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Review of geoheat opportunities in Taranaki

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PURPOSE

Ara Ake is interested in understanding the potential of the subsurface heat resource in Taranaki to support decarbonisation and energy innovation in Taranaki. A work programme is developed to compile and investigate publicly available information to identify low-temperature geothermal resources and highlight opportunities for greater geoheat use in the Taranaki region.

USE OF DATA

Date that Earth Sciences New Zealand can use associated data:
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EXECUTIVE SUMMARY

Ara Ake commissioned Earth Sciences New Zealand to evaluate the potential of repurposing existing petroleum wells prior to petroleum field closure to investigate the possible development of low-temperature geothermal resources ('geoheat') in the Taranaki region, supporting commitments to decarbonisation and energy innovation.

The work characterises the subsurface heat resource for onshore Taranaki, using publicly available geological and temperature data and available Earth Sciences New Zealand datasets.

Taranaki's subsurface temperatures are influenced by elevated regional heat flow, large aquifer systems, regional structural geology influences, surface and subsurface water flows, and volcanic topography. Industrial and commercial heat users in Taranaki, such as food and chemical manufacturing, greenhousing and space conditioning, currently rely on fossil gas for process energy. The ability to access and use naturally occurring heat from the ground represents a potential opportunity for energy decarbonisation in the region.

Data from petroleum boreholes provide valuable subsurface structure and temperature information. Repurposing petroleum boreholes to access known subsurface heat resources has been assessed. There is potential for these assets, as they are retired, to be used for heat energy production. There are a number of aspects that need to be considered, including borehole integrity, borehole abandonment practices and ongoing liabilities associated with these assets. Understanding the opportunities, as well as regulatory, economic and environmental constraints are important in assessing the reuse of petroleum infrastructure. These aspects will require detailed assessment before any repurposing occurs.

Potential opportunities for use of geoheat include district heating networks for urban and industrial clusters, process heat for food and chemical industries, greenhouse heating and integration with heat pumps for residential and commercial buildings.

Five qualitative assessments are reported:

1. Todd Energy Aquatic Centre (New Plymouth),
2. Taranaki Base Hospital (New Plymouth),
3. Greenhouses (regional),
4. Repurposing Kapuni Wells for Industrial District heating, and
5. Geothermal District heating for New Plymouth CBD and Port Taranaki.

To advance these opportunities, detailed feasibility studies will need to be developed. Work will include engagement with petroleum operators to clarify borehole status, engagement with regulators to develop an understanding of requirements associated with well repurposing, a heat demand/discharge mapping for the enterprises in the port area of New Plymouth and at other locations, and additional geo-scientific studies seeking to better characterise the geoheat opportunities in the Taranaki region.

1.0 Introduction

1.1 Project Background

Ara Ake is interested in understanding the potential of the subsurface heat resource to support decarbonisation and energy innovation in the Taranaki region. In addition, Ara Ake wishes to understand the opportunities around repurposing existing petroleum boreholes and infrastructure in the region before decommissioning of petroleum fields start to occur.

The objectives of this project are:

1. To investigate the publicly available data to identify the possible sources of low-temperature geothermal heat in Taranaki and whether they could provide thermal energy for residential, commercial, district and industrial-scale developments.
2. To investigate and identify a list of sites, where repurposing existing subsurface infrastructure may be achieved.
3. To outline applications for use of low-temperature geothermal resources.
4. Prepare a report highlighting opportunities for using low-temperature resources in Taranaki and identifying locations worth investigating further.

1.2 Introduction to Geoheat

Geothermal energy is stored heat in the subsurface. In areas where temperatures and pressures are high enough, electricity can be produced, as is seen in the Taupō Volcanic Zone (TVZ) in the central North Island. This natural heat in the ground can also be used directly and indirectly as heat (geoheat). There are numerous uses for temperatures ranging from stable ambient temperatures (12–20°C) to temperatures of over 250°C (Figure 1.1).

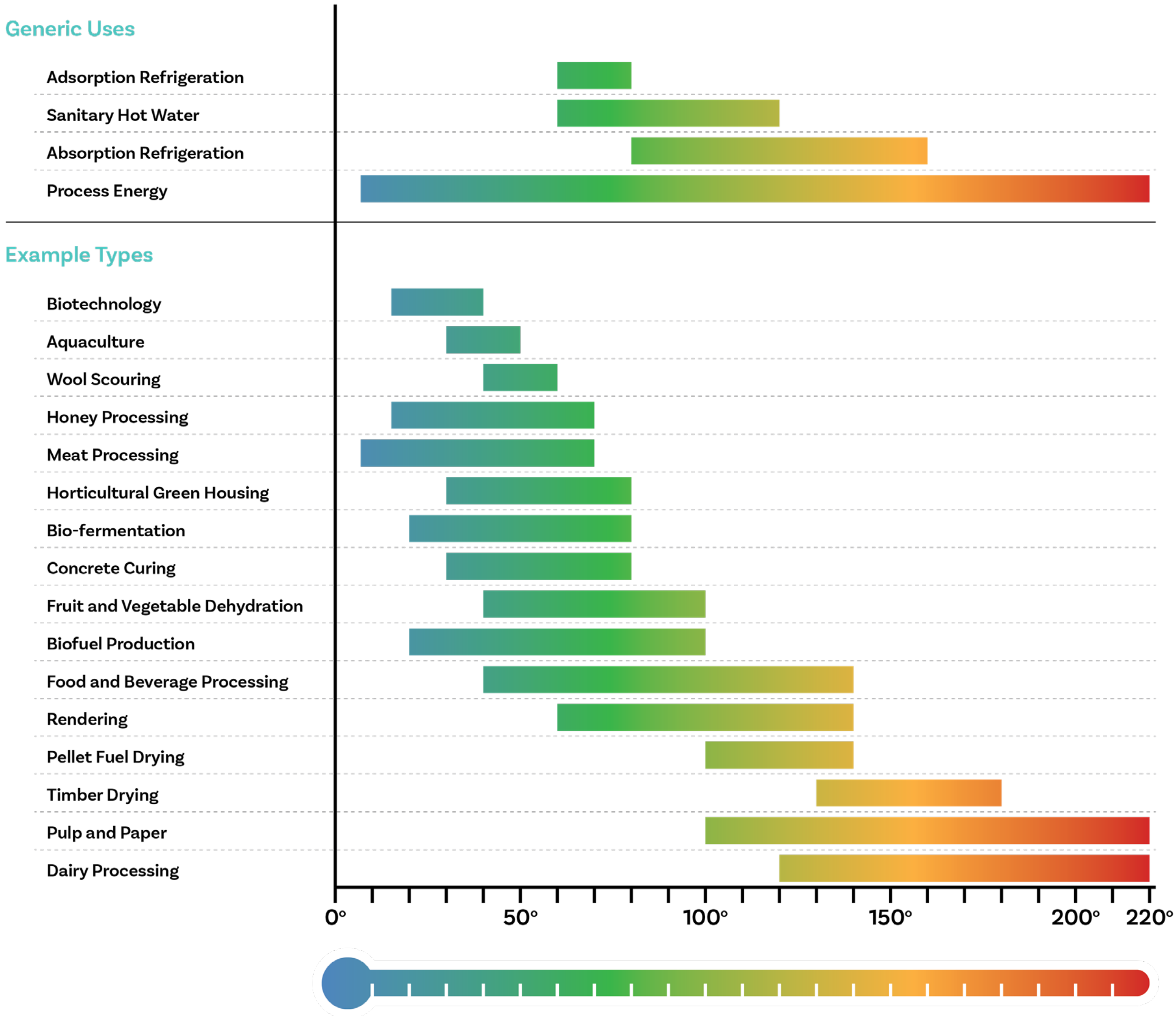


Figure 1.1 Schematic illustrating the ranges of potential use for geoheat.

Geoheat is a general term for heat sourced from within the ground for the purpose of using it in heating/cooling applications. The geothermal spectrum (Table 1.1) illustrates the wide range of temperatures that exist within the subsurface from which heat (and cooling) can be sourced. These temperatures can support a variety of applications, from low-temperature uses, such as cooling and direct heating, through to high-temperature electricity generation. A range of technologies are available to augment naturally occurring geoheat to help achieve the required temperatures of the user. Figure 1.2 shows subsurface structure from which geoheat can be extracted using different technologies.

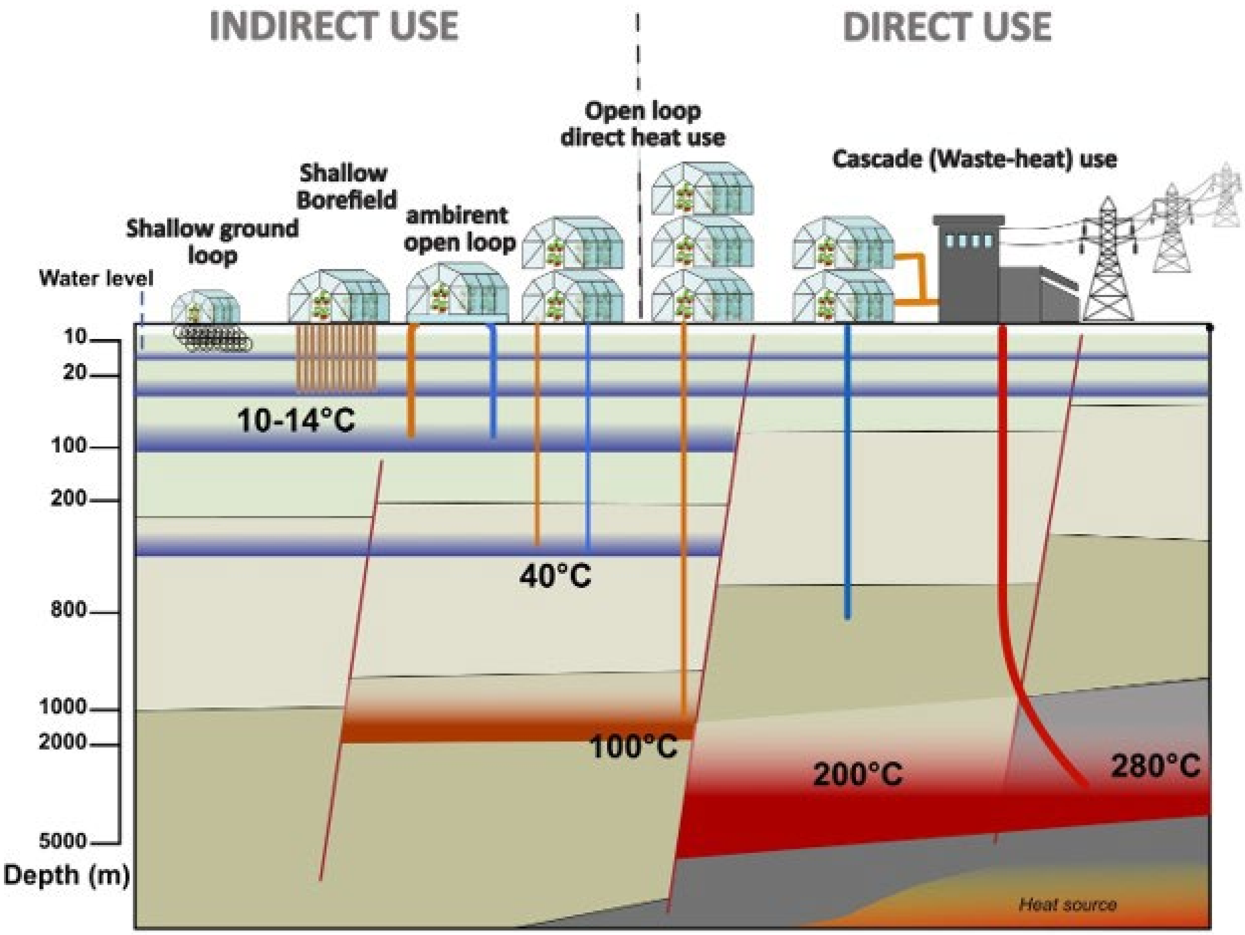


Figure 1.2 Schematic of subsurface conditions from which geoheat can be extracted.

Table 1.1 Definitions of the Geothermal Resource Spectrum

Geothermal Temperature Range	Category	Key Points
12–18°C	Ambient Groundwater (surface water and ocean water can also be considered)	• Range depends on geographic location and closely reflects the average annual air temperature. • Useful thermal source for standard Ground Sourced Heat Pump (GSHP) or Water Sourced Heat pump (WSHP). • Lower temperatures can be used for direct cooling.
18–29°C	Geothermally Enhanced Groundwater	• This is fresh groundwater that is warmed by a higher-than-normal subsurface heat gradient which does not reach 30°C (Resource Management Act definition of geothermal water). • These enhanced temperatures boost GSHP efficiency for heating.
≥30°C	RMA-defined Geothermal Water	• The temperature threshold that requires geothermal consent under New Zealand law.
30–150°C	Low-Temperature Geothermal (in New Zealand)	• The New Zealand geothermal sector classifies this temperature range as ‘low-temperature geothermal’ or ‘low enthalpy’. • Useful for heating directly or heating indirectly when combined with a GSHP.

Geothermal Temperature Range	Category	Key Points
>150°C	High-Temperature Geothermal	• Power generation and heavy industrial direct heat applications. • Site specific, e.g. 220°C fluid is used by industry for direct heat use at Kawerau from a resource at temperatures up to 280°C in the underground. Underground temperatures in the Rotokawa field, just north of Taupo have been measured at up to 340°C (the hottest so far measured in New Zealand).
>350°C	Superhot/Supercritical Geothermal	• The new frontier of high temperature geothermal energy which is actively being researched with drilling of the first well in New Zealand possibly occurring in 2027.

1.3 Heat Users in Taranaki

There are many industries that require heat for their processes. Many of these users are currently using natural fossil gas as their primary energy source due to historic low prices for gas and reliability. In the Taranaki region, these applications include space heating (and cooling), swimming pools, greenhouses, food processing (including milk and meat processing) and chemical processing. Figure 1.3 shows the locations of major heat users (>500 kW) identified by the Energy Efficiency and Conservation Authority (EECA) as part of the Taranaki Regional Energy Transition Accelerator programme (RETA) (EECA 2024). A list of known heat users can be found in Table A1.1.

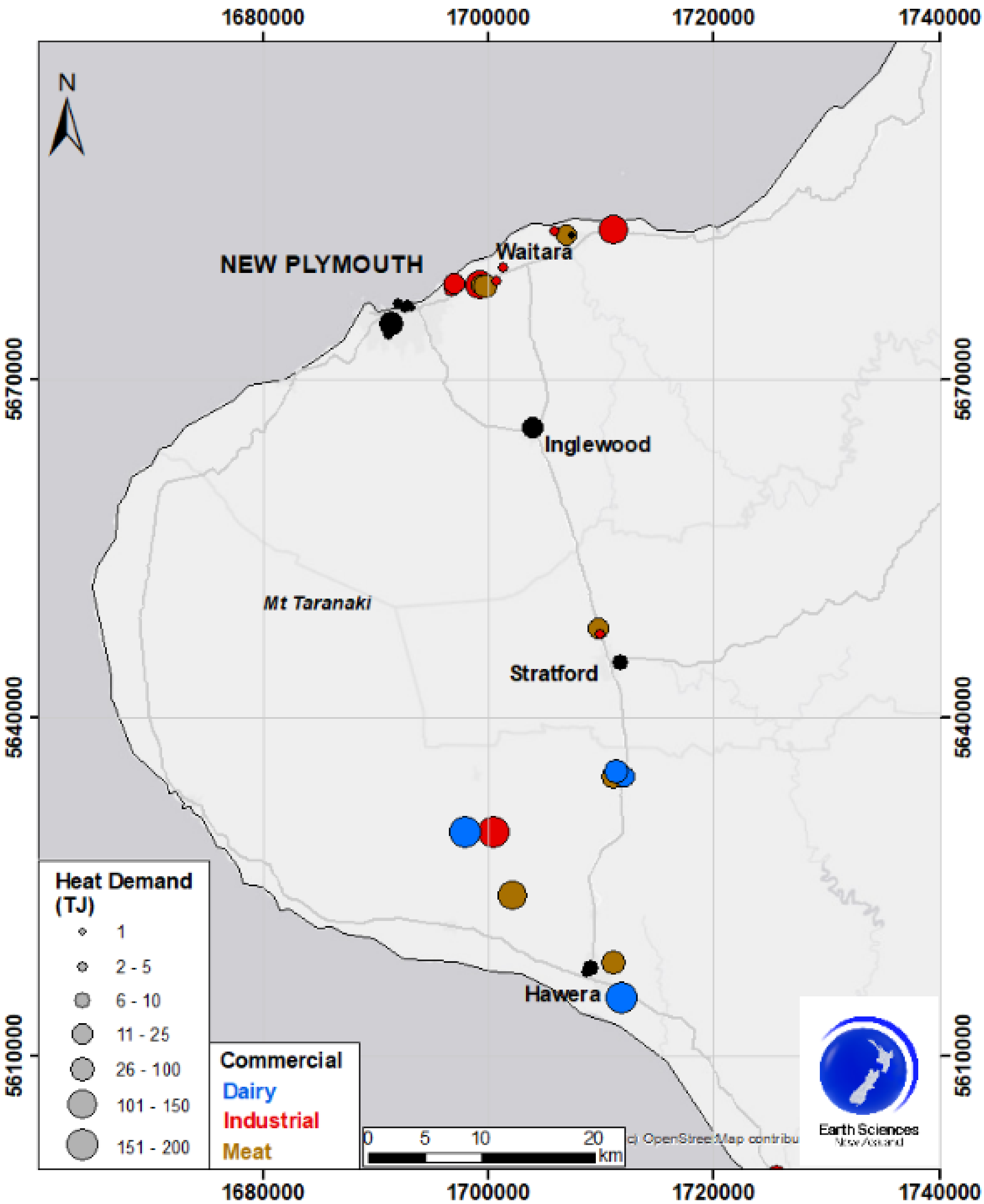


Figure 1.3 Locations of the 25 largest heat users in Taranaki (EECA 2024). The size of the symbol is reflective of the size of the energy demand for the heating activity, while the colours represent the different industrial sectors.

2.0 Resource Characterisation

The subsurface characteristics that determine geothermal heat potential (accessible heat) are:

- Solar radiation (collected from solar incidence on the surface penetrating to a shallow depth).
- Regional heat flow (derived from heat flowing from the core of earth).
- Depth, permeability, water chemistry and yield/flow of aquifers.
- Volcanic influence and the cooling of magmas and lavas through time.
- Structural controls and fault pathways.
- Tectonic processes and history such as uplift and erosion.

The combination of these different elements is the driver behind observed subsurface temperatures at a given location and depth. Observed data includes downhole temperature measurements along the length of a borehole or sometimes simply a bottom hole temperature measurement from a petroleum or water well. Forecasting beyond these actual measurements enables potential prospective areas to be identified from interpretation of local geology and hydrogeologic flow data, heat flow estimates and conceptual assessment of shallow subsurface flow.

The Taranaki Basin is well studied with extensive seismic surveys and over 400 onshore and offshore petroleum boreholes drilled. Many of these boreholes recorded geological structure and subsurface temperatures (utilising a range of techniques) and Earth Sciences New Zealand has compiled an extensive list of corrected bottom hole temperatures (Funnell et al. 1996) as well as unpublished compilations (Funnell 2025). These data are included in data tables in Section 6. In addition to these direct measurements, Reyes (2007) and Kirkby et al. (2025) have modelled regional temperatures and heat flow providing a regional context for the observed subsurface temperatures.

Subsurface temperature data include unpublished council data, published scientific data, New Zealand Petroleum and Minerals (NZP&M) petroleum exploration and production data and unpublished information held by industry and Earth Sciences New Zealand.

The following sections outline the collated subsurface data available and related interpretation of available heat resource in the Taranaki region.

2.1 Taranaki Geological Setting

Figure 2.1 shows the shallow geology of the Taranaki region, which is dominated by volcanic deposits on and around Mt Taranaki, and sandstones and mudstones in the east. Beneath the Taranaki Peninsula, the continental crust is thought to be 25–35 km thick (Stern et al. 1987). The volcanoes in this region are ~180 km above the steeply dipping subducting plate (Adams and Ware 1977), which is significantly deeper than beneath the TVZ. Past seismicity studies of the Taranaki region (Sherburn and White 2005) showed a brittle/ductile transition zone at only 10 km depth beneath Mt Taranaki. This suggests unusually hot crust beneath the volcano, caused by multiple dike and sill intrusions, and possibly partial melting of crustal rocks (Armstrong et al. 1997).

The dominant features of the Taranaki landscape are the andesitic cone of Mt Taranaki and its surrounding volcanic ring plain. The region extends into the dissected hill country to the east, and to the marine terrace formations to the south and, to a lesser extent, the north (Figure 2.1). Quaternary Egmont Volcanics cover most of the Taranaki Peninsula while Quaternary marine terraces cover the remaining coastal fringe to the north and south. They lay over a thick Tertiary sedimentary succession (sands, silt and mudstones, shells) which comprises about 5% of the total area of the Taranaki Basin at its north-eastern edge (King and Thrasher 1996), beneath which Eocene sands lay, which have been the target formation of Petroleum fields.

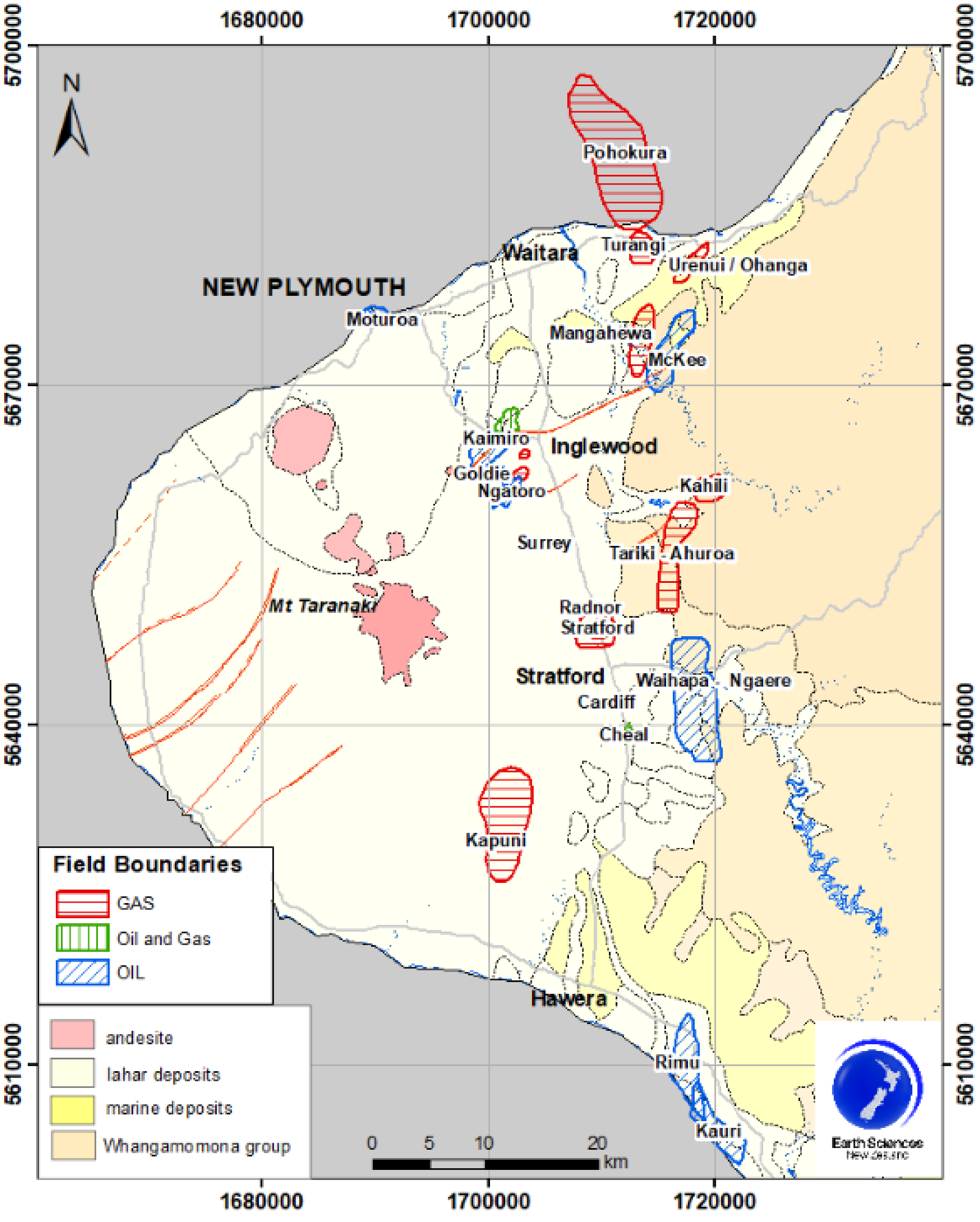


Figure 2.1 Geological setting of the Taranaki peninsula (Edbrooke et al. 2014). Red lines show the surface projection of active faults (NZAFD 2003). Hashed areas show the surface areas of petroleum fields.

Figure 2.2 shows a simplified schematic of the regional geology in the Taranaki region (Stevens 2001). Cross-sections A–A' and B–B' show how complicated the layering and unconformities in the subsurface are. The Taranaki Volcanics include the ring plain surrounding Mt Taranaki and areas of older volcanic centres. These are represented by the pinks and orange colours in Figure 2.1, and are comprised of lava, pyroclastic and lahar deposits.

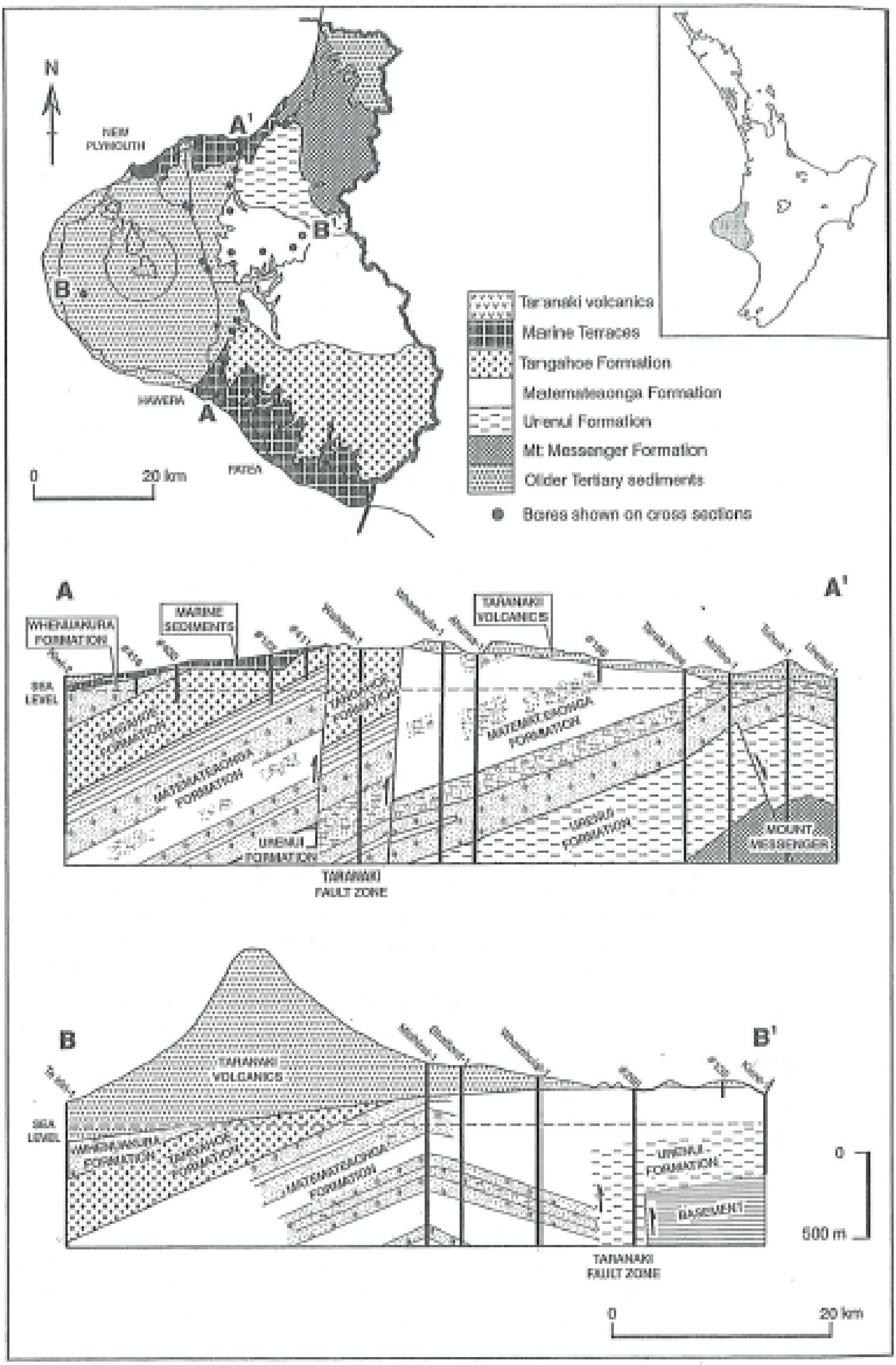


Figure 2.2 Schematic geological map and cross-section of the Taranaki region (Stevens 2001)

2.2 Hydrogeology

The Urenui and Tangahoe formations are dominantly impermeable siltstones and mudstones, which form large aquitards. Usable aquifers occur in the Taranaki volcanics, coastal marine terraces, Whenuakura Formation and Matemateaonga Formation.

Taranaki volcanic deposits contain both coarse material (sands, breccia, agglomerates) and fine materials (clay, tuff and ash), resulting in irregular lithology and anisotropic hydrological flow (Taylor and Evans 1999). Typically, the groundwater can be found 1–10 m below the surface, with generally low well flow rates (<4 L/s). Similar yields are found in the marine terrace units to the south and north of the Taranaki peninsular. Higher well yields are found in the Whenuakura Formation (~10 L/s) and Matemateaonga Formation (~15 L/s).

Surface water and groundwater are influenced by the elevation of Mt Taranaki. The shape and slope of the ring plain give rise to a radial drainage pattern. Flow rates from shallow boreholes (<20 m) typically range from 0.3 to 0.7 L/s, whereas deeper bore holes (>20 m) within the volcanics typically have flows of 0.8–1.4 L/s (Allis et al. 1997). Uplifted marine terraces extend 90 km through south Taranaki and 80 km along the north Taranaki coastline, and contain aquifers with well flow rates of approximately 0.5–2 L/s (Figure 2.3). Tertiary sediments make up the inland hill country in the east, with aquifers located within the Matemateaonga Formation, which yield flow rates of between 0.8 and 18 L/s (Allis et al. 1997). Within the Whenuakura Formation, yields of up to 10 L/s have been recorded. High-yielding, confined aquifers are reported from volcanic aquifers in the Kaitake Ranges (19 L/s), New Plymouth (10 L/s), Okato (20 L/s) and Kapuni (8 L/s) (TRC 2018).

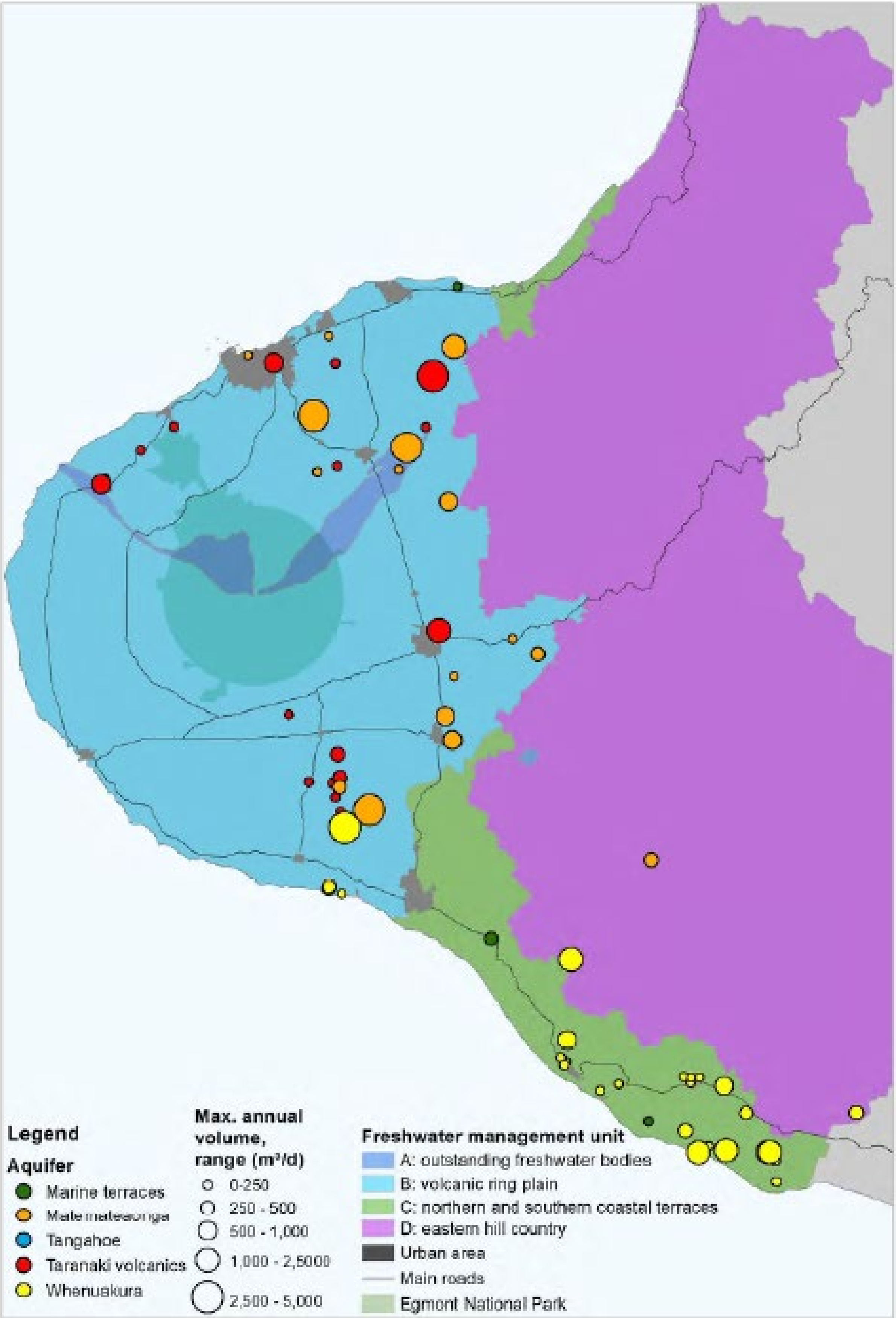


Figure 2.3 Hydrological units in Taranaki (TRC 2018). Circles show the locations of consented groundwater abstraction (as of June 2017), colours indicating the unit from which they are extracting and size indicating the volume.

Figure 2.4 shows the locations of groundwater wells in the Taranaki region. This database includes some petroleum wells with groundwater site codes. The Taranaki Regional Council (TRC) monitor several wells for changes in temperature. Table 2.1 presents the average groundwater temperatures measured in nine monitoring wells, provided by David Ge at TRC (Ge 2025).

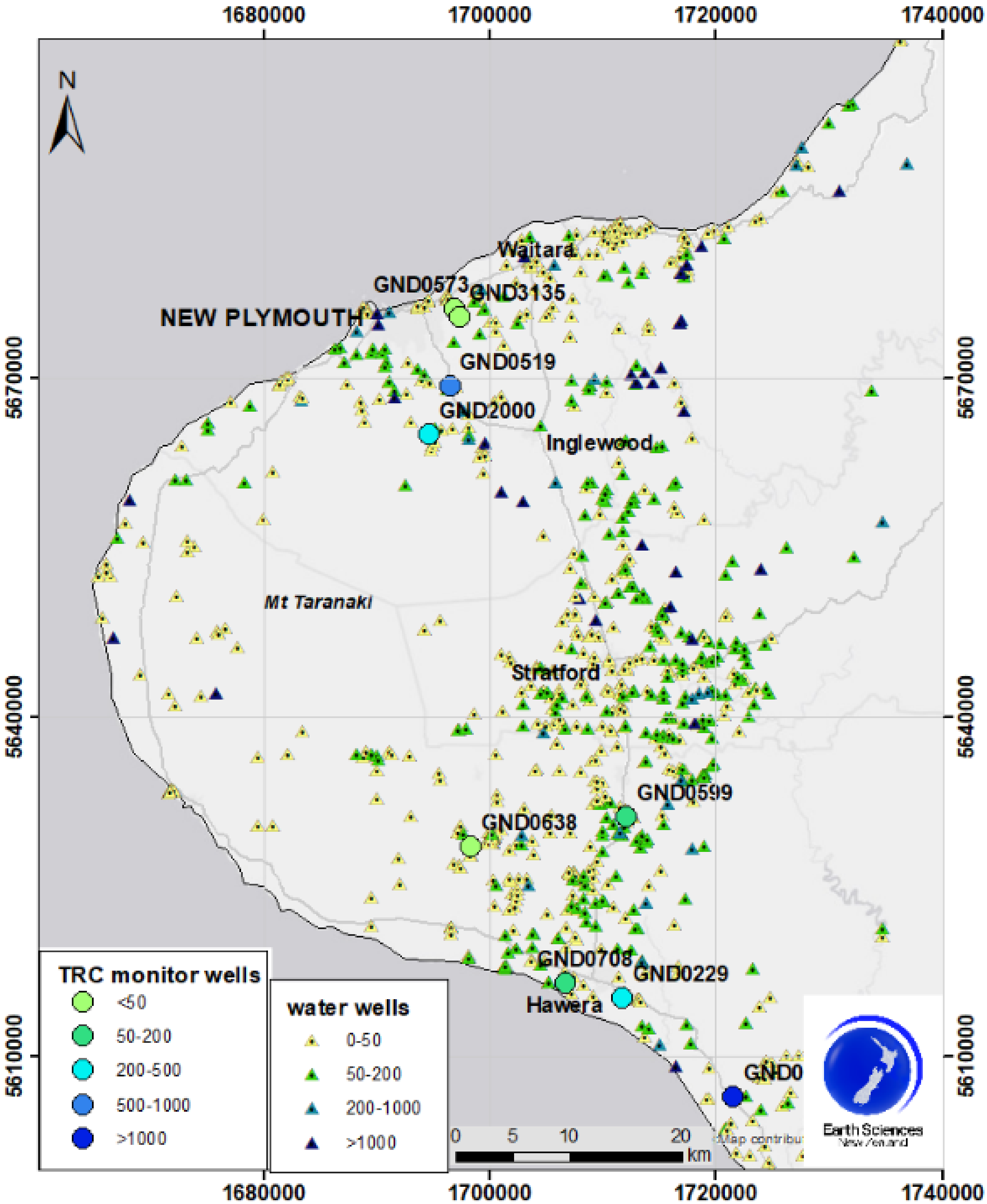


Figure 2.4 Locations of known Taranaki Regional Council (TRC) water wells in Taranaki. Circles show the locations of wells, for a given depth, with monitored temperatures.

Table 2.1 Location, depth and temperatures of Taranaki Regional Council (TRC) groundwater monitor bores shown in Figure 2.4 (Ge 2025).

Well ID	Easting	Northing	Depth (m)	Average Temperature (°C)	Maximum Temperature (°C)
GND0573	1696949	5676127	10	15.4	15.66
GND3135	1697322	5675396	15	14.99	15.66
GND0599	1712050	5631128	83	13.19	13.25
GND0638	1698332	5628562	5.9	14.56	14.99
GND0519	1696493	5669270	795	16.47	17.48
GND0447	1721529	5606411	1383	14.29	14.3
GND0708	1706711	5616538	94	13.99	14.06
GND2000	1694673	5664966	464	14.06	14.08
GND0229	1711735	5615179	297	13.75	13.75

2.3 Subsurface Temperatures

Subsurface water temperatures in Taranaki have been reviewed and compiled by Earth Sciences New Zealand for a range of purposes and projects over several years. Petroleum and basin modelling temperature research on Taranaki is compiled in the following publications: Allis et al. (1995), Funnell et al. (1996), and Kreoger et al. (2013). National heat flow models, which include Taranaki in more regional detail, can be found in Kirkby et al. (2025). Figure 2.5 shows all the recorded petroleum boreholes in Taranaki. Borehole temperatures are listed in conjunction with case studies presented in Section 6.

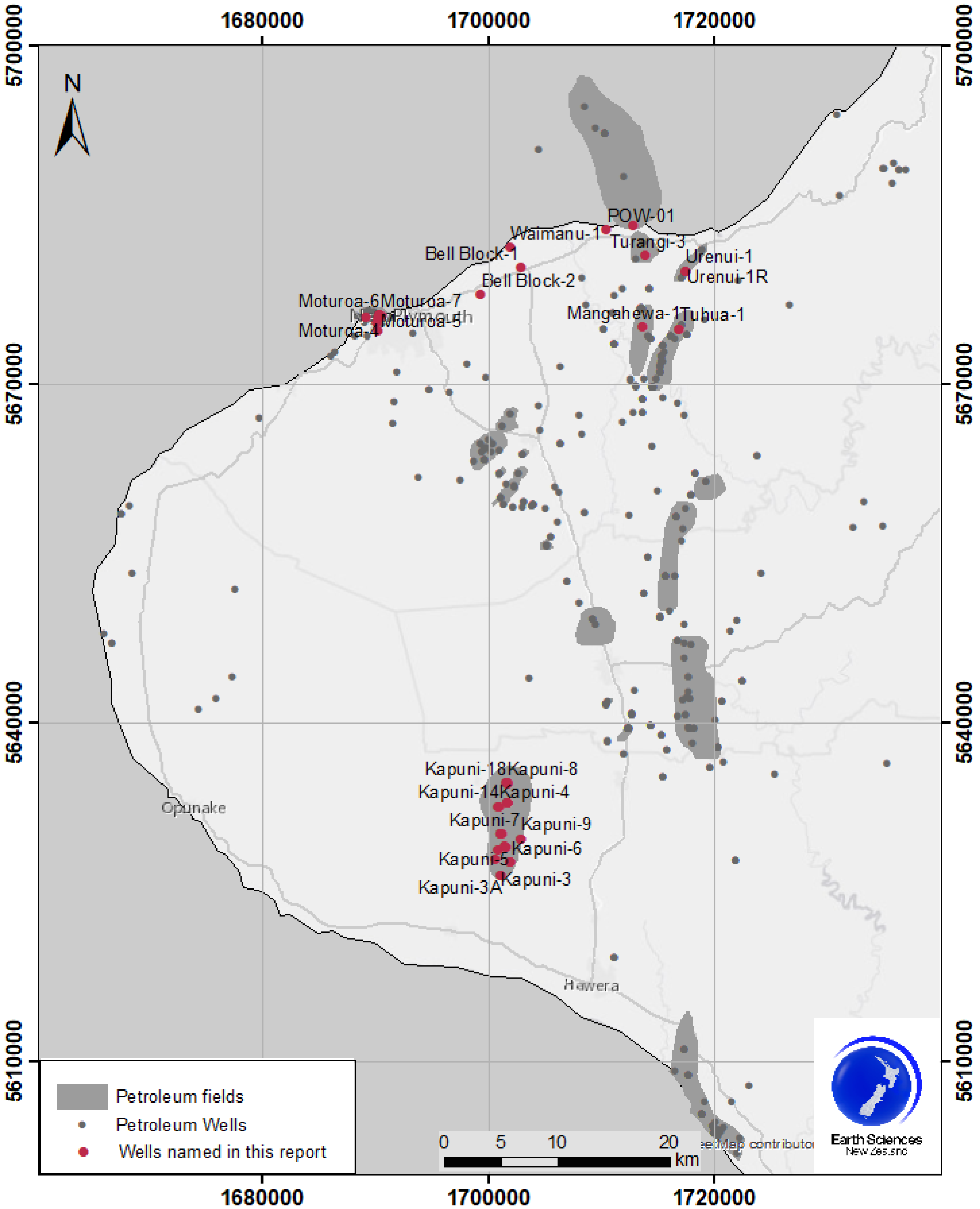


Figure 2.5 Locations of all known petroleum boreholes in the Taranaki region, boreholes marked in red are used in case study areas in Section 6.

Petroleum companies do not collect much information on the shallow aquifers, as this is not typically the target of exploration. This means that the shallow temperature profile is often less understood than the reservoir units at greater depth.

Shallow geothermal occurrences in the wider Taranaki region may remain unidentified due to sampling biases in existing petroleum subsurface datasets. Localised intervals of elevated temperature at shallower depths, such as that noted by Skinner et al. (2013) (PR4830 Mauku-1), may arise from fluids migrating upwards along deep-seated faults that act as focused thermal conduits (Figure 2.6). Such systems produce narrow, shallow zones of anomalously warm temperatures that then return to normal geothermal gradients on drilling deeper. Without a more dedicated geothermal assessment, these shallow heat anomalies remain uncertain but still hold potential for future shallow geothermal prospectivity and fluid-flow characterisation research in Taranaki.

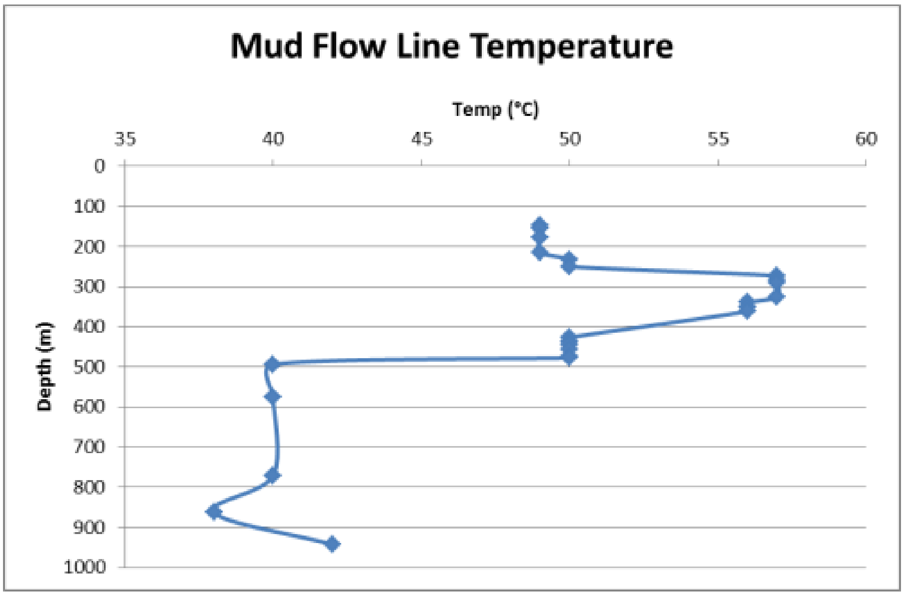


Figure 2.6 Temperature of mud in flow lines for Mauku-1 through the shallow sedimentary section (from PR4830)

2.3.1 Bottom Hole Temperature Assessments

Subsurface temperatures are routinely measured during exploration and production activities associated with the petroleum industry. While temperature is needed for various operations, it is not acquired at an accuracy for understanding geothermal potential. Table 2.2 lists some of the common petroleum operations where temperature is recorded and provides some pros and cons of the various methods.

There are various established methodologies to apply corrections to bottom hole temperatures. The data presented in this report (Section 6) have been corrected using a Horner Plot correction (Horner 1951).

Subsurface temperature in petroleum wells around the Taranaki Peninsula generally vary from 45 to 50°C at approximately 1000 m depth, 90°C along the northern coasts at ~2000 m, and 130–150°C between 4000 and 5000 m depth. At Kapuni (Figure 2.1 and Figure 2.5), measured temperatures indicate a large area of 100–120°C between 3600 and 4100 m, with a temperature of 153°C measured in Kapuni Deep-1 at 5600 m depth.

Table 2.2 Comparison of inground temperature determination within Petroleum boreholes.

Description of Temperatures Taken	Pros	Cons
Temperature sensor on wireline downhole logging tools.	Wireline is often run without circulating mud, so depending on how long the mud column in the borehole has had to stabilise temperatures, it can be more representative.	Drilling operations are very expensive, and borehole engineers continuously circulate mud to prevent oil and gas from flowing up the borehole, so boreholes are not left long enough to stabilise to give accurate temperatures.

Description of Temperatures Taken	Pros	Cons
Mud-in and mud-out temperatures used by mud engineer to understand rheology effects of temperature.	Mud engineers use high-precision sensors to keep track of mud temperatures; this is commonly recorded in borehole completion reports, so is readily available in many modern boreholes.	Circulating mud can introduce multiple artificial sources of heating and cooling that have nothing to do with formation temperatures.
Temperature taken during cementing operations to ensure that cement has fully cured. Curing rates are dependent on temperature.	Cementing contractors acquire temperatures to understand curing rates for cementing in casing to country rock. Their temperatures need to be extremely accurate. They take regular temperatures down the borehole at casing points.	Depending on the cementing contractor, temperatures may be taken but not recorded in the well completion report. Temperatures are only point measurements and, as such, there are often only at three or four casing points.
Temperatures taken at the surface of produced gas, oil and water from a specific production interval.	Temperatures of fluids at the surface give some of the most realistic potential geothermal production temperatures in an open loop system.	Fluids passing up a bore have time to cool, and temperatures are often not taken at the surface well head but instead in holding tanks where fluids have mixed and had time to cool.
Logging while drilling temperature readings.	Common measurement in most modern boreholes from downhole assemblies is a readily available dataset	Drilling can generate heat through friction and compressing drilling mud. Mud system circulates at the same time as drilling. This smears possible heat signatures and introduces significant artifacts as mud is cooled at the surface in settling tanks.

2.4 Heat Flow

Heat flow is the movement of heat within the subsurface rocks and tectonic structure. Kirkby et al. (2025) developed a national heat flow and temperature model by combining quality-controlled borehole and bottom hole temperature measurements, surface heat flow observations, thermal conductivity of rocks, sedimentation and exhumation rates, crustal thickness and crustal structure. Figure 2.7 shows the surface heat flow in the Taranaki region, based on the national model.

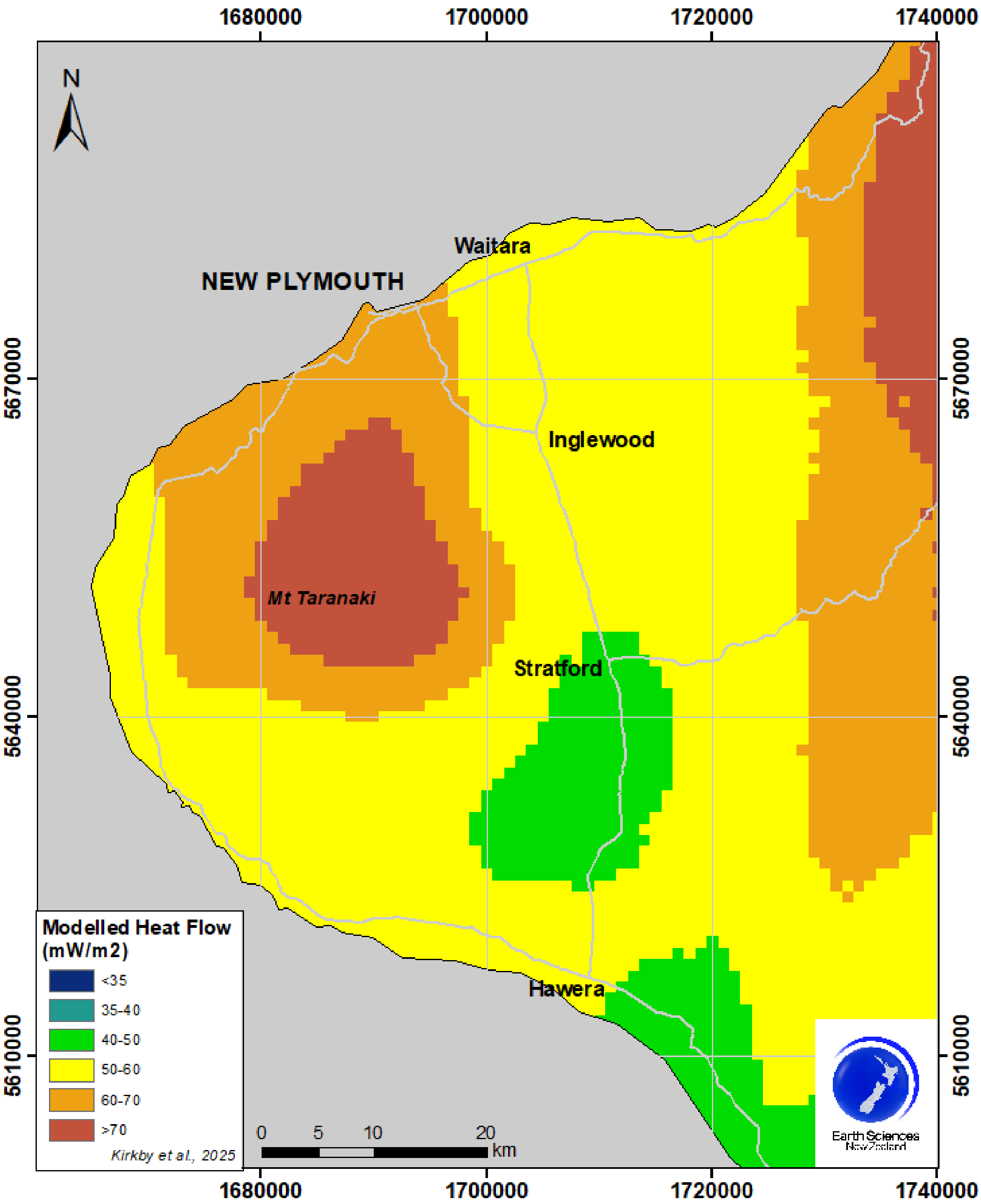


Figure 2.7 Heat flow estimates from the national heat flow model (Kirkby et al. 2025).

On average, surface heat flow in the Taranaki Basin is 60 mW/m^2 (Studt and Thompson 1969; Pandey 1981; Kirkby et al. 2025). However, it varies across the greater Taranaki region from 50 mW/m^2 in the onshore parts of the basin near Whanganui and 65–70 mW/m^2 in the southwest offshore part of the basin that has had significant uplift and erosion (Funnell et al. 1996). Higher heat flow is found in the proximity of Mt Taranaki and a small high-heat flow anomaly with a maximum of 74 mW/m^2 occurs near New Plymouth (Allis et al. 1995). This is thought to be due to either a magmatic intrusion in the crust or magmatic underplating (Allis et al.1995) and potentially uplift and erosion in northern Taranaki.

Figure 2.8 shows the modelled depth to 30°C and 80°C temperatures based on the modelled heat flow of Kirby et al. (2025). Subsurface temperatures of 30°C can generally be found at depths less than 1 km within the region, with these temperatures found at less than 500 m in the proximity of Mt Taranaki, New Plymouth and the western coastal areas. Modelled temperatures suggest that 80°C can be found at depths of <2 km in most locations in the region; however, between Stratford and Hawera, the model indicates depths >2000 m.

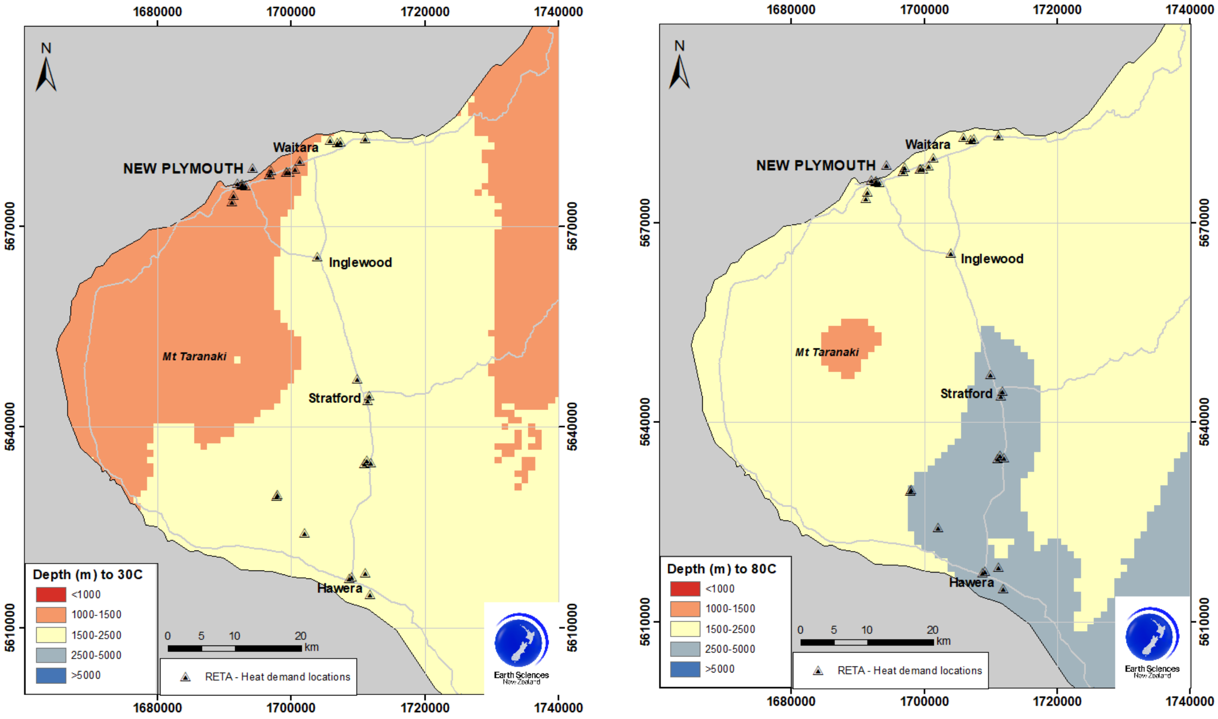


Figure 2.8 Modelled depth to a defined temperature for the Taranaki region. Left: Modelled subsurface depths at which 30°C is reached, with the locations of the Taranaki heat users shown (EECA 2025); Right: Modelled subsurface depths at which 80°C is reached, with the locations of the Taranaki heat users shown (EECA 2025).

2.5 Summary

Knowledge of subsurface temperatures at depth in Taranaki is extensive due to petroleum exploration, with some boreholes exceeding 5000 m total vertical depth. Regional heat flow shows areas around the peninsula, with elevated heat flow, suggesting higher temperatures can be reached at shallower depths in these areas.

The full spectrum of low-temperature geothermal resources (up to approximately 150°C) is present in Taranaki; however, accessing hotter temperatures generally requires drilling to depths of several thousand metres. High-temperature geothermal fields, where magma ascends close to the surface, as observed in the TVZ, are not present in Taranaki. This is because Mt Taranaki is classified as an active but dormant volcano, and geothermal heat in the region is therefore not associated with active, surface-expressed hydrothermal systems. As a result, wide-scale, large-capacity electricity generation using geothermal resources is not considered currently viable in Taranaki. Small-scale, smaller-capacity generation units might be viable.

The hydrology of the region indicates low to moderate flow rates in groundwater systems, with the most promising aquifer for yielding energy being the Matemateaonga Formation. This formation can be found at shallower depths in the centre and towards the north of the peninsular rather than in the south.

3.0 Review of Technology and Use Opportunities

3.1 Geothermal Technology

Geoheat can provide efficient space and hot-water heating, commercial air conditioning (including cooling) and industrial process heat. Technologies can range from shallow, ground-source heat pumps (GSHP), which extract low-temperature heat from soil or groundwater to direct-use geothermal systems that circulate naturally hot fluids from deeper reservoirs (Table 3.1).

Geoheat systems are classified as either:

- **Direct use**: Systems that use available geoheat directly (such as a hot pool, that requires 30–40°C, which has access to 40°C or greater temperature water); or
- **Indirect use**: Systems that require a geothermal heat pump to modify the source temperatures (such as a hot pool, requiring 30–40°C but only has access to 25°C).

There is a trade-off between accessing warmer temperatures, typically located at greater depths (higher drilling costs), and accessing the shallow, lower-temperature heat and supplementing with heat pump technology (higher operational costs). Drilling costs increase directly with depth, meaning deeper boreholes are more expensive. While deeper boreholes can deliver higher temperatures suitable for direct-use applications, it is important to consider alternative approaches.

Modelling of the costs and benefits of different options, such as direct use from a deeper borehole versus indirect use with a shallower borehole and GSHP, tailored to the specific geological conditions and operational requirements of the site can be undertaken. Ultimately, the most efficient and economical solution is site and application specific, and requires professional assessment.

Table 3.1 The Geothermal Technology Spectrum

Technology Type	Geothermal Temperature Source	Technology Temperature Delivery Range	Best Use Cases
Direct cooling	<15°C	<15°C	Chillers and space cooling
Direct use of geothermal heat	~30–150°C +*	~30°–150°C +*	Space heating, domestic hot water, baseload industrial heating, and industrial processes.
Standard GSHP	10–40°C	Up to ~65°C	Primarily used for domestic and commercial space heating, domestic hot water and low-temperature industrial processes.
High-temperature GSHP	10–75°C	~65°C to ~90°C	Low-temperature industrial processes, hot water, heating, drying.
Very high-temperature GSHP	10–50°C (requires two-stage heat pump) Or 50–100°C (one-stage heat pump)	Up to ~160–180°C	Medium-temperature industrial processes, steam, heating, drying.

Technology Type	Geothermal Temperature Source	Technology Temperature Delivery Range	Best Use Cases
Absorption chillers	70°C +	-5 to 10°C	Type of cooling system that uses heat energy instead of electricity for cool stores, cold water or buildings.
Electricity generation	130°C +	NA	Binary, Dry and Flash electricity generation depending on fluid state available.

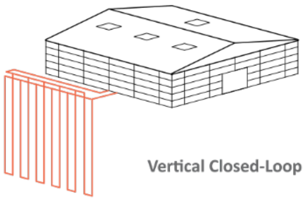
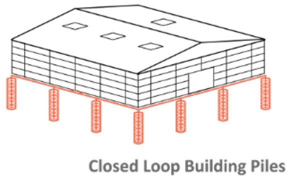
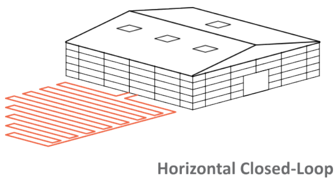
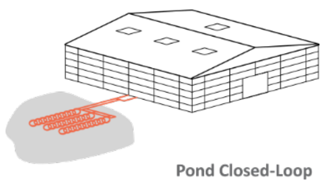
* The Resource Management Act (RMA 1991) defines geothermal water as water at temperatures of 30ºC. and above. We have chosen to end the temperature range at 150ºC as anything below this is generally classified as low temperature by the geothermal sector in New Zealand. Higher temperatures are used directly in applications, such as wood processing, food processing and milk drying facilities in Kawerau and Taupō.

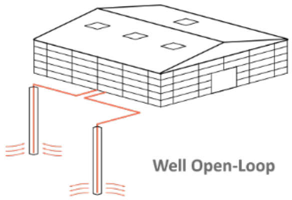
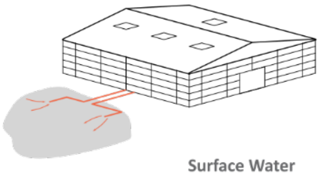
3.1.1 Types of Ground Heat Exchangers

As a generic term, ground heat exchanger (GHX) applies to infrastructure that is installed in the ground as part of both direct and indirect (GSHP) systems. Table 3.2 summarises a selection of geoheat extraction technologies that use geothermal and non-geothermal water, and briefly explains how they work. GHX systems are further classified by the type of ground loop that is used. An open loop is a system that extracts water from the subsurface, extracts the heat/cooling and returns the water back to its source or an alternative location. In these systems the groundwater moves the heat from the ground to the surface. In closed loop systems, a fluid is circulated in a series of pipes within the subsurface, which absorbs heat from the surrounding rocks returning warmer fluids to the surface. There is no groundwater extraction in these systems. An open- or closed-loop extraction system may have implications for the requirements for a resource consent.

GHXs are highly efficient, suitable for various building sizes and types, including space-limited and different lithologies, and can have high initial costs. They can be installed beneath buildings, are a form of thermal energy storage and perform best when they have a mix of heating and cooling required.

Table 3.2 Summary of geoheat extraction options

Type	Figure	Description
Closed Loop		Closed, vertical GHXs are typically installed in boreholes 50–200 m deep but could be deeper in certain applications. These systems use a polyethylene (PE) pipe filled with a water-antifreeze or brine mixture that by circulating around either absorbs heat (heating) from or rejects heat (cooling) to the ground. A GSHP then delivers heating and/or cooling as required by the application. Similar designs can be used for direct heat use if sufficient heat is available in the subsurface.
		Vertical, closed-loop systems can also be installed in the existing building infrastructure and integrated into building piles. Often called *energy piles*, these systems are generally only able to cover some of the building's heating and cooling requirements. The performance of these systems is determined by the soil moisture and whether the piles are in the groundwater zone. The advantage of these systems is that they can be installed at relatively low additional cost if a foundation is required anyway. In addition to the building, the base plate and earth-covered side walls can also be thermally activated.
		A closed horizontal GHX is typically installed at a depth of 1–2 m. Types include *surface*, *trench* and *spiral* collectors. They utilise the seasonal temperature fluctuations in the ground and are suitable for areas with plenty of space, such as rural residential areas. They work best in clayey, moisture-rich soils that allow for optimal heat transfer and regeneration. They can be a capital cost effective heating and cooling solution for rural residential properties that have suitable areas of land available.
		In areas with accessible bodies of surface water, a closed-loop GHX can also be submerged and anchored to concrete supports to ensure proper positioning above the pond bottom. Installation is quicker and less costly compared with other types of closed-loop GHX. Minimum water body depths of 2–3 m are required, while the water body needs to be sufficiently large (and permanent) for the heating and cooling requirements of the application.

Type	Figure	Description
Open Loop		Open-loop groundwater systems require an aquifer of sufficient quality and capacity to sustainably supply groundwater to a heat pump, which then typically re-injects it into the aquifer. This process benefits from the stable temperatures of the groundwater (10–14°C) and its high-heat capacity, resulting in a high coefficient of performance (COPs). The drilling depth is determined by the aquifer and the water table. An appropriate distance between the extraction and reinjection boreholes is important to avoid recirculation of the heated or cooled water. In addition to quantity, groundwater quality is also important as poor-quality groundwater will damage the installed infrastructure, leading to increased maintenance costs. Water analysis and specialised expertise are required for system design.
		If surface water is available, it can be used as a source via an open-loop system with heat exchangers similar to those described above. Open surface water loops usually require a secondary heat exchanger. The suitability of a surface water source depends on its availability, the source size and the sensitivity of the receiving ecosystem to temperature fluctuations and different water chemistry.

3.1.2 Direct Heat Use

As per the terminology, direct-use systems use the geoheat resource directly for heating applications. For example, a nominal 50°C geoheat source could be used directly for heating applications that require temperatures of less than 50°C. This simple rule similarly applies to high-temperature geoheat sources of 150°C and more.

If the geothermal waters themselves are not required (e.g. balneology / mineral baths) then a heat exchanger may be in place to physically separate the geothermal waters from the heating application. While potentially important for purposes of system maintenance (minerals in geothermal waters can cause maintenance issues), the use of this heat exchanger, combined with simple control of system flow rates, enables accurate system temperatures to be achieved. For example, a 27°C pool and a 38°C spa in a single facility could both be heated from a 50°C geoheat source simply by controlling system flow rates either side of the heat exchanger.

3.1.3 Indirect Use and GSHPs

In the event that the source temperature needs to be modified in order to meet the requirements of the application, a ground source or geothermal heat pump is used. Hence the term indirect use.

Generically, heat pumps can be air, water or ground sourced and deliver thermal energy into the building as either water or air. Refrigerant is often used as an intermediary to air delivery in the common variable refrigerant volume (VRV) or variable refrigerant flow (VRF) systems.

Basic nomenclature follows the format of, for example, air to water heat pump for an air sourced heat pump (ASHP) that delivers hot water for hydronic heating, hot water or pool heating.

A ground source (or geothermal) heat pump (GSHP) is an extended-range water source heat pump (WSHP) that has been designed to operate with a wider range of source temperatures that are typically present within a closed-loop GHX or where open-loop systems have colder source temperatures.

A brief description of the three main types of GSHP are as follows:

1. Water to air: Ducted packaged units.
2. Water to water: Hydronic heating, cooling, hot water, pool.
3. Water sourced VRF: As per conventional split or refrigerant units but with GHX connection.

Water to air heat pump is a packaged unit that is connected directly to the GHX and then delivers hot/cool air through designed ductwork (mostly in the ceiling) to indoor zones. Depending on various manufacturers, these units generally have a limited supply of domestic hot water (DHW).

Water to water heat pumps connect directly to the GHX and then deliver hot water or chilled water to various internal terminals for heating or cooling (buffer or storage tanks are generally required). Water to water heat pumps are able to supply all DHW requirements using a separate storage tank as well as pool/spa heating if required. The inclusion of thermal storage in the form of buffer tanks provides enhanced efficiencies and the potential for generating thermal storage during periods of low electricity costs (e.g. off peak or solar PV). However, this does require additional plant room space.

A variation of water to water heat pumps in geoheat applications is the water to steam or industrial heat pump that is able to provide steam for industrial applications. As a general rule based on current technology capabilities, this steam output is limited to about 70°C above the source temperature (single stage) and 160–180°C as a maximum steam output temperature.

Water sourced VRF utilises a refrigerant as the heat transfer medium between a single water sourced condensing unit and either single or multiple indoor units. They are a GHX connected version of the VRF/V style systems that are dominant in conventional systems. The main difference is that the heat pump or condensing unit is located within a plant room rather than externally or in a ventilated space.

3.2 Opportunities for Repurposing of Petroleum Boreholes

Existing subsurface infrastructure, such as petroleum wells or underground mine networks, may also be used as GHX systems. The UK, for example, is increasingly extracting geothermal energy from flooded underground coal mines. These waters are heated naturally from the conductive rocks, heating the water by 10–20°C. These fluids then act as a subsurface aquifer system which can be accessed through open-vertical loop GHX for space heating and cooling[1].

Similarly, existing petroleum infrastructure can be used for heat and/or electricity generation. Grant Canyon, in Nevada USA, co-produces electricity with oil and gas production. The geothermal energy is used to power a portion of the operations at the oil field, reducing total greenhouse gas emissions[2].

There are several aspects that need to be considered for repurposing petroleum subsurface infrastructure for geothermal GHX and heat production. Consideration needs to be given to not only the subsurface geology, thermal gradient and heat flow, but also to the status of the borehole(s). Considerations include:

- Status of the well – if plugged and abandoned, how was this done? What would need to be done to re-access the well, but not the reservoir?

[1] https://www.gov.uk/government/collections/mine-water-heat#extracting-geothermal-energy-from-former-coal-mines

[2] https://www.businesswire.com/news/home/20220518006161/en/Transitional-Energy-Successfully-Produces-Geothermal-Energy-at-Oil-and-Gas-Well?utm_source=chatgpt.com

- State of the casing/tubing, liners and cementing in the well
- Corrosion state of piping
- Fluid chemistry

Other opportunities exist with currently producing wells, which may be shut down over coming years. If these are plugged appropriately, heat extraction could be a suitable opportunity. If a well can be repurposed, then it could be used as an open-loop or closed-loop GHX source, either directly or indirectly as described in the previous section. If higher temperatures are present (>130°C), as is possible in some wells in Taranaki, smaller capacity electricity generation may be possible.

4.0 Review of Regulatory Environment

4.1 Consents

Like any natural resource, groundwater and geothermal resources must be managed carefully to ensure they remain available for future use, and to avoid adverse effects on the environment or on other users.

In New Zealand, groundwater, geothermal water and heat are currently managed under the Resource Management Act (RMA 1991) and often require a resource consent for use. Consents for water resource and energy use are managed by the regional council.

- Take and use of water from a well or bore is regulated by Rules 48 to 50 of the Regional Freshwater Plan for Taranaki (RFWP) (TRC 2001).
- Drilling a bore is regulated by Rule 46 and 47 of the RFWP. These may not be required if you are repurposing existing sites.
- The RMA (1991) defines geothermal water as water that is ≥30°C. Applications to the TRC to use ≥30°C would default to Section 14 of the RMA (1991) and be considered a discretionary activity under 87B(1)(a).
- The Coastal Plan for Taranaki has Rule 71 for activities in estuaries and aquifers in the Coastal Marine Area, which covers the use of water, energy or heat, excluding the taking or use of water which is allowed by sections 14(3)(d) or (e) of the RMA (1991). Note: This would rule out the use of existing oil and gas boreholes (to obtain geothermal heat), as they are typically located in the open coast, so the drilling of any boreholes within these areas would likely trigger the need for consents.

Policy 3 of the Regional Policy Statement for Taranaki does promote the use and development of renewable energy resources (TRC 2010).

In addition to Taranaki Regional Council requirements, proposed developments may also depend on District Council regulations. These would be site specific and relate to land-use plans, building consents, site works and compliance with local planning rules. These should be assessed early in any planned project, but are beyond the scope of this report.

It is worth noting that the Government has announced that the RMA (1991) will be replaced with two new acts that clearly distinguish between land-use planning and natural resource management, while putting a priority on the enjoyment of private property rights. The replacement statutory instruments are not enacted at the time of writing this report and are likely to impact this advice.

4.2 Repurposing Petroleum Boreholes

Repurposing petroleum boreholes for geothermal energy in New Zealand faces several overlapping regulatory instruments. These include the High Hazard Unit (HHU), Worksafe, at MBIE and requirements from Taranaki councils (regional and local). Petroleum developments onshore, like geothermal developments, are subject to the RMA (1991), which requires multiple consents for activities, such as water use, discharges and land disturbance. While these processes are well established, it is unclear how they interact with converting petroleum boreholes to geothermal, as this has not occurred before.

As a practical example:

- Borehole integrity, casing and cement and borehole design are the responsibility of the HHU at MBIE and authorities rely on them to regulate and manage petroleum boreholes.
- Regional councils are responsible for administering the RMA (i.e. managing environmental effects), but the HHU manages borehole integrity for health and safety, which covers accidental discharge. Therefore, the council relies on HHU to cover environmental aspects.
- Borehole control equipment, rules and regulations are all under Health and Safety at Work (Petroleum Exploration and Extraction) Regulations (2016). However, all other aspects of ground water are as per normal regional council RMA (1991) process.

Any petroleum borehole considered for repurposing must also comply with the conditions of its NZP&M exploration or mining permit, which now includes explicit obligations for plugging and abandoning boreholes. Decommissioning is a regulated process requiring the safe retirement of wells, removal of equipment and restoration of the site. Under the updated decommissioning regime, permit holders are legally required to meet the full financial cost of these activities, provide financial securities to ensure they can be carried out, and may be subject to liability provisions that hold former permit holders accountable if future owners cannot meet their obligations. These requirements as set out within the Crown Minerals Act 1991 and the associated decommissioning framework mean that any repurposing proposal must consider whether the well was previously abandoned in accordance with these rules, and whether MBIE (NZP&M) would still require full decommissioning compliance even if the borehole is proposed for geothermal use.

Further investigation will be needed as to whether TRC or HHU would be responsible for the approval to repurpose a petroleum well, if a well has already be plugged and abandoned.

4.3 Recommendation

Whether looking to repurpose existing infrastructure or to install alternative geoheat technology, it will be important to discuss the project with the TRC planning team. They are familiar with the consent requirements and what standards may apply. Feedback could influence design choices for a system. Importantly, planning early is expected to help streamline approvals avoiding unnecessary delay.

If a project is large in scale, the council recommend you proactively seek planning advice, the New Zealand Geothermal Association (NZGA) Companies Directory[3] can assist in identifying appropriate experts and independent planning consultants and can be found on the NZGA website: https://www.nzgeothermal.org.nz.

[3] https://www.nzgeothermal.org.nz/downloads/New-Zealand-Geothermal-Companies-Directory-2025.pdf

5.0 Reuse of Petroleum Infrastructure

There are many benefits to repurposing petroleum infrastructure for alternative uses when the production of oil and gas has ceased or no longer viable. The use of the naturally occurring heat at depth within the sedimentary basins is a promising option. In Europe, geothermal energy from sedimentary basins has been used since the 1960s for district heating and small-scale industrial processes (Lapaige et al. 2000), and more recently in the Netherlands, where a covered crop industry has converted from using natural gas for heating of the facilities to using geothermal heat sourced from between 2–3 km depth (Hollebeek et al. 2018).

Globally, methods have been proposed for using exploration boreholes as doublets. This requires using two boreholes that can be an injector and a producer pair. Fluid is introduced to a permeable subsurface layer, where it absorbs heat before returning through the production well for use at the surface (Sui et al. 2019). Alternatively, if no permeability can be found, Enhanced Geothermal Systems (EGS), which stimulate fractures through various techniques have also been investigated in petroleum environments (Li and Zhang 2008). Similarly closed-loop systems, also called advanced geothermal systems, have been investigated (Nian and Cheng 2018). In addition to retrofitting wells, heat from wastewater produced from petroleum extraction could be utilised before being discharged back underground.

Reyes (2007) estimated a capacity of 4.77 MW_e of electricity potential in the Taranaki region from subsurface temperatures >100°C. If these resources are used for direct heat, there may be up to 50 MW_{th} of heat available.

The opportunity to repurpose petroleum infrastructure could be appealing from both the current operator and the next user perspectives (Reyes 2019). Firstly, the decommissioning of producing wells is expensive. This economic cost could be buffered by finding alternative economic opportunities for use. If plugged appropriately, the use of the existing well infrastructure could be used to house closed-loop piping for geothermal heat extraction. The opportunities for heat use are dependent on the available energy and demand at the surface, but can range from space heating for commercial and industrial application, district heating, small-to-medium industrial heat users and potentially small-scale electricity generation. Reducing drilling cost for harnessing the natural geoheat resources at depth likely make these opportunities more economically appealing.

Existing petroleum boreholes can potentially be modified in one of two ways to produce heat. Firstly, by retrofitting existing boreholes or, secondly, by co-production of heat from currently producing boreholes. Retrofitting petroleum boreholes for heat can have one or two approaches. Through open-loop retrofits, where heat is extract directly from fluids at the surface, or alternatively, through closed-loop down hole heat exchangers. The technologies involved in these retrofits are explained in Section 3.

Converting existing petroleum wells into geothermal wells has some challenges, which may require innovation and technological advancements. Challenges that need considering include:

- Although temperatures may be present within the wells, the permeability and flow rates from the subsurface may be limited. Enhanced geothermal technologies and stimulation techniques may assist in improving these properties to support geothermal production.
- Similarly, the fluid composition of the subsurface from the gas reservoir may cause scaling or corrosion of existing well infrastructure. Well structure will need to be assessed before re-use and dosing may be required.
- The fluid chemistry of any potential geothermal subsurface reservoir also needs to be tested, if open-loop GHX are considered. Temperature and pressure changes can cause precipitation of minerals, in additional to any chemicals that may cause corrosion or scaling. Down hole pumping may be a way to mitigate these issues. Alternatively, a closed-loop GHX may be an alternative for heat harvesting.

- The integrity of an existing well is vital to assess before contemplating repurposing. Casing and cement degrade over time, which can cause collapse or stress in the infrastructure.
- Wellbore geometry may also present complications for re-use. Considerations of existing well bore diameter and trajectory are key in understanding the potential of a well.

In addition to the above considerations, the environmental impact will also need to be assessed and managed to ensure minor impact on the surface and subsurface environments.

5.1 International Examples

There is a lot of interest globally on repurposing petroleum infrastructure, with many trials, pilot projects and research being undertaken.

IRENA (2023) presents three examples of using oil and gas wells to recover geothermal energy in Canada, Colombia and Hungary. In British Columbia, Canada, the Tu Deh-Kah project is utilising an existing well, coupled with a new well to produce 120°C geothermal water for 7–15 MW electricity generation and cascaded heat uses[4]. In Colombia, the co-production of oil and geothermal was commissioned in 2021 at Las Maracas[5]. The geothermal water is extracted as a co-product of the oil production and separated for the generation of ~0.1 MW of electricity using an Organic Rankine Cycle binary plant. The electricity is used to power the oil pumps and onsite facilities. In Hungary, a closed-loop borehole GHX has been installed in an abandoned oil well in Kiskunhalas[6]. A small geothermal power plant produces ~0.5 MW thermal for heating and cooling applications.

The US Department of Energy launched the "Wells of Opportunity" research and development project in 2021, with a focus on retrofitting inactive or unproductive oil and gas wells for geothermal extraction and power production[7].

5.2 Taranaki Infrastructure

The status of petroleum boreholes in New Zealand is classed as 'producing', 'shut-in', 'plugged and abandoned', 'plugged', 'suspended' and 'injecting'. The status of any given borehole is maintained by NZP&M. When petroleum boreholes are drilled, they are categorised as: 'exploration', 'appraisal', or 'development'.

The most likely wells to be suitable for re-entry are those that are development wells classified as either 'plugged and abandoned', 'suspended' or 'shut-In'. 'Plugged and abandoned' status suggest that a development well has been productive but has since been stopped and is closed due to insufficient production or damage. These wells are usually plugged near the geological boundary of the reservoir at depth and then potentially at several other locations along the borehole to avoid seeping of fluids from one reservoir to another. It should be considered, however, that a borehole plugged and abandoned in the 1960s may no longer be considered acceptably plugged by modern standards. Abandonment schematics, which show where and how thick cement plugs are, is not always available, thus complicating the assessment of whether re-entry is possible.

'Suspended' or 'shut-in' bores are wells that were drilled but found to be unprofitable (at current market prices for gas or oil), and therefore put on hold until market conditions change or new completions are designed to increase production. These sites may represent locations where this infrastructure could

[4] https://tudehkah.com/

[5] https://www.thinkgeoenergy.com/first-geothermal-power-plant-inaugurated-in-colombia/

[6] https://www.thinkgeoenergy.com/geothermal-heating-to-be-implemented-in-kiskunhalas-hungary-sports-center/

[7] https://www.energy.gov/hgeo/geothermal/wells-opportunity

be repurposed to access the elevated temperatures at depth more simply than plugged and abandoned boreholes. The status of these boreholes would need to be surveyed to ensure that the casing and structure of the bores are intact and that they could be reused. Repairs may be required to ensure safe operation. Once secured, a closed-loop GHX may be installed to retrieve deep heat for direct heat use or high-temperature heat pump. If the subsurface is suitable, open-loop systems may be achievable, which could potentially support small-scale electricity production if appropriate temperatures, pressures and flows are available.

Additionally, it is worth considering methods for shutting down currently ‘producing’ boreholes. As New Zealand’s oil and gas reserves diminish, being able to repurpose the existing infrastructure for alternative energy production is potentially attractive. Methods could be developed to undertake the transition appropriately and seamlessly.

Alternatively, a by-product of oil and gas production is “produced water”. In Taranaki, Mangahewa, Kowhai and Kapuni fields produce from extremely deep formations (3000–4000 m). From these deep depths the produced water at these sites has elevated temperatures (130–150°C). These sites could have the potential for co-production, producing both oil and gas, and geothermal heat simultaneously, with only additional surface infrastructure required. Known temperatures in Mangahewa (130.1°C), Turangi (149.8°C) and Kapuni (153.2°C) are potentially hot enough to generate electricity and, with modifications to existing infrastructure, no new boreholes may be needed to be drilled, reducing economic costs dramatically.

Organic Rankin Cycle (ORC) units are well-suited for low-to-medium enthalpy sources and offer flexibility in fluid selection and cycle configuration (e.g. subcritical, supercritical, recuperated). In practice, co-produced or retrofitted boreholes above 120°C have been used to power ORC generators, producing grid or onsite electricity (i.e. Ormat). By way of note, there has been an ORC power plant operating on geothermal water at 130°C at Wairakei since 2005.

6.0 The Geoheat Opportunity in Taranaki

This section investigates the potential of geoheat use in Taranaki. It looks at the geoheat use potential for several industries and locations. This builds on the information presented in the pervious sections of this report to assess the opportunity for geoheat use for existing and new industries, repurposing of existing petroleum infrastructure and consideration of other developments. The Taranaki region has a long history of petroleum exploration, which provides a unique opportunity for a broader range of geoheat applications, whether the existing infrastructure is repurposed or the data from these wells is used for direct assessment of site opportunities.

The key geological features used for the assessment of geoheat opportunity are:

- Surface (<150 m) formations using ambient temperatures: This is a typical range for GSHP systems – whether open loop or closed loop. The shallow ambient temperature of *c.* 14–15°C enables cooling as well as heating, so is suitable for most buildings.
- Matemateaonga Formation: This formation consists of layered sandstone, siltstone, shell beds, conglomerates and minor occurrences of coal seams. It is encountered at the surface in east Taranaki, from depths of 30–40 m in New Plymouth and as deep as 250 m near Kapuni. It is effectively absent in Onaero in northern Taranaki. It has a typical thickness of 1000–2000 m. Although the onshore petroleum fields of Kauri/Rimu (southern Taranaki) are reservoired within the Matemateaonga; elsewhere, it is generally the formation that lies beneath the surface layers (e.g. Egmont Volcanics) and atop the deeper Eocene Sands that are the reservoirs in the main petroleum fields and the target of the deeper petroleum wells in the region. The Matemateaonga Formation has temperatures nearing 60°C and well flow rates, especially in the 'shell beds' of 20–30 L/s, the formation is considered a good target for geoheat systems with its warmer temperatures.
- Eocene Sands: A deeper formation that has been the main target of the petroleum industry. As per the presented well information, depths can exceed 5 km with the highest recorded temperature of 174°C at Waimanu-1 in Bell Block. Accessibility of this formation relies on the potential to repurpose existing wells. In the event that the full depth of an existing well cannot be repurposed for technical or safety reasons, it may be possible to plug towards the bottom of a well and use its upper sections, typically utilising the Matemateaonga Formation, as the source of thermal energy.

The following sections identify a selection of geoheat applications to provide an indication of the possible opportunities for the Taranaki region. It addresses a combination of individual sites as well as the potential for district or networked systems for both brownfield (New Plymouth town) and greenfield (Kapuni) applications. Although a specific building or facility is identified in some instances, the analysis should be considered as a conceptual or qualitative feasibility rather than a detailed quantitative analysis, as that was outside the remit of this scoping report.

This conceptual approach was undertaken as limited site-specific data were available for most locations. Therefore, industry benchmarks and experience from similar facilities have been adopted to guide the analysis.

Further, a detailed feasibility for a geoheat system includes elements beyond a simple energy savings and carbon reduction analysis. Elements such as a reduction in power supply to a facility, reduced plant room requirements, reduced maintenance and longer system life require a more detailed understanding of a given site and are often determining factors as to whether a geoheat system is adopted. In such instances, the energy savings are often considered a bonus.

For the purposes of this report, the below provides an indication of the types of applications that are possible and provides direction as to where additional investigation may be warranted. For the discussions below, it is assumed that resources are able to be managed sustainably through appropriate design of heating systems.

The following have been included in the qualitative case study assessments:

- Todd Energy Aquatic Centre
- Taranaki Base Hospital
- Greenhouses
- Repurposing Kapuni Wells for Industrial District heating
- Geothermal District heating for New Plymouth CBD and Port Taranaki

6.1 Todd Energy Aquatic Centre (TEAC)

Table 6.1 Summary of opportunities of geoheat technology for Todd Energy Aquatic Centre (TEAC).

Geoheat Technology Explored	Ground Source Heat Pump	Yes
	Direct Use	Yes
	Repurposed well	Maybe
	District scheme	Maybe

6.1.1 Background on Swimming Pools and Geoheat

Public swimming pools, such as the Todd Energy Aquatic Facility (Figure 6.1), are well suited to both GSHP and direct use of geoheat. These facilities are long-lasting public assets with a 24/7 heating requirement, with the lower operating costs that geoheat provides translating directly into long-term savings for the community. While geoheat systems can involve higher upfront capital investment, this is well balanced by the long operational life of both the geoheat infrastructure and the pool facilities themselves.

The return on investment is strongest for pools that operate year-round, as continuous demand allows the geoheat system to be fully utilised. Facilities that operate only seasonally tend to achieve lower returns due to reduced operating hours and shorter periods of heat demand; as such, other less efficient technologies may be more economical. For example, air source heat pumps could be a better option for a summer-only pool as they tend to work quite efficiently with higher ambient temperatures. However, their reduced performance through winter will increase energy costs as well as the sizing of the facilities' power supply and likely mean that a geoheat solution would be the better option where year-round operation occurs. This would be especially so if a facility was considering extending to year-round operation as part of a facility upgrade or redevelopment.

Furthermore, geoheat improves energy security for a public facility by using a locally sourced heat supply that is not exposed to price volatility or external supply risk, while significantly reducing emissions to support council climate targets. It also operates quietly with a small surface footprint, making it well suited to public facilities.

A geoheat pool already operates in Taranaki at the Taranaki Thermal Spa. It is located *c.* 1 km to the southwest of the Todd Energy Aquatic Centre (Figure 6.1). Of particular relevance to this report, the geothermal well was originally drilled to a depth of approximately 1000 m in 1909 during an early search for oil. While hydrocarbons were not discovered, the artesian well produced groundwater at around 40°C, which has since been successfully used for bathing.

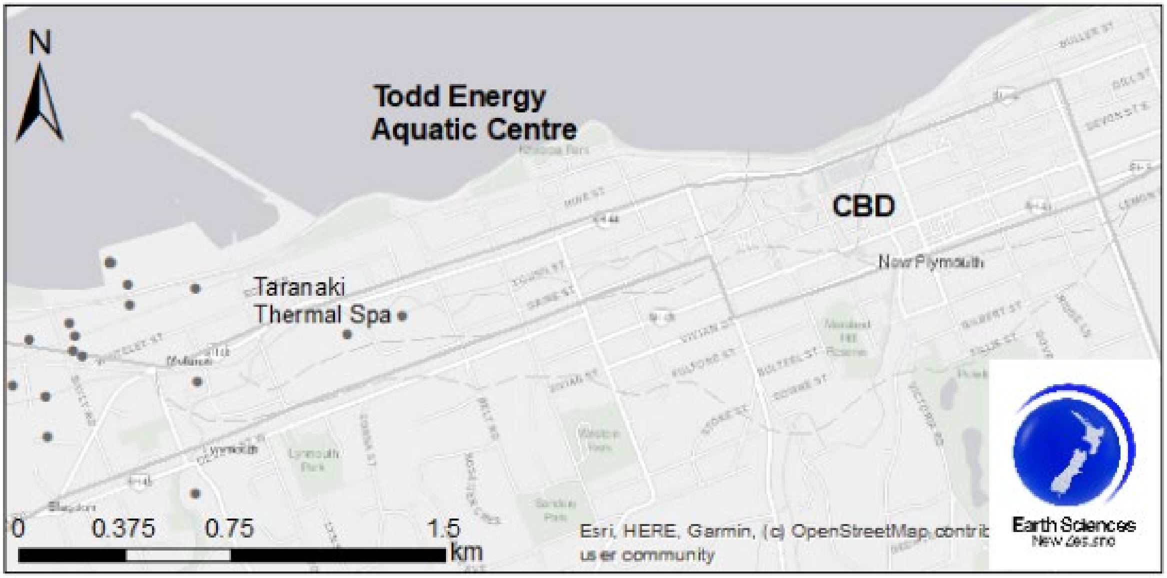


Figure 6.1 Location of Todd Energy Aquatic Centre and the Taranaki Thermal Spa. Petroleum wells associated with the Moturoa Field near Taranaki Port are shown by grey dots.

6.1.2 Site Information

The Todd Energy Aquatic Centre (TEAC) is located within Kawaroa Park on Tisch Avenue on the northern outskirts of the New Plymouth CBD. It is situated directly on the coast.

Current heating and energy usage: Based on information supplied by New Plymouth District Council (NPDC), the TEAC consists of two indoor pools that operate year-round and three outdoor pools that are open from November to April only. Total gas usage data supplied by NPDC for pool heating, space heating and hot water averaged from the last two years has enabled heating requirements to be estimated for the two areas of the facility and are summarised in Table 6.2. Adopting a gas cost of 3 c/MJ provides an annual cost of $225,000 for the existing 2,085,500 kWh or 7505 GJ usage.

Geoheat can be used for the space heating and hot water requirements of the facility.

Table 6.2 Summary of heating loads – Todd Energy Aquatic Centre

Pool Area	Annual Load (kWh/m^2)	Annual Load Demand (kWh)	Peak Heating Load Density (W/m^2)	Peak Heating Load (kW)
Indoor Pools (24/7)	752.8	**1,028,742**	243.1	**375**
Outdoor Pools (Seasonal)	N/A	**639,658**	N/A	**495**
TOTAL: Pools	-	**1,668,400**	-	**870**
Other gas usage (hot water, space heating, etc)	-	**417,100**	-	-
TOTAL: Facility	-	**2,085,500**	-	-

6.1.3 Geological Setting and Geoheat Opportunity

The Todd Energy Aquatic Centre is located immediately on the coastline and as such provides potential for geothermal as the heat source as well as the ocean as an energy source.

Table 6.3 provides a simplified summary of subsurface conditions at the site and how these may impact the type of geoheat application. The temperature values adopted in Table 6.4 were derived from Motorua-5 (Figure 6.2) that was drilled in 2006 and located approximately 1.7 km along the coastline and to the west. It had a measured temperature (uncorrected) of 91.1°C at a bottom depth of 1910 m, for a temperature gradient of *c.* 40°C/km.

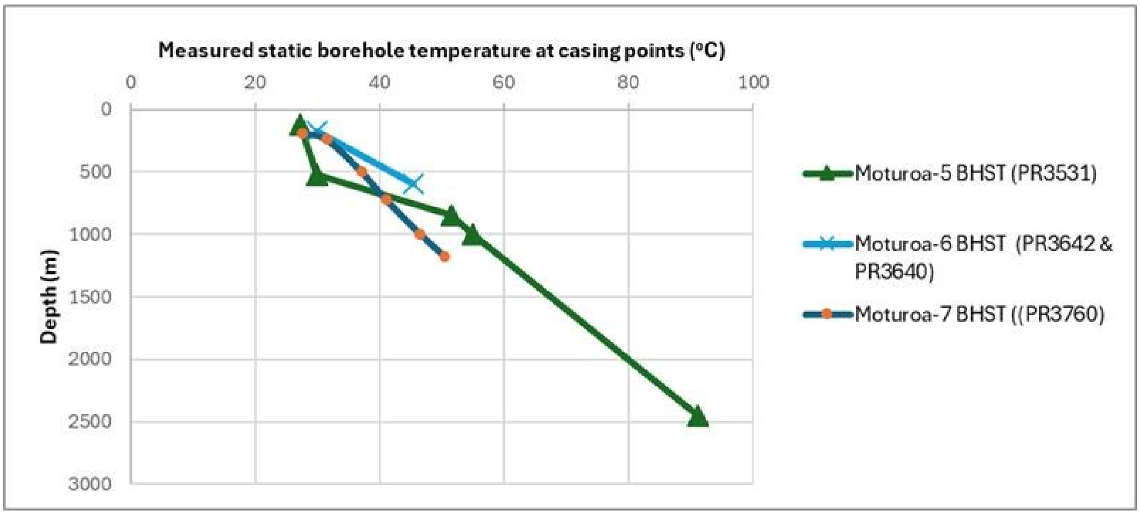


Figure 6.2 Plot of static temperatures measured at casing points in the borehole, provided by cementing contractor (Haliburton).

Table 6.3 Simplified summary of potential subsurface conditions at Todd Energy Aquatic Centre pool complex.

Geology
Volcanic debris (lahars) and marine sands: Surface to 30–160 m deep Matemateaonga Formation: *c.* 1000 m thick Eocene Sands: >1000 m deep

Depth (m)	Temperature (°C)	Groundwater Quality	Groundwater Flow (L/s)	Application			
				Heat	Cool	Direct/Indirect	Open/Closed Loop
Ocean	14–20*	Saline	Not limited	✓	-	Indirect	Both
Surface	14	Fresh	10	✓	-	Indirect	Both
250	24		10	✓	-	Indirect	Both
500	34		10	✓	-	Indirect	Open
750	44	Brackish	20	✓	-	Direct	Open
1000	54		20	✓	-	Direct	Open
1500	74		20	✓	-	Direct	Open
1910	91		20	✓	-	Direct	Open

* Note: unlike geothermal conditions, ocean water will have a small seasonal range.

Ocean water: In an exception to the geothermal focus of this report, but in an approach that utilises GSHPs in an open-loop system, a practical and cost-effective option could be to use seawater as the heat source for the GSHP. The ocean, like groundwater, provides a stable (at least within a relatively narrow temperature range) and readily available source of heat, making it a possible alternative for this location. Such seawater heating and cooling systems are quite common globally, for example, the Sydney Opera House uses the ocean waters in the harbour to provide initial heat/cool load for its space heating.

Shallow and ambient geoheat: There is limited space available within the facility's section footprint for a closed-loop GSHP installation to be considered. An open-loop GSHP installation using shallow ambient groundwater is an option, but as the site is located directly beside the sea this may risk seawater intrusion.

Medium and warm geoheat: Accessing the Matemateaonga Formation at the site would require a well to be drilled to approximately 700 m to access the required 40–45°C source for direct heating for the pools. Note that space heating and hot water may require ~60°C, depending on installed infrastructure. One extraction and one reinjection well would be required. The Matemateaonga Formation is reported to be artesian in places (e.g. the Taranaki Thermal Spa mentioned earlier), resulting in favourable flow rates for geoheat systems.

Repurposing petroleum infrastructure: Moturoa-5, -6 and -7 and the Republic New Plymouth-1 wells are located approximately 1 km along the coastline to the west of the site. Temperature data from these wells (Table 6.4) indicate that 40°C temperatures can be expected from a depth of ~700 m, aligning with the medium and warm geoheat option.

Using the nominal heat extraction rate of 150 W/m for a closed-loop system indicates that ~100 kW of heat is available, less than the required 870 kW. An open-loop system would require a flow rate of 20 L/s using a temperature differential of up to 10°C. This could be reduced further if a GSHP was used.

Unless there was potential to use one of these wells for reinjection, a separate reinjection well would need to be installed and could be located at the pool site. The location of the reinjection well would determine whether a trenched pipeline was required one way or included a return flow.

It may be possible to connect these existing wells to the site using the largely public spaces associated with the coastal walkway. Access, logistics and cost of connecting these wells would need to be explored further. It is unlikely that the cost benefit of doing this for just the TEAC could be justified. However, there may be merit if it was part of a larger district heat network (Section 6.5).

Table 6.4 Recorded temperatures, status, depth and year drilled of boreholes located in the Moturoa Field.

Well Name	Status	Corrected Bottom Hole Temperature (°C)	Total Vertical Depth (m)	Year Drilled
Republic New Plymouth-1	Plugged and Abandoned	45.7°C	962	1975
Moturoa-5	Plugged and Abandoned	91.1°C	1910	2006
Moturoa-6	Plugged and Abandoned	30°C	176	2006
Moturoa-7	Plugged and Abandoned	50.5°C	1180	2007

6.1.4 Energy Analysis Results

The results from the comparative analysis (Table 6.5) indicate that the direct-use systems and the GSHP using seawater as the heat source have significantly lower levelised cost of heating (LCOH) than the alternative ASHP and existing gas boiler.

Table 6.5 Preliminary results of energy and cost analysis for the Todd Energy Aquatic Centre (TEAC).

	Annual Thermal Load (kWh)	Peak Load (kW)	Capital Cost ($)	Annual Energy Consumption (kWh)	1-Year Opex ($)	25-year Opex ($)	Annual Carbon Emissions (kgCO²e)	25-Year Carbon Tax ($)*	LCOH** ($/kWh)
Existing natural gas boiler	1,668,400	870	0	2,085,500	225,234	8,211,866	403,920	646,271	0.17
Air source heat pump			2,100,000	667,360	160,166	5,839,549	46,715	74,744	0.16
Ground source heat pump (Seawater)			1,250,000	476,686	114,405	4,171,107	33,368	53,389	0.09
Direct use (40°C)			2,700,000	41,003	9,841	358,782	2,870	4,592	0.03

* Assuming carbon cost of $64 per tonne of CO_2 -e

** Levelised cost of heating.

Based on today's electricity price of $0.24/kWh, annual operating costs for a direct-use geothermal system are estimated at $9841. This represents savings of approximately $215,393 per year (96%) compared with gas, and $150,325 per year (94%) compared with an air-source heat pump.

The GSHP option (using seawater) has estimated annual operating costs of $114,405. This represents savings of approximately $110,829 per year (49%) compared with gas, and $45,761 per year (29%) compared with an air-source heat pump.

6.1.5 Discussion

The seawater GSHP and the direct-use geothermal system using 40–45°C from the Matemateaonga Formation at ~700 m deep, deliver the lowest annual operating costs of all options assessed. While their upfront capital costs are higher than alternative technologies, when assessed over a 25-year operating life, they provide the most competitive levelised cost of heat. It is also important to note that an ASHP located on the coast will be impacted by salty air and its corrosive elements, requiring higher maintenance and regular replacement of outdoor units. An ASHP replacement every seven to eight years has been included in the budgets.

The opportunity to include the pool in a wider district heating scheme is discussed further in Section 6.5.

6.2 Taranaki Base Hospital

Table 6.6 lists the geoheat technology that is explored in this section, highlighting which technology is feasible at the Taranaki Base Hospital.

Table 6.6 Summary of opportunities of geoheat technology for Taranaki Base Hospital.

Geoheat Technology Explored	Ground Source Heat Pump	Yes
	Direct Use	Yes
	Repurposed well	Maybe
	District scheme	Maybe

6.2.1 Background on Hospitals, the Built Environment and Geoheat

Hospitals are well suited to geoheat solutions because they require reliable heating, cooling and hot water 24 hours a day. This constant demand improves the return on investment, and, as essential services, hospitals benefit significantly from a stable, locally sourced and renewable heat supply that is not exposed to fuel price volatility or supply disruptions. An additional benefit that is somewhat unique to health care facilities is that a geoheat system has the potential to remove cooling towers, a common source of Legionnaires Disease.

As with public swimming pools, the investment case for geothermal heating of hospitals is strong because the higher upfront capital costs are balanced by the long life of the equipment, the 24/7 operation of the facility and the long-term commitment to the site.

For the purposes of this study, the mix of heating, cooling and hot water also provides a proxy for much of the built environment, such as offices, commercial buildings, galleries, museums, schools, etc. While there are also similarities to the delivery of heating and cooling across the built environment, the 24/7 operation of a hospital will typically make it a better geoheat opportunity from a purely energy savings perspective.

6.2.2 Site Information

The Taranaki Base Hospital is located on David Street in New Plymouth, *c.* 1–1.5 km southwest of the CBD (Figure 6.3). The hospital operates as a campus, comprising approximately 30 separate buildings spread across a large site, rather than one or two key buildings. In such instances, a geoheat system could be installed in a centralised or district approach or on a per building basis. Such site specificity is outside the scope of this assessment and any consideration of a geoheat system should also address the practicalities of these different approaches on an existing site.

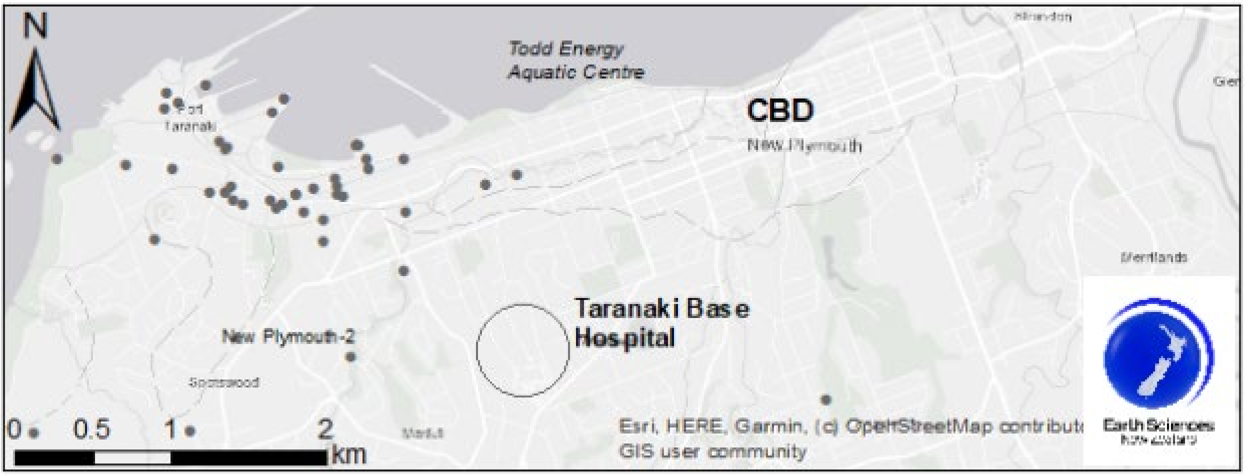


Figure 6.3 Location of Taranaki Base Hospital and nearby petroleum wells of the Moturoa Field.

6.2.3 Heating and Energy Use

The hospital's heating requirements have been sourced from a 2022 EECA funded report titled *ETA Opportunities Assessment – Taranaki District Health Board* developed by Elemental Group and Emsol. This assessment indicates that 6 MW of gas steam boilers (including redundancy) were installed across the campus for space heating, hot water and sterilisation. While annual gas usage was determined, a peak heating load was not.

The use of gas for sterilisation activities has since been displaced by the installation of two 144 kW electric boilers.

As well as reducing the heating load, the removal of sterilisation has presumably eliminated the need for steam, where space heating (40–80°C) and hot water (>60°C) require much lower temperatures.

Given this reduction in gas requirements, allowing for heating diversity (i.e. not all buildings need full heating during peak periods), the use of boiler redundancy and the typical situation where gas boilers are oversized, a peak heating demand of 2.3 MW at temperatures of up to 80°C has been adopted for the purposes of this case study (Table 6.7).

Cooling was not included in the 2022 EECA report as it is not considered a decarbonisation item. However, the heat rejected from cooling systems is often the cheapest and easiest form of heat, especially in buildings with simultaneous heating and cooling needs. To enable the consideration of cooling for the site, typical cooling requirements were adopted from other hospital projects with similar climates, noting that cooling was often driven by internal loads and fresh air requirements rather than the climate. To this end, a constant monthly peak cooling load of 1380 kW was adopted (Table 6.7).

The integration of heating and cooling needs is an important part of an efficient system. Referred to as heat recovery, rather than rejecting heat from cooling systems to the air via cooling towers, it can be 'captured' and used for heating purposes either immediately or later if thermal storage (i.e. hot water storage or even use of the ground as a thermal battery) is available. This can offset the amount of heat that needs to be created, from whatever source, and provides significant energy savings.

Table 6.7 Estimated monthly total and peak heating and cooling loads – Taranaki Base Hospital

Month	Peak Heating (kW)	Total Heating (kWh)	Peak Cooling (kW)	Total Cooling (kWh)
Jan	1282	244,254	1380	224,338
Feb	1590	178,736	1380	250,935
Mar	1590	342,795	1380	232,647
Apr	2120	428,693	1380	261,126
May	1696	510,441	1380	260,026
Jun	2141	600,769	1380	267,271
Jul	2120	685,676	1380	257,136
Aug	**2300**	702,239	1380	255,641
Sep	2014	565,714	1380	263,550
Oct	1749	541,731	1380	261,728
Nov	1802	467,283	1380	265,708
Dec	1484	305,110	1380	274,815
TOTAL	**-**	**5,573,441**	**-**	**3,074,921**

6.2.4 Geological Setting and Geoheat Opportunity

Table 6.8 provides a simplified summary of subsurface conditions underlying Taranaki Base Hospital. The temperature values adopted in the table were derived from New Plymouth-2 (Figure 6.3) that was drilled in 1965 and located *c.* 700 m to the west of the hospital. It had a measured temperature of 161°C at a bottom depth of 4400 m, for a temperature gradient of *c.* 33°C/km.

Table 6.8 Simplified summary of subsurface conditions: Taranaki Base Hospital.

Geology								
Volcanic debris (lahars) and marine sands: Surface to 30–160 m deep Matemateaonga Formation: *c.* 1000 m thick Eocene Sands: >1000 m deep								
Depth (m)	**Temperature (°C)**	**Groundwater Quality**	**Groundwater Flow (L/s)**	**Application**				
				Heat	**Cool**	**Direct/Indirect**	**Open/Closed Loop**
Surface	14	Fresh	10	✓	-	Indirect	Both
500	30		10	✓	-	Indirect	Open
1000	46	Brackish	-	-	-	-	-
1500	62		20	✓	-	Indirect	Open
2000	78		-		-	-	-
3000	110		-	-	-	-	-
4000	145		20	✓	-	Direct	Closed

The subsurface summary indicates that the available heat sources and types of GHXs include:

- Shallow closed-loop systems that will likely extend into the upper Matemateaonga.
- The Matemateaonga Formation as open or closed loop at a depth of 1500 m.
- Repurposing of New Plymouth-2 as open- or closed-loop.

Shallow and ambient geoheat (0–250m): There is sufficient space on site to accommodate both open- and closed-loop GHXs. Drilling would most likely occur within existing carpark areas, with the final above-ground infrastructure having a very small footprint and not requiring the permanent removal of any car parking spaces. The inclusion of cooling at the site provides an opportunity for shallow GSHP systems to use the ground for thermal storage irrespective of whether an open- or closed-loop system is installed.

Medium and warm: The Matemateaonga Formation has potential for up to 20 L/s at 62°C as an open loop at a depth of 1500 m. The available 62°C is capable of providing direct heat in most applications, but may be too low for some of the existing systems, which are designed for 80°C. As such, a GSHP will be required and, if so, a shallower well (*c.* 1000 m) should be considered at say 30–40°C, as the cost of drilling deeper needs to be offset against efficiency gains.

Repurposing petroleum infrastructure: As discussed in Section 5, repurposing petroleum infrastructure, such as New Plymouth-2, is typically best achieved by installing a closed-loop coaxial pipe as deep, open-loop systems are likely to have environmental or safety complications. It will require an approximately 700–1000 m (pending route options) insulated pipe connection from the site of the well to the hospital.

The available heat from a repurposed well using a coaxial closed loop is a function of its depth, the bottom hole temperatures present and the desired output temperature. For the purposes of this report, for an output of 80°C, a value of 250 W/m has been adopted for its full depth and 150 W/m for depths to *c.* 1000 m, in the event that the Eocene Sands are to be avoided completely. This results in a heating capacity of 1100 kW for the full depth and 150 kW if within the Matemateaonga Formation only.

This is almost half of the 2.3 MW peak heating demand for the full depth and reduces to *c.* 6% for the shallower Matemateaonga Formation only option. While neither of these meet the full heating demand of the site, they could provide a baseload heating demand either across the site or for one or more buildings.

The shallow 150 kW system is unlikely to be viable, while the 1100 kW deeper system is of sufficient capacity for further consideration.

However, rather than using New Plymouth-2 as a standalone system, use of the deeper, hotter temperatures may be best considered as part of a larger district system for the New Plymouth CBD. In this event, the economies of scale offset the single well investment costs through inclusion of the hospital and New Plymouth-2 into that larger system.

6.2.5 Discussion

Taranaki Base Hospital provides a complex case study. It has potential for campus-sized district heating and thermal sharing regime between its numerous buildings. However, for a scoping study there is not enough heating and cooling data available to do a good assessment of the opportunity. However, there are opportunities for utilising geoheat for the hospital site. There are several approaches that could providing efficient heat and/or heating and cooling options. These include:

For heating only, target deeper formations for elevated temperatures (estimated to be ~161°C at ~4400 m – as seen in the nearby New Plymouth-2 well). Unfortunately, New Plymouth-2 is 700 m away and will not be economical to repurpose for use at the hospital site.

For heating and cooling options, the shallow system providing ambient temperatures could be used with GSHP. This could likely be incorporated into existing HVAC systems on the site.

Alternatively, as discussed in Section 6.5, there is potential for a larger-scale district heating system for Taranaki Port and New Plymouth CBD. There could be efficiencies gained in this situation by extending the region to include Taranaki Base Hospital

6.3 Greenhouses

Table 6.9 lists the geoheat technology that is explored in this section, highlighting which technology is feasible for a 1 Ha greenhouse built in the Taranaki region.

Table 6.9 Summary of opportunities of geoheat technology for greenhousing in Taranaki.

Geoheat Technology Explored	Ground Source Heat Pump	Yes
	Direct Use	Yes
	Repurposed well	Yes – assuming immediately adjacent
	District scheme	Dependent on location

6.3.1 Background on Greenhouses and Geoheat

Covered cropping is an integral part of New Zealand’s food system, enabling year-round access to locally grown fresh vegetables. Over 90% of the tomatoes, capsicum and cucumber consumed fresh in New Zealand are grown in greenhouses. Similarly, also significant quantities of leafy greens, chilis, courgettes, eggplants, herbs, sprouted beans, nursery plants, cut flowers and medicinal marijuana (HortNZ 2023). This supports resilience in the domestic food supply, which is becoming increasingly important as climate change impacts growing conditions and supply chains. For example, during Cyclone Gabrielle, 80% of the tomatoes grown outdoors for processing were destroyed, whereas the supply of indoor grown tomatoes was relatively unaffected (HortNZ 2023).

Greenhouses are a highly efficient food production system, optimising land, water and nutrient use. Compared with outdoor growing, they produce significantly higher yields using less water. For example, high-tech tomato greenhouses can achieve yields of around 1000 tonnes per hectare per year, which is 10–20 times higher than field-grown crops, while using approximately four times less water (Grower2Grower 2019).

Despite these advantages, greenhouse operations are highly energy-intensive. Covered crops require tightly controlled indoor temperatures, resulting in significant heating demand during colder months. This heat is currently supplied predominantly by fossil-fuel boilers, including gas, coal, waste oil and diesel in New Zealand.

The sector is now at a critical crossroads. in New Zealand, rising gas prices, increasing supply uncertainty and mounting decarbonisation pressures are eroding margins and threatening viability. In Taranaki, at least one covered-crop operation has recently closed, citing gas costs as the primary reason for ceasing operations.

From a security of supply, reliability and cost perspective, many covered-crop growers in New Zealand are increasingly interested in geothermal heat for their heating needs (Seward et al. 2023). Much of this interest is informed by developments in the Dutch horticulture industry.

In response to climate change targets while maintaining industry competitiveness, the Dutch horticulture sector has transitioned toward geothermal direct-use systems for heating and processing. These systems typically involve drilling to depths of more than 2 km to access temperatures of approximately 80°C (Wells et al. 2025). Like Taranaki, the Netherlands has a long history of oil and gas exploration, resulting in well-characterised geothermal gradients.

Geothermal gradients in the Netherlands typically range between 30–35°C/km, broadly consistent with global crustal averages. Despite these relatively moderate subsurface conditions, the sector generated approximately 6.8 PJ of geothermal energy in 2022 from 36 geothermal doublets across 26 locations. This displaced an estimated 0.2 km^3 of natural gas usage (Brasnett et al. 2024).

For context, this level of geothermal heat production is comparable with New Zealand's total current geoheat use, which includes high-temperature industrial applications at Kawerau and Taupō (MBIE 2025).

6.3.2 Site Information

In this instance, we haven't chosen a specific operator for a case study or even a specific location. Rather, the analysis presents a 1 Ha greenhouse that could be located anywhere across the region, and an understanding of the underlying geoheat resource enables a site to be selected based on the ability to access the thermal resource.

The important parameters when considering an optimal location for a greenhouse based on the available geoheat resource are:

- **Temperature:** A modern greenhouse can be heated with *c.* 40°C heat using good building fabric and low-temperature heating distribution systems. Temperatures greater than this will enable a direct-use system to be installed. This will avoid onsite plant and equipment, such as GSHPs, that may impact electrical connections while also being significantly more efficient.
- **Depth**: Depth to the desired resource is mostly a cost issue. Often there will be a trade-off between the additional capital costs to drill down to a deeper and warmer heat source verses a shallower and lower-cost ambient well that will require a GSHP.

- **Flow rate**: Flow rate for an open loop will significantly influence the available heating capacity. For the same temperature, doubling the flow rate will double the available heat capacity or production from a given well. Flow rate is less important for a closed-loop system, although it can assist with 'replenishing a GHX' if groundwater flow is moving across the site.

Each of the above parameters applies almost regardless of the formation or aquifer accessed. The potential to repurpose petroleum infrastructure may mean that deeper sources can be accessed for lower cost but, as per Section 5, this introduces its own considerations.

6.3.3 Heating and Energy Usage for 1 Ha Greenhouse

A 1 Ha greenhouse facility constructed with 4 mm toughened, diffused glass has been assumed as the thermal envelope for the energy modelling undertaken.

For thermal demand modelling, a constant internal air temperature setpoint of 18°C is assumed. This conservative assumption simplifies the analysis and reflects the minimum heating requirement, while avoiding reliance on solar gains or daytime temperature elevation. The heating distribution system has been assumed as requiring *c.* 40°C and potentially up to 60°C. These ranges are addressed by the adoption of 50°C and 70°C as the target source temperatures for direct use.

The result from the thermal modelling is that a 1 Ha greenhouse with an internal setpoint of 18°C in the region will have:

- Annual thermal load: 1,564,520 kWh
- Peak heating load: 1068 kW

Given the rectangular structure and uniformity of design and usage, this value can be readily pro-rated for different greenhouse areas, but would need further calculations for a changed internal setpoint temperature.

6.3.4 Geological Setting and Geoheat Opportunity

Given that, for this application, we are not defining a specific location; we will adopt the general subsurface summary that was discussed in the opening of this Section and summarised in the below table.

Table 6.10 provides a simplified summary of subsurface conditions underlying the region. An average temperature gradient of 35°C/km has been adopted and, based on the temperatures required for a greenhouse, source temperatures are limited to 70°C. If temperatures >70°C are easily accessible, then they can be utilised. However, by placing this maximum limit we are attempting to limit potentially costly and unnecessary drilling.

Table 6.10 Simplified summary of regional subsurface conditions.

Geology								
Volcanic debris (lahars) and marine sands: Surface to 30–250 m deep Matemateaonga Formation: *c.* 1000 m thick but thins out in the north Eocene Sands: >1000 m deep								
Depth (m)	**Temperature (°C)**	**Groundwater Quality**	**Groundwater Flow (L/s)**	**Application**				
				Heat	**Cool**	**Direct/Indirect**	**Open/Closed Loop**	
Surface	14	Fresh	10	✓	-	Indirect	Open	
500	32		10	✓	-	Indirect	Open	
1000	50	Brackish	-	✓	-	Indirect	Open	
1600	70		20	✓	-	Direct	Open	
4000*	>70		-	✓	-	Direct	Both	

* Repurposed petroleum infrastructure shown as open or closed loop. Assumes 4000 m depth is accessible.

The potential to repurpose petroleum infrastructure will depend on accessibility and available temperatures. Available data indicate that both 50°C and 70°C are achievable.

- For an open-loop system, a minimum flow rate of 17 L/s is required using a temperature differential of 15°C for the peak heating load of 1068 kW.
- For a closed-loop system using the 150 W/m or 250 W/m heat extraction rate requires a depth of 7100 m or 4300 m, respectively, to match the peak heating load of 1068 kW.

Based on these two very preliminary designs, the open loop appears to be the most likely to achieve the required heating loads. The upper extraction rate of 250 W/m, adopted for higher bottom hole temperatures (nominally >140°C), corresponds to a depth commonly encountered in the region but approaches the upper limit of recorded temperatures.

6.3.5 Energy Analysis Results

The results from the comparative analysis (Table 6.11) indicate that while capital cost for the direct-use systems is greater, 25-year operating costs are significantly less due to the absence of the GSHP and its associated electricity consumption. The end result is that all of the geoheat solutions have an equal or lower LCOH than the ASHP (although only marginally in some instances) and much lower than for LPG gas heating. The exception is the GSHP using 30°C geothermal waters, as while it has a higher efficiency this does not offset the cost of drilling deeper.

Table 6.11 Preliminary results of energy and cost analysis for the 1 Ha greenhouse

Heating Type	Capital Cost ($)	Annual Energy Consumption (kWh)	25-Year Opex ($)	TOTAL: Capex + Opex ($)	LCOH ($/kWh)
LPG Gas heaters	400,000	1,762,164	17,691,263	18,091,263	0.42
ASHP*	1,400,000	711,145	8,270,981	9,670,981	0.17
GSHP 15°C	1,996,000	456,763	5,312,379	7,308,379	0.13
GSHP 30°C	5,452,000	335,698	3,904,343	9,356,343	0.18
Direct Use 50°C	5,501,000	4898	56,961**	5,557,961	0.09
Direct Use 70°C	7,904,000	4898	56,961**	7,960,961	0.15
Repurpose well (open loop)	5,200,000	4898	56,961	5,256,961	0.08
Repurpose well (closed loop)	5,900,000	4898	56,961	5,956,961	0.10

* Includes a single replacement within the 25-year life cycle.

** Direct-use systems shown as same operating costs, although there will be some variability in pumping costs.

The two best-performing systems are the 50°C direct-use system and the repurposed petroleum infrastructure as an open loop. The former illustrates the benefit of combining lower heating temperatures within the greenhouse which can also limit the required depth of drilling.

The latter shows the capital cost differential of the open loop compared with the higher cost coaxial closed-loop system with repurposed petroleum infrastructure when the other variables are equal. The previously discussed caveats and practicalities of repurposing wells will still apply and need to be considered on an individual basis.

6.3.6 Discussion

This example has been designed to demonstrate how a known significant heat user, such as a greenhouse, where heating is a significant business cost, can be relocated to or established where there is a known geoheat source. The key qualifiers for this suitable heat source are a combination of temperature, depth and flow rate. By understanding these parameters at any given location, a geoheat system can be designed either as direct use, indirect use or as an open or closed loop. Note that, in general, shallow ambient temperature closed-loop systems are not as suitable for a heating-only application as there is a risk of cumulatively extracting heat from the ground faster than it can be naturally replenished. However, this can change with deeper, higher-temperature direct-use systems.

As is so often the case with geoheat systems, the key to an efficient system starts with the facility/building. That is, reduce the heat demand and output temperatures through building design and then look at the underlying geology and geoheat potential. Identifying a location(s) where a ~50°C source can be accessed for the lowest cost is then the objective, as drilling deeper for a hotter resource does not tend to result in a lower cost system.

The availability of repurposed petroleum infrastructure may change this, depending on the ease of repurposing. For example, if the higher temperatures are readily available, then the additional cost of the lower-temperature heat distribution network may not be warranted.

Further, drilling deeper for a direct-use system is worth exploring as, while drilling costs may increase, these need to be offset against above ground costs, such as plant and equipment like GSHPs and (perhaps most significantly) whether there is sufficient power supply to the site, as power capacity upgrades can be costly. These upgrades have not been included in the capital costs presented above. There will be projects where capital cost is similar for both options due to the cost of power supply upgrades alone. In this instance, the deeper direct use would typically be recommended due to the significantly reduced ongoing energy costs.

6.4 Repurposing Kapuni Wells for Industrial District Heating

6.4.1 Background

Discovered in 1959 and brought into production in 1970, Kapuni field is the oldest producing gas condensate field in New Zealand. It is 100% owned and operated by Todd Energy. The Kapuni field is a structurally complex four-way dip closure along the Manaia Anticline. Kapuni field is part of a north-trending regional fold structure bounded on the west by the Manaia Fault. The main field area is approximately 30 km^2, measuring roughly 10 km in length by 4.5 km, while the broader geological structure of the Kapuni Anticline extends further (Figure 6.4).

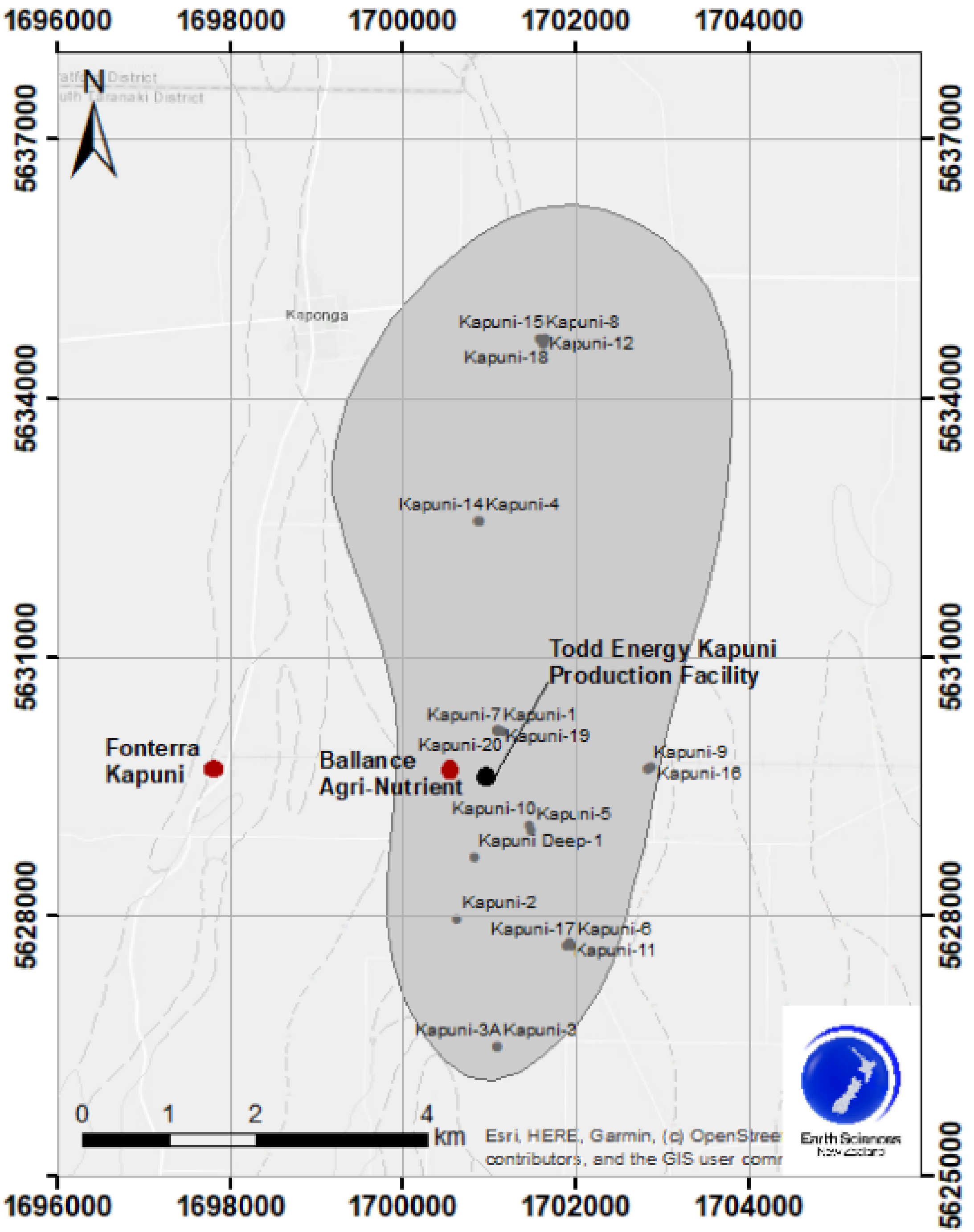


Figure 6.4 Kapuni field with well locations and large heat existing heat users located nearby (EECA 2025).

The Kapuni field consists of 30 wells distributed across 10 well sites, around the Kapuni Production station. Well sites have low-temperature separation units installed on the wellheads to separate the gas from the liquids (condensate and water) and pre-condition the gas. Using separate pipelines, the gas and liquids are transported to the Todd Energy Kapuni Production facility (Figure 6.5). The infield gas gathering system also feeds the cogeneration facilities at the Fonterra Dairy plant at Whareroa. Liquids produced during production are treated at the Kapuni Production station separating water and condensate. Water is disposed of via water injection wells with the formation injected into noted in brackets: KA1 (Mangahewa), KA7 (Moki), KA16 (Matemateaonga), KA20a (Moki), KW2 (Matemateaonga), KW3 (Matemateaonga). Todd Energy also maintain four groundwater monitoring bores at Kapuni (Table 6.12), allowing operational effects on groundwater systems to be monitored.

Table 6.12 Groundwater monitoring bores located within the Kapuni field.

Site Code	Well Site	Type	Distance from Kapuni-9/16	Interval	Depth (m)	Aquifer
GND1701	KA9/16	Bore	2971	92	337	Matemateaonga
GND2369	KA9/16	Bore	2971	280–448	448	Matemateaonga
GND1659	KA9/16	Bore	4020	123–432	432	Matemateaonga
GND2357	KA9/16	Bore	<50	35*	unknown	Volcanics

* Estimated.

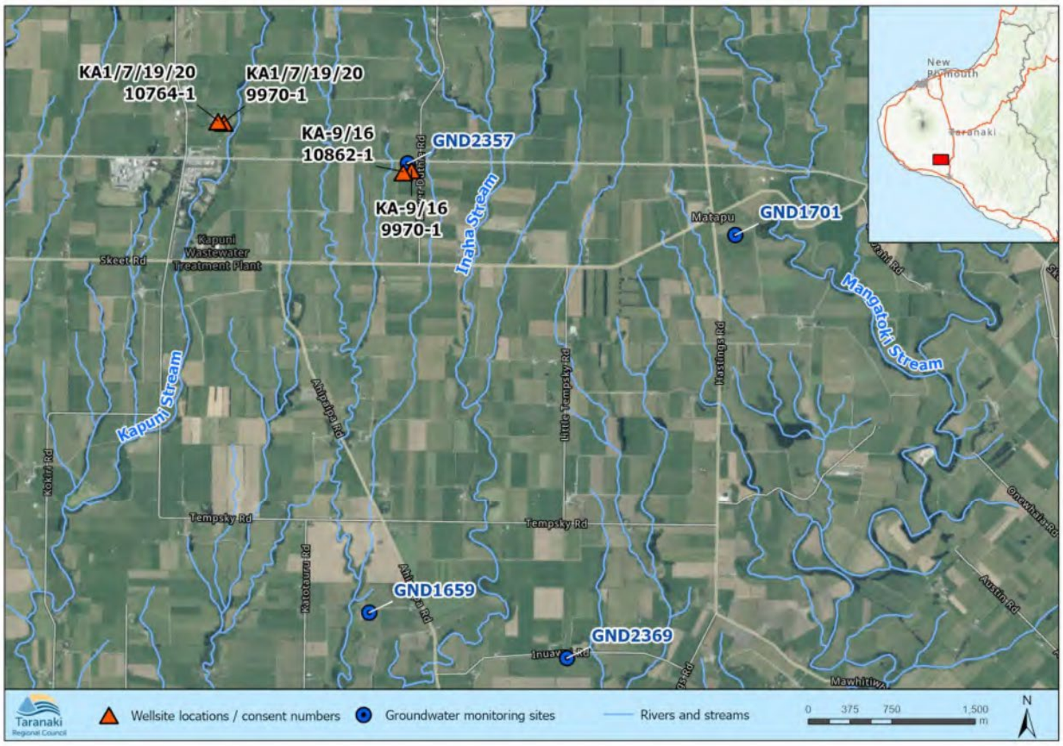


Figure 6.5 Location of monitoring sites at Kapuni (source Skinner et al. 2013).

As fields approach the end of their economic life for gas extraction, operators are increasingly focused on managing significant decommissioning and plugging and abandonment liabilities. It may be possible to delay full decommissioning through continuing to use installed fluid extraction and injection infrastructure and consents though other potential uses, such as for $C0_2$ storage.

This transition from production to decommissioning presents a unique opportunity for geoheat. The field contains a dense network of 30 wells and sidetracks ranging from monitoring bores at a depth of 337 m (GND1701) to 5670 m (Kapuni Deep-1) (Table 6.13). Excluding the shallow monitoring bores and the significantly deeper Kapuni Deep-1, their average depth is 3829 m, with a standard deviation of 123 m (3%). This low variability indicates a consistent target depth across the field. It is important to note Kapuni-21, 22, 23, 23ST1, 24 and WI-03 are not yet included in the open file under the NZP&M open file system data, so are not included in these statistics.

In terms of temperature, the average bottom hole temperature is 107.4°C with variability of 11.8°C or 11%. Again, excluding Kapuni Deep-1 (153.2°C at 5670 m), the average is 105.7°C with variability of 7.7°C or 7.3%.

The available dataset indicates a high level of consistency across the field and the deeper wells are likely to have higher temperatures.

Table 6.13 Summary of Kapuni oil and gas wells, including status, bottom hole temperature, vertical depth and year drilled.

Well	Status	BHT Temperature (°C)*	Total Vertical Depth (m)	Year Drilled
Kapuni Deep-1	Injecting	153.2	5670	1983
Kapuni-1	Producing	117.1	3968	1959
Kapuni-2	Plugged and abandoned	118.7	4112	1961
Kapuni-3	Producing	96.2	3794	1962
Kapuni-4	Producing	117.7	3898	1962
Kapuni-5	Producing	98.3	3704	1974
Kapuni-6	Producing	105.2	3779	1974
Kapuni-7	Suspended	107.1	3770	1974
Kapuni-8	Producing	115.1	4074	1975
Kapuni-9	Injecting	104.2	3799	1975
Kapuni-10	Shut-in	107.7	3772	1975
Kapuni-11	Shut-in	101.8	3696	1975
Kapuni-12	Producing	106.2	3608	1983
Kapuni-14	Producing	107.4	3893	1987
Kapuni-15	Producing	(135.4)	4770	1992
Kapuni-15A	Producing	(91)	3812	1992
Kapuni-16	Injecting	(100)	3757	2003
Kapuni-17	Producing	(107.9)	3806	2010
Kapuni-18	Producing	(105.9)	3922	2010
Kapuni-19	Producing	(100)	3675	2013
Kapuni-20A	Producing	(100)	3690	2013
Kapuni-21	Producing	(107.8)	3896	2021
Kapuni-22	Producing	(109.5)	3897	2021
Kapuni-23 ST1	Producing	(113.1)	3905	2022
Kapuni-24	Producing	(113)	3897	2022
Kapuni-25	Producing	(98.9)	3648	2023
Kapuni-27	Producing	(89.4)	3893	2023
Kapuni-28	Producing	(107.8)	3901	2023
	Average**	**105.6**	**3829**	-
	Standard deviation**	**7.7**	**123**	-

* All temperatures are at bottom of hole with uncorrected temperature readings in brackets.

** Excludes the shallow monitoring wells and the significantly deeper and hotter Kapuni Deep-1.

6.4.2 Site Information and Resource Assessment

For the purposes of this assessment, this Section will focus on the potential to repurpose petroleum infrastructure as a heat source. District energy systems typically require larger heat sources and many of the flow rates in the shallow aquifers are insufficient for a large heat supply. In the event that smaller cooling loads are required, the shallow aquifers could be investigated.

Table 6.14 augments the bore information from Table 6.13 with an estimate of heating capacity for both open- and closed-loop geoheat systems. It is based on an output temperature of 60°C, a range of open-loop flow rates from 10 to 30 L/s and a closed-loop heat transfer rate of 200 W/m. The full depth of each well has also been included. Each of these parameters influences the calculated capacity and have been adopted as follows:

- Output temperature (open loop): 60°C has been adopted as it meets most building heating requirements as well as applications such as pools and greenhouses. It can also be a good starting temperature for baseload or pre-heating in an industrial facility, or as the starting point for an industrial/steam heat pump. Higher output temperatures (see 80°C totals in Table 6.14) reduce the available capacity and could be an option at specific sites, either supplied from a heat network or as an individual system connected to a single well.
- Output temperature (closed loop): Closed loop coaxial systems have an output temperature that is *c.* 50% of the bottom hole temperature.
- Flow: The values of 10, 20 and 30 L/s align with the available information on groundwater flows across the region. This is the rate of groundwater flow that is pumped from the subsurface to the surface and returned. Closed-loop flow is the flow within the coaxial pipe, is optimised based on the design and is not subject to groundwater conditions.
- Closed-loop heat transfer rate: The discussion uses a range of 150 to 250 W/m with the mid-range value of 200 W/m being adopted.
- Depth: The full depth of each well has been used to show the maximum potential. It is noted that full depth of the bores may not be available for environmental or safety reasons and, in that scenario, reduced available well length will reduce the thermal capacity. New wells could, of course, be drilled deeper, and Kapuni Deep-1 provides an indication of the temperatures present at depth.

Table 6.14 Estimated heat capacity for each well in the Kapuni field.

Well	Temperature (°C)*	Total Vertical Depth (m)	Open-Loop Capacity (kW)				Closed-Loop Capacity (kW)	
			Output (°C)	Flow (L/s)			Heat Transfer Rate (W/m)	Output (°C)
				10	20	30	200	
Kapuni Deep-1	153.2	5670	60	4000	7900	11,800	1200	77
Kapuni-1	117.1	3968	60	2400	4800	7200	800	59
Kapuni-2	118.7	4112	60	2500	5000	7400	900	59
Kapuni-3	96.2	3794	60	1600	3100	4600	800	48
Kapuni-4	117.7	3898	60	2500	4900	7300	800	59
Kapuni-5	98.3	3704	60	1700	3300	4900	800	49
Kapuni-6	105.2	3779	60	1900	3800	5700	800	53
Kapuni-7	107.1	3770	60	2000	4000	6000	800	54
Kapuni-8	115.1	4074	60	2400	4700	7000	900	58
Kapuni-9	104.2	3799	60	1900	3800	5600	800	52
Kapuni-10	107.7	3772	60	2100	4100	6100	800	54
Kapuni-11	101.8	3696	60	1800	3600	5300	800	51
Kapuni-12	106.2	3608	60	2000	3900	5900	800	53
Kapuni-14	107.4	3893	60	2000	4000	6000	800	54
Kapuni-15	(135)	4800	60	3200	6300	9500	1000	68
Kapuni-15A	(91)	3812	60	1400	2700	4000	800	46
Kapuni-16	(100)	3757	60	1700	3400	5100	800	50
Kapuni-17	(107.9)	3806	60	2100	4100	6100	800	54
Kapuni-18	(105.9)	3922	60	2000	3900	5800	800	53
Kapuni-19	(100)	3675	60	1700	3400	5100	800	50
Kapuni-20A	(100)	3690	60	1700	3400	5100	800	50
Kapuni-21	(107.8)	3896	60	2100	4100	6100	800	54
Kapuni-22	(109.5)	3897	60	2100	4200	6300	800	55
Kapuni-23 ST1	(113.1)	3905	60	2300	4500	6700	800	57
Kapuni-24	(113)	3897	60	2300	4500	6700	800	57
Kapuni-25	(98.9)	3648	60	1700	3300	5000	800	49
Kapuni-27	(89.4)	3893	60	1300	2500	3800	800	45
Kapuni-28	(107.8)	3901	60	2100	4100	6100	800	54
Average	**107.4 (105.6)**	**3898 (3829)**	-	**2048**	**4037**	**6026**	**822**	-
Total kW at 60°C	-	-	-	**55,300**	**109,000**	**162,700**	**22 200**	-
Total kW at 80°C	-	-	-	**32,300**	**63,500**	**94,800**	-	-

* All temperatures are at bottom of hole with uncorrected temperature readings in brackets.

Note: Brackets are calculated values excluding Kapuni Deep-1.

As with the previous case studies outlined above, the results in Table 6.14 illustrate that open-loop systems have greater thermal capacity than closed-loop systems and their capacity increases with flow rate. However, it is important to note that a closed-loop system may be required for environmental and safety considerations.

The estimated range of thermal capacity available from the wells is 22.2 MW for the closed loop and ranges from 55 to 163 MW for the open-loop systems. Note that the capacity range reduces to 32–95 MW for an 80°C output. Given the Kapuni field has a total area of ~30 km^2 and ~30 wells are identified, this provides a heat availability of approximately 2–6 MW per km^2. Geoheat wells would typically be closer together than petroleum wells. As such, if the area is optimised for geoheat, more wells could be installed, increasing the heating capacity of the area. Further investigations of total available heat resource are warranted to understand its full geoheat potential.

It is uncertain whether the larger Kapuni Anticline at *c.* 144 km^2 has similar temperatures and thus would increase the available thermal resource as well as the area for locating heat users. This would require new wells to be drilled, to better understand and quantify the potential geoheat resource over the wider Kapuni anticline area.

For the purposes of this case study, a thermal capacity value of 100 MW at 60°C will be adopted in a district heating network.

6.4.3 Opportunity

While the focus of this assessment is on heating, the available temperature profile provides a range of potential applications, such as direct- or indirect-use systems, the presence of temperatures >70–80°C provide an opportunity for cooling via absorption chillers or the generation of electricity via binary/organic rankine cycle plant.

The cooling and electricity generation applications would be considered on a site-specific basis as they require hotter than the nominated 60°C and warrant further investigation. Typical applications for cooling using absorption chillers include cold storage and data centres. These are not discussed further, but should be considered for further investigation.

In terms of existing large heat users listed in the RETA (EECA 2024), Ballance Agri-Nutrients (~320 MW) and Fonterra (~100 MW) require temperatures >100°C. As such, the available resource, as adopted here at 60°C, could provide baseload or pre-heat or be the input for an industrial or steam heat pump. Given the scale of both sites, there may be value in investigating deeper wells where higher temperatures are known, as well as to understand available flow rates and thus whether they are suitable for these specific sites.

In terms of new heat users that could be attracted to the region if a low-cost heat resource is available, the 100 MW at 60°C could be utilised to heat:

- *c.*100 Ha of greenhouses as per the above case study that showed a 1 Ha greenhouse requiring *c.* 1 MW of heat.
- Swimming pools as per the above case study.
- Most buildings can be heated with a 60°C source temperature, i.e. underfloor heating is typically 30–40°C and, with proper sizing, radiators and fan coil units can be operated with 50–60°C. For example, 100 MW could heat over 8000 homes at an average of 12 kW of heat per home.
- Industries requiring temperatures up to 100°C include some forms of dairy processing and many sectors that require large volumes of hot water for washdown and hygiene purposes.
- District heating for the nearby Manaia township, providing residents and businesses with a sustainable and potentially lower-cost alternative to traditional electric or gas heating.

Applications that require higher temperatures could source the heat directly or be boosted using supplementary heat from electric boilers, heat pumps or biomass boilers.

The trade-off between total capacity and output temperature will be a planning and design consideration for any proposed system.

6.4.4 Economic Considerations

The economic framework for a Kapuni district heat project centres on the strategic shift of capital expenditure from decommissioning to the repurposing of existing petroleum infrastructure and the installation of surface piping networks for use in geoheat systems. Various estimates indicate similar cost ranges for these two activities, where the repurposing has an opportunity to provide an ongoing revenue stream. Importantly, as the current operator of the Kapuni field, repurposing also has the potential for continuation of Todd Energy's business activities in the region and to be a catalyst for new industries seeking low-cost heat for their operations.

It is estimated that the cost of repurposing a decommissioned gas well into a geothermal heat exchanger is approximately 10% to 30% of the cost required to drill a new dedicated geothermal well. This significant reduction in initial capex drastically lowers the barrier to entry for renewable heat projects in the region. With resource consents in place for both extraction and reinjection at Kapuni, there are potential significant cost savings and certainty that improve project economics. The existing consents will need to be reviewed to ensure that they can be applied to a geoheat system.

Operational expenditures are projected to be relatively low, consisting primarily of electricity consumption for high-efficiency circulation pumps and routine maintenance of the well head and surface heat exchangers. The greenhouse case study indicated an LCOH of 8–10 c/kWh, which compared favourably to ASHPs at 17 c/kWh and LPG at 42 c/kWh, while insulating them from the volatility of carbon pricing and global gas markets. It could be expected that the economies of scale associated with a district geoheat system could also realise similar opex savings and would form the basis of any future business case.

6.4.5 Discussion

The Kapuni field represents a unique 'ready-made' low-temperature geothermal laboratory. Preliminary data suggest that the temperatures and existing infrastructure provide a viable path toward a district geoenergy/heating pilot.

The existing infrastructure, such as bore, reinjection, pipe network and existing resource consents at Kapuni, represents a substantial sunk cost for the operators, particularly as significant legislated decommissioning costs are still pending. As such, there is a compelling case for further investigation to understand how these regulated abandonment liabilities compare with the capital required to repurpose the wells for geoheat. By transitioning these assets into a geothermal heating / energy network, an existing financial liability might be able to be transformed into an ongoing revenue stream.

From a circular economy perspective, repurposing these bores avoids the expense of drilling new geothermal wells, typically ranging from $5M to $15M per well depending on depth and complexity, which usually accounts for 50–70% of total geothermal project capital costs.

Furthermore, this transition directly supports regional decarbonisation goals and can assist with not just repurposing the wells but repurposing local industry from fossil fuels to clean, sustainable geoheat. This repurposing of industry applies to both the highly skilled local workforce as well as those industries that requires heat, whether existing or attracted to the region by the availability of the heat resource.

6.5 Geothermal District Heating for New Plymouth CBD and Port Taranaki

6.5.1 Background

This case study explores the potential for a brownfield district heating development centred on the New Plymouth CBD and Port Taranaki (Figure 6.6). Unlike the rural, well-dense environment of Kapuni, this project focuses on high-density urban and industrial heat loads. By leveraging Taranaki's favourable geothermal gradient and existing industrial land at the port, the project aims to decarbonise municipal infrastructure and maritime industries, providing a scalable model for New Zealand’s urban centres.

The focus for this case study is the Moturoa field, a compact but historically significant reservoir covering approximately 2 km^2 (Figure 6.6). Despite its modest surface area compared with other fields in the Taranaki region, its location is strategically important. It sits directly beneath the Moturoa suburb and extends into the western fringe of the New Plymouth CBD. Historically significant for its early oil exploration, the precinct contains a dense concentration of legacy and decommissioned wellbores, some dating back to the late 19th century. Several periods of petroleum exploration have occurred in the region with major advances in the mid-1960s, mid-1970s, mid-1990s and mid-2000s. Many of these bore holes were highly deviated, which complicates understanding of the observed temperatures, but all encountered an elevated geothermal gradient. Some of the highest calibrated bottom hole temperatures were encountered in bore holes in this region.

Table 6.15 summarises the available information on bores within the Moturoa area. Due to the range of depths drilled, averaged values, as calculated for the Kapuni case study, have not been included as they are not representative for Moturoa.

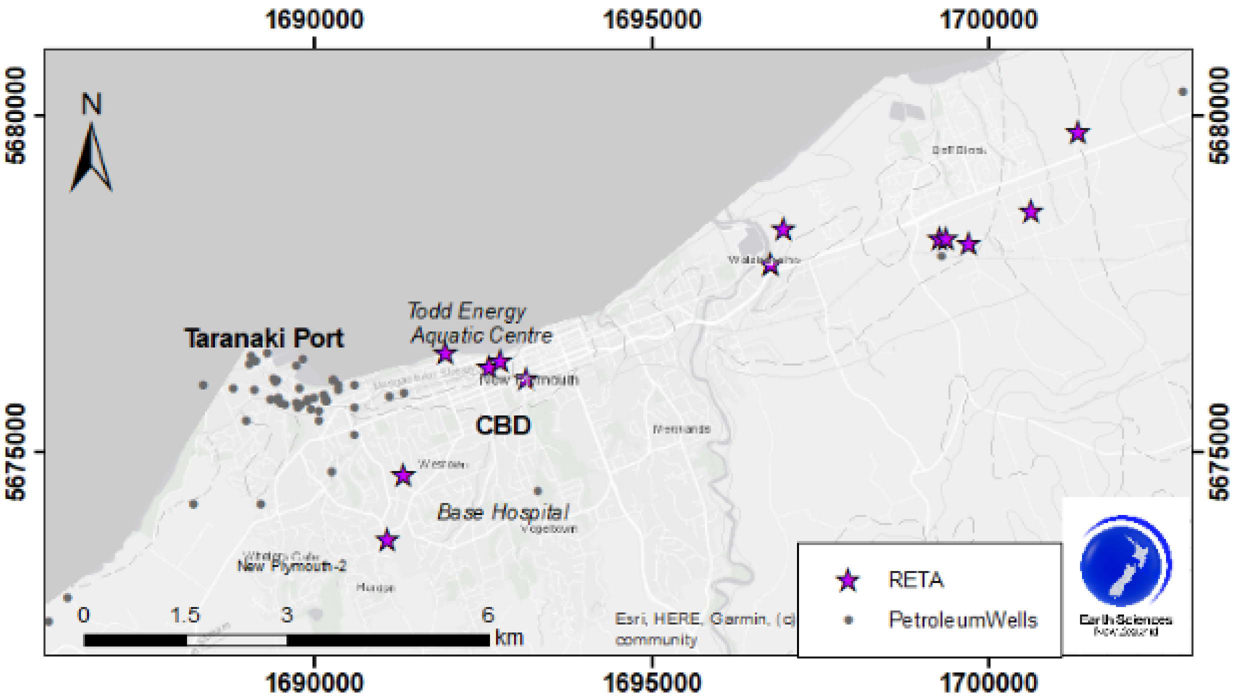


Figure 6.6 Location of petroleum wells (grey dots) and heat users (purple stars) in the New Plymouth region.

Table 6.15 Recorded temperatures, status, depth and year drilled of bore holes located in the Moturoa Field.

Well	Status	BHT Temperature* (°C)	Total Vertical Depth (m)	Year Drilled
Paritutu-1	Plugged and Abandoned	96.7°C	2363m	1993
Toka-1	Plugged and Abandoned	138.9°C	3820m	1995
New Plymouth-2	Plugged and Abandoned	161.3°C	4411m	1965
Republic New Plymouth-1	Plugged and Abandoned	45.7°C	962m	1975
Republic New Plymouth-2	Plugged and Abandoned	49°C	910m	1975
Republic New Plymouth-4	Plugged and Abandoned	46.9°C	945m	1976
Moturoa-5	Plugged and Abandoned	(91.1°C)	1910m	2006
Moturoa-6	Plugged and Abandoned	30°C	176m	2006
Moturoa-7	Plugged and Abandoned	50.5°C	1180m	2007

* All temperatures are at bottom of hole with uncorrected temperature readings in brackets.

6.5.2 Geothermal Resource Assessment

For the purposes of this assessment, this Section will focus on the potential to repurpose petroleum infrastructure as a heat source. District systems typically require larger heat sources and many of the flow rates in the shallow aquifers are insufficient for a large heat supply.

In situations where cooling loads are required and most heating demand occurs at lower temperature, the shallow aquifers could be investigated. As per the Todd Energy Aquatic Centre case study, the ocean is also a possible thermal source for heating and cooling. For this district energy scheme, both the shallow aquifer and ocean are plausible, and further investigation would be warranted. A district energy system based on a low-temperature geothermal resource that supports both heating and cooling is consistent with fifth-generation network technology as demonstrated in numerous international case studies (e.g. Neustadt am Rubenberge, Germany; Framingham, USA; Zurich Switzerland; Thermoroad, Denmark).

As with the Kapuni case study, Table 6.16augments the borehole information from Table 6.15 with an estimate of heating capacity for both open- and closed-loop geoheat systems and is based on the same parameters.

Table 6.16 Heat capacity estimations for New Plymouth CBD and Port Taranaki.

			Open-Loop Capacity (kW)				Closed-Loop Capacity (kW)	
Well	**BHT Temperature (°C)**	**Depth (m)**	**Output (°C)**	**Flow (L/s)**			**Heat Transfer Rate (W/m)**	**Output (°C)**
				10	**20**	**30**	**200**	
Paritutu-1	96.7	2363	60	1600	3100	4700	600	48
Toka-1	138.9	3820	60	3400	6700	10,000	960	69
New Plymouth-2	161.3	4411	60	4300	8600	12,800	1110	81
Republic New Plymouth-1	45.7	962	60	N/A	N/A	N/A	150	23
Republic New Plymouth-2	49	910	60	N/A	N/A	N/A	140	25
Republic New Plymouth-4	46.9	945	60	N/A	N/A	N/A	150	23
Moturoa-5	91.1	1910	60	1400	2700	4000	480	46
Moturoa-6	30	176	60	N/A	N/A	N/A	30	15
Moturoa-7	50.5	1180	60	N/A	N/A	N/A	180	25
Total kW at 60°C	-	-	-	**10,700**	**21,100**	**31,500**	**3600**	-
Total kW at 80°C	-	-	-	**7300**	**14,400**	**21,400**	-	-

N/A used where output temperature is greater than bore temperature.

The estimated range of thermal capacity available from the wells is 3.6 MW for the closed loop and ranges from 11 to 32 MW for the open-loop systems. Note that the capacity range reduces to 7 MW from 21 MW for an 80°C output. Given the Moturoa field has a total area of 2 km^2, this provides a heat availability of *c.* 5–15 MW per km^2. As with the use of this metric at Kapuni, it represents a high-level screening indicator only. Moturoa results in a higher calculated value due to the higher concentration of wells in a smaller area. Further investigations of total available heat resource are warranted to understand its full geoheat potential.

For the purposes of this case study, a thermal capacity value of 20 MW at 60°C will be adopted in a district heating network.

6.5.3 Opportunity

The Taranaki RETA (EECA 2025) did not identify any large gas users near the Port. Rather, the main gas users in the CBD area were all council-owned buildings. They include the theatre, art gallery, museum and TEAC, and would have a maximum combined heat load c. 5 MW. The Taranaki Base Hospital was also included and is about 1.2 km from the coast.

This geothermal supply could potentially replace natural gas boilers for space heating and domestic hot water for these sites, providing a significant reduction in the city's Scope 1 emissions.

Furthermore, the brownfield sites near the Port offer opportunities for ‘thermal-synergy’ businesses, such as industrial laundries, cold stores or food processing units, which can plug directly into a high-capacity thermal network. This concentrated demand significantly reduces the ‘distance-to-user’ heat loss compared with rural networks.

6.5.4 Economic Assessment

The economic framework for the New Plymouth CBD project centres on the strategic shift of energy procurement from more volatile commodity markets to local, predictable infrastructure. Unlike the Kapuni project, which benefits from existing/productive wellbores, any New Plymouth system may require higher initial capex as the existing wells are ‘plugged and abandoned’ and costs to repurpose are unknown and unpredictable. It is not yet clear what this means in terms of their suitability for geoheat and is something that warrants further investigation. Alternatively, a series of new geoheat wells could be drilled for the purposes of servicing the CBD.

This additional capex could be offset by the significantly higher density of the possible heat users.

6.5.5 Discussion

A New Plymouth CBD and Port district energy scheme is technically ambitious but potentially economical due to the high density of heat demand. It represents a vital step in ‘future-proofing’ the city's energy infrastructure.

A New Plymouth-based district heat network offers a unique value proposition compared with a rural counterpart. The ‘sunk cost’ here is not found in old/existing wells, but in the existing high-density heat demand within a small geographic radius. There is a compelling case to investigate the conversion of legacy boiler systems to a centralised geoheat loop. From a circular economy perspective, a Port-centred development can utilise waste heat from existing industrial processes to supplement geothermal extraction. This transition supports a regional decarbonisation pathway, offering a renewable, baseload alternative for urban energy consumers currently reliant on the gas or electricity networks.

7.0 Summary and Discussion

This report examines the availability, characteristics and potential utilisation of lower temperature geothermal (geoheat) resources in the Taranaki region. Industrial heat users in Taranaki currently depend largely on fossil gas; however, geological, hydrogeological and petroleum industry datasets indicate substantial opportunities to replace or supplement this demand with geoheat technologies.

A range of geoheat technologies is potentially applicable in Taranaki, including direct-use geothermal systems, GSHPs, high-temperature and industrial heat pumps, and closed- or open-loop ground heat exchangers. The choice of system depends on depth, temperature, geological conditions, and site-specific energy demand. In many cases, shallow systems supplemented by heat pumps may be more cost-effective than deeper drilling to access hotter temperatures for direct use.

Significant opportunities exist to repurpose petroleum infrastructure for geothermal applications. Wells that are suspended, shut-in or recently plugged and abandoned may be suitable for conversion to closed- or open-loop geothermal systems, provided well integrity and casing condition are verified and able to be made accessible for repurposing. Produced water from deep formations as part of the oil and gas operations, where temperatures exceed 130°C, represents a potential co-production heat source.

Regulatory considerations include the Resource Management Act (1991), regional freshwater and coastal plans, and petroleum well integrity requirements overseen by the High Hazard Unit of MBIE. Early engagement with the Taranaki Regional Council is recommended to clarify consenting pathways, particularly for activities involving geothermal water (>30°C), groundwater takes, well drilling or re-entry into petroleum wells.

Five case-studies have been developed, which describe opportunities for geoheat use:

1. Todd Energy Aquatic Centre

There is a good opportunity for either a seawater GSHP or direct geothermal use (40–45°C) from the Matemateaonga Formation at ~700 m deep to supply heat energy to the Todd Energy Aquatic Centre. The economic assessment of various technologies shows these two systems have the lowest annual operating costs compared with other energy options. While the upfront capital costs are higher than the alternative technologies, when assessed over a 25-year operating life, they provide the most competitive levelised cost of heat to the facility.

2. Taranaki Base Hospital

There are sound geoheat options for the hospital site. These include the use of higher temperatures from deeper wells if a heating-only system is to be considered. Or if a combined heating and cooling system is to be designed, then this should use a shallow ground heat exchanger, possibly a combination of open and closed loop incorporating thermal storage, with GSHPs that are integrated into the existing HVAC systems.

3. Greenhouse opportunities

This assessment was designed to demonstrate how a known significant heat user, such as a greenhouse, where heating is a significant business cost, can be relocated to or established in a location where there is a known suitable geoheat source. The qualifiers for a suitable location heat source are a combination of temperature, depth and flowrate.

Efficiency in building and greenhouse design means that heat resources of about 50°C are needed for the supply of energy to these facilities. These temperatures can be found in most areas of Taranaki at depths between of 500 and 1500 m.

The assessed two best performing systems are a 50°C direct-use system and open-loop repurposed petroleum wells. Cost savings may accrue through the use of existing well infrastructure.

4. Greenfield development at Kapuni field

The Kapuni field represents a unique ‘ready-made’ low-temperature geothermal laboratory in the Taranaki region. Available data suggests that the temperatures and existing infrastructure provide a viable path toward a district heating/energy scheme pilot.

The existing infrastructure, wells, pipe networks and existing resource consents, represents a substantial sunk cost for the operators, particularly as significant decommissioning costs are still pending. These also are a potential geoheat energy scheme opportunity. There is a strong case for further investigation, including to understand how these regulated abandonment liabilities compare with the capital required to repurpose the wells and some of the infrastructure for a geoheat energy facility. By transitioning these assets into a geothermal heating/energy network, an existing financial liability might be able to be transformed into an ongoing revenue stream.

5. District heating opportunity for New Plymouth CBD and Port Taranaki

A New Plymouth-based district heat network offers a unique value proposition. The existing high-density heat demand within a small geographic area provides a sound basis for a district heating network where heat can be shared between multiple users. There is a compelling case to investigate the conversion of legacy boiler systems to a centralised geoheat loop.

A New Plymouth CBD and Port district heating scheme is technically ambitious but potentially economic due to the high density of heat demand.

A heat demand/discharge mapping exercise is recommended along with some additional geo-scientific studies seeking to better characterise the opportunity.

7.1 Concluding remarks

Taranaki hosts a well-characterised, regionally consistent low-temperature geothermal resource with clear potential for heating, cooling and some small-scale power applications. While high-temperature electricity generation is not viable, the combination of existing subsurface data, accessible heat at depth and opportunities to reuse petroleum infrastructure presents a strong basis for future geoheat development in and across the region.

All provisional assessments worked up in the report have merit for further investigations. Opportunities to support smart energy transition from natural gas in the region through utilising geoheat are anticipated to be feasible, providing another source of energy, improving energy efficiency and supporting economic growth.

We would recommend that further assessment of the shallow aquifers and potential geothermal resource(s) be investigated, as the assessments undertaken as part of this work were based on somewhat limited data.

The potential for repurposing existing petroleum infrastructure for heat extraction to support energy hubs or small-scale electricity generation is worth further investigation as an opportunity in the Taranaki region.

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APPENDIX

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APPENDIX 1 Taranaki Heat Users

Table A1.1 Heat users in Taranaki (data source from EECA [2024]).

Name	Sector	Heat Demand Range (TJ)
ANZCO Foods Eltham	Meat	25–100
ANZCO Foods Waitara	Meat	10–25
Ballance Agri-Nutrients Kapuni	Industrial	≥100
Downer New Plymouth Asphalt	Industrial	1–5
Downer New Plymouth Bitumen	Industrial	5–10
Fonterra Brands Eltham Bridge St	Dairy	10–25
Fonterra Eltham Collingwood St	Dairy	25–100
Fonterra Kapuni	Dairy	≥100
Fonterra Whareroa	Dairy	≥100
Francis Douglas Memorial College	Commercial	1–5
Hāwera Aquatic Centre	Commercial	5–10
Hawera Hospital	Commercial	1–5
La Nuova Inglewood	Commercial	10–25
Little Knoll Greenhouses Ltd Patea	Industrial	5–10
Mckechnie Aluminium Solutions Bell Block	Industrial	≥100
Methanex Motunui	Industrial	≥100
NPDC Civic Centre	Commercial	<1
NPDC Len Lye Centre	Commercial	1–5
NPDC Puke Ariki	Commercial	1–5
NPDC Todd Energy Aquatic Centre	Commercial	1–5
NPDC Waitara Pool	Commercial	<1
NPDC Wastewater treatment plant	Industrial	10–25
Poppas Peppers New Plymouth	Industrial	1–5
Silver Fern Farms Hawera	Meat	25–100
Silver Fern Farms Waitotara	Meat	10–25
Stratford High School	Commercial	5–10
Taranaki Abbattoir Stratford	Meat	10–25
Taranaki Base Hospital	Commercial	25–100
Taranaki By-Products Hawera	Meat	≥100
Taranaki Galvanizers Stratford	Industrial	1–5
Technix Bitumen Port Taranaki	Industrial	1–5
Tegel Bell Block Feedmill	Meat	10–25
Tegel New Plymouth	Meat	25–100
Van Dyck New Plymouth	Industrial	1–5
Waverley Primary School	Commercial	<1
Western Institute of Technology in Taranaki (WITT) Taranaki	Commercial	1–5

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