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Tauhara Geothermal Field – New Zealand: Initial Reservoir Response to 224 MWe Additional Generation

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ABSTRACT

Production in the Tauhara geothermal field in New Zealand began in 2006 with a 20 MWth direct heat supply to the timber drying kilns at the Tenon Mill and an expansion to a 28 MWe binary power plant in 2010. In 2024, a 174 MWe triple flash, condensing steam turbine (the Tauhara power station) and a 50 MWe binary plant (Te Huka U3) were commissioned. These changes resulted in a step increase in fluid extraction from the Tauhara reservoir from 9 Mt/y to 47 Mt/y. In this paper, we will present an overview of our monitoring strategy for the Tauhara reservoir and present examples of the well datasets acquired that document the initial response of the reservoir after ~1 year production, including downhole measurements and geochemical data. We compare these changes with the expected changes predicted by the numerical reservoir model. When integrated and evaluated with a geoscientific context, these new data are supporting our ongoing efforts of focused monitoring and adaptive management to maintain reservoir health and improve our understanding of the resource.

1 INTRODUCTION

The Tauhara geothermal field is located north of Lake Taupo in the Taupo Volcanic Zone in New Zealand (Figure 1) and has an unusual attribute that it is hydraulically connected to another geothermal reservoir, Wairākei, to the NW (McDowell et al., 2021) (Figure 2). While large scale production at Wairākei started in 1956 and power station commissioning in 1958, commercial extraction at Tauhara began in 2006 with 2 million tonnes/year (Mt/y) for a 20 MWth direct heat supply to the timber drying kilns at the Tenon Mill. In 2010, this increased to 9 Mt/y for the Te Huka Unit 1 and 2, a 28 MWe binary power plant. The production and reinjection areas for these developments was located in the Tauhara North area of the reservoir.

From 2023, further developments occurred in the Tauhara reservoir, commencing with the construction of the Tauhara power station, a 174 MWe triple flash, condensing steam turbine. The steamfield commissioning started in July 2023 and electricity generation began in March 2024. All the production for this power station occurs in Tauhara East reservoir domain (Figure 2), which is further differentiated into a central-southern high temperature sector around 280-300°C, and a northern sector with slightly cooler temperatures around 270°C. Separated geothermal water (SGW) from this power plant is injected into the Tauhara North at deeper depths than production.

Following this, a second development commenced with the Te Huka Unit 3 station: a 50 MWe binary plant that began commissioning in August 2024. Production and reinjection for this unit occurs in Tauhara North. As a result of these new developments, production in the Tauhara reservoir increased from 9 Mt/y to 47 Mt/y. As anticipated, the increased volumes of production and reinjection fluids generated a number of changes that will be discussed in this paper.

Prior to and following the commissioning of the new stations, a more extensive monitoring program was initiated, to constrain baseline conditions in the Tauhara field and to capture the reservoir response to production and reinjection. This included completing several surface-based surveys (as required by the conditions of Contact's resource consent) a year earlier than required, to capture baseline conditions, for example, the 8-yearly microgravity survey, 4-yearly vertical levelling survey for subsidence, thermotolerant vegetation survey, and thermal infrared (TIR) survey. These data will be presented in future forums as follow-up surveys are conducted over the next few years and are not discussed further in this paper. Downhole monitoring data collected include reservoir pressures and temperature from static and flowing PTS surveys, fluid and gas chemistry, and micro seismicity information from Contact Energy's downhole seismic network. These data are presented and discussed in this paper.

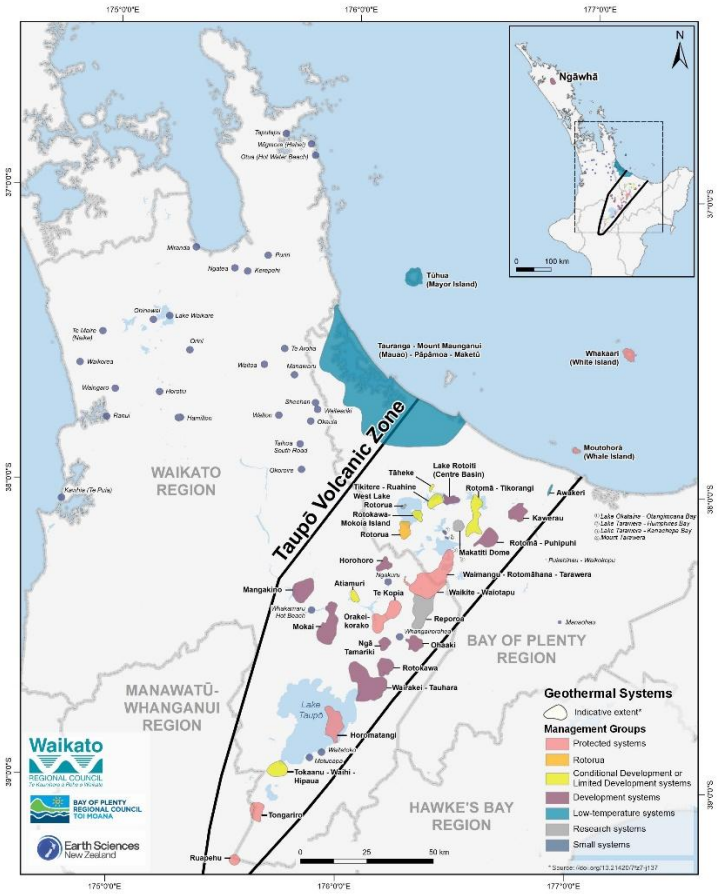


Figure 1: Location of the Taupo Volcanic Zone in New Zealand (figure from Earth Science NZ, 2025).

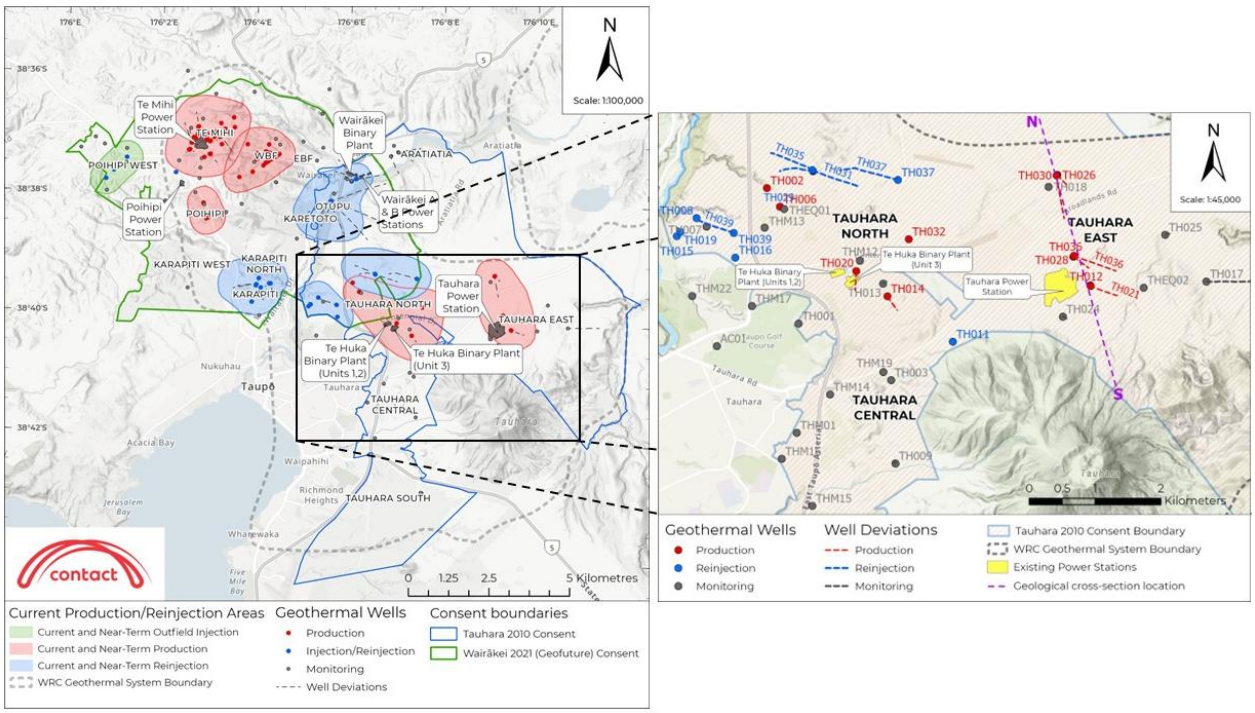


Figure 2: *Left*: Field map highlighting the production and injection areas on the Wairākei and Tauhara fields; *Right*: Zoomed view of the Tauhara field. Note location of cross section presented in Figure 5).

2 RESERVOIR RESPONSE

2.1 Reservoir Pressure

Historically, the Tauhara liquid pressures have followed the same trend as Wairākei pressures. Since 2012, the pressures of Tauhara and Wairākei have diverged, with Wairākei pressures decreasing in response to increased extraction at Te Mihi (associated with power station commissioning in 2013/2014) and Tauhara pressures increasing in response to increased deep reinjection at Karapiti associated with the Te Mihi station commissioning (Figure 3). However, with the increased extraction from the Tauhara reservoir from 2024, this trend has changed. TH03 (Tauhara Central reservoir domain, intermediate depth) and THM17 (Tauhara North reservoir domain, shallow depth) pressure trends changed from increasing to stabilising after the Tauhara power station commissioning. No pressure response in these wells was observed associated with the increase in extraction from Tauhara North following Te Huka Unit 3 station commissioning in late 2024, however pressures decreased when there was no Karapiti reinjection during the Te Mihi outage, confirming the hydraulic connection between the Tauhara and Wairākei reservoirs.

The deep monitoring well TH24 (Tauhara East) pressure trend reveals a rapid response to changes in Tauhara East production, as expected due to the proximity of TH24 with the Tauhara East production wells. However, similar to TH03 and THM17, it also does not show significant response to the increased Tauhara North production after Te Huka U3 commissioning, suggesting some complexity in the Tauhara reservoir connectivity.

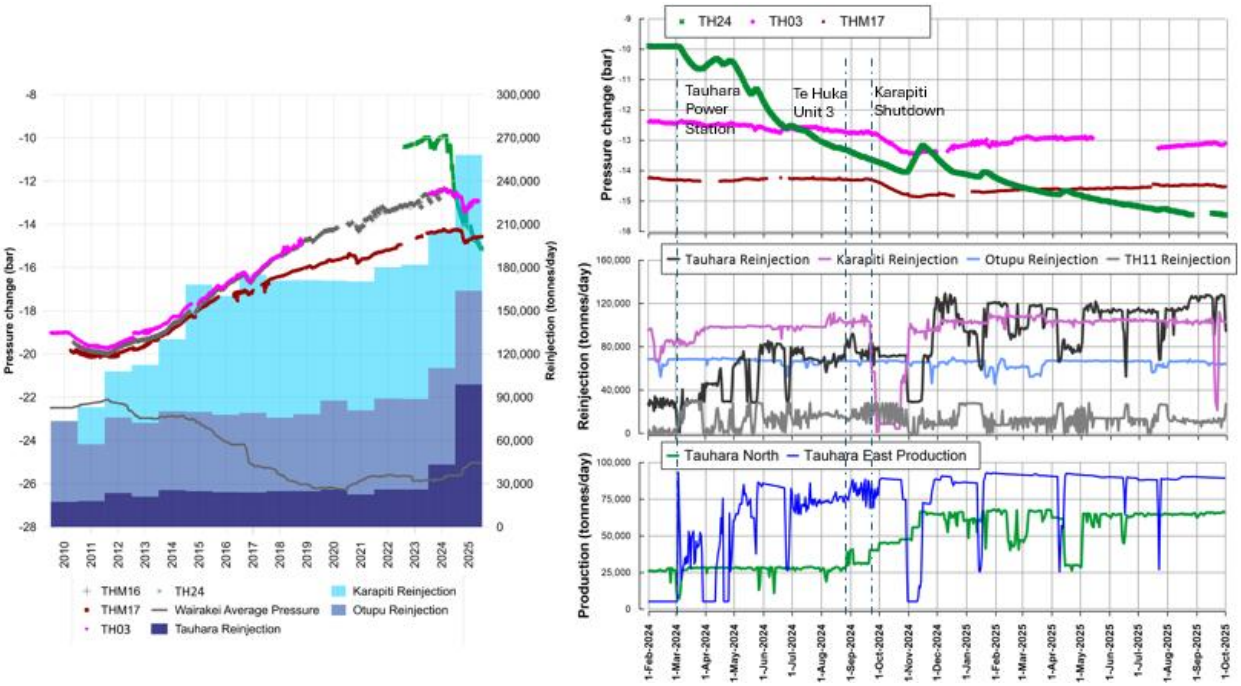


Figure 3: *Left*: Historic reservoir response to extraction and reinjection at the Wairakei and Tauhara fields; *Right*: Detailed reservoir response from the new developments.

The reservoir model has simulated the historical trends of the reservoir pressure in Tauhara reasonably well, including the drawdown of ~22 bar observed through the first 40 years of production. The stabilisation of the reservoir pressure during the 1980s and into the 2000s can also be seen in the modelled trends, however the model underestimates the pressure recovery observed since 2015 (Figure 4). In Tauhara North – near monitoring well TH03 – the model overestimates the pressure drawdown because of additional extraction from production wells feeding Tauhara power station and Te Huka Unit 3. However, the stabilising pressure trend observed after the new developments is also observed in the modelled response and these pressures are forecasted to increase at a moderate rate as a result of pressure support from reinjection. In Tauhara East, the model overestimates the initial reservoir decline as a result of Tauhara power station startup, with actual pressures from TH24 showing about 5 bar of pressure decline while the model estimates a 10 bar decline for the same period. The model forecasts that within the next two years, the reservoir pressure trend in Tauhara East will transition to a longer period of stabilisation.

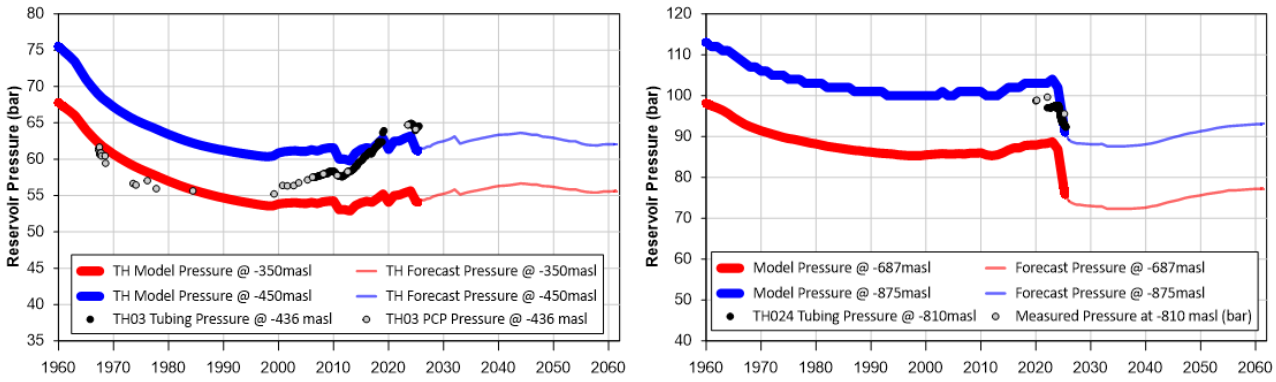


Figure 4: *Left*: Reservoir model pressures at TH03 plotted against downhole surveys and capillary tubing pressure measurements.; *Right*: Deep reservoir model pressures at representative elevations plotted against downhole capillary tubing pressure measurements at TH24.

2.2 Chemistry and Temperatures

2.2.1 Tauhara East

There are six production wells in the Tauhara East reservoir domain. For clarity, the following discussion separates the two northern production wells in this domain (TH26, TH30) from the four wells in the central-southern end of this Tauhara East reservoir domain (TH36, TH28, TH12, TH21) - refer to Figure 2 for domain and well locations.

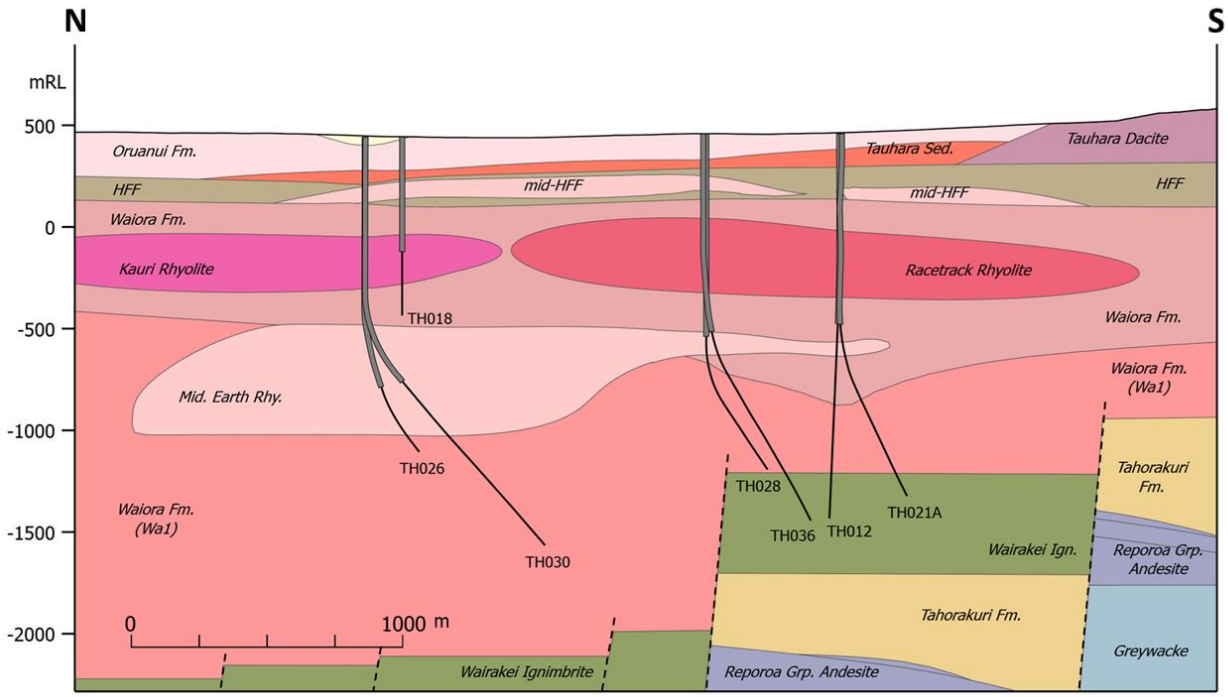


Figure 5: Cross-section of the Tauhara East wells.

2.2.1.1 Tauhara East: Northern sector

While TH30 and TH26 show some chemistry changes from pre- to post-commissioning, they have displayed relatively stable chemistry trends since, with no indications of dilution (Figure 65). Geothermometer temperatures remained mostly stable in the first half of the year, with some indication in recent samples of a slight decline in temperature (Figure 7). Measured downhole temperatures for TH30 show good agreement with the Na/K geothermometer temperature and indicate no cooling post-commissioning. Recent downhole temperature measurements have not been possible at TH26 due to a restriction in the wellbore at 350 m.

2.2.1.2 Tauhara East: Central-Southern sector

The production wells in the central-southern end of the Tauhara East reservoir domain have also shown some changes from pre- to post-commissioning, with the exception of TH36. The most noticeable change has been

the lower temperature of TH12, TH21 and TH28, which have all shown drops in both Na/K geothermometer and measured downhole temperature from their pre-commissioning state (Figure 6). To track these changes closely, the monitoring program has been increased significantly, with 6-weekly TFT round measurements in some wells and additional chemistry sampling to track any signs of dilution or cooling. Chemistry trends are relatively stable post-commissioning, with only slight declines in chloride concentrations to note. There are several possible hypotheses for the changes in well temperature from pre- to post-commissioning. One hypothesis is recharge from the Middle Earth Rhyolite. The majority of the feedzones in TH26 and TH30 tap this body, with measured temperatures 15 - 20 °C cooler at these wells when compared with the Tauhara East wells. During the completion tests of TH12, TH21, TH28 and TH36, inflows were observed in these wells at the Middle Earth Rhyolite (Figure). The chemistry of the northernmost wells is not significantly different, so there could be cooler recharge coming from this geologic body without materially impacting the chemical trends of these Tauhara East wells.

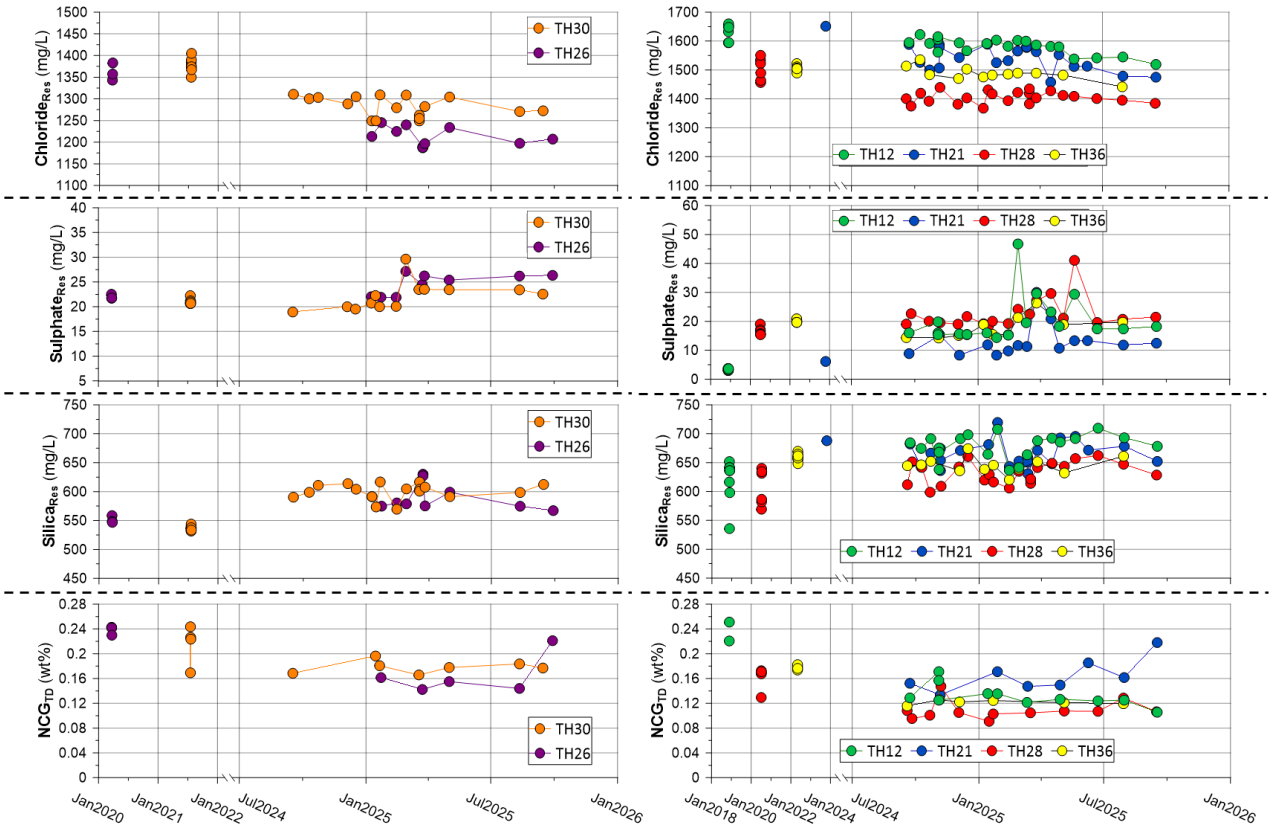


Figure 65: Key chemistry trends for the Tauhara East wells.

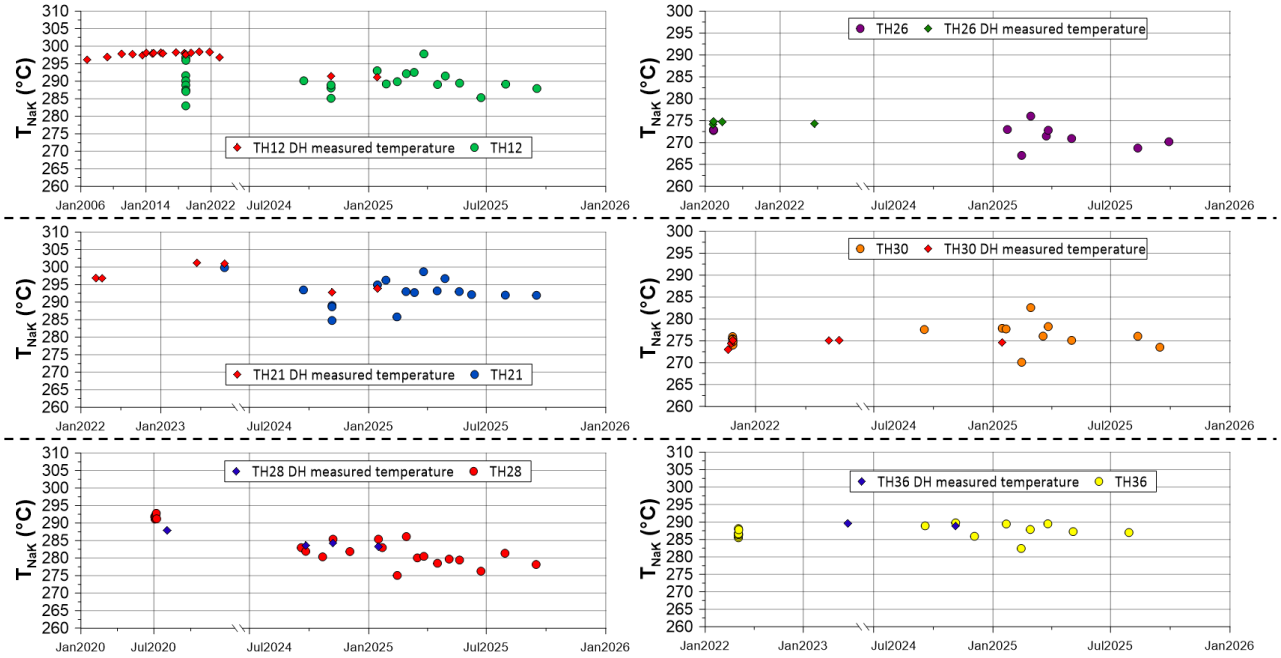


Figure 7: Measured downhole temperature and Na/K geothermometer temperature for the Tauhara East wells.

Another possibility is interference between these Tauhara East wells. When pre-commissioning temperatures were measured for each well, all other wells were in a shut condition, so we could have been observing high apparent reservoir temperatures for some wells that did not reflect realistic production temperatures with all wells on production. The exception is TH36, which has maintained the downhole temperature measured in 2023. During pre-commissioning flow testing, there were indications of communication between all four wells in the central/southern end of the Tauhara East reservoir domain, so interference now that the station is fully operational is not unexpected. The final potential cause of cooling could be influence from injection in TH11. Some of the chemical changes observed from pre- to post-commissioning in the three wells that have cooled could indicate influence from this source, although it is very difficult to track through chemical trends given the variability of the fluid composition being reinjected, ranging from pure condensate to flashed SGW and mixtures of both of these end members. A reservoir tracer test is currently underway with naphthalene disulfonate (NDS) variants injected into three wells in the Tauhara reservoir (two in Tauhara North, one in Tauhara Central): the results from this test will provide valuable insight into any influence from using TH11 for reinjection. A combination of these three factors could be the cause of the lower temperatures observed post-commissioning. Despite the changes in temperature from pre- to post-commissioning, the measured temperature of the Tauhara East wells has been relatively stable during the reporting period. This stability is also reflected in the Na/K geothermometer trends, although recent data at TH28 may be indicating some cooling. TH12, TH21 and TH36 have shown slight decreases in chloride in recent months, however, most other chemical trends are relatively stable in the post-commissioning period. The data indicates that while there have been some changes observed from pre-commissioning data, the field has adapted relatively well to the large change in extraction.

2.2.1.3 TH28 low permeability

One well in Tauhara East, TH28, has been showing an ongoing decline in productivity. This is in contrast with the rest of the Tauhara East wells that have shown slower decline to date. This behaviour could be attributed to low permeability of the well. TH28 had a low injectivity index during the completion test (34 tph/bar) compared to 67 tph/bar of TH36 and > 200 tph/bar for TH12 and TH21. When TH28 is flowing, it exhibits significant pressure drop of at least 30 bar in the wellbore (Figure 8, left). To compare, TH12 has a pressure drop of 6 bar for 500 tph.

An evaluation of the fracture permeability using borehole imaging in TH28 indicates that only a few fractures with low acoustic amplitude are present in the main feed zone (FZ1) (**Fehler! Verweisquelle konnte nicht gefunden werden.**, right). This is significantly lower than the fracture intensity observed in the main feed zone of its nearby well, TH36. Other minor feed zones of TH28, FZ2 and FZ3, show no identifiable fractures, suggesting either non-structural or undetected permeability. The overall fracture density in TH28 is very low particularly in the Waiora formation, which primarily hosts the reservoir. The low permeability of TH28 due to less fractures and combined with the fact that all wells in the Tauhara East are interconnected based on the interference test, could explain

the lower output of TH28 and higher pressure drop in the wellbore during discharge. During normal operation when all wells are producing, fluid will prefer to flow to the more permeable wells compared to TH28.

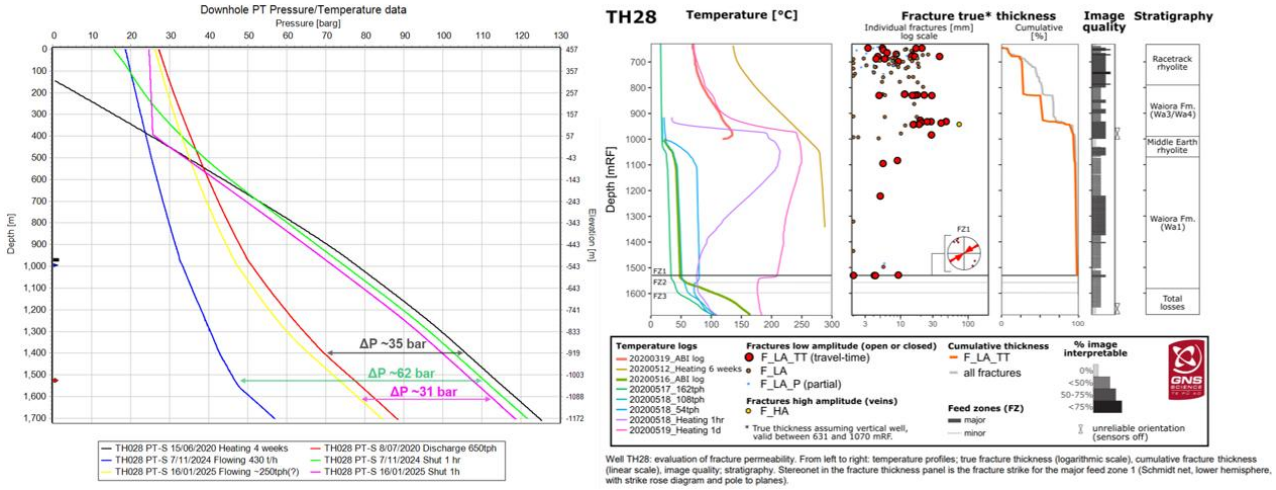


Figure 8: Left: TH28 high pressure drop during discharge.; Right: TH28 fracture permeability evaluation.

2.2.2 Tauhara North

There are four active production wells in the Tauhara North sector: TH06, TH14, TH20 and TH32 (noting production well TH02 is connected but not currently being used for production) (Figure 2). Historically, the wells in Tauhara North have been influenced by dilution from steam-heated waters, resulting in a decrease in analytes such as chloride and silica, and an increase in sulphate and bicarbonate. Despite this dilution, there had been minimal decline in the measured temperatures of these wells prior to commissioning of the Tauhara and Te Huka U3 power stations, particularly TH14 and TH20. Following a period of stability (2020-2024) in terms of measured temperature and chemical trends, some of the Tauhara North wells have seen noticeable change post-commissioning of the new power stations on the field. TH14, TH20 and TH32 have shown changes in chemical trends that indicate a change in the reservoir processes influencing these wells. TH14 has seen the largest change, followed by TH32 and finally TH20 (Figure 9). TH06 chemistry trends and measured temperature have stayed relatively stable through this period of change for the other Te Huka wells.

TH14, TH20 and TH32 have all seen a decrease in chloride, potassium, sodium, calcium and silica while sulphate has increased and bicarbonate has remained relatively stable. TH20 has seen the most modest change in chemistry and has not shown any evidence of thermal breakthrough in either measured downhole temperature or Na/K geothermometer temperature (Figure 9). TH32 has seen moderate change in chemistry and has an associated decline in measured and geothermometer temperature (Figure 9), although the magnitude of change in the Na/K geothermometer is larger (6.5 °C) than that observed in downhole measured temperature (1 °C). As stated above, the largest chemical changes have occurred at TH14, with an associated decline in measured downhole temperature of around 3.4 °C since the new power stations came online, which is also reflected in the Na/K geothermometer, albeit with a larger magnitude (Figure 9). Additional surveillance activities (including more frequent chemistry sampling) were initiated and will continue until this trend is better understood.

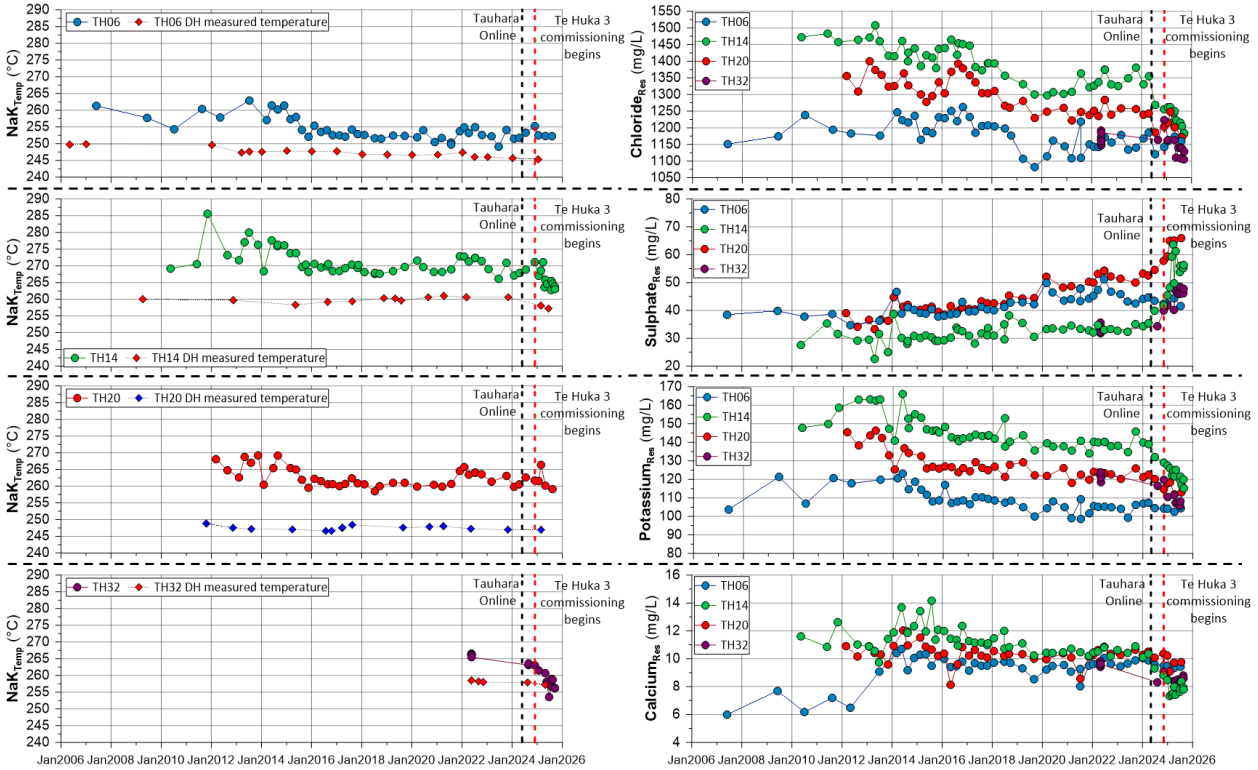


Figure 9: *Left*: Na/K geothermometer and downhole temperature trends; *Right*: Key chemistry trends for the Tauhara North wells.

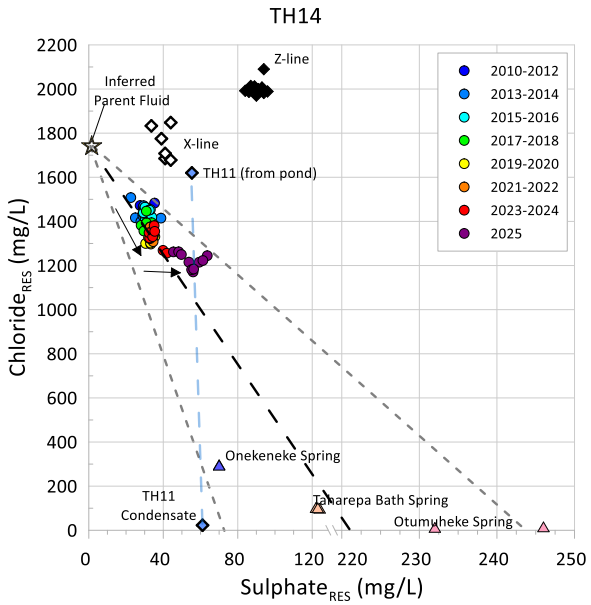


Figure 10: Chloride vs sulphate cross-plot for TH14.

The changes described above suggest there is influence from a different end member fluid in the last year, particularly at TH14 and TH32. The chloride vs sulphate cross-plot for TH14 shows the change in trajectory of the dilution trend (Figure 10). Previously, the trend showed strong correlation with dilution by steam-heated waters/springs but now the trend appears to be tracking towards a different end member. To understand the changing chemistry trends, mixing models were created for various potential end member fluids. These mixing models aimed to match the changes seen at TH14, given the magnitude of change is most pronounced at this well. These mixing models allowed us to rule out several potential end members, including the steam-heated water end member that is hypothesized as being responsible for the dilution trends seen in the 2012 to 2020 period. Two potential end members stood out as potential sources of the chemical changes we have seen; the fluid being reinjected in TH11 and that of a mid-depth monitor well with a high sulphate signature. While the mixing models focused on recharge from one additional end member, the reality could be that multiple sources are influencing the chemical trends seen in the Tauhara North wells. The reservoir tracer test that is currently

underway will likely provide valuable insight in understanding the changes seen at the Te Huka wells in the last year.

2.3 Observed Microseismicity

As part of ongoing monitoring, Contact Energy has installed several downhole seismic stations to track seismic activity across the Wairākei -Tauhara field (Sepulveda et al., 2013). While most of the stations are located within Wairākei, two are positioned in the Tauhara sector. Complemented by GeoNet stations within and around the Wairākei-Tauhara area operated by Earth Science New Zealand, along with a dense seismic network in Wairākei, the Tauhara sector is still in a good coverage. Historically, Tauhara has exhibited lower seismic activity compared to Wairākei and other nearby high-temperature geothermal fields such as Rotokawa (Sepulveda et al., 2015). Prior to the commissioning of the Tauhara power station in March 2024, most recorded seismicity was associated with reinjection operations at Te Huka, with some influence from the nearby Karapiti reinjection. The rest of the Tauhara area remained relatively quiet, with only a few scattered microearthquakes.

Figure 11 (left) shows the spatial distribution of seismic density (number of microearthquakes per 200 m block size) at an elevation of -2000 msl, where most the events occurred during a one-year period before commissioning of Tauhara power station. Seismic events in the Te Huka reinjection area were generally shallower than those in Karapiti, reflecting differences in reinjection depths. During this period, the recorded median moment magnitude (Mw) was 0.65. Following the commissioning of the Tauhara power station, which involved increased production and reinjection volumes, seismicity increased in the reinjection zones around Te Huka, Tauhara North, and TH11. Figure 11 (right) shows seismicity during one-year period post-commissioning, with Te Huka reinjection now exhibiting a larger cluster at similar depths and an increased median Mw to 0.83.

In the Tauhara North reinjection area, a new NW-SE trending seismic cluster emerged. The average depth of this cluster located around -2400 msl, with a median Mw of 0.64. While at the TH11 reinjection well, seismic events formed a vertically aligned cluster dipping slightly southward beneath the well. The event rate at TH11 was lower compared to the other reinjection areas, with a median Mw of 1.37. In contrast, the production area did not exhibit a corresponding increase in seismicity, likely due to relatively stable reservoir pressures after station commissioning.

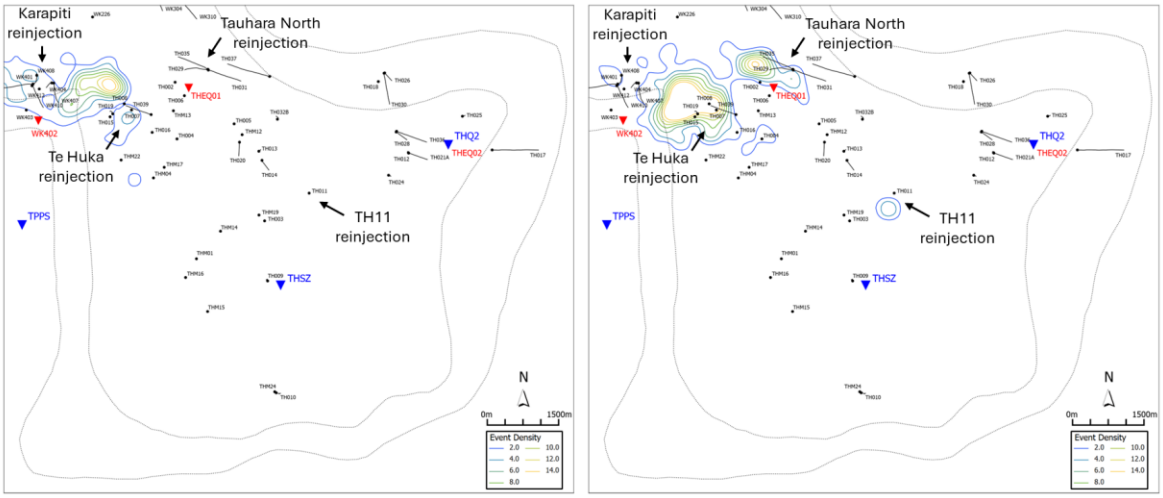


Figure 11: Seismic event density maps for the Tauhara sector showing microearthquake distribution per 200 m block at an elevation of -2000 msl. Left: One-year period before commissioning of the Tuhara power station (April 2023 – March 2024). Right: One-year period after commissioning (April 2024 – March 2025). Seismic stations are marked with inverted triangles (red: Wairākei seismic network (WSN), blue: GeoNet). Note that at THEQ2, both a WSN and GeoNET station are installed in close proximity.

3 SUMMARY

After recent new developments, changes have been observed in the Tauhara reservoir, which is expected following a significant increase in mass extraction. The changes are mostly within the expected range based on modelled predictions, and in many cases the changes are smaller than expected.

- Tauhara Central and Tauhara North reservoir pressures were previously increasing due to the deep reinjection in Karapiti and Otupu. With the increased extraction in the Tauhara East and increased reinjection in the North for the Tauhara power station, these pressures have stabilised. In September 2024, these pressures declined when there was no Karapiti reinjection due to a Te Mihi station outage and they have since been increasing when Karapiti reinjection resumed, confirming the hydraulic linkage between the Tauhara and Wairākei reservoirs. Pressure response with the increased extraction in the North for Te Huka Unit 3 is less certain due to the overlapping activities around Tauhara and Karapiti.
- Tauhara East pressures have continued to decline due to the increased extraction in this area. Reservoir pressures in this area do not show significant response to the increased Tauhara North production, but effects may have been masked by multiple simultaneous activities around the reservoir. By October 2025, deep liquid pressures in the eastern part of the field have declined up to 5 bar compared to 10 bar forecast by the reservoir model, while deep liquid pressures in Tauhara North and Central appear to have stabilised. These pressures will continue to be monitored to assess reservoir response.
- Despite changes in chemistry and fluid temperature between pre- and post-commissioning of the new power stations, the post-commissioning trends for most wells indicate relatively stable trends and temperatures. At Tauhara East, while lower fluid temperatures in TH12 and TH21 were observed when compared with pre-commissioning data, the downhole measurements and chemical trends post-commissioning are showing signs of stabilisation. TH36, TH30 and TH26 show stable chemistry and temperatures, although the mass flow at TH26 is impacted by a restriction within the casing at 350 m. TH28 has seen a decline in mass flow associated with its low permeability and interference with the other Tauhara East wells.
- At Tauhara North, TH14, TH20 and TH32 have seen changes in many chemical trends, which are most pronounced at TH14. These chemical changes have been accompanied by a decline in measured temperature at TH14 (3.4 °C) and TH32 (1 °C). TH20 measured temperature has remained stable. Efforts to understand these changes have focused on geochemical mixing models with potential end members. The reservoir tracer test, which is currently underway, will provide helpful insight in understanding these changing processes, alongside continued close monitoring of the wells experiencing change. TH06 has shown relatively stable chemistry and temperature.
- There was an increase in seismicity observed during the one-year period following the commissioning of the Tauhara power station, particularly in the reinjection areas. While seismic activity had already been occurring at Te Huka, both number and magnitude of events increased post-commissioning, and new seismic clusters emerged in the Tauhara North and at TH11 reinjection. In contrast, the production area remained seismically quiet, likely due to relatively stable reservoir pressure.

While changes have been observed, the Tauhara reservoir is in good health and is expected to stabilize in the next couple of years. There are several areas that require continued focused monitoring and adaptive management to maintain reservoir health and improve our understanding of the resource. The observed connectivity between different areas (Tauhara North, East and Central) within the field, along with external influences such as Karapiti injection, will require ongoing assessment to refine flow path interpretations and reinjection/production strategies.

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