What to expect when you're not expecting—Drilling in the Tauranga Geothermal System

Rochelle Gardner[1], Michael Rosenberg[2]

[1]Bay of Plenty Regional Council, PO Box 364, Whakatane 3158, New Zealand

[2]Earth Science NZ (formerly GNS Science), Private Bag 2000, Taupo, New Zealand

rochelle.gardner@boprc.govt.nz

Keywords: *Low temperature geothermal, Tauranga Geothermal System, Drilling Standards, new geological formation*

ABSTRACT

Under the Resource Management Act 1991 (NZ), Bay of Plenty Regional Council (BOPRC) is responsible for managing the groundwater and geothermal resources of the region. The Council undertakes an ongoing drilling program throughout the region to improve its understanding of groundwater, low temperature and high temperature geothermal resources through its state of the environment (SOE) monitoring networks. Council uses the lithological information collected during drilling to improve 3-D geological modelling, which is key to setting aquifer allocation limits.

As part of this programme, in 2024 BOPRC planned to drill in 2024, three new monitoring wells in the west of the Te Puke region. Planned drilling targets were the deeper aquifers, represented by the Aongatete, Waiteariki, and the Pokai-Chimp-Pokopoko formations, to better monitor effects from inland takes by horticulture operations. Based on the existing drilling, modelling and consented data, the targeted completion depth was approximately 480 metres for the deepest of the wells, anticipating a maximum water temperature of approximately 40–45°C, which is elsewhere typical for the Tauranga Geothermal System.

During drilling of the first well, artesian flow of 8 litres per second was unexpectedly encountered at 318m below ground, with a temperature of 68.6°C. A Pressure, Temperature, Spinner (PTS) survey was subsequently undertaken to determine downhole temperature, and to locate the main flow/fractures. The highest temperature recorded was 76.34°C, with the spinner indicating flows at 310 – 312m and from below 320m (the maximum clear depth). Shut in pressure on the well was recorded as approximately 0.7 bar (10psi) and the maximum downhole pressure was 32.5 bar (471psi).

Analysis of the drill chip samples (collected at 1m intervals) indicated the hot main feed zone occurs in a previously unknown lava of the Minden Rhyolite Subgroup. Council is currently working with local iwi to name the new rhyolite.

1. TAURANGA GEOTHERMAL SYSTEM

1.1 Geological Setting

The Tauranga Geothermal System (TGS) is a large low-temperature geothermal system located in the Bay of Plenty region between Waihi Beach in the northwest and Te Puke and Maketu in the southeast (Figure 1). The system boundary is largely inferred by borehole thermal data and modelled thermal gradients, supported by regional electrical resistivity data for part of the eastern side. In addition to the science which has been described (Zuquim & Box, Geothermal Systems of the Bay of Plenty region - Inventory and Extent, 2023), there were planning decisions made on the final locations for management purposes, the draft boundary extents have been made available online through Bay of Plenty Maps (Bay of Plenty Regional Council, 2025). Geothermal water is specified by the Resource Management Act (RMA, 1991) as water with temperatures 30°C or greater. Volcanic aquifer (i.e., predominantly ignimbrite) temperatures range between 30-70°C at depths of 200-700m, with the overlying cold-water aquifers having an ambient temperature around 15-20°C.

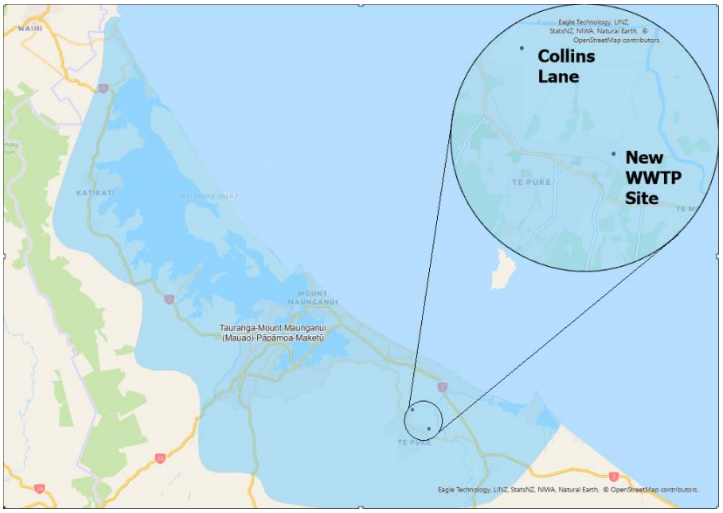

Figure 1: Location of the new and former monitor bores at Te Puke in the Tauranga Geothermal System (Bay of Plenty Regional Council, 2024).

The TGS is not yet well understood but may in part be a by-product of waning magma systems residing in crust in the southeast (Zuquim et al. 2022), perhaps related to the southern Coromandel Volcanic Zone (CVZ). The CVZ was active between 18 million and ~2 million years ago producing a succession of intermediate to silicic volcanism, including andesitic and rhyolitic lavas and ignimbrites erupted in the Tauranga region ~2.95–1.90 Ma ago (Pittari et

al. 2021). The CVZ volcanic rocks are overlain by assorted ignimbrites and tephra from Taupo Volcanic Zone volcanism <1.2 Ma, and by alluvial, marine, estuarine and volcaniclastic sediments of the Tauranga Group (Zuquim 2023).

2. GROUNDWATER/GEOTHERMAL MONITORING

At the start of 2025, BOPRC has 86 bores/wells around the region that are being monitored:

- 53 have continuous water level monitoring.
- 25 are dipped quarterly for water level.
- 67 are sampled quarterly for water quality.
- 1 is sampled annually for water quality.
- 9 are monitored for saltwater intrusion.
- 4 are high temperature monitoring (M Series Rotorua) continuous pressure and annual temperature
- 4 are geothermal/groundwater monitoring (G series Rotorua), manual fortnightly water level

Several of the Council owned bores are at an age where replacement is needed and/or the bores are no longer fit for purpose.

With the additional risk in Rotorua of bore failure (i.e., loss of integrity due to corrosive effects of high temperatures and acidic fluids and historically poor construction), the bores are currently on annual well head inspections and air-cap testing. For bores outside of the high temperature systems, well head inspections are undertaken quarterly, and any downhole inspections are taken after a change in water quality, colour or levels is noted. Where bores are owned by the Council, downhole inspections with a camera are undertaken on a 5-yearly basis. Where possible, the BOPRC Science team will replace a bore before failure of the existing one so that overlapping data can be collected to compare and calibrate – in most cases we will aim for 12 months of dual data collection.

3. DRILLING AT TE PUKE

3.1 Design and Planning

After the decommissioning of the previous site on the Kaituna Plains at Collins Lane (five shallow groundwater bores and a lysimeter), BOPRC worked with Western Bay of Plenty District Council (WBoPDC) to determine the best location for long term aquifer monitoring in Te Puke. Space was created for three monitoring bores outside the Animal Shelter/Wastewater Treatment Plant at 18 Gordon Street, Te Puke.

The new site is located ~8 km inland from the existing monitoring site at Taylor's Reserve, Pāpāmoa (which has three monitoring bores targeting depths of 76m, 46m and 25m) (Zemansky, Rose, & Tschritter, 2012) and is ~3 km southeast of the decommissioned site at Collins Lane but importantly none of the new wells were intended to intercept the same units targeted at either of those sites. Instead, it was intended to target monitoring of the Aongatete, Waiteariki and the Pokai-Chimp-Pokopoko Formations to better capture the cumulative effects at the coast from the inland consented groundwater takes.

Three bores (BN23-0020, BN24-0009 and BN24-0010) were planned with target depths determined from 3-D geological modelling (GNS Science, 2017) (Figure 2) and existing bore logs. The proposed target depths and screen intervals were:

- Bore BN23-0020: 400m deep, screened 380m to 400m
- Bore BN24-0010: 200m deep, screened 150m to 200m
- Bore BN24-0009: 100m deep, screened 80m to 100m

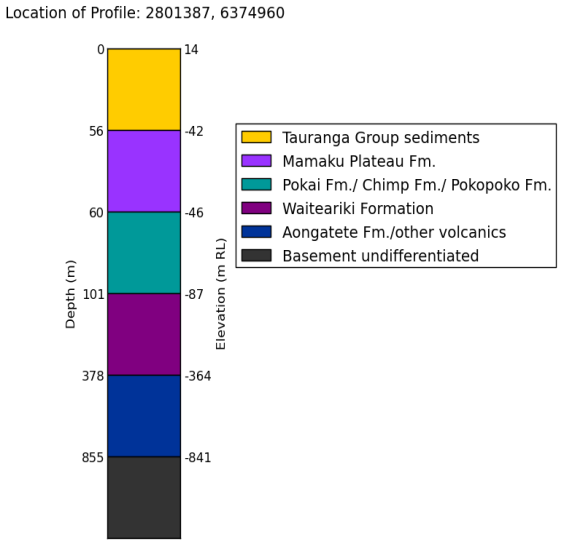

Figure 2: 3-D Geological Model Profile at 18 Gordon Street, Te Puke

BOPRC awards drilling contracts through a closed tender process, where drillers that meet set criteria (e.g., driving distance to site and registration with the New Zealand Drilling Federation) are invited to tender for work.

Drill Force NZ Ltd was awarded the contract for the drilling and testing of the new bores in Te Puke and work began on the 25th of March 2024. Drill Force utilised "Rig 1" which is a DSM Mayhew SD54M (rotary mud) drilling rig that was built by Drilling Supply and Manufacturing in Austin, Texas, USA specifically for Drill Force. The rig is capable of drilling to depths exceeding 1000m and can be configured for large diameter cold water bores, coal seam, shale gas and oil bores (Drill Force NZ Ltd, 2025). Drilling operations were undertaken from 7am to 6pm Monday to Friday to limit noise for the nearby residential area – exceptions were made for casing and cementing so that this key work could be completed uninterrupted.

Drilling chip samples were collected at 1m intervals (Figure 3) before the screened muds were discharged into in-ground pits. Samples were described and analysed then archived. These will be stored until after the geological model has been updated and any changes to allocation have been made.

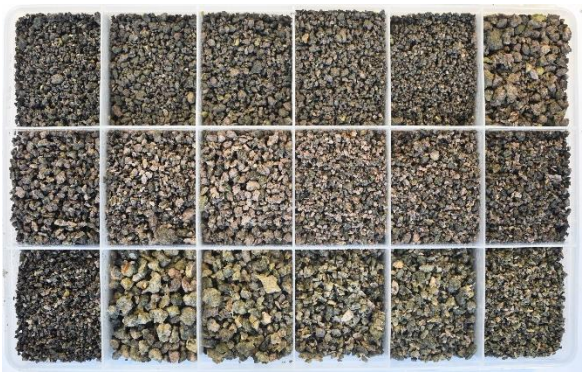

Figure 3: Example of archived chip samples (347–364 m) from BN23-0020

3.2 Issues and Testing

During the drilling of the first bore (BN23-0020), we encountered unexpected flowing artesian conditions (approximately 8 liters per second). To secure the bore when unattended over a weekend, all drill rods were pulled out of the bore and a cap was attached to close it in. While closing in the bore, the drillers noted that the drilling rods were starting to get hot to the touch. On the following Monday morning, once cold-water supply had been secured and the mud emptied from the in-ground pits, the bore was discharged to determine temperatures (Figure 4).

Figure 4: Temperature reading during early flow testing of the bore.

During the flow testing, the water temperature exceeded 70°C and continued to climb. With limited cold water on hand, the bore was shut in.

Previously, the hottest known bore in the Tauranga Geothermal System was approximately 63°C and was significantly deeper. Given that information, temperatures above 70°C were not anticipated and drilling at the Te Puke site was planned and undertaken using the standard for drilling of soil and rock NZS4411:2001 which is designed to be used for the construction of bores under 70°C.

For all drilling over 70°C, either Shallow Geothermal Guidelines or NZS2403:2015 Code of Practice for deep geothermal wells is followed and requires a Details of Work Notice (DOWNs) from WorkSafe, in addition to the drilling consent from BOPRC. After the bore was closed in, contact was made with WorkSafe to seek permission for BOPRC and Drill Force to safely complete the bore installation. As part of the DOWNs submission, Worksafe were provided with the bore construction details, including depths of casing strings and cement volumes used between strings (Table 1).

The geothermal aquifer encountered at BN23-0020, while hot and flowing, had no detectable gas present. Consequently, the bore was considered a lower risk (compared to bores within high temperature systems like Rotorua or Kawerau) and was left capped while the BOPRC and WorkSafe developed a plan. In the interim, to limit disruption to the drilling schedule, work continued on the shallower bores (BN24-0009 and BN24-0010).

Depth	318m
Diameter	6” 152mm SCH40
Casing Shoe	252m (6”)
Total number of casings	5 – all cement grouted in place
Under reamed and Cement Plug	258m – 275m
Master Valve (to be fitted)	150NB Steel Class 15 RF ANSI 150 Flanged connection
Temperature	70.37°C after 3.5 hours (from 23°C)

Table 1: Construction of BN23-0020

Once WorkSafe approved the updated drilling plan for BN23-0020, the bore was drilled an additional 55m, to a termination depth of 330m, so that additional testing could be undertaken. The extra depth was needed to allow for tooling to pass through the bore and measure pressure, flow and temperatures at depth.

MB Century and Andrew Austin (Kiwi Geothermal) undertook a series of PTS runs to confirm measurements. The highest temperature recorded was 76.34°C, with the spinner indicating that there were flows at 310 – 312m and from below 320m (the maximum depth the PTS tool could get to). Shut-in pressure on the bore was measured at approximately 0.7 bar (10psi), and the maximum downhole pressure was 32.5 bar (471psi) as shown in Figure 5.

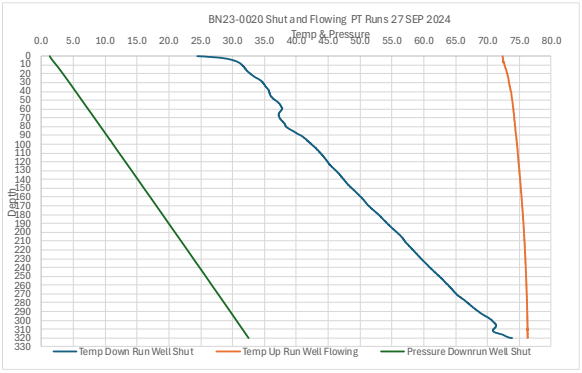

Figure 5: PTS Outputs from BN23-0020 supplied by Andrew Austin (Kiwi Geothermal).

Following the testing, well head assemblies were fitted to all three bores on site and a single concrete pad laid before fencing was installed (Figures 6 and 7).

Figure 6: Completed site works. Left to Right BN23-0020, BN24-0009 and BN24-0010.

Figure 7: Completed headworks for BN23-0020.

3.3 New Formation

Using all drill chip samples collected by BOPRC, GNS Science (now Earth Sciences NZ) described and identified the geological units, as this information could potentially change allocation limits. As part of this work, a previously unknown rhyolite lava unit was identified (Rosenberg, 2025). A summary of lithology is illustrated in Figure 8.

Minden Rhyolite Subgroup is a collective term for rhyolite lava domes in the Bay of Plenty/Coromandel regions, and most have a mineral assemblage of hypersthene, hornblende and biotite (Houghton & Cuthbertson, 1989). The drilled unit is potentially the easternmost of the group of Minden Rhyolite domes mapped in the Pāpāmoa Range (Briggs et al. 1996), but further petrography and geochemical analyses are planned to characterise and formally correlate the new lava.

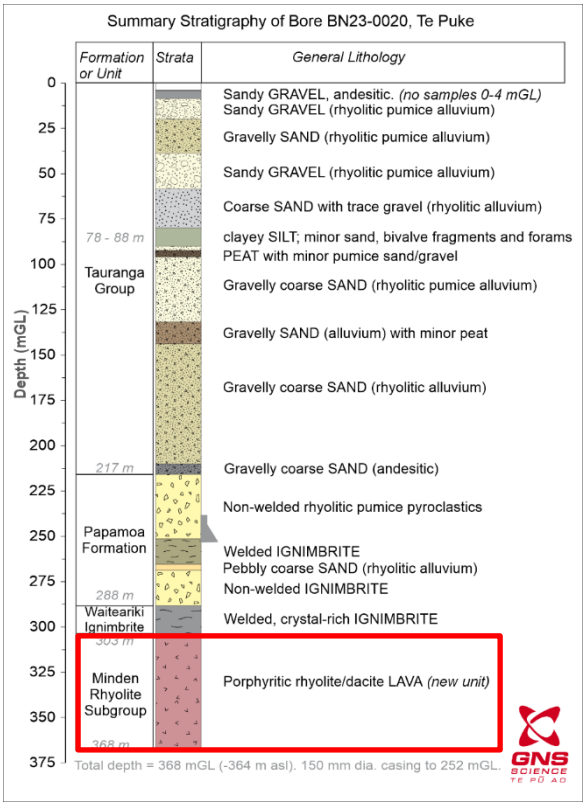

Figure 8: Lithology summary of BN23-0020 (Rosenberg, 2025).

3.4 Implications

The information obtained from this drilling programme will help inform any future updates of the Tauranga Geothermal Reservoir Model, which in turn will inform groundwater and geothermal allocation frameworks.

A potential benefit of intersecting this high temperature zone within the TGS is that it may provide more accessible (cost per depth of drilling) geoheat options for the Te Puke area (GeoExchange NZ Ltd, 2024) (Bay of Plenty Regional Council, 2024). The Council is working with tangata whenua and the community to build understanding of the resource.

Prior to the discovery at Te Puke, all drilling consents issued in the TGS needed to adhere to the soil and rock drilling standard NZS4411:2001. However, as the temperatures encountered at Te Puke site exceeded 70°C, future drilling programs that target geological units deeper than ~200-250m should address Shallow Geothermal Guidelines and submit a DOWNs application to WorkSafe for approval.

While the Council is considering how to collect information on the new unit to determine its lateral extent and thickness and to define potential aquitard layers. Any new drilling consents in the Te Puke/Maketu area planned to exceed 200m depth will need to follow the WorkSafe Shallow Geothermal Guidelines. Once more information on the unit is known, we will be better able to define the consenting process.

BOPRC is working in partnership with local iwi and hapū to formally name the new geological unit. The placeholder name "Te Puke Rhyolite" has been given, while the final name will carry cultural and historical significance, acknowledging mana whenua of the area.

4. CONCLUSIONS

The discovery of the new geological unit and the fluid temperature associated with it will have an impact on geological modelling and geothermal understanding in the eastern edge of the TGS. Due to the higher than average (for the TGS) temperatures that were found, BOPRC is reassessing how drilling consents in the Te Puke – Maketu area will be granted. More stringent standards and safety requirements are needed when drilling at higher temperatures than that for cold-water and require approval from WorkSafe.

ACKNOWLEDGEMENTS

Many thanks to the Bay of Plenty Geothermal Program members, specifically Jason Laurent, Penny Doorman and Breda Savoldelli for your help in testing and communication around the discovery of the new geological formation. I would also like to thank Andrew Austin from Kiwi Geothermal who has helped with arranging testing and spent time teaching RG about the findings and Rhys Fenton from Worksafe who helped to guide us through this unexpected process.

REFERENCES

Bay of Plenty Regional Council. (2024). *The geoheat potential of the Tauranga Geothermal System.* Whakatane: Bay of Plenty Regional Council. Retrieved from https://atlas.boprc.govt.nz/api/v1/edms/document/A4840185/content

Bay of Plenty Regional Council. (2025, August 18). *Plan Change 11 - Geothermal (DRAFT)*. Retrieved from Bay of Plenty Maps: https://maps.boprc.govt.nz/apps/07d6f654ba974007bc7b41b5159ab092/explore

Booden, M. A., Smith, I. E., Mauk, J. L., & Black, P. M. (2012, March 15). Geochemical and isotopic development of the Coromandel Volcanic Zone, northern New Zealand, since 18 Ma. *Journal of Volcanology and Geothermal Research, 219-220*, 15-32.

Briggs, R. M., Hall, G. J., Harmsworth, A. G., Hollis, A. G., Houghton, B. F., Hughes, G. R., . . . Whitbread-Edwards, A. R. (1996). *Geology of the Tauranga area : sheet U14. Scale 1:50,000.* Report 22.

Drill Force NZ Ltd. (2025). *RIG #1 - D.S.M. Mayhew SD/HD54M Heavy Duty Drilling Rig*. Retrieved from Drill Force: https://www.drillforce.co.nz/equipment/rig-1-dsm-mayhew-sd-hd54m-heavy-duty-drilling-rig/

GeoExchange NZ Ltd. (2024). *Preliminary Scoping Study: Geoheat Potential of the Tauranga Geothermal System.* Auckland: GeoExchange NZ Ltd.

GNS Science. (2017). *Geological Profile*. Retrieved from Earth Beneath Our Feet: https://data.gns.cri.nz/ebof/findLocation.jsp

Houghton, B. F., & Cuthbertson, A. S. (1989). *Sheet T14BD - Kaimai Geological Map of New Zealand 1:50000.* Wellington: Department of Scientific and Industrial Research.

Pittari, A., Prentice, M. L., McLeod, O. E., Yousef Zadeh, E., Kamp, P., & Vincent, K. A. (2021). Inception of the modern North Island (New Zealand) volcanic setting: spatio-temporal patterns of volcanism between 3.0 and 0.9 Ma. *New Zealand Journal of Geology and Geophysics, 64*(2-3), 250 - 272. doi:https://doi.org/10.1080/00288306.2021.1915343

Rosenberg, M. D. (2025). *Geological interpretation of monitor bore BN23-0020, Te Puke.* Wairakei: GNS Science. Retrieved from http://atlas.boprc.govt.nz/api/v1/edms/document/A4875696/content

Zemansky, G., Rose, J., & Tschritter, C. (2012). *Installation of Wells at Taylor Reserve and Otamarakau Marae for Seawater Intrusion Monitoring.* Wairakei: GNS Science.

Zuquim, M., & Box, C. (2023). *Geothermal Systems of the Bay of Plenty region - Inventory and Extent.* Whakatane: Bay of Plenty Regional Council.

Zuquim, M., & Savoldelli, B. (2023). *Tauranga Geothermal System.* Science. Tauranga: Bay of Plenty Regional Council.