorua District (light blue line) and the Taupō District (dark blue line).

PART A

Well Drilling Activities

3 Differences between deeper supercritical drilling and conventional geothermal field drilling.

Part A of this report considers well drilling activity for a 6km well drilled to access supercritical geothermal resources.

While there are no current examples in New Zealand of such a well, well drilling to ~3.5 km is already occurring today as part of conventional geothermal development. Should supercritical conditions be found at depth, the well itself will be little different to a conventional geothermal well. Some casing sizes might be larger (or smaller) depending on the ultimate objective of the deeper portion of the well and some wellhead components will be rated for higher pressures and accordingly will be larger.

Beyond 3.5km, different conditions need to be anticipated. These conditions may require rig plant with greater hoisting capacity, greater drilling pumping pressures, with larger generators / motive power, and possibly larger drilling fluid cooling systems on the rig site to cool the fluids if greater fluid volumes are also pumped. More specialised downhole tools may also be required.

In testing a supercritical well, fluids of differing states can be expected to be produced at different times. On initial discharge the fluid could be expected to be liquid water, and then steam and water until the well heats up enough to produce supercritical water or superheated steam depending on the operating conditions.

Overall, the same drilling processes will be employed for supercritical drilling to greater depths, as are currently used in conventional geothermal drilling.

Using conventional drilling approaches and existing consenting processes for these activities provides a sound basis to consider the consent requirements for a deep 6km exploratory well.

4 Well Pad Construction

Well drilling sites require a pad to be constructed on which the drilling rig is erected and supporting equipment positioned. Earthworks form the pad and settling ponds (drill ponds), with stormwater drainage from off the well pad collected and captured in the ponds. Clean storm water from around the drill pad is directed to perimeter drains and is soaked to ground in the surrounding area.

A layer of base course is applied to the pad to provide adequate support for heavy vehicle loads and vehicle movements on the site that bring in the materials that are used in constructing the well. The area needed for a well pad is typically ~100 metres by ~150 metres, which includes a drilling waste pond ~15 metres wide constructed along one side. The ponds are typically 4 to 5 metres deep with a volume of at least 2500m^3. Examples from operators at various locations are included in Table 1 below.

Table 1 Examples of rig pad dimensions and drilling waste pond volumes

Location	Rig pad dimensions (Includes main pond)		Main Drilling Pond Volume
	Length (m)	Width (m)	m^3
Rotokawa	150	100	>2,500
Ngawha	120	80	>3,000
Tauhara	150	100	~4,000

Figure 3 Contact Energy Well site at Rakaunui Road, Taupō. Photo courtesy of MB Century.

5 Well Drilling

The drilling of one deep exploratory well could require the drilling of up to three wells, from two well pads, anticipated as follows.

1. A narrow diameter pilot well, on the exploratory well drill site, to establish the underground formation conditions down to about 1,000m. Information from this well will be used to confirm the upper casing string design for the 6km deep exploratory well.
2. A fluid disposal well to take drill site liquid waste and any geothermal liquid discharged at the surface. The need for such a well will depend on the availability or otherwise of a suitable well in the near vicinity of the exploratory well site that can be used for fluid disposal. This well would need to connect to formations significantly deeper than groundwater aquifers and could be as deep as 1,500m.
3. The 6km exploratory well. This will include a large diameter pre-collar, set at up to 100m deep from the ground surface. This 'pre-collar' pipe is installed prior to the establishment of the drilling rig on the site that will drill the deep well.

The primary functions of a drilling rig are hoisting and rotating of the drill string, pumping fluids to clean out the drilled hole and provide hydrostatic support and cooling in support of the drilling process, and providing effective well control to manage any downhole pressures encountered. Rotary drilling rigs are used for drilling geothermal wells in New Zealand with the drill pipe rotated, driving the bit, cutting the underground formation to progress the hole. The major components of a drilling rig are shown schematically in Figure 4 and Figure 5. Figure 3 shows the fluid circulation circuit along with the location of various discharges associated with a drilling operation.

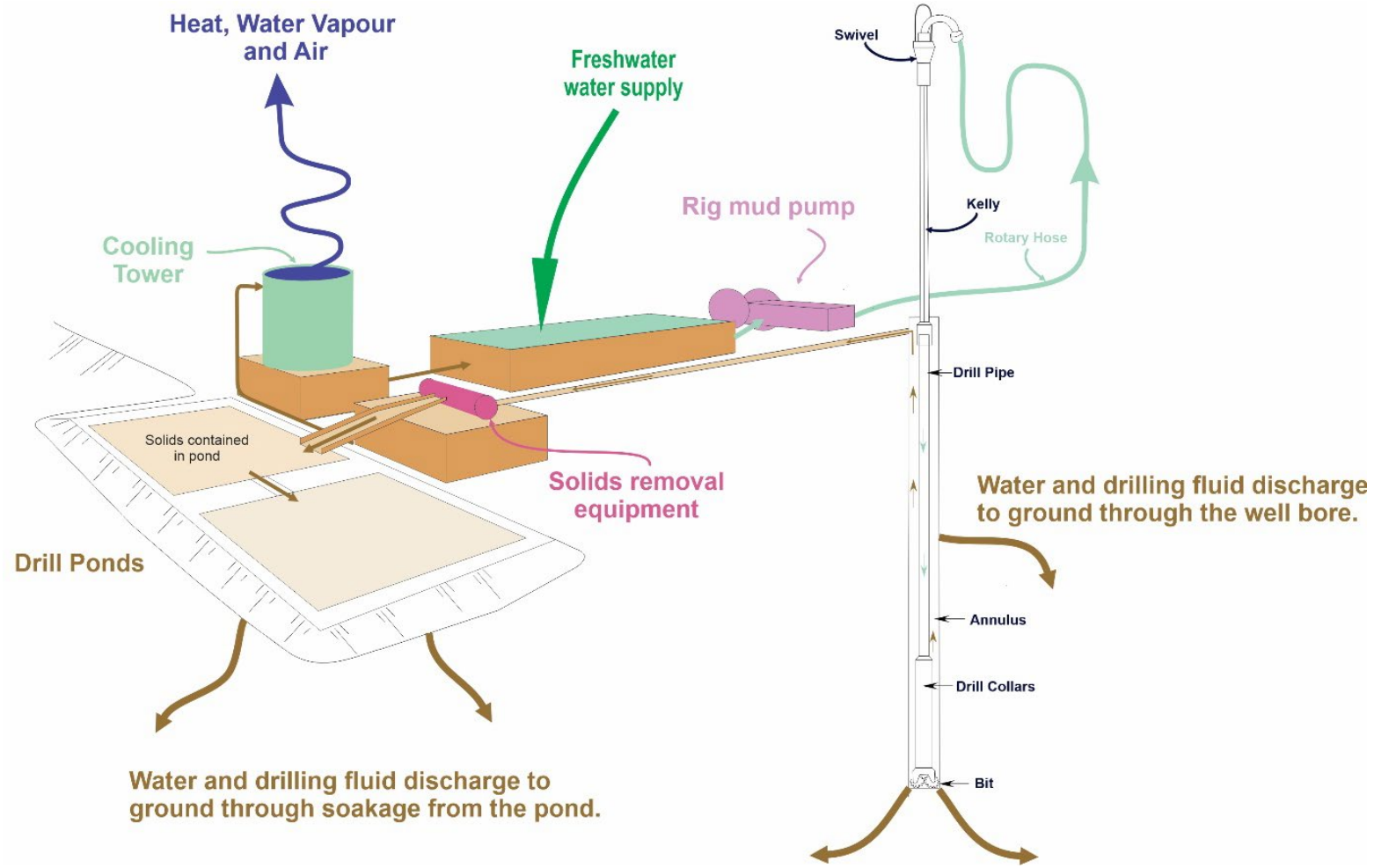

Figure 4 Drilling rig schematic showing the drilling fluid circulation system including, tanks, cooling tower, mud pumps, drill string, bit, annulus returning the fluid from underground, solids removal equipment and the drilling ponds. The freshwater supply to the rig is shown along with discharges of water and drilling fluids to land, both beneath the drilling pond and from the wellbore.

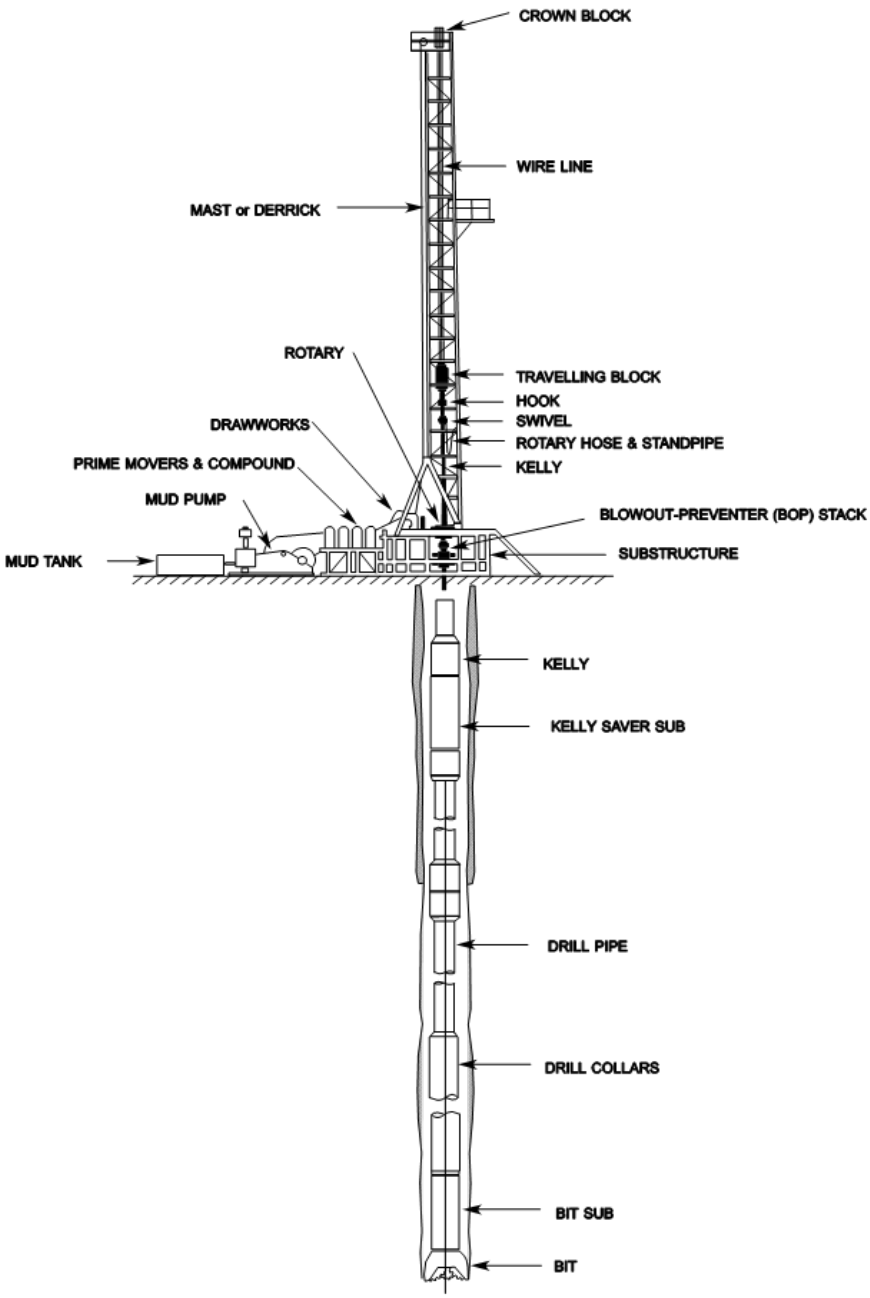

Figure 5 Schematic identifying some of the major components of a rotary table drilling rig. Rig height is up to ~ 60m for a rig that can stack 3 lengths of drillpipe into the mast. Sourced from Robson, Q. and Winmill, R. 2000.

The drilling process, and fluid management techniques used when drilling wells are briefly described below.

Wells are created by drilling a section of hole, then cementing a protective steel casing to stabilise the hole and to contain well pressures. Once one section is cased, the next section is drilled with a smaller

bit size down to the next casing depth and this section is then cased and cemented. This process is repeated using progressively smaller hole and casing sizes until the required depth is reached.

The final interval, the 'open' hole, usually has a slotted or perforated pipe (called a liner) run into it. The slots/perforations allow the reservoir / aquifer fluids to flow through the liner whilst holding the wall of well from collapse.

During drilling, the drill pipe is kept in tension to avoid drill pipe buckling, which would induce fatigue failure. This is achieved by placing heavy walled pipe called drillcollars below the drillpipe and using a portion of their weight to push the bit, and the remainder to keep the drillpipe in tension. This weight distribution is controlled from surface by the driller.

The formation chips – called cuttings - created by the rotating bit are removed from the bottom of the hole by fluids circulated down the inside of the drill pipe and back up the annulus to the surface. The removed solids are discharge to a drilling pond. (See Figure 3)

If a permeable zone is intersected as the drilling progresses, then not all the drilling fluids will return to the surface. Some of the fluid may flow out underground into the permeable zone, depending on the difference in pressure between the fluid in the well annulus and the pressure of the permeable zone.

Drilling fluids used are water-based mud, aerated drilling fluids, or water and combinations of each with various chemical additives to control the properties of the fluid to assist in the efficient removal of the cut formation from the bit. The corrosion potential of the drilling fluid is managed with chemicals added to reduce corrosion of the drill pipe, the well casing materials in the well and the drilling rig equipment on the surface. The environmental impacts of the discharge of contaminants from the drilling process will need to be considered in any resource consent application.

Solid materials (drilled solids) are removed from the drilling fluids being circulated using a range of devices (solids control equipment) such as shaker beds, hydro-cones, and centrifuges. The drilled solids and some residual water are then passed into the drill site pond(s), with settling occurring in the pond. The residual turbid liquid may be treated with a flocculating agent to further promote settlement of sediment. Some of the pond liquid may be able to be recycled back into the drilling mud system. The residual liquid, depending upon the consented and the appropriate method, is discharged to a pond to soak underground or is injected into a disposal well. The settled solids accumulate in the pond(s) until the completion of drilling where they may be left to reside or sometimes are removed to landfill at another site.

Drilling operations are designed to minimise the volume and toxicity of wastes produced with the volume of liquid waste minimised by using efficient solids control equipment and drilling fluid recycling.

During each stage of casing cement, excess cement may be circulated out of the well. This will be dumped into the drill site pond where it will generally dilute in the fluids existing in the pond.

5.1 Drilling Rig Water Supply

A reliable high-capacity water supply is critical for efficient and safe geothermal drilling operations. In geothermal drilling in New Zealand the operations frequently lose drilling water - often all of it - into permeable downhole formations. Under these circumstances all water delivered to the wellsite is lost downhole and water needs to be constantly replenished.

Surface water is usually used for geothermal well drilling with the supply requirements structured to meet the requirements of the New Zealand Geothermal Drilling Standard NZ2403:2015. The Standard references a 2,000m well, drilled with an 8.5 inch open hole section, requiring a minimum of 2,800 tonnes/day (2,000 litres/minute) of water. Open hole drilling of a 6,000m well, with water and with no water returning to the surface, could reasonably expect to consume upwards of 4,000 litres/minute (6,000 tonnes per day). This water requirement is anticipated to be needed for at least 4.5 months (140 days) in drilling a deep geothermal exploratory well.

During drilling the operation requires a minimum pump flow rate to lift the cuttings away from the drill bit - either to surface or into the permeable formations. This flowrate is independent of whether the water is returning to the surface or not. The water supply is also critical for well control; cold water flows into any permeable formations and prevents the water boiling and turning into steam in the wellbore or condenses any down-hole steam encountered. This requirement is expected to be more pronounced for a supercritical well based on the temperatures expected.

The freshwater is used not only for the drilling operation but also for well testing operations that occur after the well is completed to characterise the permeable zones in the well. For well testing a 6,000m well, a water requirement of ~5,500 tonnes per day should be adequate.

Figure 6 provides an indication of cumulative requirements for freshwater used for well drilling and testing phases while Figure 7 provides actual data from the drilling (orange columns) and cementing (green columns) of a Contact Energy well drilled to a depth of 2,000m for comparison.

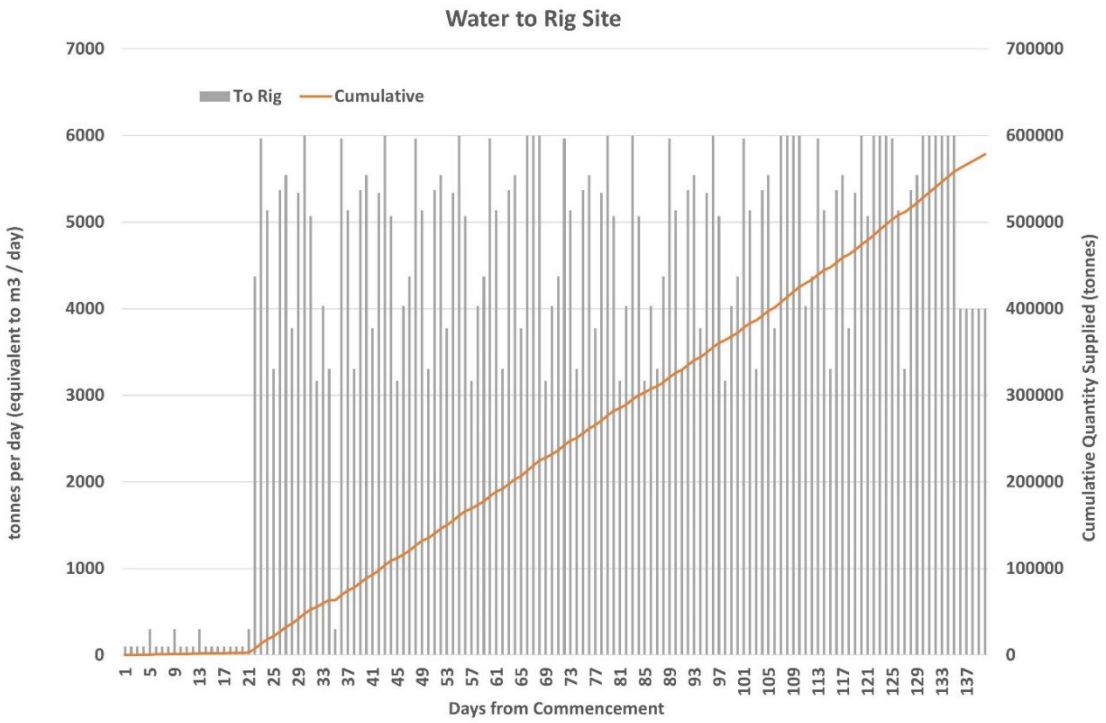

Figure 6 Indicative graph of anticipated water use for a 6km exploratory well drilling

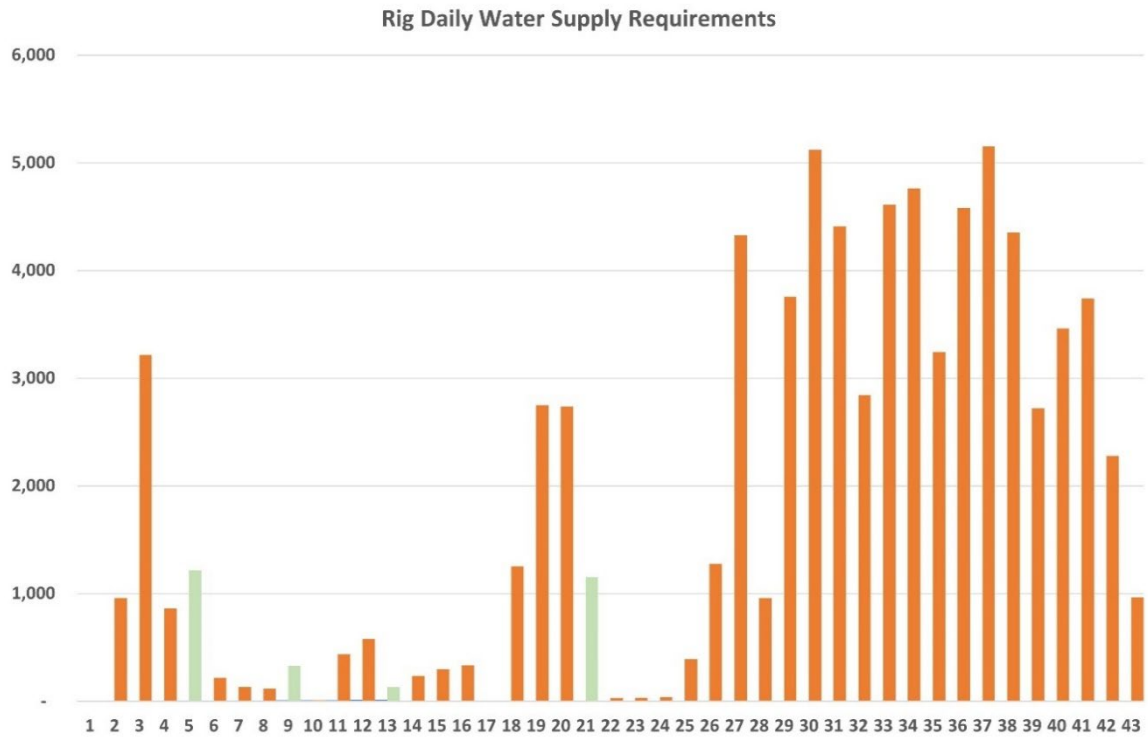

Figure 7 Daily water usage in m3/day for drilling an actual 2,000m well at Tauhara. Green columns are the days on which casing cementing operations were undertaken. Data provided by Contact Energy Ltd

Existing geothermal operations in the North Island take water from various water bodies, including the Waikato River, which services a number of the central North Island geothermal fields. The table below indicates some of the water sources and abstraction rates that are currently consented at various geothermal fields in the North Island:

Table 2 Examples of water abstraction associated with existing geothermal drilling operations

Geothermal Field	Waterbody	Abstraction Rate (t/day)	Consent
Mokai	Mokauteure Stream[1]	4,800	WRC 930753
Wairakei	Te Rautehuia and Waikato River	10,000	WRC 104709
Tauhara	Waikato River	10,000	WRC 961044
Rotokawa	Waikato River	3,800	WRC 120655
Ohaaki	Waikato River	30,000[2]	WRC 126154
Ngāwhā[3]	Mangatawai Stream (2 sites) and Ngāwhā Stream	Cumulative takes of up to 14,640 tonnes per day depending on individual stream flow rate. Cumulative instantaneous flow rate of up to 170 l/sec.	AUT 038620-09-01, -10-01 & -11-01

1 Maximum abstraction flow rate of 56 litres per second

2 Drilling water is only a part of this consent

3 Three water supply points seeking to have a supply greater than 3,000 litres / minute over any 48 hour period (8600 tonnes).

If the water body is of lower capacity, then holding reservoirs may be installed to provide a buffer to support peak drill rig requirements, such as occurs at Ngāwhā.

Surface water is taken either via submersible or ground mounted centrifugal pumps. In smaller water bodies, a low dam structure may need to be installed[1] to ensure an adequate depth of water above the pump inlet pipework is obtained. These pumps feed booster/transfer pumps which deliver the water to the drill site, typically via above-ground pipelines. For exploratory drilling, these pipelines are temporary for the duration of the drilling and testing operations.

Drilling water reservoirs are often built for drilling projects as part of the water supply system. These reservoirs allow for holding additional water for drilling in the event of a pump failure, which is important for drilling efficiency and for well control.

5.2 Drilling Fluids

Drilling with a water-based bentonite mud is the usual practice in the upper sections of the hole where casing is to be installed and cemented to the formations. The drilling mud functions to; clean the hole,

[1] Works in or on the bed of a river will attract additional resource consent considerations.

lifting the cuttings from the bit face, cool and lubricate the bit, cool the hole, stabilising the walls of the drilled hole, and provide pressure control intended to prevent the influx of formation fluids, including any gas, while drilling.

Freshwater supplied to the rig is used to mix up the drilling mud in the onsite drilling tanks. These are steel tanks around 2m high. The mud used in the upper cased hole sections typically consists of a suspension of sodium montmorillonite (bentonite) clay in fresh water. This fluid is treated with chemicals and various natural and synthetic polymers to obtain the desired rheological properties.

The majority of water-based drilling mud additives used are non-hazardous (in terms of the ERMA New Zealand's Hazardous Substances and New Organisms Act 1996). The products are also biodegradable or will thermally degrade with time. The chemical additives are approved for use by the relevant Regional Council prior to being purchased for the drilling operation where drilling is being undertaken.

For the purposes of this report, drilling has been assumed to be undertaken using mud until the 4th casing string has been cemented, after which drilling fluids are primarily water with only limited fluid returns to the surface.

5.3 Casing Cementing

Cement is used to secure the well casings to the ground and to seal off unwanted permeable zones encountered in the course of drilling. In cementing casing, the objective is to fill the casing to hole annulus, and once set this anchors the casing firmly to the ground or to any casing string that is higher up in the hole. The cement sheath also prevents the uncontrolled flow of fluids up the outside of the casing string from deeper down in a well. Being alkaline the hardened cement sheath provides protection to carbon steel against external casing corrosion from formation fluids.

By cementing casing into the well, the internal wellbore becomes isolated from the country rock. This in turn protects aquifers located above the target depth from becoming contaminated with geothermal fluid.

The Code of Practice for Deep Geothermal Drilling (NZS 2403:2015) requires that the cementing operations are undertaken to specified technical standards. Generous quantities of cement slurries are used to ensure thorough sealing of the annulus between casings and formations.

The majority of the cement slurry is displaced from inside the casing during the cementing operation, leaving only a few cubic metres of "green" cement to be drilled out from the lower part of the casing after the cement has cured. Displaced cement slurry is sent to the onsite drill ponds.

5.4 Water Drilling

It is normal practice to drill in the production zone of a geothermal reservoir using water as the drilling fluid (rather than mud). Continuing to drill with mud in this section of the well can result in mud particles sealing off permeable zones damaging the productivity. Periodically small quantities of polymer may be added to the water to improve its hole clearing and cleaning properties. These "sweep" volumes of fluid, between 1,000-5,000 litres, are pumped periodically or as required to help clear the cuttings out away from the hole.

All of this water may be lost to the underground formations depending on the permeability of the well. The locations where fluid is "lost" in a well indicates that a permeable zone has been encountered. It is these loss zones that ultimately produce geothermal fluid for production.

Air can be pumped along with the water (aerated drilling fluids) to assist in removing the cuttings from the well being drilled.

5.5 Groundwater Aquifers

Groundwater aquifers above any deeper target zones have to be passed through. This means that during the drilling operation it is possible for drilling fluid and drilled cuttings to be pushed out into the groundwater aquifers prior to the installation of the casing that isolates the hole from the ground water. Once installed, the casing prevents groundwater moving into the well and prevents drilling and well fluids from within the well passing out to the groundwater.

5.6 Discharges from well drilling

During drilling in the upper sections of a geothermal well (those sections that will be cased off), an estimated 100 m^3 per day water and mud may be discharged into the onsite drill ponds.

As part of casing cementing operations, up to 300 m^3 of water-based mud and cement slurry could be discharged to the drilling sump. These operations will occur during each casing cementing operation, which usually takes less than 24 hours per casing string installed.

Figure 8 is an indicative chart with time (in days) showing the volumes of water, drilling fluids and cementing fluids discharged to the drill ponds as the operation progresses.

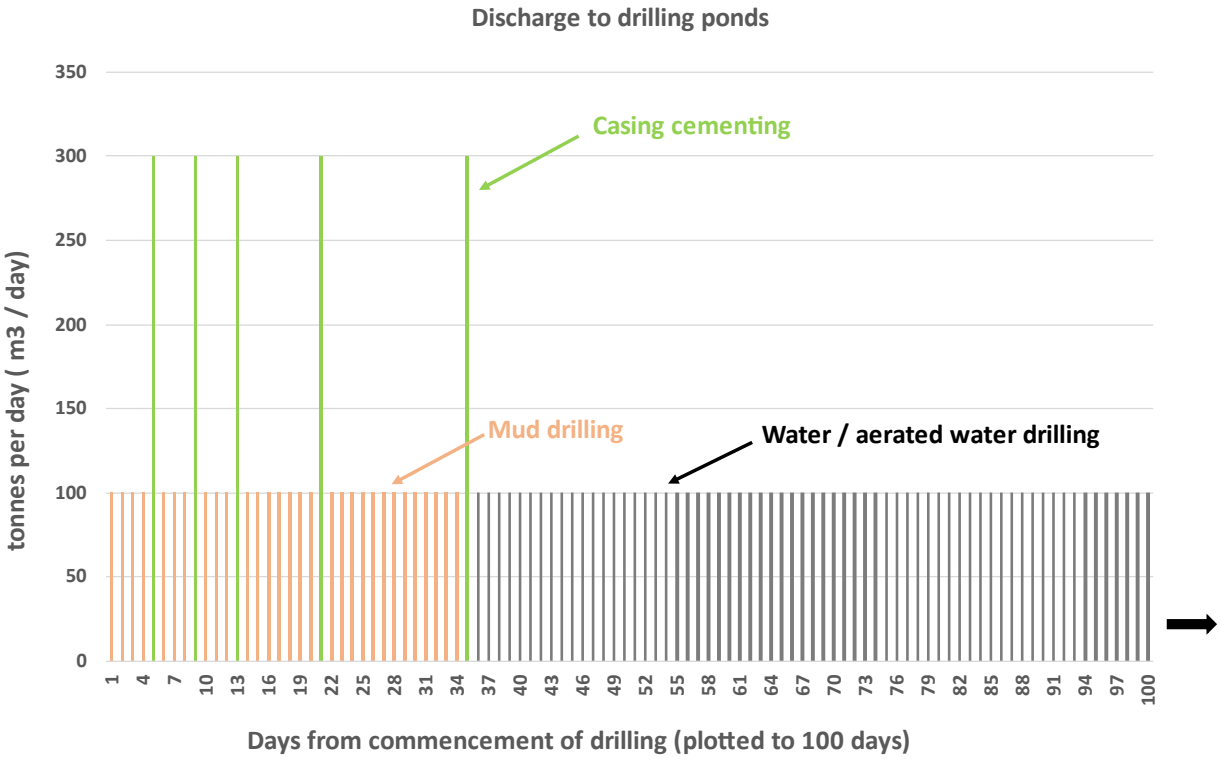

Figure 8 Indicative chart of potential discharge of drilling fluids to onsite drill ponds, plotted out to 100 days from commencement of exploratory well drilling operations

6 Well testing

Well completion tests, monitoring of well heating after drilling, and discharge tests are necessary to provide key data about the well and the geothermal conditions the well penetrates. This is particularly important for any deep exploratory well drilled, as the characterisation of the fluids and the geothermal conditions encountered will provide the geothermal sector with its first insight into deeper hotter geothermal conditions. The key activities in well testing are discussed below.

6.1 Well Completion Testing

To undertake the completion tests, up to 4,000 litres per minute (~5,500 tonne per day) of water is injected into the well to assess the capacity of the well to take fluid under different conditions. This enables the injectivity of the well to be determined and the locations of various permeable zones to be identified. Downhole logging tools are run into the well a number of times during the testing to measure pressure, temperature and fluid velocity. The velocity change of the injection fluid in the well (changing both due to hole size, inflows of hot fluid, and outflows of injected water) combined with changes in wellbore temperature and pressure at the different injection rates enable the location of the permeable zones to be interpreted. All of the water pumped into the well will move out into the underground formation through the permeable zones, meaning that all water used is consumed in this process. Typically, these tests take 24 hours to complete in a 3,500m well. For a 6,000m exploratory well with a 3,000m open hole length these tests could take up to 48 hours to complete.

6.2 Well Heat Up

A heat up period follows the shutting off of the water into the well as part of the completion test. Currently for the wells in the Taupō Volcanic Zone the heat up period is typically one month (with pressure, temperature and spinner surveys performed after one hour, one day, one week and one month). For a 6,000m exploratory well, the heat up period could be expected to be up to 3 months, with downhole surveys performed at one hour, one day, one week, two weeks and repeated every two weeks thereafter until the well is full heated.

The flow testing described in Section 6.3 will follow from the well heating period if an assessment indicates that the well is likely to be able to be flowed to the surface.

6.3 Flow testing

After the well is heated, a well discharge test is undertaken.

Typically, the initial well discharge will last between several hours and up to one day in duration. This initial discharge will clear the well of any rock cuttings remaining after drilling. Preliminary measurements of the output of the well will be made during this test and these will be used to establish appropriately

sized equipment for any longer term well output test. Because of the depth of the exploratory wells being considered, initiating well discharge may be quite difficult.

If supercritical or superheated conditions have been encountered, it may take some time for the well flow to heat the well to the operating temperature condition and during the initial period of discharge liquid water and steam will likely be produced to the surface. This was the experience in testing the IDDP1 420˚C well in Iceland (Ingarson et al 2014). As the flow test progresses, it is expected that the fluid flowing at the surface will be superheated steam. Supercritical fluids are not expected at the surface, given the reduction in pressure as the fluid travels up the well.

The well will be operated at different wellhead conditions to capture data to develop a characteristic curve for the output of the well. The chemistry of the fluids will be sampled to develop an understanding of the constituent species in the fluids. This includes any gases that come with and out of the water as it travels from deep underground to the surface. These gases could include the greenhouse gases; carbon dioxide and methane. The chemical characterisation of the fluids will be important in further understanding the underground geothermal conditions and in developing the understanding of how the fluids are best managed at the surface in energy extraction processes whilst ensuring quality environmental outcomes.

Flow of superheated steam to the surface at atmospheric pressure is likely to be at a maximum rate of about 70 kg/sec (6,000 tonnes per day) (Rivera and Carey, 2023). The well flows could be greater in the earlier heating period when liquid is in the discharge, ~ 7,000 tonnes per day.

At an enthalpy of 3,000 kJ/kg and a flow of 70 kg/sec a heat discharge of up to ~200 MW_{th} could be anticipated whilst the well is flowing.

The discharges from the well are diverted to a low emissions containerised muffler (LECM) system as shown in Figure 9. This equipment muffles the noise of the well being discharged. Geothermal water (if produced) is discharged to the rig site drill pond. Steam is vented to the atmosphere through the top of the LECM during testing.

Flow testing of a deep exploratory well could be expected to continue for several months.

Figure 9 Flow testing a geothermal well through an 'LECM' test setup. Photograph courtesy Western Energy Services.

7 Indicative Well Drilling Project Timeline

The indicative duration of the physical work to establish, test and decommission an exploratory well is as follows:

- 2 weeks to a month to set up site access.
- 2 months to construct the well pad(s) and drill ponds.
- 1-2 weeks to establish the rig on the well site ready to drill the 1,000 m pilot hole.
- 1 month to drill the 1,000m casing confirmation well.
- Optional drilling of the 1,500m injection well

  (Note in drilling this well, there will be fluid disposed to ground. The process has to start with some surface drilling discharges to construct a well that can subsequently take fluid)
- 3-4 weeks to disestablish the rig used for the 1,000 / 1,500m well and establish the rig and equipment to be used for drilling the 6,000 m exploratory well.
- 4-6 months to drill the 6,000 m well.
- 2 weeks to disestablish the rig used for the 6,000 m well, during which time the exploratory well will be shut in and heating.
- 3 months for well heat up, establishing the well testing equipment and including a period of producing fluid from the well.
- 3 months flow testing
- 2 months for well decommissioning to ensure site is secure
- 2 weeks for site tidy up.

PART B

Investigative

Consenting Scenarios

8 Consenting parameters

In Part B of this report, we set out the anticipated parameters for take and use of natural resources and discharges to the environment associated with the exploratory well drilling activities (as described in Part A). It includes the anticipated requirements for:

- Drilling activities and establishment of the well(s)
- Take and use of freshwater
- Take and use of geothermal water and associated energy
- Discharge of drilling fluids
- Discharge of geothermal fluids
- Discharge to air
- Discharge of stormwater
- Discharge of wastewater (wastewater and grey water)

8.1 Establishment of a geothermal well

Land use consents are required for the drilling activity and establishment of a geothermal well. These consents usually have a requirement to follow the deep drilling code of practice (NZ2403:2015), which includes conditions relating to maintenance and abandonment.

8.2 Take and use of freshwater

Freshwater is required for well drilling, completion testing and to a much lesser extent, to provide potable water for general use at the drill site. For the purpose of this report, we have focused on the freshwater needs for well drilling and testing, with freshwater assumed to be abstracted from a nearby surface water body at a rate of up to 6,000 tonnes/day for an anticipated duration of around 140 days for drilling, and ~5,500 tonnes/day for up to 48 hours for completion testing. The flow rate range is between 100 and 6,000 tonnes per day depending on the operations being undertaken and the amount of water being lost to the formations in the well at any given time.

This represents a significant volume of water, albeit on a temporary basis. Availability of water is a key consideration to be able to pursue an exploratory well drilling operation of the scale envisaged. Regional Councils maintain a record of surface and ground water resources and are responsible for determining the amounts of surface water available for allocation to resource consent holders, while ensuring that sufficient water is retained in the natural system to maintain ecosystem health. Factors such as the

temporary nature of drilling, water storage, seasonal availability of water (generally more water is available in winter) and potential for significant benefits from accessing supercritical geothermal resources are all relevant considerations when seeking to take and use freshwater.

Where catchments do have water available for allocation, resource consents can be applied for, and water is made available on a first-in-first-served basis (i.e., it is allocated to the earliest resource consent applicant first). Where a catchment has no allocation remaining, an alternative source of water will need to be found. For example, this could come from another resource consent holder who has spare capacity. The consenting framework is therefore very location specific, with any take considered to be consumptive with no water returning to the original source. Access to surface water will potentially require an intake structure in the body of a river/stream which have separate consenting requirements but are not explored in further detail in this report.

Groundwater aquifers may be another suitable alternative. If this is required, hydrogeological studies will need to be undertaken to identify the viability of taking water at rates of up to 6,000 tonnes/day for several months from an underground aquifer in the locale of the drill site. Several groundwater wells would likely be required to reliably supply the necessary volume. Consent would likely be required to establish groundwater bores, however as this is considered a standard process it is not explored further in this report.

Water used in the exploratory well drilling is fully consumptive, as it is lost to ground or to the well during the drilling operations.

8.3 Take and use of geothermal water and fluid and associated energy

Geothermal fluid will be extracted from the subsurface through the well as part of flow testing for a period up to 3 months (running 24/7) at an anticipated maximum rate of 7,000 tonnes/day. During flow testing it is anticipated that the geothermal fluid discharged will initially be a mix of geothermal water and steam, which will later become a superheated steam only discharge, as described in Section 6.3.

8.4 Discharges

8.4.1 Discharge of drilling fluids

During the drilling of the well, drilling fluids which are freshwater with additives including bentonite clay and other chemicals, are temporarily discharged in the following ways:

1. Into ground water as the drilling operation passes through the ground water table and ground water aquifers. Once a cemented well casing is in place no further discharge into the ground water can occur. For the purpose of this scenario testing report, the anticipated duration that the ground water aquifers might receive a discharge of drilling fluid is 5 days. Drilling fluid

additives used during this phase of the drilling are non-toxic and as with current practice for geothermal wells, the chemicals used are all approved for use by the Regional Council. The volumes of water that might be lost to the groundwater are difficult to estimate, however it is good practice to manage this to a practical minimum.

2. Some drilling fluid, including freshwater, is carried into the lined drill pond with the solids separated from the drilling fluids in the drilling fluid cleaning equipment (such as shaker beds, hydro-cones, and centrifuges). Liquid and sediment further separate in the lined pond with the liquid often being transferred to a second pond that facilitates continued separation / sedimentation. If the second pond is unlined water can infiltrate into the groundwater as a discharge to land. Figure 10 below provides an indicative graph of the discharge of drilling fluids to the drilling ponds during different phase of the drilling operations.

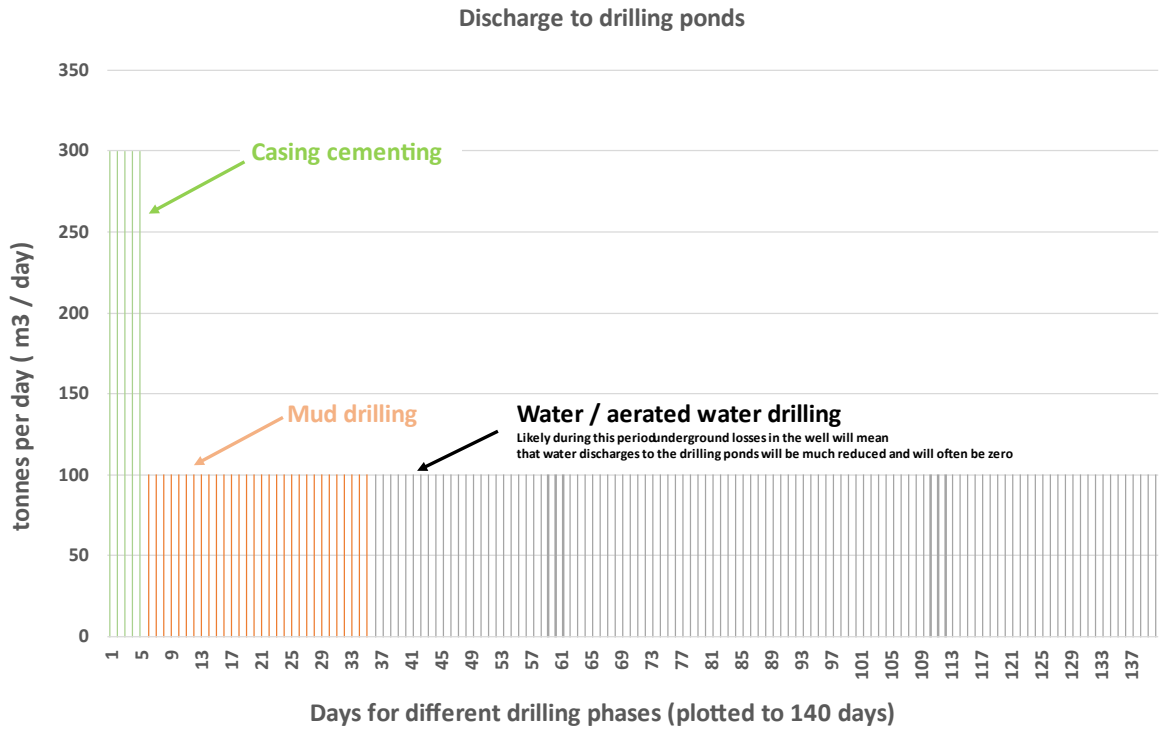

Figure 10 Indicative graph of discharge of drilling fluids to site drill ponds during different phases of the drilling operations. Note during the water drilling phase that discharges to the drilling ponds although plotted here at 100 m^3/day will be much reduced and will often be zero-

In locations where the discharge to land of the residual drilling pond fluids needs to be avoided then the option of injecting these fluids would be needed. One practical issue in a location where there are no suitable injection wells available is that a well needs to be constructed and in order to drill that drilling fluids will be discharged to land.

The settled solids in the bottom of the holding ponds are either left in the pond or disposed of separately to a landfill offsite.

For the purpose of these scenarios, it is anticipated that ~100 tonnes/day, of drilling fluid will be discharged to holding ponds, for a period of 90-140 days, and subsequently discharged to ground or injected into a separate injection well.

8.4.2 Discharge to air

Discharge to air, in the form of geothermal steam is anticipated during flow testing. For the purposes of this analysis, a maximum discharge of steam of 6,000 tonnes/day is anticipated for the duration of flow testing for approximately 2 to 3 months. Heat energy is released to the atmosphere as part the fluid discharge at rates of up to ~200 MW_{th}. Discharges from deep geothermal wells are anticipated to include some gases, as discussed in Section 6.3 including the greenhouse gases carbon dioxide and methane.

It is acknowledged that within the Bay of Plenty Region, an airshed exists that applies to the extent of Rotorua city. This airshed is contaminated currently as a result of smoke from home fires in winter. Any discharges to air at Sites 3 and 4 may need to consider the airsheds as part of the resource consent process.

8.4.3 Discharge of stormwater

Stormwater is generated from access roads and the drilling rig pad.

Drill pad storm water is directed to the drilling pond and is managed along with the other fluid discharges from the drill pond. Management of stormwater from other areas of the site are manged in a way that minimises adverse effects on the surrounding environment through achieving compliance with permitted activity standards or consent conditions if a consent is being exercised.

8.4.4 Discharge of wastewater

Wastewater (sewage) and grey water will be generated onsite during the drilling operations, it is anticipated that this will be able to be managed for the duration of the activity to meet permitted activity standards. It is likely that wastewater generated will be collected from site and disposed of to the nearest appropriate treatment facility. No further consideration of the consenting requirements for the disposal of wastewater is included in this analysis.

8.5 Summary of consenting parameters

For the purposes of the determining the consenting requirements at each of the scenario sites, we have used the resource use parameters identified in Table 3 below.

Table 3 Consenting Parameters used in Consenting Scenarios

Resource/ Use	Used for	Nature of the resource	Quantity	Duration
Drilling activity and well establishment	Drilling and establishing the well	Use of land for the purpose of establishing a well	N/A	Several months
Drilling fluid	Drilling the well	Freshwater (surface water or groundwater) mixed with bentonite mud and drilling chemicals to enable drilling.	Quantity of Freshwater needed = maximum 6,000 tonnes/day. Could be ground or surface water.	90-140 days With average use of around 4,000 tonnes/day for the duration of the drilling.
Drilling fluid waste	Rock material from the drilling brought to surface and stored in pond, rock material cleaned out.	Freshwater with suspended rock materials, clay and drilling chemicals and potentially some geothermal fluids (depending on pressure conditions in the well).	Freshwater mixed with bentonite mud and chemicals to enable drilling. Estimated volumes of 100 m^3/day water and mud discharged into the onsite drilling sump and up to 300 m^3/day during cementing casing for 24 hours per casing string.	90-140 days (as above for drilling fluid)
	Drilling fluid to be injected			
	Drilling fluid to be discharged to ground			
	Drilling fluid likely lost to groundwater			
	Solids left over – to landfill (could be the pond itself or could be taken offsite)			
Well testing	Completion testing – pumping freshwater into the well to test the pressure change in the well and temperature change in the well at different flow rates.	Freshwater	Freshwater = approx. 5,500 tonnes/day or 4,000 litres/minute	1-2 days running 24/7 but running at different flow rates to allow for testing.
Flow testing	Understand the well capacity and characterise the chemistry. Initially, likely to have a mix of steam and water and will become a steam only discharge after a week or two.	Geothermal fluid (steam and water)	Geothermal fluid discharged to surface ponds and then reinjected, up to 7,000 tonnes/day	~10 days
			Air discharge, 6,000 tonnes/day maximum	2-3 months

9 Resource consent requirements

As outlined in An Overview of New Zealand's Geothermal Planning and Regulatory Framework, 2021[2], a resource consent is the legal mechanism for allowing an activity to be undertaken that would otherwise contravene a rule in a regional plan, district plan or in a National Environmental Standard.

Where a resource consent is required, the relevant plan or national standard will determine whether the activity is a controlled, restricted discretionary, discretionary or non-complying activity (see Table 5-3). The activity status determines what will be considered when deciding on a resource consent application and whether the resource consent must, can or cannot be granted.

Table 4 Summary of Activity Status of Rules

Activity Status	Resource Consent Required?	Comments
Permitted	No	There can be specific conditions or performance standards which need to be met
Controlled	Yes	Council must grant a resource consent for a controlled activity but can impose conditions on that consent
Restricted Discretionary	Yes	Council must limit the matters that they will consider when assessing the application and are only able to impose conditions on a consent in relation to these matters if granted. Consent can be declined.
Discretionary	Yes	Consent can be granted with conditions or declined. If granted the consent must comply with the requirements and conditions of the consent.
Non-complying	Yes	The consent authority may decline or grant the consent, with or without conditions. However, the consent can only be granted if the activity has no more than a minor effect on the environment or will not be contrary to the objectives and policies of the plan.
Prohibited	No resource consent can be applied for	No application for a resource consent may be made for the activity and the consent authority must not grant a consent for it.

[2] Kissick, D., Climo, M., Carey, B., 2021 An Overview of New Zealand's Geothermal Planning and Regulatory Framework. Traverse Environmental Limited

10 Deep Exploratory Well Planning Scenario sites

10.1 Site identification

Four scenario sites with different characteristics and associated consenting frameworks have been identified for analysis within the Taupō Volcanic Zone. These sites provide a range of different characteristics that might be encountered for consenting.

While exact drill site locations are not presented in this report, scenario site locations have been used to inform a realistic range of consenting scenarios.

Two of the scenario sites are located in the Bay of Plenty Region, both in the Rotorua District. The other two sites are located in the Waikato Region, both in the Taupō District. Each region and district have their own operative consenting frameworks that determine the resource consent requirements for each site.

A brief overview of four scenario sites are summarised in Table 5, with Figure 11 and Figure 16 locating the scenario sites.

Table 5 Summary of Scenario Site characteristics

Site	Region	District	Geothermal Field Classification	Overlays / land status considerations
1	Waikato Region	Taupō District	Research Geothermal System (default classification)	• Ngāti Tūwharetoa Statutory Acknowledgement (Waikato River and its tributaries) • Raukawa Statutory Acknowledgement (Waikato River and its tributaries) • Affiliate Te Arawa Iwi Statutory Acknowledgement (Part of Waikato River (Atiamuri Dam to Huka Falls)). • Property Title encumbrance for geothermal exploration
2	Waikato Region	Taupō District	Rotokawa Development Geothermal Systems	• Affiliate Te Arawa Iwi (Rotokawa) Statutory Acknowledgement • Ngāti Tūwharetoa Statutory Acknowledgement (Waikato River and its tributaries, Rotokawa and Lake Rotokawa) • Raukawa Statutory Acknowledgement (Waikato River and its tributaries)

				• Property Title encumbrance for geothermal exploration
3	Bay of Plenty Region	Rotorua Lakes District	Unidentified	• Scenic Reserve • Outstanding Natural Feature/Landscape (Makatiti Dome Northern Slopes) (Rotorua Lakes District Plan) • Natural Heritage Area (Rotorua Lakes District Plan) • Māori Freehold Land
4	Bay of Plenty Region	Rotorua Lakes District	Unidentified	• Māori Freehold Land

While the focus of the scenario testing is on resource use and the requirements for resource consents under the Regional Planning frameworks, we have paid attention to any characteristics of the scenario sites in the relevant District Plan which would likely influence development on these sites. This includes consideration of identified Outstanding Natural Features and Landscape, as well as natural and historic heritage overlays.

10.2 Potential to utilise existing consents

A range of resource consents already exist for geothermal development in the Taupō Volcanic Zone. We have selected existing contents in the Rotokawa and Wairākei-Tauhara Development Geothermal Systems in the Waikato Region to explore whether existing consents could enable, or with minor changes allow the development of a ~6km deep geothermal exploratory well. This analysis is presented in Sections 13.2 and 16 below.

Before relying on existing consents to enable deep drilling, careful consideration is needed to ensure that there is sufficient legal scope within the existing consents to enable the deep drilling activities. This consideration should be undertaken alongside the relevant regulatory authority.

10.3 Scenario assumptions

In the development of this report, and to provide context to the scenario testing sites, the following assumptions have been made to assist in determining consenting requirements:

- All scenario sites are located at least 100m from any Significant Geothermal Feature identified in a Regional or District planning document
- All scenario sites are located at least 50m from any Geothermal Water Features

- All scenario sites are located in a manner to ensure that they do not trigger resource consent requirements from any of the following National Environmental Standards:
    - National Environmental Standard for Assessing and Managing Contaminants in Soil to Protect Human Health 2011.
    - National Environmental Standards for Freshwater 2020.
- To enable the abstraction of freshwater for well drilling and testing, it is anticipated that structures will be required either within the surface waterbody, or in groundwater to abstract the water necessary. While this requirement is acknowledged, the details of the consenting requirements of these structures are not included in any of the scenarios. A discretionary activity consent is assumed to be required.

11 Summary of consenting requirements

Table 6 provides a summary of the consenting requirements for each of the potential sites considered. The detailed analysis of each site is outlined in Sections 12- 16 below.

Table 6 Summary of consenting requirements for each scenario site

	Waikato Region				Bay of Plenty Region	
Resource/ Use	Scenario Site 1	Scenario Site 2 – New consents	Scenario Site 2 – Existing consents	Existing consents – Tauhara II	Scenario Site 3	Scenario Site 4
Act of well drilling	Controlled Activity Rule 3.8.4.7 - for drilling a well below the water table	Controlled Activity Rule 3.8.4.7 - for drilling a well below the water table	Existing consent likely to be sufficient without further changes subject to compliance with consent conditions.	Existing consent (WRC ref 120548) likely to be sufficient without further changes subject to compliance with consent conditions.	Discretionary Activity Not strictly provided for in the Bay of Plenty Regional Plan so assumption is that consent will be required under Section 87B (1)(b) of the RMA.	Discretionary Activity Not strictly provided for in the Bay of Plenty Regional Plan so assumption is that consent will be required under Section 87B (1)(b) of the RMA.
Freshwater for drilling	**Restricted Discretionary Activity** Rule 3.3.4.1– for the taking of Surface Water within the primary allocable flow **OR** **Discretionary Activity** Rule 3.3.4.23 – for the taking of Surface Water in excess of the primary allocable flow **OR** **Discretionary Activity**	**Restricted Discretionary Activity** Rule 3.3.4.1– for the taking of Surface Water within the primary allocable flow **OR** **Discretionary Activity** Rule 3.3.4.23 – for the taking of Surface Water in excess of the primary allocable flow **OR** **Discretionary Activity**	Likely to require more water than the current consent allows for, therefore new consent likely to be required as Discretionary Activity under Rule 3.3.4.23	Existing consent (WRC ref 961044) likely to be sufficient without further changes subject to compliance with consent conditions.	**Discretionary Activity** Rule 43 – for the taking of Surface Water or Groundwater	**Discretionary Activity** Rule 43 – for the taking of Surface Water or Groundwater

Resource/ Use	Waikato Region				Bay of Plenty Region	
	Scenario Site 1	Scenario Site 2 – New consents	Scenario Site 2 – Existing consents	Existing consents – Tauhara II	Scenario Site 3	Scenario Site 4
	Rule 3.3.2.24 for taking Groundwater	Rule 3.3.2.24 for taking Groundwater				
Drilling fluid waste	**Permitted Activity** Rule 3.8.4.3 for the discharge of water and drilling fluids onto or into land or into groundwater (Full injection) **OR** **Discretionary Activity** Rule 3.8.4.4 for the discharge of water and drilling fluids onto or into land or into groundwater (Partial or no injection)	**Permitted Activity** Rule 3.8.4.3 for the discharge of water and drilling fluids onto or into land or into groundwater (Full injection) **OR** **Discretionary Activity** Rule 3.8.4.4 for the discharge of water and drilling fluids onto or into land or into groundwater (Partial or no injection)	Existing consent for the discharge of drilling fluids likely to be sufficient without further changes subject to compliance with consent conditions.	Existing consent (WRC ref 120549) likely to be sufficient without further changes for the discharge of drilling fluids subject to compliance with consent conditions. If a new consent (under Rule 3.3.4.23) is required for it would be considered as a **Discretionary Activity.**	Discretionary Activity Not strictly provided for in the Bay of Plenty Regional Plan so assumption is that consent will be required under Section 87B (1)(b) of the RMA.	Discretionary Activity Not strictly provided for in the Bay of Plenty Regional Plan so assumption is that consent will be required under Section 87B (1)(b) of the RMA.
Well completion testing	**Restricted Discretionary Activity** Rule 3.3.4.1– for the taking of Surface Water within the primary allocable flow **OR** **Discretionary Activity** Rule 3.3.4.23 – for the taking of Surface Water in excess of the primary allocable flow **OR**	**Restricted Discretionary Activity** Rule 3.3.4.1– for the taking of Surface Water within the primary allocable flow **OR** **Discretionary Activity** Rule 3.3.4.23 – for the taking of Surface Water in excess of the primary allocable flow **OR**	Existing consent likely to be sufficient without further changes subject to compliance with consent conditions.	Existing consent (WRC ref 961044) likely to be sufficient without further changes subject to compliance with consent conditions.	**Discretionary Activity** Rule 43 - Take and use of surface or groundwater **AND** Rule 12 – **Permitted** Activity for a change of land use activity in the catchment of Lake Okataina.	**Discretionary Activity** Rule 43 - Take and use of surface or groundwater **AND** Rule 12 – **Permitted** Activity for a change of land use activity in the catchment of Lake Okataina.

Resource/ Use	Waikato Region				Bay of Plenty Region	
	Scenario Site 1	Scenario Site 2 – New consents	Scenario Site 2 – Existing consents	Existing consents – Tauhara II	Scenario Site 3	Scenario Site 4
	Discretionary Activity Rule 3.3.2.24 for taking Groundwater AND Rule 3.5.8.2 Controlled Activity for discharge of water from well testing into water or onto land.	**Discretionary Activity** Rule 3.3.2.24 for taking Groundwater AND Rule 3.5.8.2 Controlled Activity for discharge of water from well testing into water or onto land.				
Flow testing	**Discretionary Activity** Rule 6.1.9.2 for air discharge in excess of 5 megawatts	**Discretionary Activity** Rule 6.1.9.2 for air discharge in excess of 5 megawatts	Existing consent likely to be sufficient without further changes subject to compliance with consent conditions.	Likely due to the scope definition of consent (WRC ref 120547) and also the hydrogen sulphide conditions along with the uncertainty associated with deep geothermal well hydrogen sulphide levels, it will be prudent to seek a separate consent for deep well testing and its associated air discharges. Therefore, a **Discretionary Activity** under Rule 6.1.9.2 for air discharge in excess of 5 megawatts is likely required.	**Discretionary Activity** Rule AIR R16 Discharge of air in excess of 1,000 tonnes/day	**Discretionary Activity** Rule AIR R16 Discharge of air in excess of 1,000 tonnes/day
	Discretionary Activity Rule 7.6.3.6 for Takes of Geothermal Water and Energy and Associated Discharges in Research Geothermal Systems for	**Discretionary Activity** Rule 7.6.1.4 for Large and Other Takes of Geothermal Ground Water and Energy from	Existing consent likely to be sufficient without further changes subject to compliance with consent conditions.	Existing consent for take of geothermal water and energy likely to be sufficient without further changes subject to	**Discretionary Activity** GR R2 (Rule 73) Discretionary to take and use geothermal water, heat or energy	**Discretionary Activity** GR R2 (Rule 73) Discretionary to take and use geothermal water, heat or energy

Resource/ Use	Waikato Region				Bay of Plenty Region	
	Scenario Site 1	Scenario Site 2 – New consents	Scenario Site 2 – Existing consents	Existing consents – Tauhara II	Scenario Site 3	Scenario Site 4
	Scientific Investigation or Enhancement Purposes	Development Geothermal Systems **AND** **Discretionary Activity** Rule 7.6.1.5 for Reinjection/ Injection from Development Geothermal Systems **AND/OR** **Discretionary Activity** Rule 7.6.1.6 for Surface Discharges from Development Geothermal Systems		compliance with consent conditions. If the liquid discharge from flow testing is injected, then consent WRC ref 120545 is likely to be sufficient without further changes subject to compliance with consent conditions. If however during the early phase of flow testing due to the volume of liquid to be discharged to ground being possibly greater than 4000 tonnes per day, then a variation to the existing consent (WRC ref 120549) or a new consent (under Rules 7.6.1.5 or 7.6.1.6) will be required . Both are considered as a **Discretionary Activity.**	**AND** **Restricted Discretionary Activity** GR R9 (Rule 77) – Discharge of Geothermal Water by Reinjection (Discharge of Geothermal Water onto or into land in circumstances where it may enter water (including land soakage and reinjection) **AND/OR** **Discretionary Activity** GR R10 (Rule 77A) - Discharge of Geothermal Water onto or into land (including land soakage)	**AND** **Restricted Discretionary Activity** GR R9 (Rule 77) – Discharge of Geothermal Water by Reinjection (Discharge of Geothermal Water onto or into land in circumstances where it may enter water (including land soakage and reinjection) **AND/OR** **Discretionary Activity** GR R10 (Rule 77A) - Discharge of Geothermal Water onto or into land (including land soakage)
Stormwater	**Permitted Activity** Rule 3.5.11.5 – Permitted for stormwater generated from access roads etc Stormwater generated from the drilling rig pad should be managed with other fluid discharges from the drill pond.	**Permitted Activity** Rule 3.5.11.5 – Permitted for stormwater generated from access roads etc Stormwater generated from the drilling rig pad should be managed with other fluid discharges from the drill pond.	Permitted activity or existing consent likely to be sufficient without further changes subject to compliance with consent conditions.	Permitted activity or existing consent (WRC ref 120551) likely to be sufficient without further changes subject to compliance with consent conditions.	**Permitted Activity** Rule DW R22	**Permitted Activity** Rule DW R22

Resource/ Use	Waikato Region				Bay of Plenty Region	
	Scenario Site 1	Scenario Site 2 – New consents	Scenario Site 2 – Existing consents	Existing consents – Tauhara II	Scenario Site 3	Scenario Site 4
Additional considerations/ requirements	• Early Engagement with Affiliate Te Arawa Iwi, Ngāti Tūwharetoa and Raukawa in relation to their Statutory Acknowledgements over the Waikato River and its tributaries • Applications will need to ensure alignment with direction in Te Ture Whaimana – Vision and Strategy for the Waikato River resulting from Treaty Settlement • Need for a plan change to change the Research System to a Development Geothermal System should production in this location be sought in future • Land is subject to a legal encumbrance for geothermal exploration.	• Early engagement with Affiliate Te Arawa Iwi/Hapū in relation to their Statutory Acknowledgement over the Rotokawa geothermal area • Early Engagement with Ngāti Tūwharetoa and Raukawa in relation to their Statutory Acknowledgements over the Waikato River and its tributaries • Applications will need to ensure alignment with direction in Te Ture Whaimana – Vision and Strategy for the Waikato River resulting from Treaty Settlement • Land is subject to a legal encumbrance for geothermal exploration. • System Management Plan for Rotokawa Geothermal Field required	• Any new consent for additional water during drilling will require engagement with both Affiliate Te Arawa Iwi/hapū, Ngāti Tūwharetoa and Raukawa will be required in relation to the various statutory acknowledgements held by these parties. • Further applications will need to align with direction in Te Ture Whaimana – Vision and Strategy for the Waikato River resulting from Treaty Settlement. • Land is subject to a legal encumbrance for geothermal exploration. • System Management Plan for Rotokawa Geothermal Field or update required	• Any new consents for air discharges and discharges from well testing will require engagement with both Affiliate Te Arawa Iwi/hapū, Ngāti Tūwharetoa and Raukawa will be required in relation to the various statutory • Further applications will need to align with direction in Te Ture Whaimana – Vision and Strategy for the Waikato River resulting from Treaty Settlement. • Update to the System Management Plan for Wairākei-Tauhara Geothermal Field required	• Land is Māori Freehold Land • Scenic Reserve Status and the need to alter this status to enable well drilling and construction in this area • Makatiti Dome Outstanding Natural Features and Landscapes and Significant Natural Area classification – requires significant additional resource consenting under the Rotorua Lakes District Plan	• Land is Māori Freehold Land

12 Site 1 description

Scenario site 1 is located in the Waikato Region and is situated between but outside of the Ohaaki and Ngātamariki Development Geothermal System boundaries as shown on Figure 11.

The site is located outside of any of the following layers / areas identified in the Taupō District Plan:

- Outstanding Natural Feature or Landscape area
- Amenity Landscape Area
- Hot Ground Hazard Area
- Significant Natural Area
- Electricity Core Generation Site

The site is not located within any areas of Public Conservation Land managed by the Department of Conservation.

The site is within the area of interest of Affiliate Te Arawa Iwi, Ngāti Tūwharetoa and Raukawa who all hold a Statutory Acknowledgement over the Waikato River and its tributaries as shown on Figure 12.

In addition, consideration of the Te Ture Whaimana, Vision and Strategy for the Waikato River is required. The Vision and Strategy outlines the Vision of Waikato River iwi (being Waikato-Tainui, Ngāti Tūwharetoa, Raukawa, Te Arawa, Maniapoto) for the Waikato River as:

> *"Our Vision is for a future where a healthy Waikato River sustains abundant life and prosperous communities who, in turn, are all responsible for restoring and protecting the health and wellbeing of the Waikato River, and all it embraces, for generations to come."*

Te Ture Whaimana sets out objectives and strategies for achieving this Vision.

There is an encumbrance on the land title granting Profit a Prendre (a type of interest in land that confers a right to use part of another's land) for the purpose of geothermal exploration. For any geothermal exploration on this site, the landowner and parties benefitting from the encumbrance would need to approve or be part of the activities.

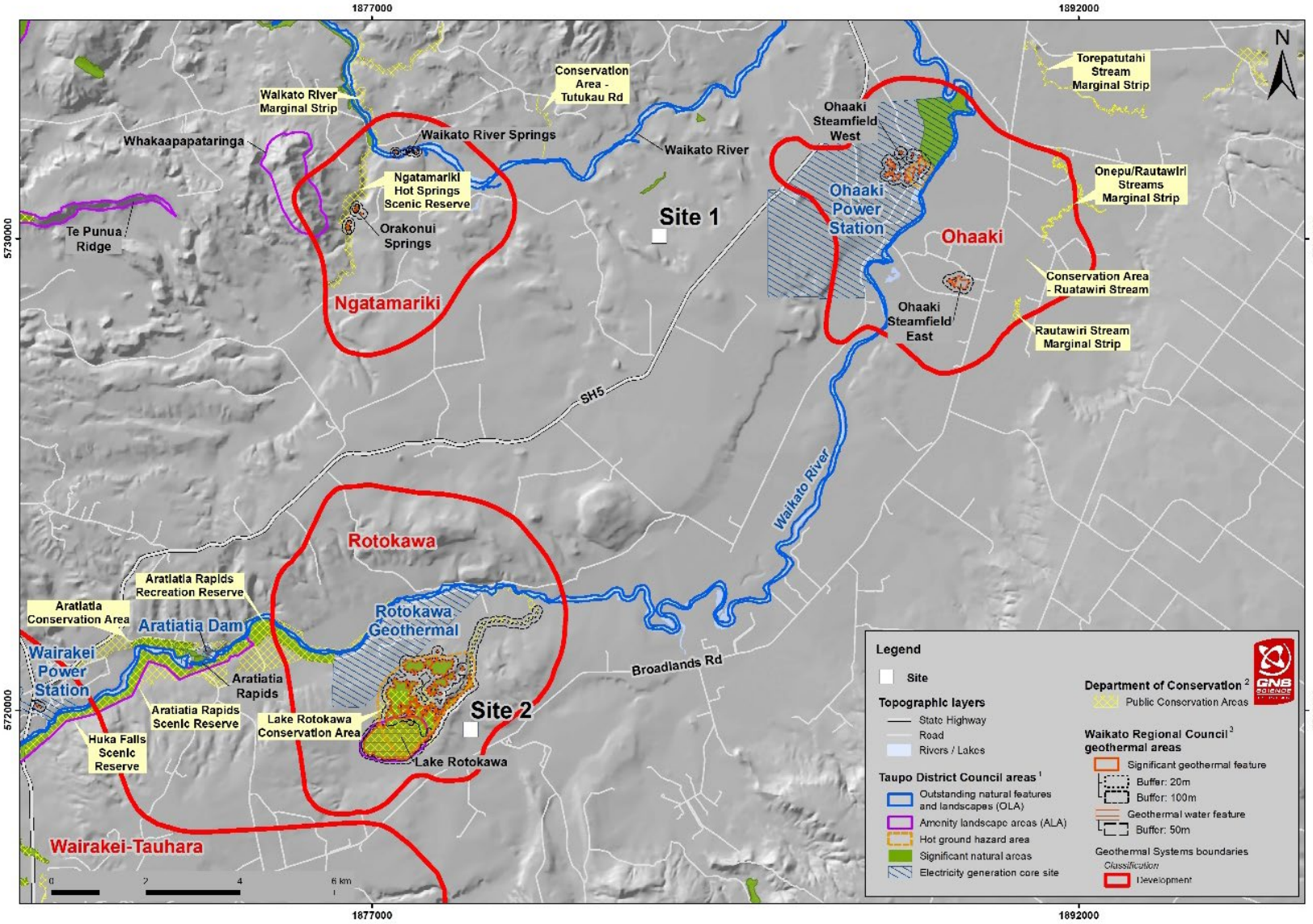

Figure 11 Scenario Site 1 and 2 locations in the Waikato Region

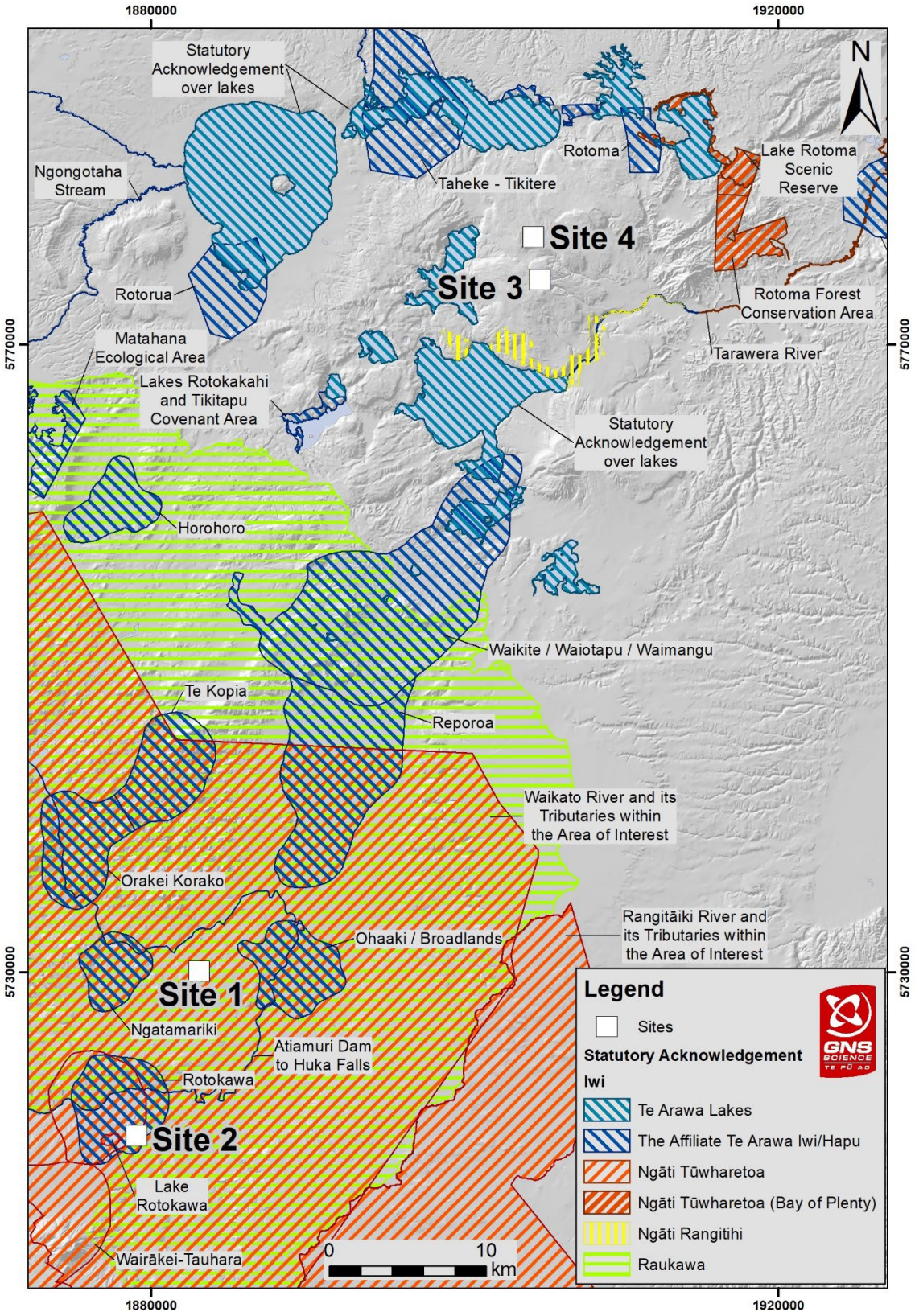

Figure 12 Scenario Sites and the relevant Statutory Acknowledgements in these areas (Data provided from Jacobs)

12.1 Anticipated resource consent requirements

The following table outlines what we anticipate will be the resource consenting requirements at Site 1.

Table 7 Scenario Site 1 Resource Consent Requirements Summary

Resource/ Use	Purpose	Nature of the resource	Anticipated rule/activity status	Comments
Act of well drilling	Consent for drilling the well	Activity of drilling a well below the water table	Rule 3.8.4.7 – Controlled Activity for drilling a well below the water table	Anticipate being able to meet the requirements for a controlled activity, but not a permitted activity due to the two day duration limitation. Controlled to Discretionary/Non-complying is generally driven by location of the well to be drilled. The scenario site has been identified as being >100m from any Significant Geothermal Feature identified in the Waikato Regional Plan and >50m from any lake or stream and not near any known archaeological or wāhi tapu sites.
Drilling fluid	Drilling the well	Freshwater mixed with bentonite mud and chemicals to enable drilling. Quantity of Freshwater needed = maximum of. 6,000 tonnes/day, averaging around 4,000 tonnes/day. Could be ground or surface water. Duration: 90-140 days	**Restricted Discretionary Activity** Rule 3.3.4.1– for the taking of Surface Water within the primary allocable flow **OR** **Discretionary Activity** Rule 3.3.4.23 – for the taking of Surface Water in excess of the primary allocable flow	Assuming water for this site would be taken from the Waikato River. Enquiries made in September 2022 indicate that there is availability of water in the Waikato River of around 1m^3/sec* during November to April and up to 5.50m^3/sec May to August. This indicates sufficient water is available to abstraction from the Waikato River. *1m^3/sec is equivalent to 86,400 tonnes/day
			OR Rule 3.3.2.24 Discretionary Activity for taking groundwater	Alternative to source from groundwater – Site 1 is located within the "Reporoa Basin – West of Waikato River" Assessed Aquifer where there is a limit on the Sustainable Yield from the aquifer of 16,500m3 (x1000) per year. (Table 3.6 in chapter 3.3 Water Takes)

Resource/ Use	Purpose	Nature of the resource	Anticipated rule/activity status	Comments
Drilling fluid waste	Rock material from the drilling brought to surface and stored in pond, rock material cleaned out. AND Drilling fluid to be injected AND Drilling fluid to be discharged to ground AND Drilling fluid likely lost to groundwater AND Solids left over – to landfill (could be the pond itself or could be taken offsite)	Freshwater with suspended rock materials, clay and drilling chemicals and potentially some geothermal fluids (depending on pressure conditions in the well). Quantity: • Up to 100 m^3/day during drilling of the upper sections of the well for 90-140 days • Up to 300 m^3/day during cement casing for 24 hours per casing string	Either Rule 3.8.4.3 – **Permitted** Activity for the discharge of water and drilling fluids onto or into land or into groundwater OR Rule 3.8.4.4 – **Discretionary** Activity for the discharge of water and drilling fluids onto or into land or into groundwater	Drilling activities create waste materials that are collected in ponds with the surplus fluids either discharged to land or injected into a well. Usually two ponds are used. The first pond is lined and allows for settlement of rock particles and other solids brought up from underground. The second pond is a soakage pond that has permeability adequate to allow the liquid to infiltrate the soil and groundwater. While there may be some geothermal water in this fluid, it is predominately freshwater used for drilling with some contaminants from the drilling process such as clay and chemicals used in drilling. Key considerations to determine activity status are: - No discharge to surface water or land where the contaminants may enter surface water. This would require a 100% injection approach to be permitted - Drilling fluids are freshwater or aerated water based – in this instance they would be freshwater or groundwater based depending on availability of water resources - Bentonite and cement may be used – other products (including polymers and surfactants may be used provided they are not considered to be a hazardous substances under the Hazardous Substances and New Organisms Act ("HASNO") Act. - Discharge is not within 20m of a Significant Geothermal Feature.

Resource/ Use	Purpose	Nature of the resource	Anticipated rule/activity status	Comments
Well testing	Completion testing – pumping freshwater into the well to test the pressure change in the well and temperature change in the well at different flow rates.	Freshwater Quantity of Freshwater needed = 4,000 litres/minute (~5,500 tonnes/day) Duration: 1-2 days of 24/7 operation at different flow rates to allow for testing.	**Restricted Discretionary Activity** Rule 3.3.4.1– for the taking of Surface Water within the primary allocable flow **OR** **Discretionary Activity** Rule 3.3.4.23 – for the taking of Surface Water in excess of the primary allocable flow OR Rule 3.3.2.24 Discretionary Activity for taking groundwater AND Rule 3.5.8.2 Controlled Activity for discharge of water from well testing into water or onto land.	Assuming water for this site would be taken from the Waikato River Note: Water use is consumptive as it will enter the underground formations during the completion testing process. For consenting purposes, it is understood that the water take would be regarded as fully consumptive. Alternative to source from groundwater – Site 1 is located within the "Reporoa Basin – West of Waikato River" Assessed Aquifer where there is a limit on the Sustainable Yield from the aquifer of 16,500m3 (x1000) per year. (Table 3.6 in chapter 3.3 Water Takes)
Flow testing	Understand the well capacity. Initially, likely to have a mix of steam and water and then as time goes by, will only be steam discharge.	Steam Quantity of stream discharged = 6,000 tonnes/day maximum Duration: Up to 90 days	Rule 6.1.9.2 – Discretionary Activity for air discharge in excess of 5 megawatts	Discharge of steam is anticipated during the testing phase of 6,000 tonnes/day which is a discharge equivalent to about 200 megawatts of heat.
		Geothermal fluid (steam and water) Quantity of geothermal fluid discharged: up to 7,000 tonnes/day (to surface ponds and then injected) Duration: 5-10 days	Rule 7.6.3.6 – Discretionary Activity for Takes of Geothermal Water and Energy and Associated Discharges in Research Geothermal Systems for Scientific Investigation or Enhancement Purposes	The Waikato Regional Plan notes that any site that is outside of the identified large system boundary and do not meet the definition of a Small Geothermal System or are not hydrologically connected to a known Development system automatically fall into the Research System category. This classification is intended to be temporary to allow for reclassification once more is known about the system. Key considerations for this activity status are:

Resource/ Use	Purpose	Nature of the resource	Anticipated rule/activity status	Comments
				- Allows of take for up to 10,000 tonnes/day of geothermal energy or water. Should this volume be exceeded, consent would be required as a non-complying activity under 7.6.3.7 - Discharge of water and associated naturally occurring contaminants into water or onto or into land arising from the taking of geothermal water where this is for the purpose of scientific investigation.
Stormwater	Discharge if stormwater generated from access roads etc. Stormwater generated from the drilling rig pad should be managed with other fluid discharges from the drill pond.	For the full duration of the activity.	Rule 3.5.11.5 – Permitted Discharge of Stormwater onto or into land	The discharge of stormwater to land is a permitted activity provided that any hazardous substances in the stormwater are at levels that are consistent with the relevant national guidance including the Hazardous Substances and New Organisms Act ("HASNO")

12.2 Additional considerations/requirements

A default 'research geothermal system' status applies at Scenario Site 1. In order to produce energy from a well site in this location in future, a Plan Change to the Waikato Regional Plan would be required to formally reclassify the system to a Development Geothermal System, should the well testing prove the resource to be suitable for large scale future energy development.

The process for undertaking a plan change of this nature would rely on the testing outcomes of the exploratory well to justify the change.

Engagement with Affiliate Te Arawa Iwi, Ngāti Tūwharetoa and Raukawa for any consent application is necessary, particularly in order to recognise Statutory Acknowledgements in the area. Regional Councils are required to have regard to statutory acknowledgements when determining who is an affected party for the purpose of notification of any application. Resource consent applications will need to ensure that they align with the direction of Te Ture Whaimana, the Vision and Strategy for the Waikato River. In addition, an assessment of cultural effects of any application will be required with any resource consent application lodged.

A legal encumbrance relating to geothermal exploration over the Site 1 area is in place and would need to be considered as part of any resource consent application process.

12.3 Consenting timeline

Timeframes associated with resource consenting processes are highly variable. We have estimated a possible timeframe and steps associated with resource consenting requirements for exploratory well drilling at Site 1 in the diagram below.

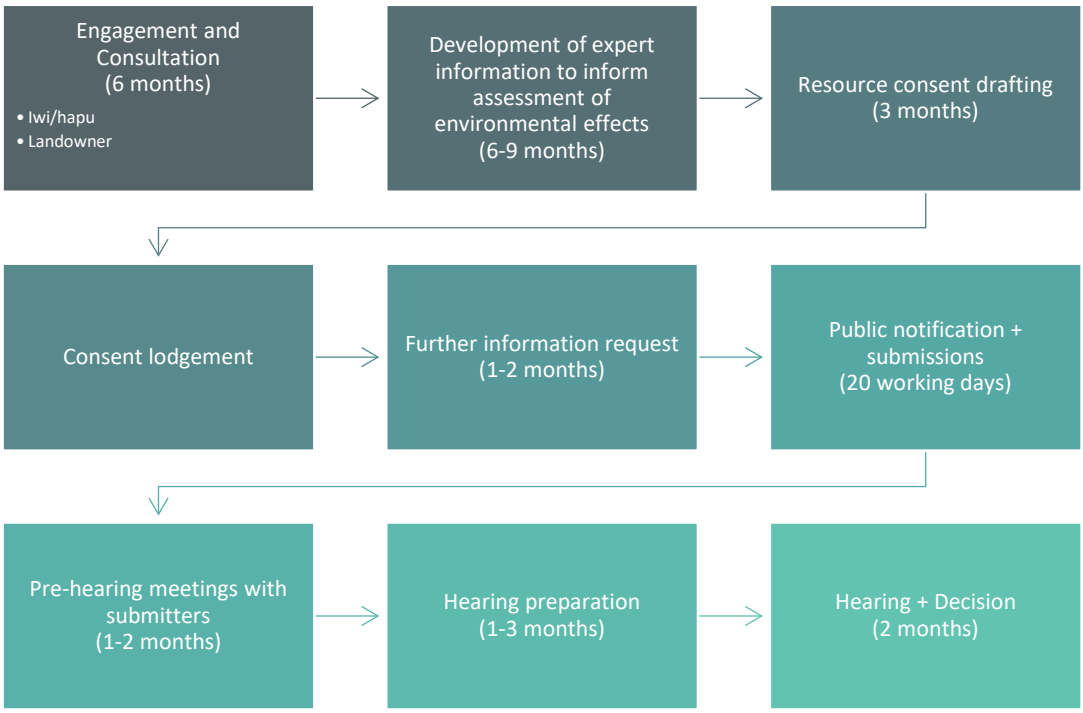

Figure 13 Resource Consent process timeframe for Site 1

Based on the above steps, we estimate it could be around 18 months – 2.5 years for a resource consent process to be completed, allowing sufficient time for engagement with the relevant parties. This can be reduced where a number of steps can be run concurrently i.e., engagement/consultation can occur while expert information to support an application is being developed.

13 Site 2 description

Scenario site 2 is also located in the Waikato Region and is located within the Rotokawa Development Geothermal System boundary but is outside of the land area currently being utilised for geothermal resource use supporting the Rotokawa and Nga Awa Purua Power Stations as shown on Figure 14. The site is inside the area over which the Rotokawa Joint Venture Limited hold resource consents (Consents under AUTH136402).

The site is located outside of any mapped or identified area in the Taupō District Plan including:

- Outstanding Natural Feature or Landscape area
- Amenity Landscape Area
- Hot Ground Hazard Area
- Significant Natural Area
- Electricity Core Generation Site

The site is not located within any areas of Public Conservation Land managed by the Department of Conservation.

The site is within the area of interest of Ngāti Tūwharetoa and Raukawa who both hold a Statutory Acknowledgement over the Waikato River and its tributaries while Ngāti Tūwharetoa also hold Statutory Acknowledgement over the Rotokawa Geothermal Field and Lake Rotokawa, as shown on Figure 12.

In addition, consideration of the Te Ture Whaimana, Vision and Strategy for the Waikato River is required.

The site is also within the area of interest of Affiliate Te Arawa Iwi/Hapū who hold a Statutory acknowledgement over the Rotokawa Area as shown on Figure 12.

Like Site 1, there is an encumbrance on the land title granting Profit a Prendre for the purpose of geothermal exploration. For any geothermal exploration on this site, the landowner and parties benefitting from the encumbrance would need to approve or be part of the activities.

Given that the site is located within an existing consented area, it might be possible to utilise the existing resource consents for geothermal resource use and development rather than needing to rely on a new suite of consents. Both options are considered below.

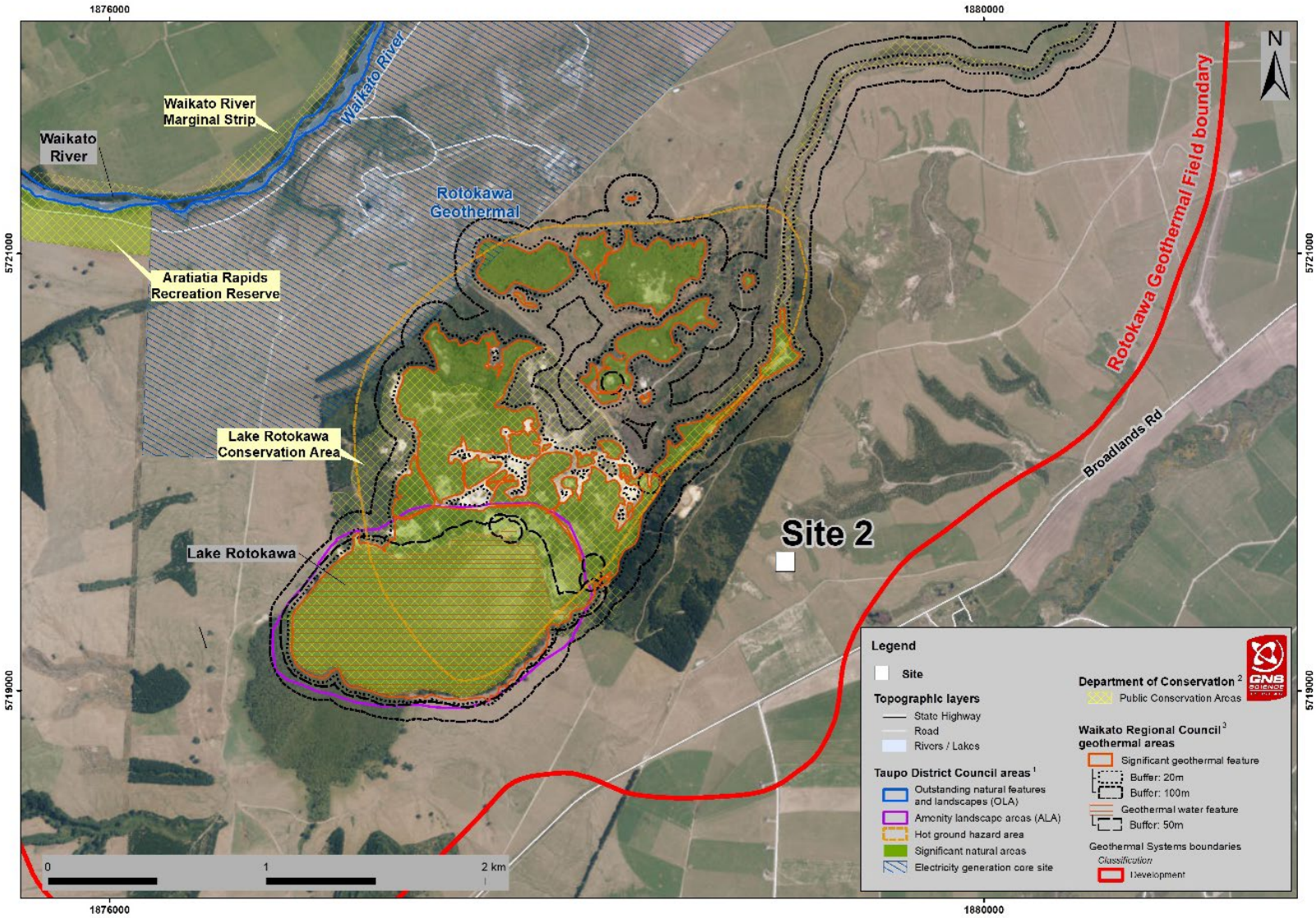

Figure 14 Scenario Site 2 Location

13.1 Anticipated resource consent requirements – new consents

The following table outlines what we anticipate will be the resource consenting requirements at Site 2 if we were to pursue new resource consents for the site.

Table 8 Scenario Site 2 Resource Consent Requirements Summary

Resource/ Use	Purpose	Nature of the resource	Anticipated rule/activity status	Comments
Act of well drilling	Consent for drilling the well	Activity of drilling a well below the water table	Rule 3.8.4.7 – Controlled Activity for drilling a well below the water table	Anticipate being able to meet the requirements for a controlled activity, but not a permitted activity due to the two day duration limitation. Controlled to Discretionary/Non-complying is generally driven by location of the well to be drilled. The scenario site has been identified as being >100m from any Significant Geothermal Feature identified in the Waikato Regional Plan and >50m from any lake or stream and not near any known archaeological or wāhi tapu sites.
Drilling fluid	Drilling the well	Freshwater mixed with bentonite mud and chemicals to enable drilling. Quantity of Freshwater needed = maximum of 6,000 tonnes/day, averaging around 4,000 tonnes/day. Could be ground or surface water. Duration: 90-140 days	**Restricted Discretionary Activity** Rule 3.3.4.1– for the taking of Surface Water within the primary allocable flow **OR** **Discretionary Activity** Rule 3.3.4.23 – for the taking of Surface Water in excess of the primary allocable flow OR Rule 3.3.2.24 Discretionary Activity for taking groundwater	Assuming water for this site would be taken from the Waikato River. Enquiries made in September 2022 indicate that there is availability of water in the Waikato River of around 1m^3/sec* during November to April and up to 5.50m^3/sec May to August. This indicates sufficient water is available to abstraction from the Waikato River. *1m^3/sec is equivalent to 86,400 tonnes/day Alternative to source from groundwater – Site 2 is located within the "Reporoa Basin – West of Waikato River" Assessed Aquifer where there is a limit on the Sustainable Yield from the aquifer of 16,500m3 (x1000) per year. (Table 3.6 in chapter 3.3 Water Takes)

Resource/ Use	Purpose	Nature of the resource	Anticipated status	rule/activity	Comments
Drilling fluid waste	Rock material from the drilling brought to surface and stored in pond, rock material cleaned out. AND Drilling fluid to be injected AND Drilling fluid to be discharged to ground AND Drilling fluid likely lost to groundwater AND Solids left over – to landfill (could be the pond itself or could be taken offsite)	Freshwater with suspended rock materials, clay, and drilling chemicals and potentially some geothermal fluids (depending on pressure conditions in the well). Quantity: • Up to 100 m^3/day during drilling of the upper sections of the well for 90-140 days • Up to 300 m^3/day during cementing casing for 24 hours per casing string	Either Rule 3.8.4.3 – Permitted Activity for the discharge of water and drilling fluids onto or into land or into groundwater OR Rule 3.8.4.4 – Discretionary Activity for the discharge of water and drilling fluids onto or into land or into groundwater		Drilling activities create waste materials that are collected in ponds with the surplus fluids either discharged to land or injected into a well. Usually two ponds are used. The first pond is lined and allows for settlement of rock particles and other solids brought up from underground. The second pond is a soakage pond that has permeability adequate to allow the liquid to infiltrate the soil and groundwater. While there may be some geothermal water in this fluid, it is predominately freshwater used for drilling with some contaminants from the drilling process such as clay and chemicals used in drilling. Key considerations to determine activity status are: - No discharge to surface water or land where the contaminants may enter surface water. This would require a 100% injection approach to be permitted - Drilling fluids are freshwater or aerated water based – in this instance they would be freshwater or groundwater, based depending on availability of water resources - Bentonite and cement may be used – other products (including polymers and surfactants may be used provided they are not considered to be a hazardous substances under the Hazardous Substances and New Organisms Act ("HASNO") Act. - Discharge is not within 20m of a Significant Geothermal Feature.

Resource/ Use	Purpose	Nature of the resource	Anticipated rule/activity status	Comments
Well testing	Completion testing – pumping freshwater into the well to test the pressure change in the well and temperature change in the well at different flow rates.	Freshwater Quantity of Freshwater needed = 4,000 litres/minute (~5,500 tonnes/day) Duration: 1-2 days of 24/7 operation at different flow rates to allow for testing.	**Restricted Discretionary Activity** Rule 3.3.4.1– for the taking of Surface Water within the primary allocable flow **OR** **Discretionary Activity** Rule 3.3.4.23 – for the taking of Surface Water in excess of the primary allocable flow OR Rule 3.3.2.24 Discretionary Activity for taking groundwater AND Rule 3.5.8.2 Controlled Activity for discharge of water from well testing into water or onto land.	Assuming water for this site would be taken from the Waikato River Note: Water use is consumptive as it will enter the underground formation during the completion testing process. For consenting purposes, it is understood that the water take would be regarded as fully consumptive. Alternative to source from groundwater – Site 2 is located within the "Reporoa Basin – West of Waikato River" Assessed Aquifer where there is a limit on the Sustainable Yield from the aquifer of 16,500m3 (x1000) per year. (Table 3.6 in chapter 3.3 Water Takes)
Flow testing	Understand the well capacity. Initially, likely to have a mix of steam and water and then as time goes by, will only be steam discharge.	Steam Quantity of stream discharged = 6,000 tonnes/day maximum Duration: Up to 90 days	Rule 6.1.9.2 – Discretionary Activity for air discharge in excess of 5 megawatts	Discharge of steam is anticipated during the testing phase of 6,000 tonnes/day which is a discharge equivalent to around 200 megawatts of heat.
		Geothermal fluid (steam and water) Quantity of geothermal fluid discharged: up to 7,000 tonnes/day (to surface ponds and then injected) Duration: 5-10 days	Rule 7.6.1.4 – Discretionary Activity for Large and Other Takes of Geothermal Ground Water and Energy from Development Geothermal Systems AND	Scenario site 2 is located within the Rotokawa Development Geothermal System. As a result, a different set of rules apply to Site 2 than those that applied to Site 1 (being in a research Geothermal system). The Discretionary Activity Rule applicable to Site 2 requires the following conditions to be met:

Resource/ Use	Purpose	Nature of the resource	Anticipated rule/activity status	Comments
			Rule 7.6.1.5 – **Discretionary** Activity for Reinjection/ Injection from Development Geothermal Systems **OR** Rule 7.6.1.6 – **Discretionary** Activity for Surface Discharges from Development Geothermal Systems	Takes exceeding 6,000 tonnes/day require a draft System Management Plan prepared and provided as part of the resource consent application documentation. It is noted that an SMP already exists for the Rotokawa Development Geothermal System.
Stormwater	Discharge if stormwater generated from access roads etc Stormwater generated from the drilling rig pad should be managed with other fluid discharges from the drill pond.	For the full duration of the activity.	Rule 3.5.11.5 – **Permitted** Discharge of Stormwater onto or into land	The discharge of stormwater to land is a permitted activity provided that any hazardous substances in the stormwater are at levels that are consistent with the relevant national guidance including the Hazardous Substances and New Organisms Act ("HASNO")

13.1.1 Consenting timeline

Timeframes associated with resource consenting processes are highly variable. We have estimated a possible timeframe and steps associated with resource consenting requirements for exploratory well drilling at Site 2 in the diagram below.

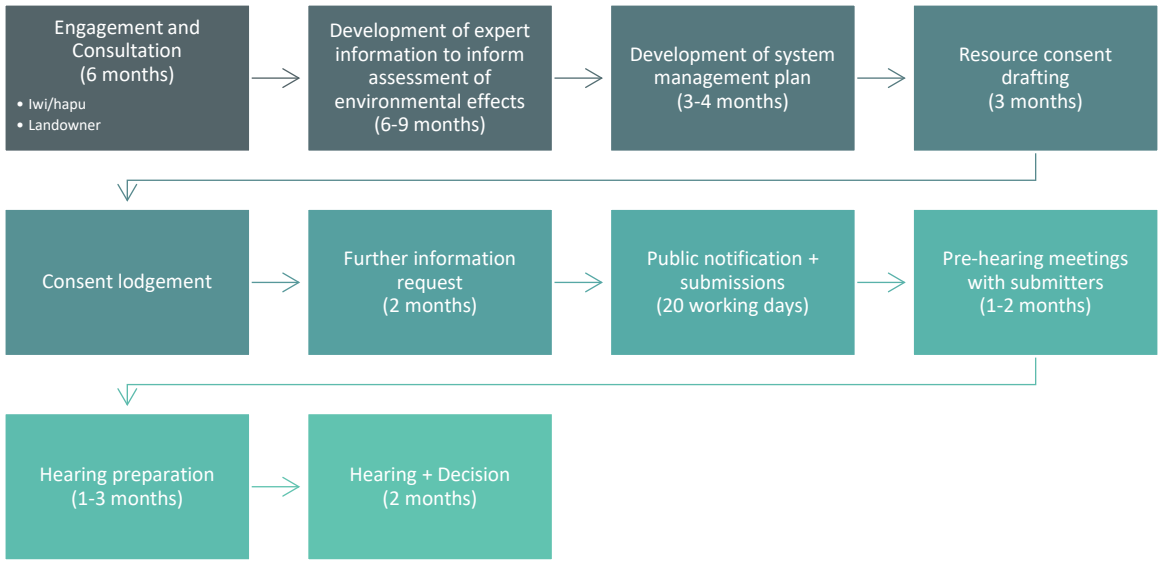

Figure 15 Resource Consent process timeframe for Site 2

The process for obtaining resource consent for Site 2 is similar to Site 1, with the additional requirement of developing or updating a system management plan due to the site being located within the Rotokawa Development Geothermal System. This additional step can be completed alongside the other expert assessments and is therefore not anticipated to add significant additional time to the resource consenting process.

Based on the above steps, we estimate it could be around 18 months – 2.5 years for a resource consent process to be completed.

13.2 Utilising existing resource consents for Deep Drilling at Rotokawa Development Geothermal Field

An alternative option available at Site 2 is the potential to utilise existing consents (issued in 2008) already held for geothermal exploration and production within the Rotokawa Development Geothermal System.

Existing development within the Rotokawa Geothermal Field comprises the two power stations – the 34MW Rotokawa A power station commissioned in 1997, the 140MW Nga Awa Purua power station commissioned in 2010, and the associated supporting steamfield and infrastructure

Table 9 outlines the existing resource consents held for geothermal exploration/production and identifies aspects of the consent conditions which may need to be varied to enable the consent to be utilised for ~6km geothermal exploratory activity.

Table 9 Summary of existing consents and associated conditions held for the Rotokawa Development Geothermal System likely to be used if ~6km deep drilling is pursued

Existing consent reference	Relevant conditions of consent with potential implications for deep well drilling/testing
Freshwater take Resource Consent AUTH120655.01.03 Take of water from the Waikato River	Expiry on 1 July 2032 Requirements for the activity to be undertaken in general accordance with the application for resource consent. To utilise this consent, operators would need to be comfortable that the proposed water take activities associated with deep drilling are consistent with what was originally proposed or a variation to the consent may be required. Location specific requirements about where in the Waikato River water can be abstracted from which would need to be met. Maximum water take Is limited to 394 litres/second while the maximum daily take volume is 3800 m^3/day, with an exception for up to 13 calendar days where water volume can be up to 8,500m^3/day and maximum annual take volume not to exceed 1,390,800m^3/year. It is likely that this water volume would not be adequate to support the drilling of a ~6km deep well (anticipated at a maximum of 6,000 tonnes/day) and therefore it is likely a new consent would be needed to enable additional water to be used, or an alternative groundwater source is identified for the additional water needed. Additional restrictions apply on daily take volumes where the taking of water would cause the level of Lake Taupō to be below 355.95 m above sea level, or the flow in the Waikato River to be less than 50m^3/s – daily take volumes restricted to 3,230m^3/day or 7,225m^3/day (on the 13 exception days). This would further limit the amount of water available for deep drilling and would also require additional water to be sourced and consented. Intake velocity to not exceed 0.3m/s which is a standard condition to ensure aquatic species are not affected by at the water intake. A new consent would likely be required for this activity given the remaining consent term and when a deep exploratory well might be drilled.
Freshwater use Resource Consent 120656 Use of water from the Waikato River	Expiry on 1 July 2032 A new consent would likely be required for this activity given the remaining consent term and when a deep exploratory well might be drilled. Daily volume of water used to not exceed 8,500m^3/day (with a range of other restrictions from the take consent), which in combination with other exiting uses may be insufficient to also enable the drilling time required for a deep exploratory well.
Discharge of geothermal water etc to land through injection	35-year expiry date

Existing consent reference	Relevant conditions of consent with potential implications for deep well drilling/testing
Resource Consent AUTH136402.02.01 Discharge to land of geothermal water together with steam condensate, cooling water and added chemicals into underground strata through injection wells.	Volume per year limited 22,143,000 tonnes/year, at an average of 60,500 tonnes/day up to a maximum of 70,5000 tonnes per day. Likely to be sufficient, subject to managing all consented activities and the deep well within this limit.
Discharge of stormwater + contaminants to land Resource Consent AUTH136402.04.01 To discharge stormwater and stormwater-borne contaminants into land	35-year expiry date If permitted activity cannot be met, this consent could be relied on for stormwater discharge
Take and use of geothermal water and energy for well testing Resource Consent AUTH136402.08.01 To take and use geothermal water and associated energy and heat from underground strata for well testing purposes.	35-year expiry date Maximum volume of geothermal water taken shall not exceed 25,000 tonnes in any 24-hour period. This will be sufficient to enable the testing of a deep geothermal well providing total consented use is within this limit.
Discharge of freshwater, geothermal water, steam and chemicals Resource Consent AUTH136402.09.01 Discharge of freshwater, geothermal water, steam condensate and added chemicals into groundwater (including geothermal water) in associated with well drilling and testing or steam field maintenance activities.	35-year expiry date Maximum daily discharge volume of 15,000 tonnes/day is anticipated to be sufficient to enable the testing of a deep geothermal well. Chemical being discharged are limited to those added for the purposes of limiting or removing scale deposition, biocidal control of organic growth, to conduct tracer test and to enable safe and efficient ongoing maintenance and operation and listed in the schedule attached to the consent. No discharges to into or onto land that could affect aquatic life.
Discharge to Air Resource Consent AUTH136402.10.01 Discharge of geothermal vapour and non-condensable gases to air from activity associated with well drilling, well testing or steam field maintenance.	35-year expiry date Requirement to keep hydrogen sulphide to a practicable minimum – with no specified limits, testing activities may result in hydrogen sulphide being generated to levels not anticipated by the existing consent, however it is noted that the gas levels at Rotokawa have been reducing as the reservoir has been produced.
Discharge of drilling fluids into underground water Resource Consent AUTH136402.11.01 Discharge of freshwater, drilling muds and fluids, all containing various solids, chemicals and other contaminants into soakage facilities and by seepage into underground water during drilling and testing of wells.	35-year expiry date The maximum discharge shall not exceed: a. 10,000 tonnes per day discharge of water during injection testing. b. 4,500 tonnes per day discharge of water during completion testing. c. 10,000 tonnes per day discharge of drilling fluids into land and underground water (for example, in the event of down hole losses during drilling). d. 600 tonnes per day discharge of drilling fluids, but not including stormwater, onto land and from there by seepage into underground water.

Existing consent reference	Relevant conditions of consent with potential implications for deep well drilling/testing
	Based on the volume restrictions above, it is anticipated that existing consented volumes will be sufficient to enable deep well drilling. Volume requirements to enable for completion testing may require amendment.
Well drilling Resource Consent AUTH136402.12.01 To drill deep geothermal wells, monitoring wells, and to undertake well testing and drilling activities that involve drilling below the water table and to construct well pads, pipelines and roads and undertake earthworks and vegetation clearance in High Risk Erosion Areas.	35-year expiry date Existing consent could be relied on subject to well tracks required to meet the following conditions: a. pass beneath the Waikato River bed at no less than 500m below it; and b. are contained outside the vertical boundaries of a 30 metre buffer zone around any wāhi tapu site as identified in any district plan, in the NZ Archaeological Association's Site Recording Scheme, or by the Historic Places Trust except where Historic Places Trust approval has been obtained; and; c. are contained outside the vertical boundaries of a 50 metre buffer zone around Lake Rotokawa and Significant Geothermal Water Features as identified in Regional Plan Map "Lake Rotokawa" (May 2007).

13.2.1 Summary of consent variations/new consents required

Based on the analysis of consents summarised in Table 9, a variation or new consent would be expected to be required to enable a greater volume of freshwater take and use to enable the deeper drilling. The completion testing volume under AUTH136402.11.01 may require amendment by way of variation. The remaining consents are likely to be sufficient to enable deeper drilling, provided the associated consent conditions can be achieved in combination with other current and consented activities occurring on the broader Rotokawa site.

There are a series of general conditions that apply to all the Rotokawa resource consents. All these conditions are relevant to activities undertaken which rely on these consents. Where compliance cannot be achieved or it is unclear whether it will be achieved, a variation to the consent conditions or a new consent focussed on the deep well testing may be needed.

The general conditions require that a system management plan be provided for the Rotokawa Development Geothermal System. While the existing consent holder has prepared a system management plan, it is likely that alterations will be needed to this plan to include ~6km deep drilling and well testing to ensure these activities are anticipated by the system management plan.

13.2.2 Consenting timeline

The process for seeking a variation to the existing consents for additional freshwater take and use is very similar to that required for an entirely new consent and given the significance of the water requirements, would likely be the determining factor in whether deep drilling could be successful in this location. Both require consent to be obtained for a Discretionary Activity, following the process outlined in Figure 15 above.

13.3 Additional considerations/requirements

Engagement with Ngāti Tūwharetoa, Raukawa and Affiliate Te Arawa Iwi/Hapū for any consent application is necessary, including as a result of Statutory Acknowledgements in the area. Regional Councils are required to have regard to statutory acknowledgements when determining who is an affected party for the purpose of notification of any application. As a minimum, applications will need to ensure that they align with the direction of Te Ture Whaimana, the Vision and Strategy for the Waikato River. In addition, an assessment of cultural effects of any application will be required with any resource consent application lodged.

A legal encumbrance relating to geothermal exploration over the Site 2 area is in place and would need to be considered as part of any resource consent application process. Review and updating of the existing system management plan for the Rotokawa Development Geothermal Field is required as part of any future consent applications.

14 Site 3 description

Scenario site 3 is located in the Bay of Plenty Region and is situated outside of the any identified Geothermal System boundaries from the Bay of Plenty Regional Plan as shown on Figure 16 which the BOPRC would consider as a research system[3].

The site is located within several areas specified in the Rotorua Lakes Council District Plan including:

- Outstanding Natural Feature or Landscape area – Makatiti Dome Northern Slopes
- Natural Heritage Area

The site is also located within the Makatiti Dome Scenic Reserve which is an area of Public Conservation Land.

The site is not identified as being within any areas of Statutory Acknowledgement as shown on Figure 12 but is recorded as Māori Freehold Land on the certificate of title.

[3] BOPRC have advised that a plan change is being prepared, at the time of writing, which is exploring the potential identification of a geothermal system in this area, but decisions on that will be some time away.

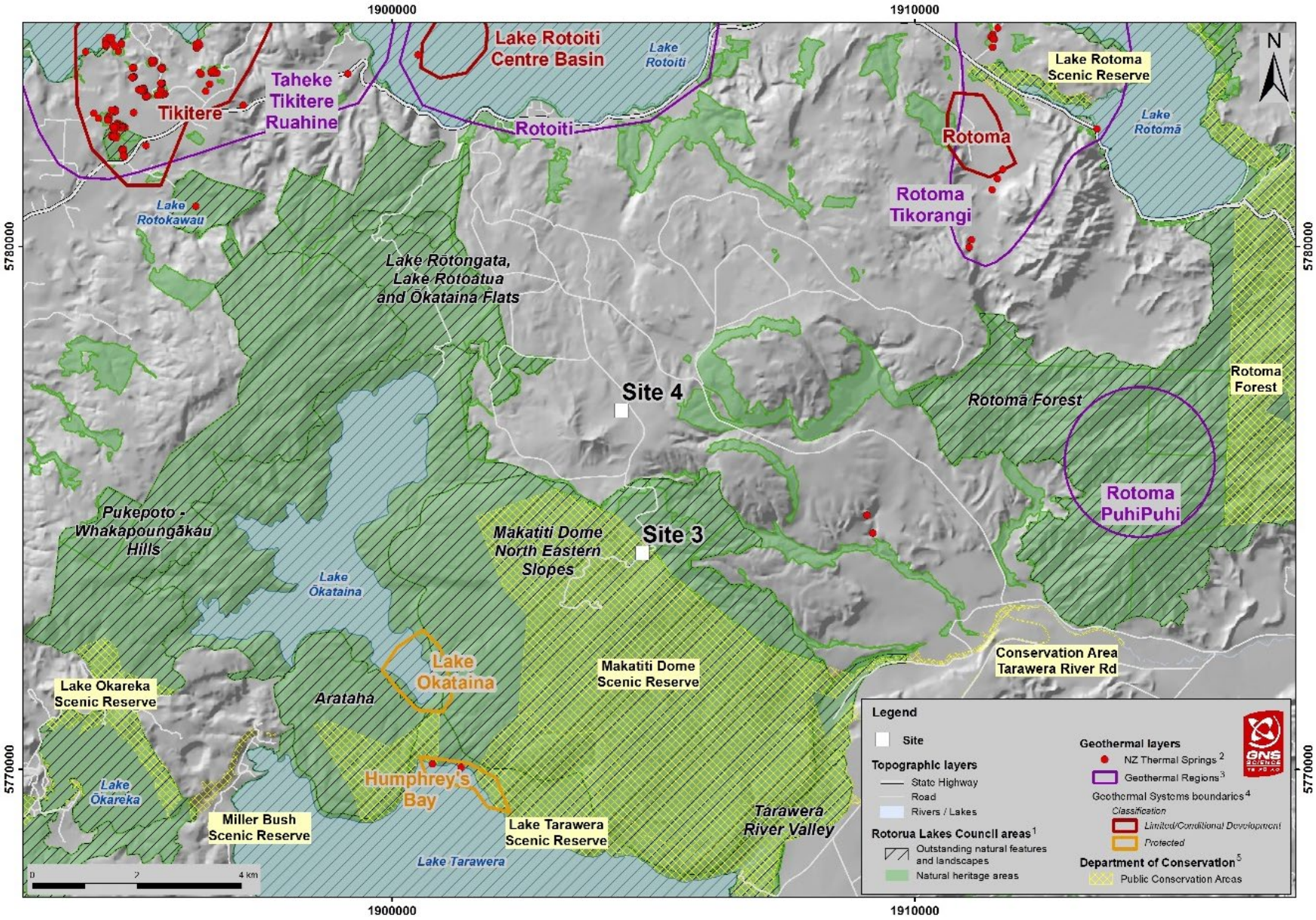

Figure 16 Scenario Sites 3 and 4 locations

14.1 Anticipated resource consent requirements

The following table outlines what we anticipate will be the resource consenting requirements at Site 3.

Table 10 Scenario Site 3 Resource Consent Requirements Summary

Resource/ Use	Purpose	Nature of the resource	Anticipated rule/activity status	Comments
Act of well drilling	Consent for drilling the well	Activity of constructing a well	Discretionary Activity Not strictly provided for in the Bay of Plenty Regional Plan so assumption is that consent will be required under Section 87B (1)(b) of the RMA.	There is currently a gap in the Plan for the drilling of a well outside of an identified Geothermal Management Area therefore a default discretionary activity is assumed based on advice from BOPRC.
Drilling fluid	Drilling the well	Freshwater mixed with bentonite mud and chemicals to enable drilling. Quantity of Freshwater needed = maximum of 6,000 tonnes/day, averaging around 4,000 tonnes/day. Could be ground or surface water. Duration: 90-140 days	Rule 43 – Discretionary Activity Take and use of surface or groundwater	Potentially Lake Okataina or Lake Tarawera or their tributaries could be a source of surface water. Groundwater could also be used under the same rule – noting there is no current assessment of groundwater availability in this area from BOPRC.
Drilling fluid waste	Rock material from the drilling brought to surface and stored in pond, rock material cleaned out. AND Drilling fluid to be injected AND Drilling fluid to be discharged to ground AND	Freshwater with suspended rock materials, clay, and drilling chemicals and potentially some geothermal fluids (depending on pressure conditions). Quantity: • Up to 100 m^3/day during drilling of the upper sections of the well for 90-140 days	Discretionary Activity Not strictly provided for in the Bay of Plenty Regional Plan so assumption is that consent will be required under Section 87B (1)(b) of the RMA.	Drilling activities create waste materials that are collected in ponds with the surplus fluids either discharged to land, or injected into a well. Usually two ponds are used. The first pond is lined and allows for settlement of rock particles and other solids brought up from underground. The second pond is a soakage pond that has permeability adequate to allow the liquid to infiltrate the soil and groundwater. While there may be some geothermal water in this fluid, it is predominately freshwater used for drilling with some contaminants from the drilling process such as clay and chemicals used in drilling.

Resource/ Use	Purpose	Nature of the resource	Anticipated rule/activity status	Comments
	Drilling fluid likely lost to groundwater AND Solids left over – to landfill (could be the pond itself or could be taken offsite)	• Up to 300 m^3/day during cementing casing for 24 hours per casing string		Advice from BOPRC is that during drilling, the discharge of drilling fluid will be covered by the drilling rule. As there is currently a gap in the Plan for the drilling of a well outside of an identified Geothermal Management Area, a default discretionary activity is assumed in relation to discharge of drilling fluid waste also.
Well testing	Completion testing – pumping freshwater into the well to test the pressure change in the well and temperature change in the well at different flow rates.	Freshwater Quantity of Freshwater needed = 4,000 litres/minute (~5500 tonnes/day) Duration: 1-2 days of 24/7 operation at different flow rates to allow for testing.	Rule 43 – **Discretionary** Activity Take and use of surface or groundwater AND Rule 12 – **Permitted** Activity for a change of land use activity in the catchment of Lake Okataina.	Potentially Lake Okataina or Lake Tarawera or their tributaries could be a source of surface water. Groundwater could also be used under the same rule – noting there is no current assessment of groundwater availability in this area from BOPRC.
Flow testing	Understand the well capacity. Initially, likely to have a mix of steam and water and then as time goes by, will only be a steam discharge.	Steam Quantity of stream discharged = 6,000 tonnes/day maximum Duration: Up to 90 days	Rule AIR R16 **Discretionary** Activity Discharge of geothermal gases and steam into air from any bore associated with the anthropogenic use of geothermal water and geothermal energy.	Discharge cannot meet the permitted activity standards under Rule AIR R4 which is specific to geothermal discharges but provides for discharges that are < 1,000 tonnes/day.
		Geothermal fluid (steam and water) Quantity of geothermal fluid discharged: up to 7,000 tonnes/day (to surface ponds and then reinjected) Duration: 5-10 days	GR R2 (Rule 73) **Discretionary** to take and use geothermal water, heat or energy AND GR R9 (Rule 77) – **Restricted Discretionary** Activity Discharge of Geothermal Water by Reinjection (Discharge of Geothermal Water onto or into land in circumstances where it may enter water (including land soakage and reinjection) AND/OR GR R10 (Rule 77A) **Discretionary** Activity	Drilling activities create waste materials that are collected in ponds and either discharged to land or reinjected into a well. If ponds are used and the waste fluid is not reinjected, usually two ponds are used. The first pond is lined and allows for settlement of rock particles and other solids brought up from underground. The second pond is a soakage pond that has permeability to allow the liquid to infiltrate soil and groundwater.

Resource/ Use	Purpose	Nature of the resource	Anticipated rule/activity status	Comments
			Discharge of Geothermal Water onto or into land (including land soakage)	
Stormwater	Stormwater discharge from the well pad site throughout the construction, well drilling and testing phases		DW R22 Permitted Activity – Discharge of Stormwater to land soakage	No resource consent required for a permitted activity.

14.1.1 Consenting timeline

Site 3 requires not only a resource consenting process like the other three sites, but also requires an approval process under the Reserves Act to reclassify or revoke the current Scenic Reserve classification of the land to enable exploratory drilling. Like resource consent processes, reserve management change/revocation processes can have highly variable timeframes. We have estimated a possible timeframe and steps associated with resource consenting requirements for exploratory well drilling at Site 3 in the diagram below.

We consider that the reserve classification change/revocation process could add around an additional 7 months to the timeframe for approvals (totalling between 2-3 years). If this reserve process is unsuccessful, progression to a resource consent application would not continue, which has implications for the staging and sequencing of the regulatory approvals process.

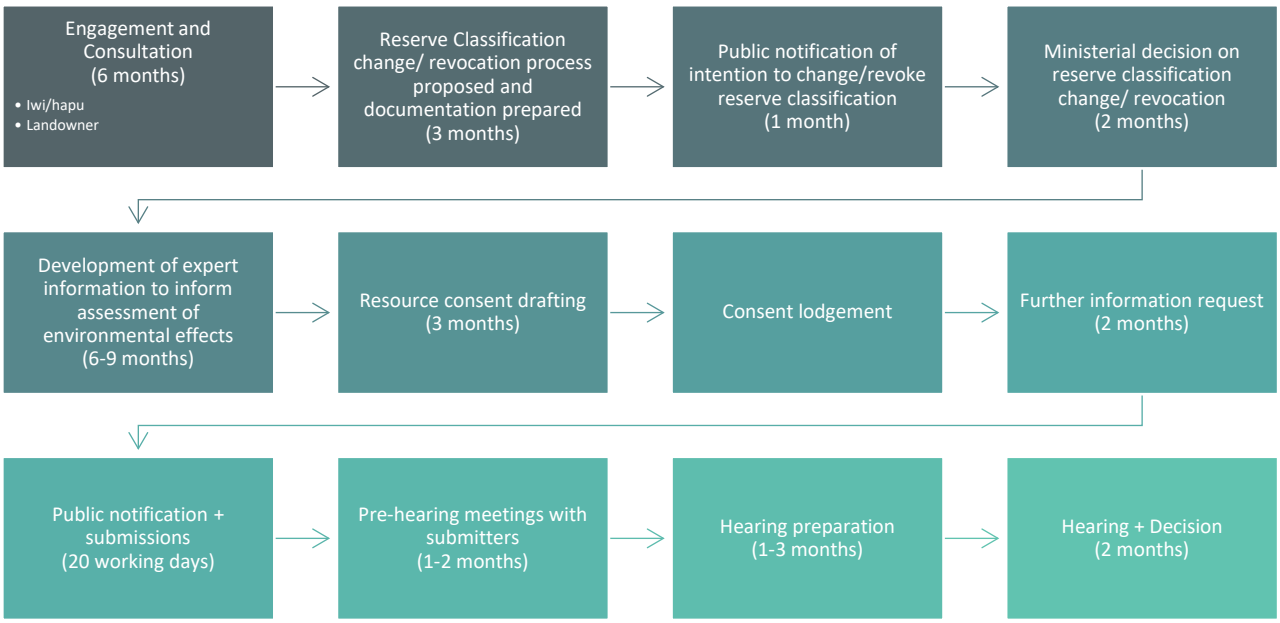

Figure 17 Reserve Classification change/revocation and Resource Consent preparation processes for Site 3

14.3 Additional considerations/requirements

14.3.1 Māori Freehold Land

The land at Scenario site 3 is identified as being Māori Freehold Land. This recognises that the land has economic and cultural value and while it can be treated as general land that can be sold or transferred, there are imperatives in place through the Te Ture Whenua Māori Act 1993 to ensure that the land stays in the hands of its owners, whānau and hapū. The cultural value of the land is considered to be a tangible whakapapa (genealogical) link for owners to their past and present whānau, hapū and iwi[4]. An assessment of cultural effects of any application will be required with any resource consent application lodged.

14.3.2 Reserve Status

Given the Scenic Reserve status of the wider Site 3 area, consideration of the requirements of the Reserves Act 1977 are needed. A Scenic Reserve is classified under the Reserves Act 1977 "*for the purposes of protecting and preserving in perpetuity for their intrinsic worth and for the benefit, enjoyment, and use of the public, suitable areas possessing such qualities of scenic interest, beauty, or natural features or landscape that their protection and preservation are desirable in the public interest*".

Given the intended protection under the Scenic Reserve classification, development of a geothermal well in this area is likely to require the need for approval under the Reserves Act to change the classification of the reserve, potentially to a Scientific Reserve, to provide for the establishment of a geothermal well. The process of this change requires an application to the Minister of Conservation and will require a fully publicly notified process to enable the change. There is no guarantee that a change of this nature for exploratory drilling would be approved.

14.3.3 Makatiti Dome - Outstanding Natural Feature/Landscape and Natural Heritage Area

Site 3 is located within the Makatiti Dome Outstanding Natural Features and Landscapes ("ONFL") area.

General direction through the objectives and policies in the Rotorua Lakes District Plan ("District Plan") is that ONFL areas are to be protected from the adverse effects of inappropriate use and development

Buildings and structures, earthworks and the disturbance of indigenous vegetation in an ONFL will require resource consent as a discretionary activity under the District Plan.

[4] Māori Land online https://maorilandcourt.govt.nz/your-maori-land/#maori-freehold

Site 3 is also identified as being within the Significant Natural Area “Makatiti Dome North Eastern Slopes” due to its ecological significance. The District Plan seeks to avoid, remedy or mitigate the adverse effects of development on these areas.

While likely not insurmountable, these additional resource consent requirements add significant additional complexity to this site and it is likely that if an alternative site can be found, that would be preferable to development in this more sensitive area.

15 Site 4 description

Scenario site 4 is also located in the Bay of Plenty Region and is situated outside of any identified Geothermal System boundaries from the Bay of Plenty Regional Plan as shown on Figure 16.

The site is located outside of any specified areas on the Rotorua Lakes Council District Plan including:

- Outstanding Natural Feature or Landscape area
- Natural Heritage Areas

The site is not located within any areas of Public Conservation Land or on any sites identified as being Outstanding Natural Features or Landscapes or in areas of Significant Natural Areas.

The site is not located within any areas of Statutory Acknowledgement as shown on Figure 12 but is recorded as Māori Freehold Land on the certificate of title.

15.1 Anticipated resource consent requirements

The following table outlines what we anticipate will be the resource consenting requirements at Site 4.

Table 11 Scenario Site 4 Resource Consent Requirements Summary

Resource Use	Purpose	Nature of the resource	Anticipated rule/activity status	Comments
Act of well drilling	Consent for drilling the well	Activity of constructing a well	Discretionary Activity Not strictly provided for in the Bay of Plenty Regional Plan so assumption is that consent will be required under Section 87B (1)(b) of the RMA.	There is currently a gap in the Plan for the drilling of a well outside of an identified Geothermal Management Area therefore a default discretionary activity is assumed based on advice from BOPRC.
Drilling fluid	Drilling the well	Freshwater mixed with bentonite mud and chemicals to enable drilling. Quantity of Freshwater needed = maximum of 6,000 tonnes/day, averaging around 4,000 tonnes/day. Could be ground or surface water. Duration: 90-140 days	Rule 43 – Discretionary Activity Take and use of surface or groundwater	Potentially Lake Okataina or Lake Tarawera or their tributaries could be a source of surface water. Groundwater could also be used under the same rule – noting there is no current assessment of groundwater availability in this area from BOPRC.

Drilling fluid waste	Rock material from the drilling brought to surface and stored in pond, rock material cleaned out. AND Drilling fluid to be injected AND Drilling fluid to be discharged to ground AND Drilling fluid likely lost to groundwater AND Solids left over – to landfill (could be the pond itself or could be taken offsite)	Freshwater with suspended rock materials, clay, and drilling chemicals and potentially some geothermal fluids (depending on pressure conditions in the well). Quantity: • Up to 100 m^3/day during drilling of the upper sections of the well for 90-140 days • Up to 300 m^3/day during cementing casing for 24 hours per casing string	Discretionary Activity Not strictly provided for in the Bay of Plenty Regional Plan so assumption is that consent will be required under Section 87B (1)(b) of the RMA.	Drilling activities create waste materials that are collected in ponds with the surplus fluids either discharged to land, or injected into a well. Usually two ponds are used. The first pond is lined and allows for settlement of rock particles and other solids brought up from underground. The second pond is a soakage pond that has permeability adequate to allow the liquid to infiltrate the soil and groundwater. While there may be some geothermal water in this fluid, it is predominately freshwater used for drilling with some contaminants from the drilling process such as clay and chemicals used in drilling. Advice from BOPRC is that during drilling, the discharge of drilling fluid will be covered by the drilling rule. As there is currently a gap in the Plan for the drilling of a well outside of an identified Geothermal Management Area, a default discretionary activity is assumed in relation to discharge of drilling fluid waste also.
Well testing	Completion testing – pumping freshwater into the well to test the pressure change in the well and temperature change in the well at different flow rates.	Freshwater Quantity of Freshwater needed = 4,000 litres/minute (~5,500 tonnes/day) Duration: 1-2 days of 24/7 operation at different flow rates to allow for testing.	Rule 43 – Discretionary Activity Take and use of surface or groundwater AND Rule 12 – Permitted Activity for a change of land use activity in the catchment of Lake Okataina.	Potentially Lake Okataina or Lake Tarawera or their tributaries could be a source of surface water. Groundwater could also be used under the same rule – noting there is no current assessment of groundwater availability in this area from BOPRC.
Flow testing	Understand the well capacity. Initially, likely to have a mix of steam and water and then as time goes by, will only be a steam discharge.	Steam Quantity of stream discharged = 6,000 tonnes/day maximum Duration: Up to 90 days	Rule AIR R16 Discretionary Activity Discharge of geothermal gases and steam into air from any bore associated with the anthropogenic use of geothermal water and geothermal energy.	Discharge cannot meet the permitted activity standards under Rule AIR R4 which is specific to geothermal discharges but provides for discharges that are < 1,000 tonnes/day.

		Geothermal fluid (steam and water) Quantity of geothermal fluid discharged: up to 7,000 tonnes/day (to surface ponds and then reinjected) Duration: 5-10 days	GR R2 (Rule 73) **Discretionary** to take and use geothermal water, heat or energy **AND** GR R9 (Rule 77) – **Restricted Discretionary** Activity Discharge of Geothermal Water by Reinjection (Discharge of Geothermal Water onto or into land in circumstances where it may enter water (including land soakage and reinjection) **AND/OR** GR R10 (Rule 77A) **Discretionary** Activity Discharge of Geothermal Water onto or into land (including land soakage)	Flow testing requires water to be collected in ponds and either discharged to land or reinjected into a well. If ponds are used and the fluid is not reinjected, usually two ponds are used. The first pond is lined and allows for settlement of rock particles and other materials that might be brought up from underground. The second pond is a soakage pond that has permeability to allow the liquid to infiltrate soil and groundwater.
Stormwater	Stormwater discharge from the well pad site throughout the construction, well drilling and testing phases		DW R22 **Permitted** Activity – Discharge of Stormwater to land soakage	No resource consent required for a permitted activity.

15.1.1 Consenting timeline

Timeframes associated with resource consenting processes are highly variable. We have estimated a possible timeframe and steps associated with resource consenting requirements for exploratory well drilling at Site 4 in the diagram below.

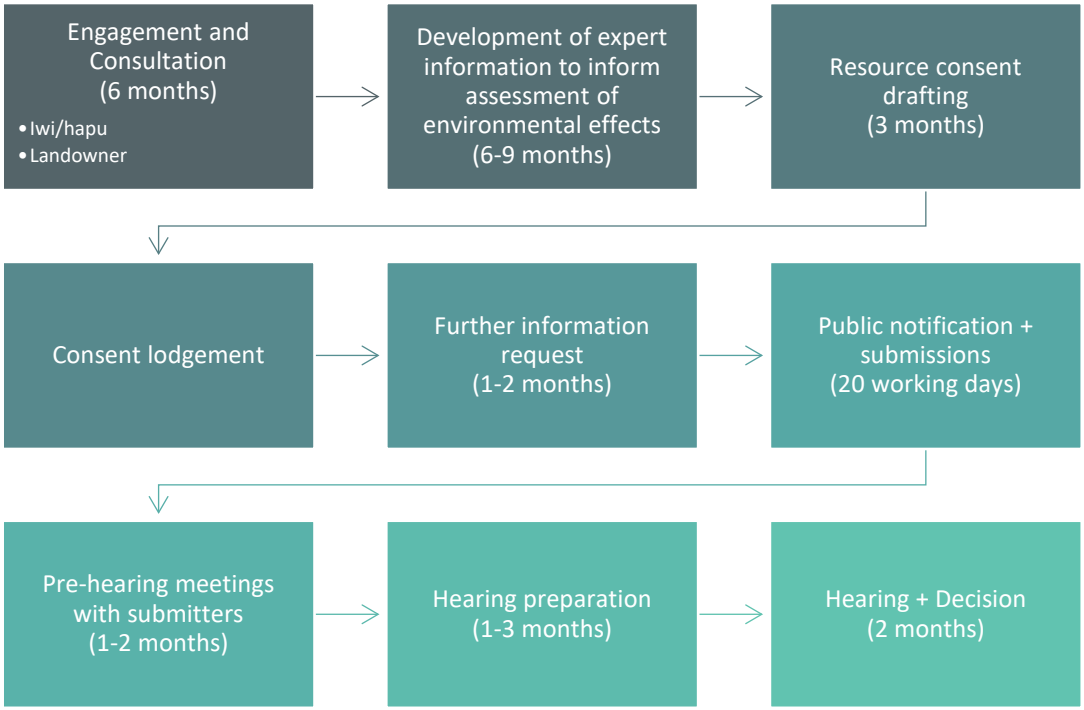

Figure 18 Resource Consent process timeframe - Site 4

The steps involved in applying for resource consent for Site 4 are the same as those for Site 1. A similar estimate of around 18 months – 2.5 years is anticipated for a resource consent process to be completed for Site 4.

15.2 Additional considerations/requirements

15.2.1 Māori Freehold Land

The land at Site 4 is identified as being Māori Freehold Land. This recognises that the land has economic and cultural value and while it can be treated as general land that can be sold or transferred, there are strong rules around ensuring that the land stays in the hands of its owners, whānau and hapū. The cultural value of the land is considered to be a tangible whakapapa (genealogical) link for owners to their past and present whānau, hapū and iwi[5]. An assessment of cultural effects of any application will be required with any resource consent application lodged.

[5] Māori Land online https://maorilandcourt.govt.nz/your-maori-land/#maori-freehold

16 Utilising existing resource consents for Deep Drilling – Tauhara II Geothermal Development

In December 2010, a series of resource consents were granted for Tauhara II Geothermal Development Project (EPA 2010). The application documents outline the main components of the project as:

- A power station and ancillary facilities that uses geothermal energy to generate approximately 240 MWe net;
- A new switchyard and modifications to the transmission lines to connect the power station to the nearby national electricity transmission network;
- Cross-country pipelines with separator stations connecting well pads to the power station and injection wells;
- Geothermal wells for production and reinjection/injection; and
- New vehicle access to the consent application area from local roads and state highways and the provision of internal service roads and other infrastructure such as water, power, and telecommunications.

Development under the Tauhara II suite of consents is currently underway.

Table 12 provides a summary of the relevant consent documents and the associated conditions likely to be of particular relevance to a deep drilling proposal.

Table 12 Assessment of relevant resource consents for the Tauhara II Geothermal Development Project and their associated conditions

Existing consent reference	Relevant specific conditions of consent with potential implications for deep well drilling/testing
Geothermal water and associated energy take and use EPA 10/1.004 (WRC 120544): Water permit to take and use up to 213 kilotonnes per day of geothermal water and associated energy and heat within the Consent Application Area for any purpose directly or indirectly associated with the generation of electricity or the direct supply of steam, water or heat including well and aquifer testing and well maintenance.	This would be the main consent relating to the take and use of geothermal fluids for testing. The volume of fluids consented. Conditions restricting the physical location of works to be within boundaries of the consented area. Volume limit of 213 kilotonnes/day would likely be sufficient for the well testing phase of a deep well in conjunction with other abstraction occurring. 35-year expiry date
Discharge of Water into land and underground water EPA 10/1.005 (WRC 120545): Discharge permit to discharge up to 194 kilotonnes per day of water including geothermal water, steam condensate, cooling water blowdown, suspended material, and added chemicals and tracers into land and underground water through reinjection and/or injection wells within the Consent Application Area.	Conditions restricting the physical location of reinjection/ injection wells to be within boundaries of the consented area. Discharge volumes of up to 168 kilotonnes/day including geothermal water steam condensate, cooling water blowdown, suspended material, and added chemicals and tracers. This volume is likely sufficient to include well testing required for a deep well. 35-year expiry date
Discharge of Contaminants to Air EPA 10/1.007 (WRC 120547): Discharge permit to discharge contaminants to air from two geothermal power stations and any direct use of heat and associated structures and steamfield activities within the Consent Application Area, including from geothermal wells (including during drilling, testing and maintenance), separation plants and silencers, pipeline drains, vents and condensate traps and all associated geothermal steamfield equipment.	Hydrogen sulphide emissions would need to be kept to less than 60 kg/hour from Tauhara I and 900 kg/hr from Tauhara II Power Stations. Where there may be unknowns associated with deep drilling and hydrogen sulphide production a separate application may be needed to provide adequate certainty for the gas discharges associated with deep well flow testing. 35-year expiry date
Land Use consent to drill wells EPA 10/1.008 (WRC 120548): Land use consent to construct and/or alter wells drilled below the groundwater table within the Consent Application Area.	There are no conditions or apparent restrictions on the depth of well drilling under this consent therefore no apparent reason why drilling couldn't extend to ~6km deep under this consent. Conditions restrict the physical location of reinjection/injection wells, including well tracks, to within the boundaries of the consented area. Archaeological and wāhi tapu sites would need to be understood for the site. Heritage New Zealand Pouhere Taonga maintains the Heritage Register which would need to be checked. However, this would require input from local iwi/hapū to ensure wāhi tapu (ancestral sacred sites) where identified and located prior to a drilling location being confirmed. This will likely have already been undertaken as part of establishing suitable locations for current drilling operations. 35-year expiry date

Existing consent reference	Relevant specific conditions of consent with potential implications for deep well drilling/testing
Discharge of water onto or into land and underground water EPA 10/1.009 (WRC 120549): Discharge permit to discharge water, including geothermal water, steam condensate, cooling tower blowdown, drilling muds and drilling fluids, all containing various solids, added chemicals and other contaminants during well drilling, well and aquifer testing and well commissioning onto and into land and underground water, within the Consent Application Area.	Drilling discharges of 100 to 300 m^3 per day are within the volume limits of the consent and this consent would be expected to be able to be used during the actual drilling operations Around 7,000 tonnes/day of discharge are anticipated for a ~6km deep geothermal well for a period up to ~10 days as part of flow testing a deep exploratory well, current restrictions on this consent limit the max. daily discharge via soakage ponds to 4,000 tonnes/day for this type of discharge. Therefore, variation to this consent, or a new consent would be required to enable the discharge anticipated from a deep well using pond soakage discharge. Other conditions include the provision for up to 15,0000 tonnes/day or 2.5 million tonnes per year of geothermal water to be discharged. Any discharge would need to be included with in these cumulative limits. Condition restrictions on chemical species cover: (a) Arsenic: 0.42 kg/month; (b) Boron: 63 kg/month; (c) Sodium: 9,450 kg/month; and (d) Chloride: 12,180 kg/month. Restrictions on the contaminant concentrations in geothermal water discharged are uncertain from a deep geothermal well, therefore these levels may not be met. May be appropriate to obtain a separate consent for exploratory well testing until contaminant concentrations are better understood from the deep resources. 35 year expiry date
Discharge of Stormwater and Groundwater onto or into land EPA 10/1.011 (WRC 120551): Discharge permit to discharge stormwater and groundwater including contaminants onto or into land by way of soakage (including in circumstances which may result in those contaminants entering water) within the Consent Application Area.	If the permitted activity in the regional plan does not apply to the well testing, this consent could be relied upon. 35 year expiry date
Take and Use of surface water from the Waikato River WRC 961044: Water permit to take and use surface water from the Waikato River for well drilling and testing, construction activities, domestic use, firefighting, cooling tower filling and makeup, power plants, steamfield and related and ancillary purposes.	Maximum rate of extraction shall not exceed 10,000 tonnes/day. It is anticipated that this water would be adequate to support the drilling of a ~6km deep well (anticipated maximum 6,0000 tonnes/day). Condition restricting the use of water for "purposes associated with the Tauhara I and Tauhara II Geothermal Development Projects. Those Projects include the Tauhara I Binary Plant on Centennial

Existing consent reference	Relevant specific conditions of consent with potential implications for deep well drilling/testing
	Drive, the Tauhara II Power Station north of Mount Tauhara and existing and future direct heat supply utilising resource consents held by the consent holder." There is a potential need for a variation to this consent for water use for an exploratory well not previously anticipated as part of the Tauhara I or II developments. Interpretation on this requirement would need to be sought from the Waikato Regional Council. 25 year expiry date (expiring 30 June 2026) In terms of timing, a new consent would likely be required for this activity given the remaining consent term and when a deep exploratory well might be drilled which is not going to be before 2026.

16.1 Summary of consent variations/new consents required

Based on the analysis of consents summarised in Table 12, a variations or new consents will likely be required to enable a greater volume of water being discharged onto or into land and underground water to enable flow testing as part of deeper exploratory activity. There is also the potential for a deeper well to exceed the consented hydrogen sulphide emissions levels and a variation or new consent may be required. The remaining consents are likely to be sufficient to enable deeper drilling, provided the associated consent conditions can be achieved, noting that the consent that currently enables the take and use of freshwater from the Waikato River for drilling expires in June 2026.

16.2 General conditions

There are a series of general conditions that apply to all the Tauhara resource consents. All these conditions are relevant to activities undertaken which rely on these consents. Where compliance cannot be achieved or it is unclear whether it will be achieved, a variation to the consent conditions or a new consent focussed on the deep well testing may be needed.

The general conditions require that a system management plan be provided for the Wairākei-Tauhara Development Geothermal System. While the existing consent holder has prepared a system management plan, it is likely that alterations will be needed to this plan to include ~6km deep drilling and well testing to ensure these activities are anticipated by the system management plan.

16.3 New consent/ consent variation timeline

Timeframes associated with resource consenting processes are highly variable including those associated with the variation of the conditions on existing consents. Given the public interest associated with the Tauhara II development, it is likely that changes to current consent conditions may need to be publicly notified. As a result, a new consent application or alteration to an existing consent application could have similar processes as outlined for Sites 1, 2 and 3 above taking up to 2.5 years to complete.

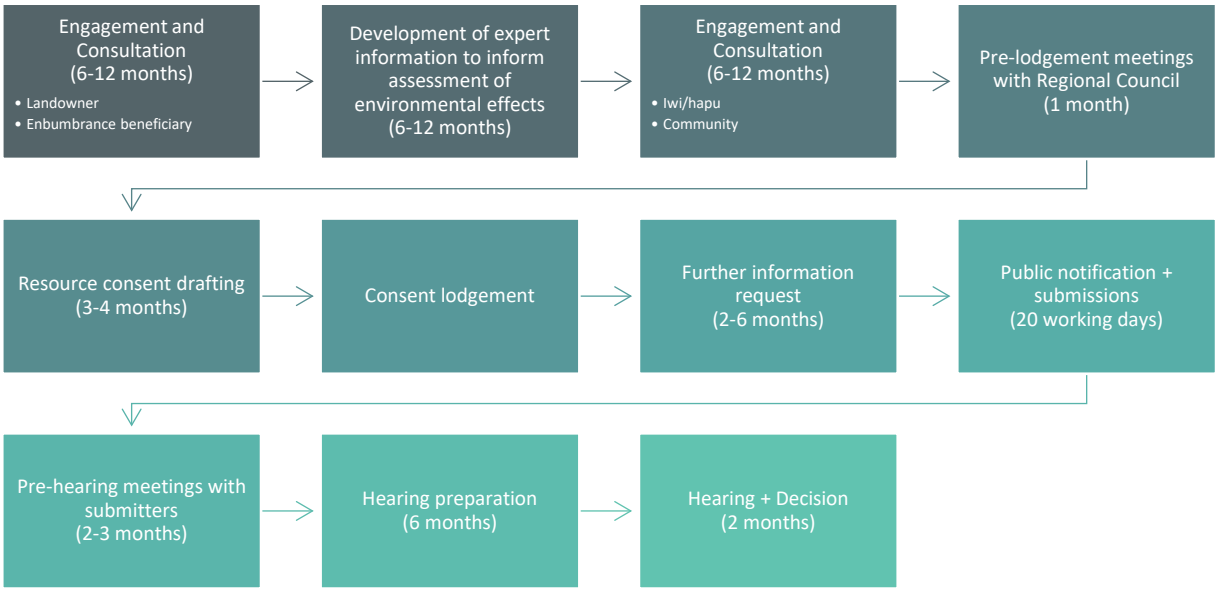

Figure 19 Resource Consent process timeframe – condition change or new consents required Tauhara II

16.4 Additional considerations/requirements

Engagement with Ngāti Tūwharetoa, Raukawa and Affiliate Te Arawa Iwi/Hapū for any consent application is necessary, including to recognise their Statutory Acknowledgements in the area. Regional Councils are required to have regard to statutory acknowledgements when determining who is an affected party for the purpose of notification of any application. In addition, applications will need to ensure that they align with the direction of Te Ture Whaimana, the Vision and Strategy for the Waikato River.

Review and updating of the existing system management plan for the Wairākei-Tauhara Development Geothermal Field is required as part of any future consent applications.

17 Conclusion

This report explores four standalone scenario sites and establishes the resource consent requirements for drilling a 6km deep geothermal well at each site. Also considered, is the potential to utilise existing resource consents at two sites where the establishment and production from geothermal wells have already been approved.

Of the three sites investigated where there are no established geothermal operations present, it is anticipated that the Site 4 in the Bay of Plenty has the potential to have the least limitations for the establishment of a deep exploratory well, provided that a suitable and available water source can be identified to provide the quantities of water needed for safe and efficient well drilling. Freshwater availability for use is a key resource management issue nationwide and given the volumes required, this will be an important element to resolve to enable drilling to proceed.

Generally, amending an existing consent is expected be a more straight-forward option than starting the resource consent process on a 'greenfields' site. However, assessing the existing suite of consents for the Rotokawa Geothermal Power Development and Tauhara II identified that neither were likely to be completely adequate for the full range of well drilling and testing activities anticipated. Preparation of resource consent applications and applications for variations needs to be factored into the planning timeline as part of preparation for deep exploratory drilling. These consent processes could take between 18 months – 2.5 years to complete.

Of the options considered, utilising the existing Rotokawa Geothermal Power Development consents would likely be the quickest way of consenting a deep exploratory well for the purposes of expanding our understanding of New Zealand's supercritical geothermal resources.

Obtaining resource consent for deep exploratory drilling activities will need to be carefully and rigorously planned for. It is important to ensure that the individual characteristics and requirements at a prospective site can be identified and addressed in any new application for consent(s) or in any variation to existing consent applications.

18 Acknowledgements

We are grateful for provision of drill site water use data, drilling expertise and particularly the review of Part A by Ralph Winmill, Senior Drilling Engineer, for Contact Energy Limited.

We appreciate the oversight of Penny Doorman and Mary Pappon, Bay of Plenty Regional Council and Mark Brockelsby, Waikato Regional Council on the regulatory aspects of the report.

Thanks to Western Energy Services and MB Century for the provision of images in the report.

19 References

Contact Energy (Contact), 2021. *GeoFuture Project – Wairākei Geothermal Field - Project Description.* Report being part of the documentation in an Application for Resource Consents to Waikato Regional Council 17 December 2021.

Environmental Protection Agency Board of Inquiry, 2010, *Final Report and Decision of the Board of Inquiry into the Tauhara II Geothermal Development Project; Volumes 1 and 2.* Report being the final decision produced under Section 149R of the Resource Management Act 1991. Decision retrieved from https://www.epa.govt.nz/assets/FileAPI/proposal/NSP000009/Boards-decision/a79c094a8c/Tauhara-II-Final-Decision-Volume-1.pdf. Consents retrieved from https://www.epa.govt.nz/assets/FileAPI/proposal/NSP000009/Boards-decision/342165bc23/Tauhara-II-Final-Decision-Volume-2-Part-2.pdf

Ingason, K., Kristjansson, V., Einarsson, K., *Design and development of the discharge system of IDDP-1.* Geothermics 49: 58-65. (2014)

Kissick, D., Climo, M., Carey, B., 2021 *An Overview of New Zealand's Geothermal Planning and Regulatory* Framework. Traverse Environmental Limited

NZS 2403, 2015. *Code of Practice for Deep Geothermal Wells*. New Zealand Standard.

Rivera, J., and Carey, B. *Comparative Geothermal Well Performance – Supercritical and Sub-Critical.* GNS Science Report 2023/01. ISBN 978-1-99-105800-3, DOI: 10.21420/EKKW-D514 (2023).

Robson, Q. and Winmill, R. 2000. *Wairākei Geothermal Field – Summary of Geothermal Drilling* Contact Energy.

Rotokawa Joint Venture (RJV), 2007. *Rotokawa Resource Consent Project Description*. Report being part of documentation in an application.

Rotokawa Joint Venture (RJV), 2015. *Geothermal Drilling Waste Management Plan.* Plan approved by the Waikato Regional Council as part of the RJV Rotokawa Resource Consents.

Top Energy Limited (Top), 2014. *Ngawha Expansion Project. Resource Consent Applications, Notice of Requirement and Assessment of Environmental Effects.* Application for resource consents to the Far North District Council and the Northland Regional Council.

Waikato Regional Council. 2008. Various resource consent certificates relating to consents granted to the Rotokawa Joint Venture for the development of Rotokawa Geothermal System.