BAY OF PLENTY REGIONAL COUNCIL
TOI MOANA

Rotorua and Tikitere geothermal surface features - monitoring sites surveying results

Bay of Plenty Regional Council
Environmental Publication 2024/05

Prepared by: Mariana Zuquim, Geothermal Scientist

5 Quay Street
P O Box 364
Whakatāne
NEW ZEALAND

ISSN: 1175-9372 (Print)
ISSN: 1179-9471 (Online)

Acknowledgements

Thank you Nick Macdonald and Thomas Brakenrig (GNS Science) for your ongoing support during the survey and for providing RTK-GPS data for the Tikitere geothermal surface features in the forestry block. Ngā Mihi Rob Donald (BOPRC) and Thomas Brakenrig (GNS Science) for peer-reviewing the report. Finally, thank you Jacqui Kaai for formatting and finalising the document as per BOPRC standards.

Executive summary

The Bay of Plenty Regional Council (BOPRC) contracts out GNS Science to monitor 37 geothermal surface features in the Rotorua Geothermal System and five features in the Tikitere Geothermal System, as part of its geothermal environmental monitoring programme. Geothermal activity in those areas is of immense value locally and regionally.

The results of this monitoring programme are crucial to understand changes in those geothermal systems and they also help inform the environmental management and plan provisions for those systems.

The Rotorua Geothermal System is a high-temperature geothermal system located in the southern end of the Lake Rotorua, Bay of Plenty, and is the by-product of volcanic activity associated with the Rotorua Caldera. The Tikitere Geothermal System is located along the south of Lake Rotoiti and is associated with the Ōkataina Volcanic Centre.

Between 2023 and 2024, BOPRC carried out a geographic and level survey to accurately determine the geographic coordinates for 36 geothermal surface features in the Rotorua Geothermal System and five features in the Tikitere system, two of which were carried out by GNS Science. One of the surface features in Rotorua (RRF0505) could not be visited due to safety constraints.

Bay of Plenty Regional Council utilised the RTK-GPS technique (Real Time Kinematic) to determine the location. A mix of optical surveying and RTK-GPS was applied for the level surveys, for surface features with water level readings as part of the monitoring programme.

The level survey included all the datum currently used for the monitoring programme, as well as historical datum where those could be located. Some datums were installed during this project to upgrade some sites.

The results of this survey enabled BOPRC to offset historical water level data with confidence and accuracy. This will also ensure that datum changes that will invariably occur in the future, does not compromise the continuity of the water level time-series. Deriving water level in elevation will also enable a comparison of water level across multiple features and understand pressure variations in the geothermal aquifer within and across the different thermal areas.

Contents

1 Introduction

The Rotorua Geothermal System is a high-temperature geothermal system located in the southern end of the Lake Rotorua, Bay of Plenty. The system is a by-product of the volcanism associated to the Rotorua Caldera between ~240 and 160 thousand years ago. The ngāwhā is of immense value locally and regionally, and the geothermal activity one of the main drawcards for the Rotorua City. Use and preservation is carefully balanced and managed to ensure that the health of the surface features and the aquifer are not adversely affected by extraction beyond current levels (BOPRC, 2024).

The Tikitere Geothermal System is located along the south of Lake Rotoiti and is associated with the Ōkataina Volcanic Centre, a large volcanic complex to the east of the Rotorua Caldera, that has been active over the last 400,000 years and last erupted on 10 June 1886 (Mount Tarawera). The geothermal surface features are of high value to Māori and tourism as well, but extractive uses are significantly less intensive than in Rotorua.

The Bay of Plenty Regional Council (BOPRC) monitors 37 geothermal surface features in Rotorua Geothermal System and five features in the Tikitere as part of its wider environmental monitoring programme (Figure 1 and Figure 7). The monitoring of geothermal surface features is crucial to understand changes in the geothermal system's short and long-term (Scott *et.al.* 2021), and its results help inform the environmental management and plan provisions for those systems.

For Rotorua, the broad principles of the monitoring programme were established by the Task Force programme of the mid-1980s (Ministry of Energy, 1985), which was then downsized and adjusted over time, to suit the current environmental management settings and expected changes to the system. In Tikitere, regular environmental monitoring commenced in 2021. The monitoring programme in Tikitere is also significantly less comprehensive than in Rotorua, due to the significantly smaller level of extractive use and constraints on access to some of the thermal areas.

Between 2023 and 2024, BOPRC carried out a geographic and level survey to accurately determine the geographic coordinates for 36 geothermal surface features in the Rotorua Geothermal System and five features in the Tikitere system, two of which were carried out by GNS Science and results shared with BOPRC. The surface feature RRF0505 in Rotorua could not be accessed due to safety constraints. The site locations are presented in Figure 1 to Figure 7.

BOPRC utilised the RTK-GPS technique (Real Time Kinematic) to determine the location. A mix of optical surveying and RTK-GPS was applied for the level surveys, for surface features with water level readings as part of the monitoring programme.

The level survey included all the datum currently used for the monitoring programme, as well as historical datum where those could be located. Some datums were installed during this project to upgrade some sites.

The results of this survey enabled BOPRC to offset historical water level data with confidence and accuracy. This will also ensure that datum changes that will invariably occur in the future does not compromise the continuity of the water level time-series. Deriving water level in elevation will also enable a comparison of water level across multiple features and understand pressure variations in the geothermal aquifer within and across the different thermal areas (Ministry of Energy, 1985).

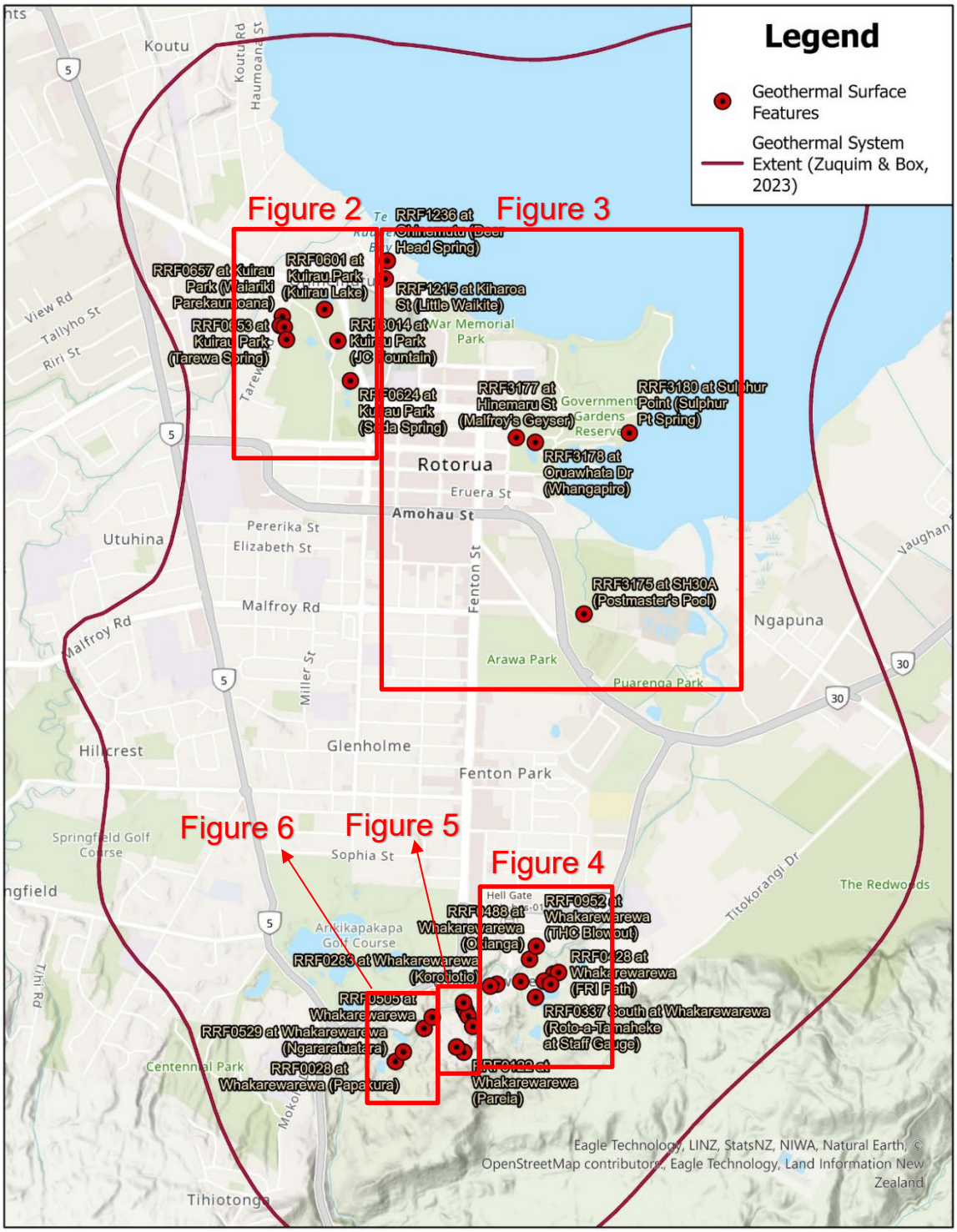


Figure 1 – General map showing locations of the geothermal surface features surveyed in Rotorua. Not all features are labelled. See detailed maps.

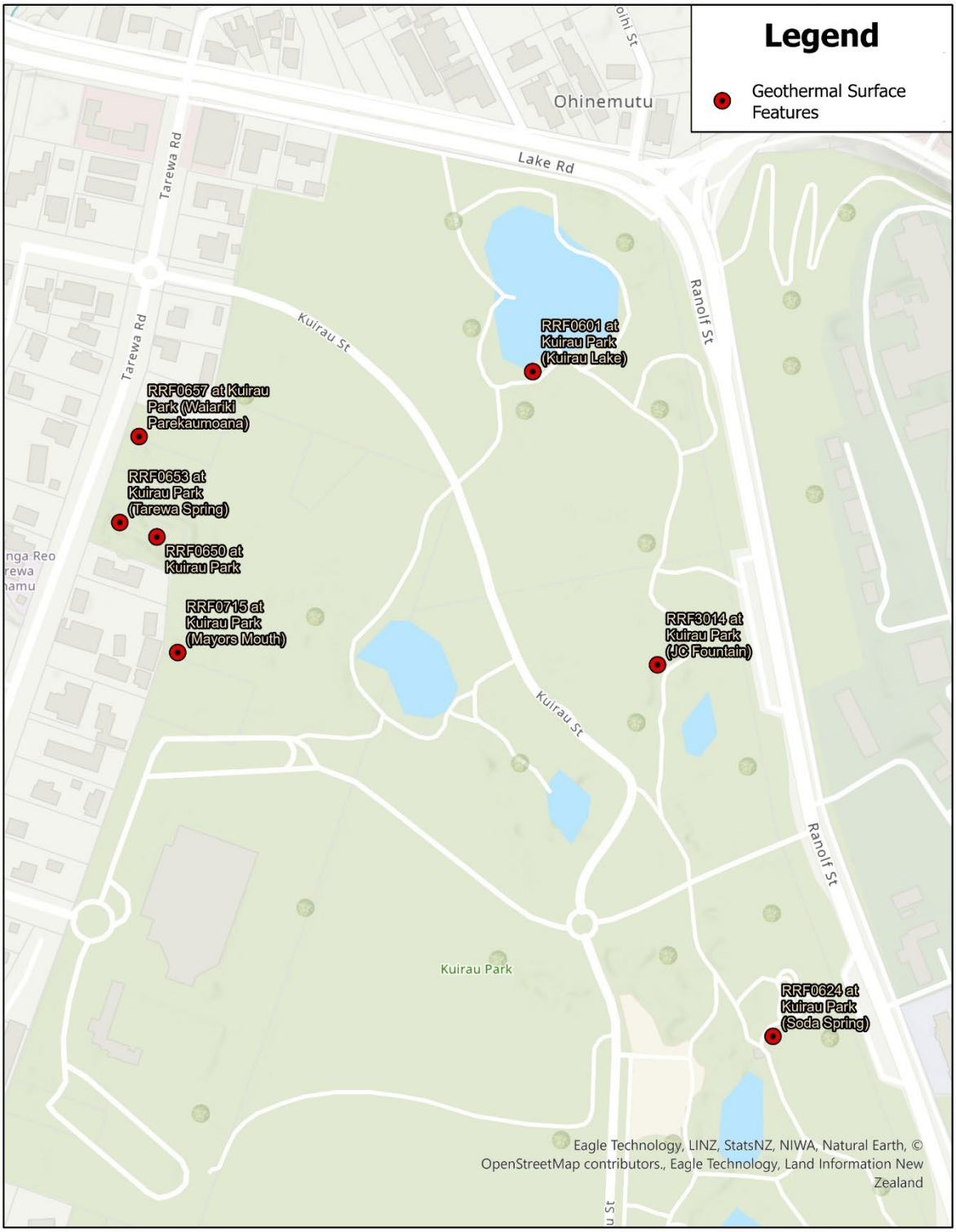


Figure 2 – Surveyed sites in the Kuirau area, Rotorua.

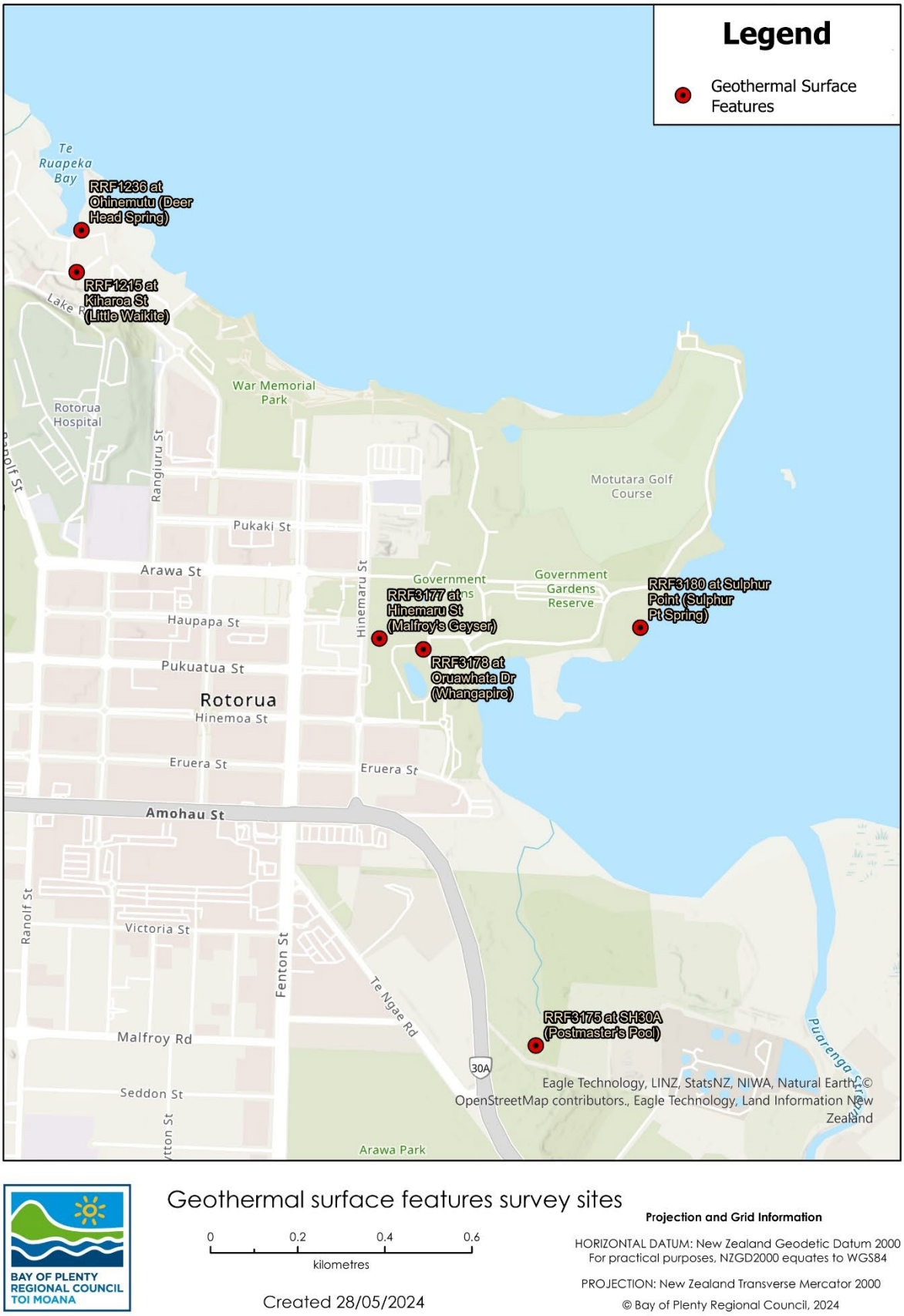


Figure 3 – Surveyed sites in the Ōhinemutu, Government Gardens and Ngāpuna areas, Rotorua.

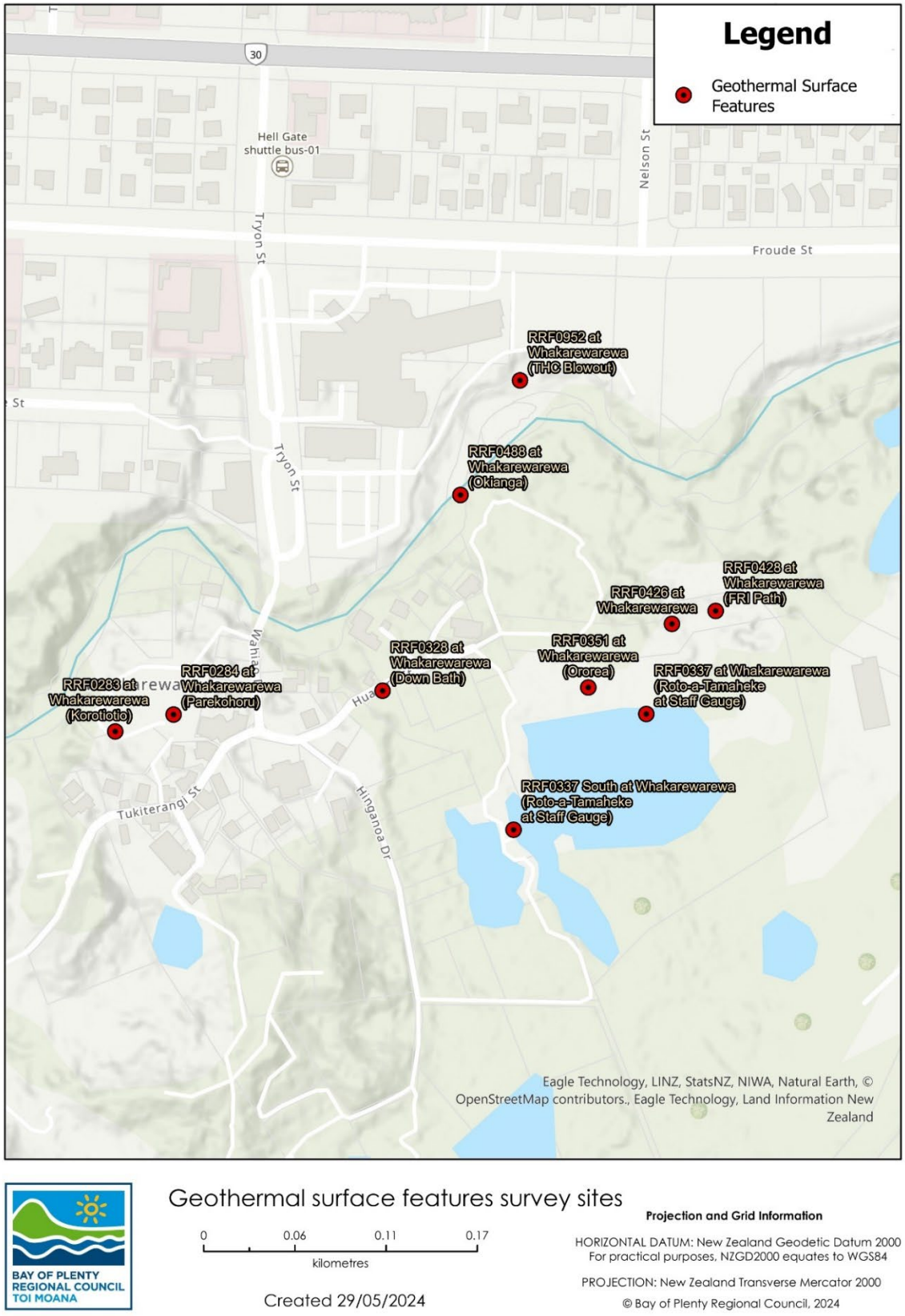


Figure 4 – Surveyed sites in the Whakarewarewa area, Rotorua.

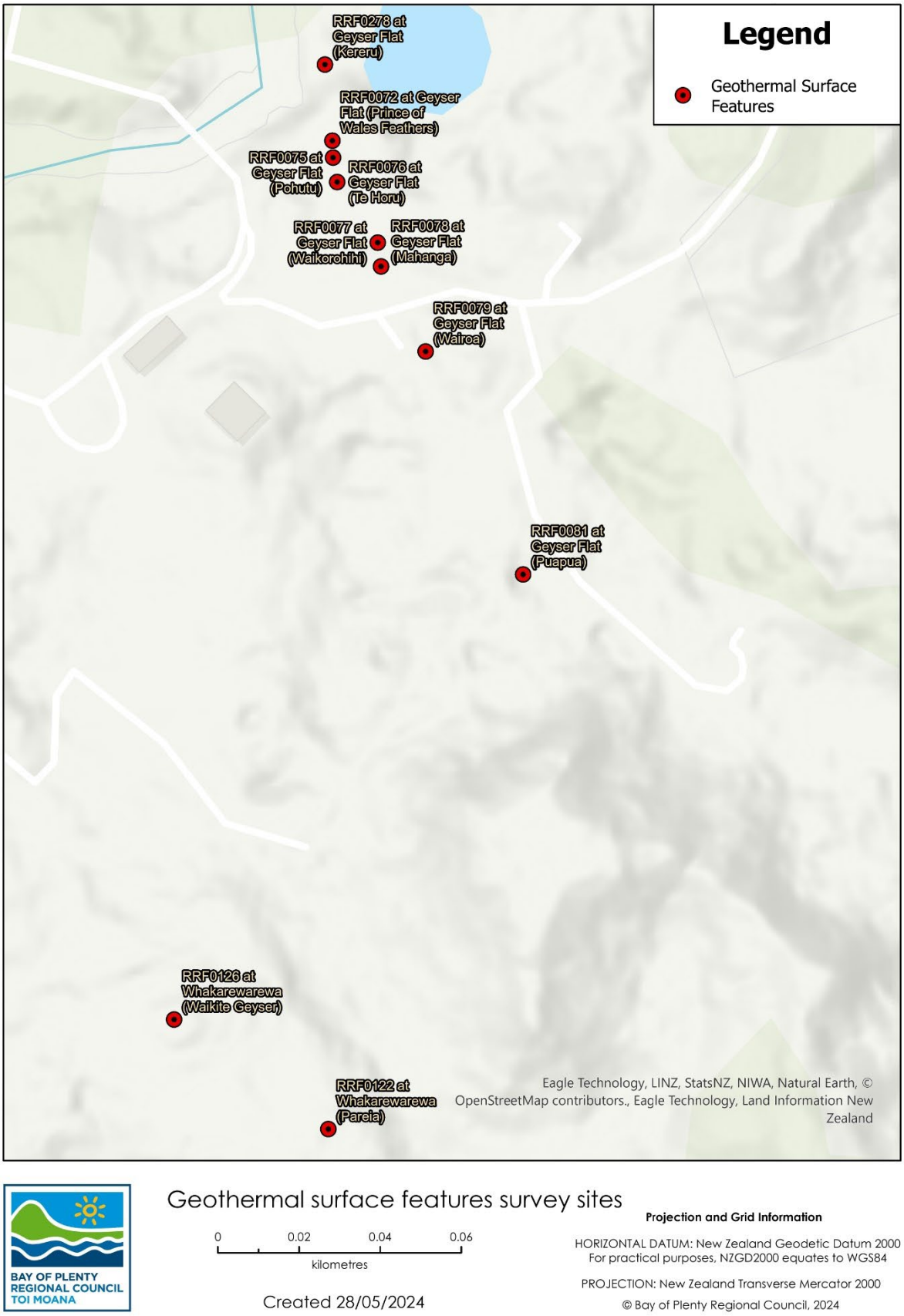


Figure 5 – Surveyed sites in the eastern area of Te Puia, Whakarewarewa Valley, Rotorua.

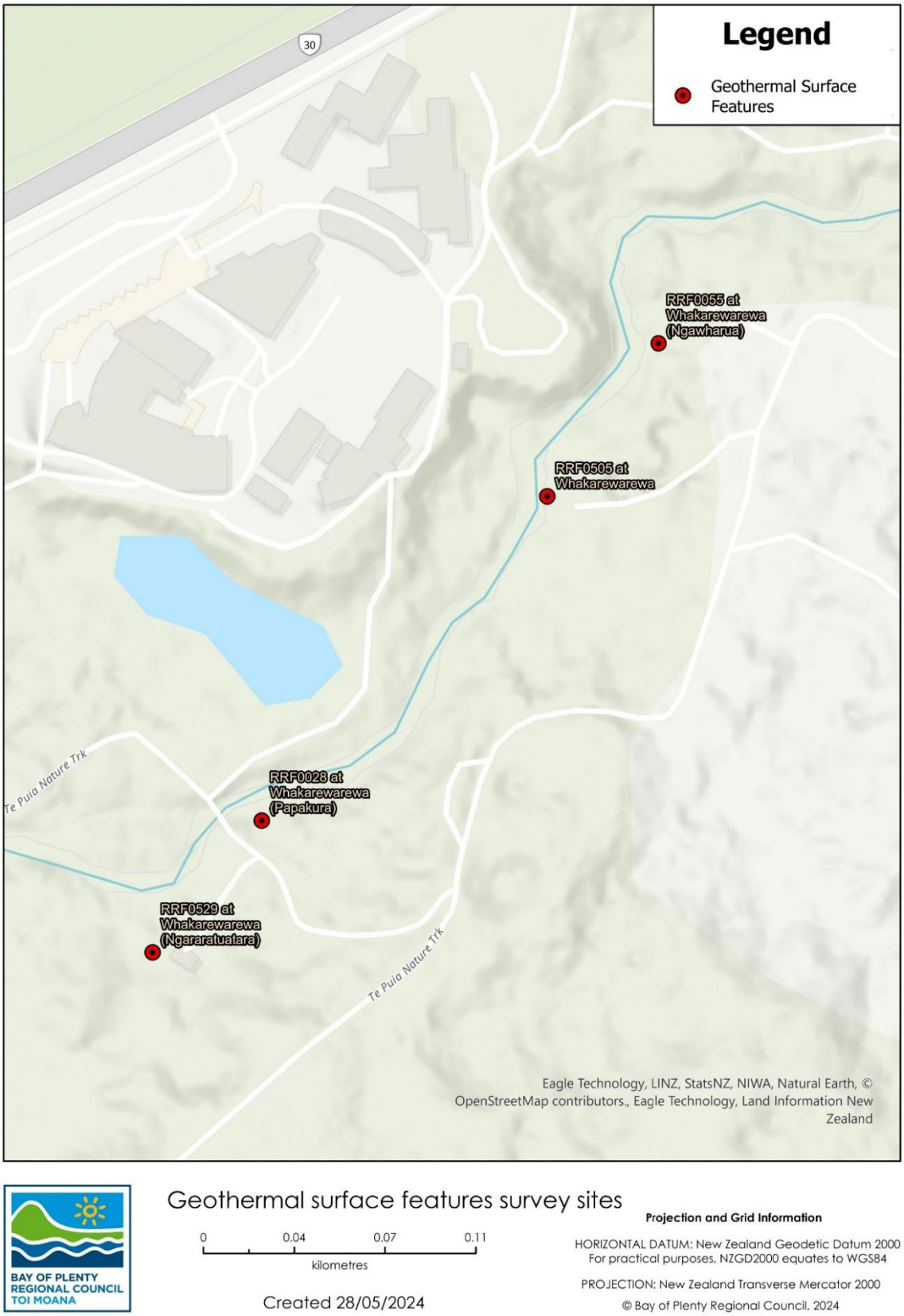


Figure 6 – Surveyed sites in the western area of Te Puia, Whakarewarewa Valley, Rotorua.

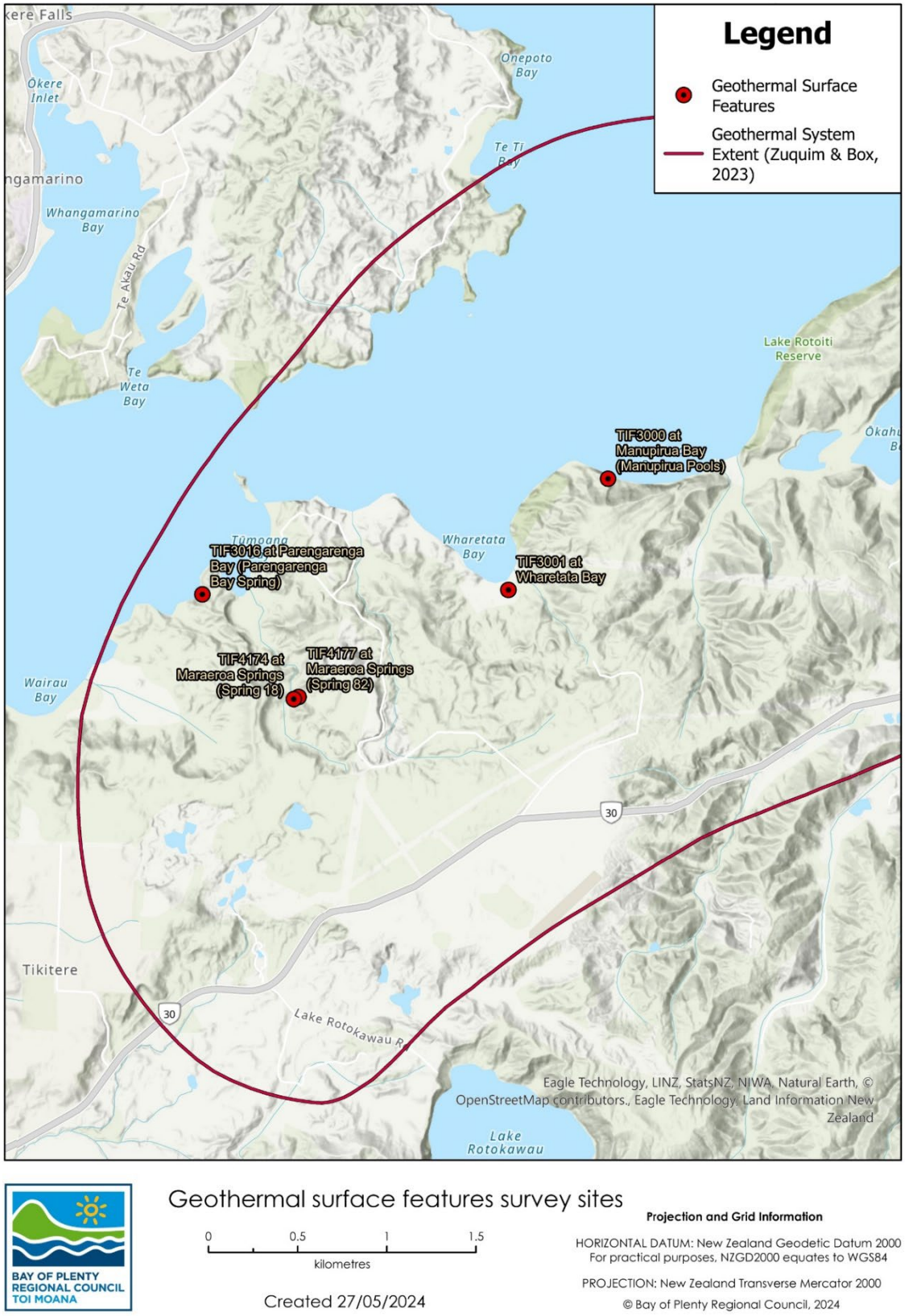


Figure 7 – Surveyed sites in the Tikitere Geothermal System.

2 Methods

Two (2) methods were used for this survey: RTK GPS with long read times and optical level surveying. A detailed description of the methodology is beyond the scope of this report, given that those methods are well accepted and commonly deployed for surveying.

Vertical Datum were surveyed in Moturiki Datum and converted to NZVD for presentation. The coordinates were acquired in BOP2000 coordinate system and converted to NZTM for presentation, except for the Manupirua pool in Tikitere. No GPS position could be taken for the site due to lack of GPS signal, so the position was taken from the BOPRC map.

The surveys were carried out in the following dates:

- Rotorua: 22-24 March 2023 and 23 April 2024
- Tikitere: 14 March 2023 and 22 April 2024[1]

2.1 Accuracy of the survey

A Trimble R12 in RTK with long read times was used for the GPS survey, to bring accurate levels from Freenet Benchmark network nearby to the monitoring sites. The GPS readings achieved Vertical Precision (95%) of between 5 mm and 8 mm for Rotorua (excluding sites that required position data only)[2]. The Tikitere geothermal sites are two or three kilometres from the LINZ benchmark network, which reduced vertical accuracy to within approximately 25 mm. The results of the survey carried out by GNS Science in two sites in Tikitere are reported to 1σ (standard deviation) accuracy (RMS = 68%).

For the optical surveying, a Wild Heerbrugg NAK2 manual optical level with an E-type staff was used to transfer a final height to each site. This instrument and staff allow readings down to three decimal places, and on some occasions, half-millimetre accuracy is discernible. The Freenet BMs survey, which provided the origin heights, appears to have been undertaken with a modern digital level combined with Invar staff, which is capable of four decimal places. This optical surveying still achieved vertical miscloses ranging from 0 to 2½ mm.

[1] By GNS Science staff. Further details on the survey carried out by GNS Science are not included in this report.

[2] Long readings collect hundreds of individual measurements over the duration of the reading, therefore, if one reading attains say Vertical Precision (95%) = 0.006 m, this means that 95% of those hundreds of measurements fit within a 6 mm vertical range.

3 Results

A summary of the results of this survey are presented in Table 1 (Rotorua) and Table 2 (Tikitere) below. BOPRC holds extensive records and details on this survey. Those can be accessed upon request, but only key results are included in this short report.

The survey yield quality level data with sufficient accuracy to enable the offset of water level historic data to a common datum. The process of offsetting the data has also been completed and the time-series are now published and available for download by internal and external stakeholders via BOPRC Data portal[3] for externals (Figure 8) and Aquarius system (BOPRC data system available internally only; Figure 9) and this is considered a significant step forward to provide access to quality data, which is one of the BOPRC functions under Section 35 of the Resource Management Act (RMA).

[3] Environmental data (boprc.govt.nz)

Table 1 – Summary of the survey results for Rotorua (coordinates and vertical position)

RRF feature number	Common name	General area	Description	Datum for water level readings	Elevation	Easting	Northing	Notes
			Survey is to TOP of screw		NZVD2016	NZTM	NZTM	
RRF0028	Papakura	Te Puia	Screw just installed	Current datum	299.154	1884776.621	5770802.216	Precise height. Position accuracy <0.2 m
RRF0028	Papakura	Te Puia	Natural hole in the rock	Old datum	299.197	1884776.603	5770802.231	Precise height. Position accuracy <0.2 m
RRF0028	Papakura	Te Puia	Old nail against a boulder	Old datum	299.453	1884777.817	5770801.833	Precise height. Position accuracy <0.2 m
RRF0055	Ngawharua	Te Puia		Water level not measured	296.1	1884929.857	5770985.878	Height in general vicinity
RRF0072	Prince of Wales Feathers	Te Puia		Water level not measured	302.2	1885098.511	5771045.448	Height in general vicinity
RRF0075	Pohutu	Te Puia		Water level not measured	302.7	1885098.326	5771040.399	Height in general vicinity
RRF0076	Te Horu	Te Puia	Screw in rock just installed	Current datum	301.969	1885098.525	5771033.832	Precise height. Position accuracy <0.2 m
RRF0077	Waikorohihi	Te Puia		Water level not measured	303.9	1885109.093	5771019.271	Height in general vicinity
RRF0078	Mahanga	Te Puia		Water level not measured	304.4	1885110.736	5771012.764	Height in general vicinity
RRF0079	Wairoa	Te Puia	Screw in rock	Current datum	303.891	1885120	5770992	Precise height. Position calculated from aerial photo, accurate to <1 m
RRF0081	Puapua	Te Puia	Screw in rock - not at edge, draped WL readings	Current datum	306.126	1885140.877	5770936.907	Precise height. Position accuracy <0.2 m
RRF0122	Pareia	Te Puia		Water level not measured	313.9	1885098.052	5770799.408	Height in general vicinity
RRF0126	Waikite Geyser	Te Puia		Water level not measured	314.5	1885058.566	5770828.685	Height in general vicinity
RRF0278	Kereru	Te Puia		Water level not measured	297.0	1885095.921	5771063.189	Height in general vicinity
RRF0283	Korotiotio	Whakarewarewa	Nail in horizontal fence-timber	Current datum	299.474	1885239.168	5771149.528	Precise height. Position accuracy <0.2 m
RRF0284	Parekohoru	Whakarewarewa		Water level not measured	299.2	1885269.35	5771160.192	Height in general vicinity
RRF0328	DownBath	Whakarewarewa	White painted dot on top of S/S box	Current datum	294.816	1885399.4	5771175.4	Precise height. Position calculated from aerial photo, accurate to <1 m
RRF0337	Roto-a-Tamaheke, original site	Whakarewarewa	Screw in rock	Old datum, monitored site shifted to RRF0337 South	295.009	1885557.977	5771160.912	Precise height. Position accuracy <0.2 m
RRF0337 South	Roto-a-Tamaheke, new site	Whakarewarewa	Screw in rock	Current datum	294.904	1885477.726	5771091.313	Precise height. Position accuracy <0.2 m
RRF0351	Ororea	Whakarewarewa	Brass-coloured nail, horizontal in rock	Current datum	294.85	1885523.404	5771176.937	Precise height. Position accuracy <0.2 m
RRF0426	Unnamed feature	Whakarewarewa	Screw in rock just installed - Forenail	Current datum	293.461	1885573.568	5771214.702	Precise height. Position accuracy <0.2 m
RRF0426	Unnamed feature	Whakarewarewa	Screw in rock just installed - Backnail	Backup datum	293.458	1885573.679	5771214.648	Precise height. Position accuracy <0.2 m
RRF0428	FRI Path	Whakarewarewa		Water level not measured	292.9	1885600.382	5771222.28	Height in general vicinity
RRF0488	Okianga	Whakarewarewa		Water level not measured	291.1	1885445.693	5771292.886	Height in general vicinity
RRF0505	Unnamed feature	Te Puia		Water level not measured	296.54	1884887	5770926.987	Calculated from map. No safe access. No elevation
RRF0529	Ngararatuatara	Te Puia	Original pin with flat head, in rock	Current datum	301.951	1884735.2	5770750.6	Precise height. Position calculated from aerial photo, accurate to <0.3 m
RRF0529	Ngararatuatara	Te Puia	New, additional screw, in rock, ½m from old	Backup datum	301.94	1884735.5	5770751	Precise height. Position calculated from aerial photo, accurate to <0.3 m
RRF0601	Kuirau Lake	Kuirau	Flat, round, bolt head in concrete cylinder	Current datum	283.469	1884359.303	5774743.245	Precise height. Position accuracy <0.2 m
RRF0624	Soda Spring	Kuirau	Flat, round, bolt head in rock	Current datum	285.165	1884493.973	5774367.873	Precise height. Position accuracy <0.2 m

Table 1 (continued) – Summary of the survey results for Rotorua (coordinates and vertical position)

RRF feature number	Common name	General area	Description	Datum for water level readings	Elevation	Easting	Northing	Notes
			Survey is to TOP of screw		NZVD2016	NZTM	NZTM	
RRF0624	Soda Spring	Kuirau	Sinter lip	Old datum	284.752	1884494.28	5774367.266	Precise height. Position accuracy <0.2 m
RRF0650	Kuirau Spring	Kuirau	Screw in rock - not at edge, draped WL readings	Current datum	283.107	1884145.532	5774651.03	Precise height. Position accuracy <0.2 m
RRF0653	Tarewa Spring	Kuirau	Screw in rock	Current datum	283.162	1884123.843	5774659.741	Precise height. Position accuracy <0.2 m
RRF0657	Waiariki Parekaumoana	Kuirau	Edge of rock ledge, no screw here	Current datum	282.946	1884139.907	5774709.748	Precise height. Position accuracy <0.2 m
RRF0715	Mayor's Mouth	Kuirau	Screw in rock	Current datum	283.262	1884156.314	5774584.865	Precise height. Position accuracy <0.2 m
RRF0952	THC Blowout	Whakarewarewa		Water level not measured	291.7	1885489.488	5771363.245	Height in general vicinity
RRF1215	Little Waikite	Ōhinemutu		Water level not measured	281.1	1884680.497	5774908.068	Height in general vicinity
RRF1236	Deerhead Spring	Ōhinemutu		Water level not measured	281.1	1884690.498	5775006.49	Height in general vicinity
RRF3014	JC Fountain	Kuirau Park	Screw in rock just installed	Current datum	286.14	1884432.6	5774579.228	Precise height. Position accuracy <0.2 m
RRF3014	JC Fountain	Kuirau Park	Old measure spot interface geyserite/rock	Old datum	285.876	1884432.631	5774578.797	Precise height. Position accuracy <0.2 m
RRF3175	Postmaster's Pool	Sulphur Point	Screw in rock, at pool	Current datum	282.328	1885735.2	5773129	Precise height. Position calculated from aerial photo, accurate to <1 m
RRF3177	Malfroy's Geyser	Government Gardens	Screw in rock - not at edge, draped WL readings	Current datum	284.317	1885373.49	5774064.727	Precise height. Position accuracy <0.2 m
RRF3178	Whangapipiro Pool	Government Gardens	White painted dot on top of intake pipe	Current datum	283.719	1885473.395	5774039.187	Precise height. Position accuracy <0.2 m
RRF3178	Whangapipiro Pool	Government Gardens	Sinter lip by the pipe	Old datum	283.43	1885473.218	5774038.309	Precise height. Position accuracy <0.2 m
RRF3180	Sulphur Point	Sulphur Point		Water level not measured	280.4	1885975.469	5774089.613	Height in general vicinity

Table 2 – Summary of the survey results for Tikitere (coordinates and vertical position), including coordinate results obtained by GNS Science.

TIF feature number	Common name	General area	Description	Datum for water level readings	Elevation	Easting	Northing	Notes
			Survey is to TOP of screw		NZVD2016	NZTM	NZTM	
TIF3000	Manupirua Pools	Lake Rotoiti	Lake Rotoiti. Commercial pools, boat access only		279.204	1896810	5784476	Calculated from map. No GPS signal possible here. No elevation
TIF3001	Wharetata Bay	Lake Rotoiti		Top of stake in pool for measuring WL	279.281	1896251	5783853	Standing at pool, look to right
TIF3016	Parengarenga Bay	Lake Rotoiti		Screw in rock at pool	342.5	1894531	5783832	Screw installed March 2024
TIF4174	Spring 82	Forestry block			342.5	1895071	5783250	GPS by GNS Science. Height in the general vicinity
TIF4177	Spring 18	Forestry block			279.204	1895045	5783237	GPS by GNS Science. Height in the general vicinity

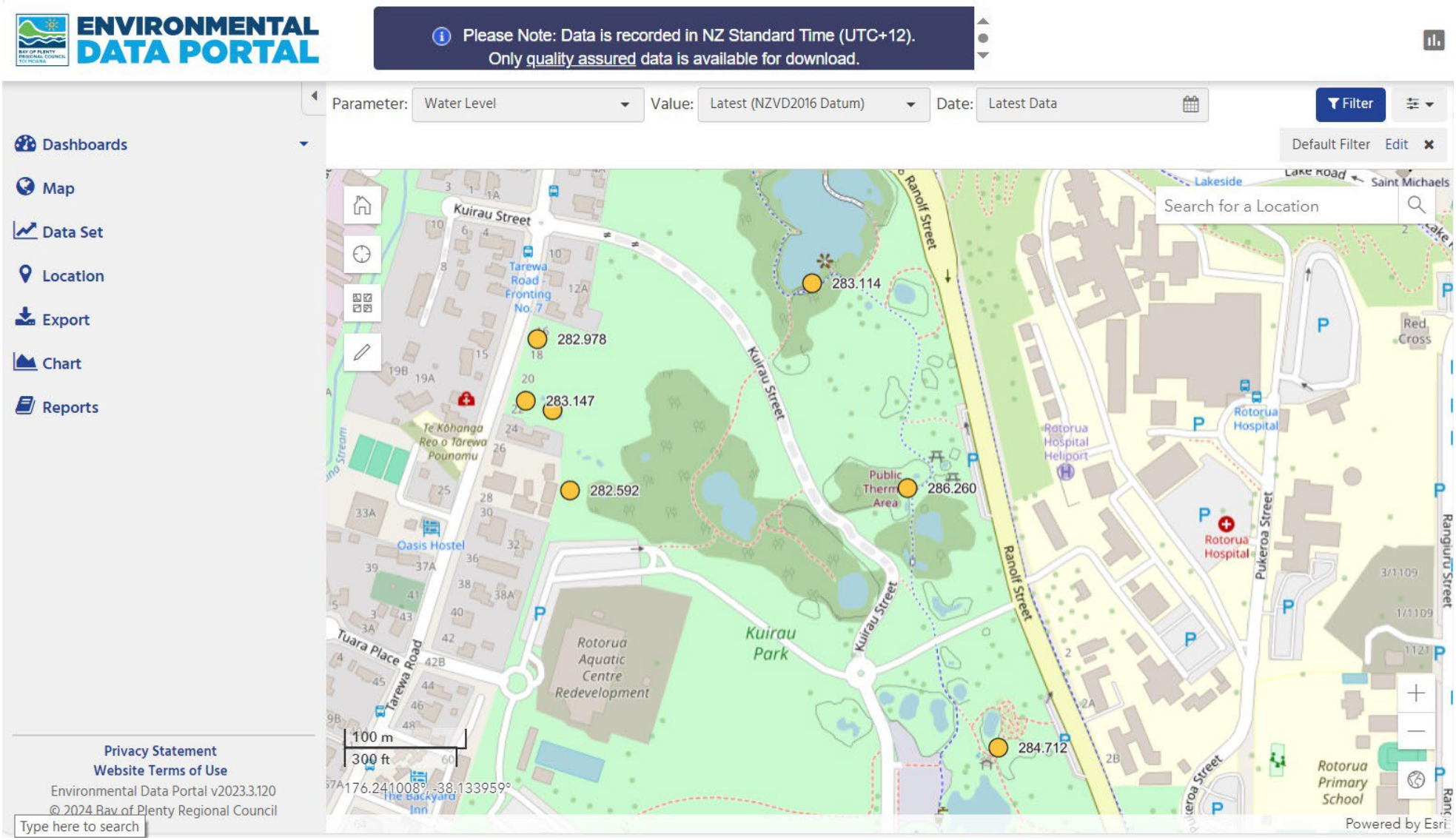


Figure 8 – Example of water level data (NZVD2016 datum) displayed in the BOPRC data portal. The time series can then be downloaded for each feature (Figure 9). Note that the geographic location has also been determined using this survey's results.

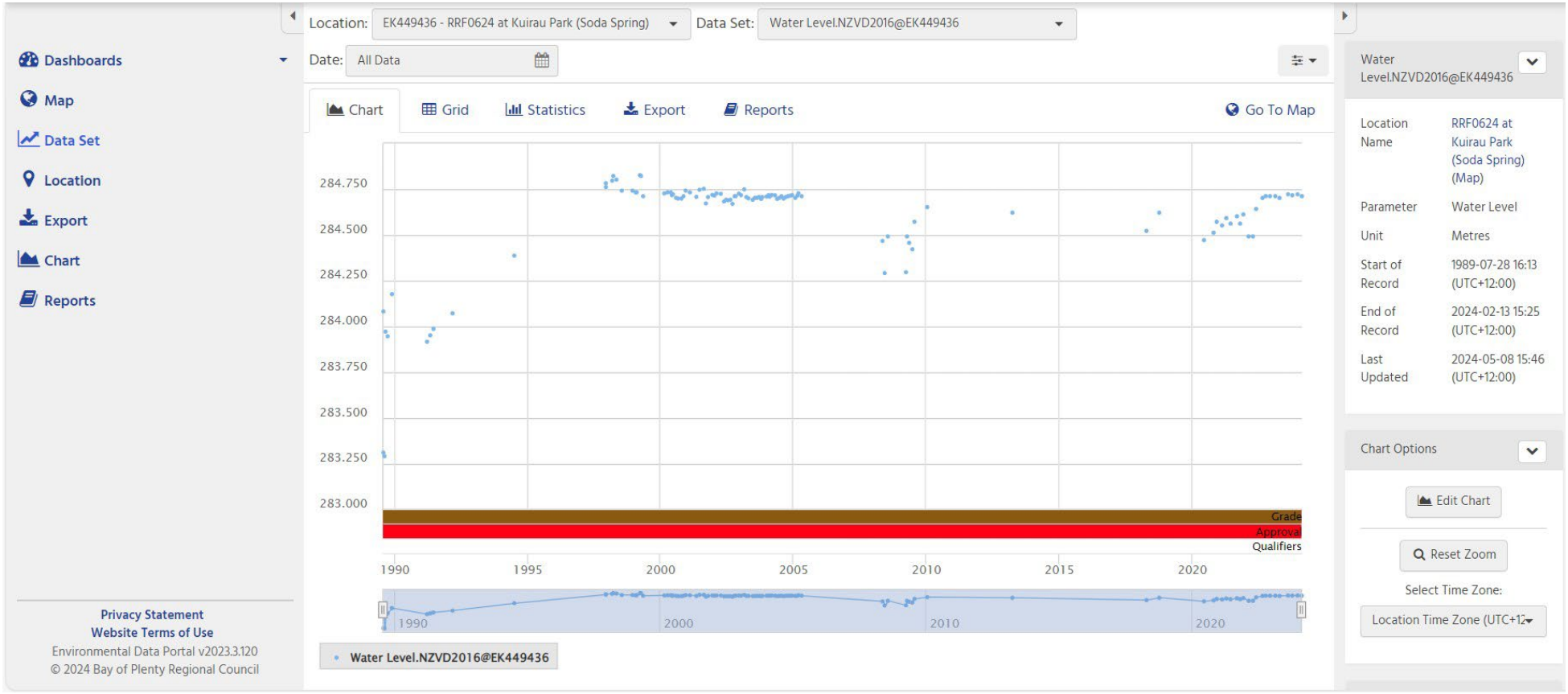


Figure 9 – Example of water level data (NZVD2016 datum) that can be downloaded from the BOPRC data portal. Data for RRF0624 – Soda Spring in Kuirau Park

4 Discussion and conclusions

This project successfully achieved its objective to survey the geographic location of the geothermal surface features and the datum level (historic and current) with sufficient accuracy for the monitoring programme (mostly < 20 mm for coordinates and <10 mm for level). Those historic datum have never been surveyed before.

This work enabled BOPRC to offset the whole water level time-series for the datum changes to create a robust dataset that often spans over 30 years. This work also safeguards the monitoring programme for datum changes in the future. Datum changes are required regularly due to the nature of geothermal surface features (e.g. changes can compromise access due to hazardous access to the monitoring site, datum are flooded as water level rises) and the environment (corrosive atmosphere that require frequent screw replacements).

The results of this survey also enabled BOPRC to share its monitoring data through its portal and provide access to this high-value dataset to the communities with an interest in geothermal, key external stakeholders. Sharing this information also ensures that BOPRC meets its functions under the RMA.

It is acknowledged that many Iwi/Hapū have interest in geothermal, as well as Crown Research Institutes and Universities, Rotorua Lakes Council and the Department of Conservation. The publishing of the geothermal surface features data is a major step to work in partnership with those organisations/communities.

5 References

BOPRC. 2024. Ngā Wai Ariki o Rotorua He Mahere Wahahaere Pūnaha:- Rotorua Geothermal System Management Plan.

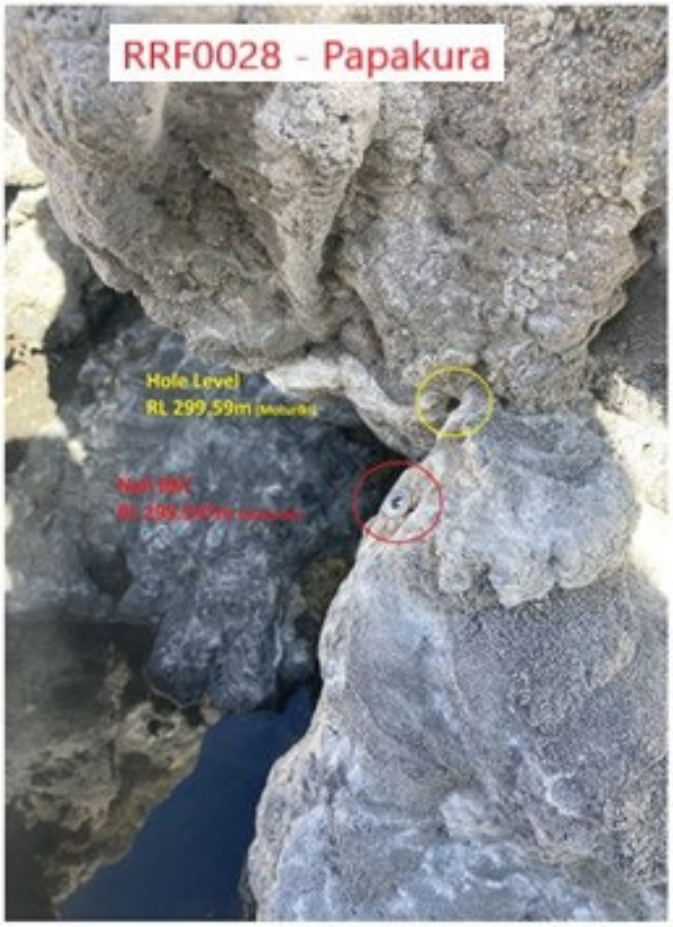
Ministry of Energy. 1985. The Rotorua Geothermal Field. A report to the Geothermal Monitoring Programme and Task Force 1982-1985. Wellington (NZ): Ministry of Energy.

Scott, B.J., Kissling, W.M., Moreau, M., Sajkowski, L., Burnell, J.G., Brakenrig, 9T., Reeves, R.R. (2021). Assessing the Rotorua Geothermal System: a review of data sets. GNS Science Consultancy Report 2020/84. 101p.

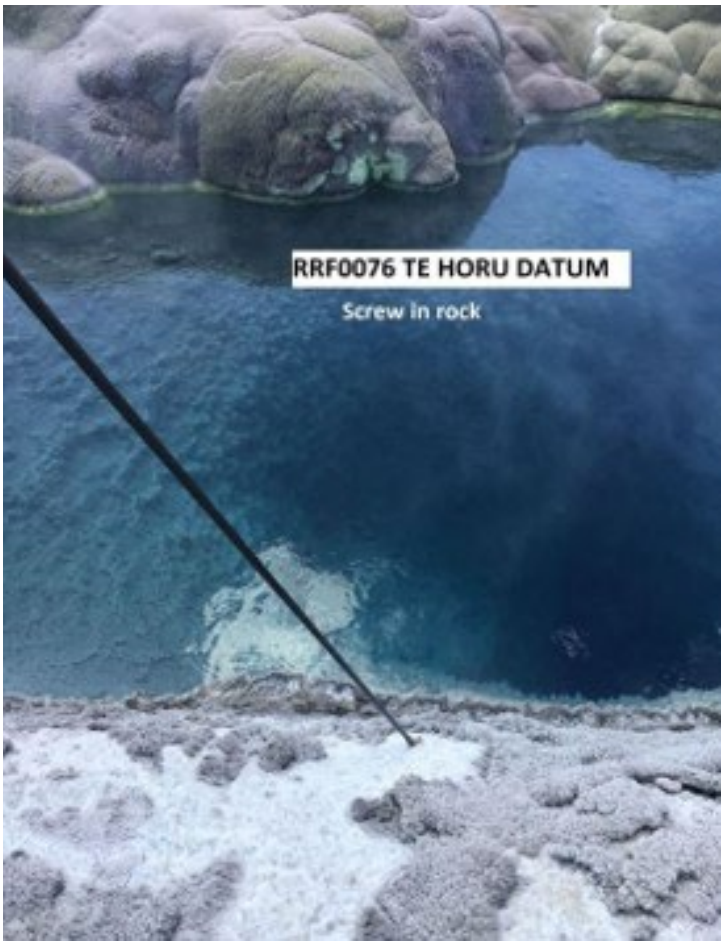
Appendices

Appendix 1:
Datum photos

RRF0028 Papakura old datum



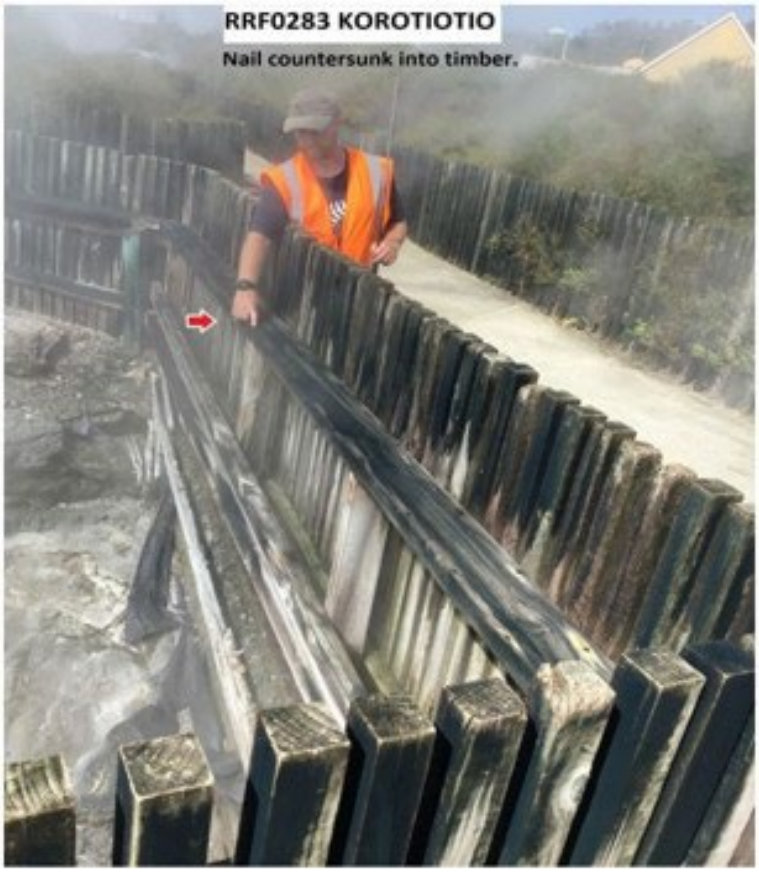
RRF0028 Papakura old datum (hole) and new datum (screw)



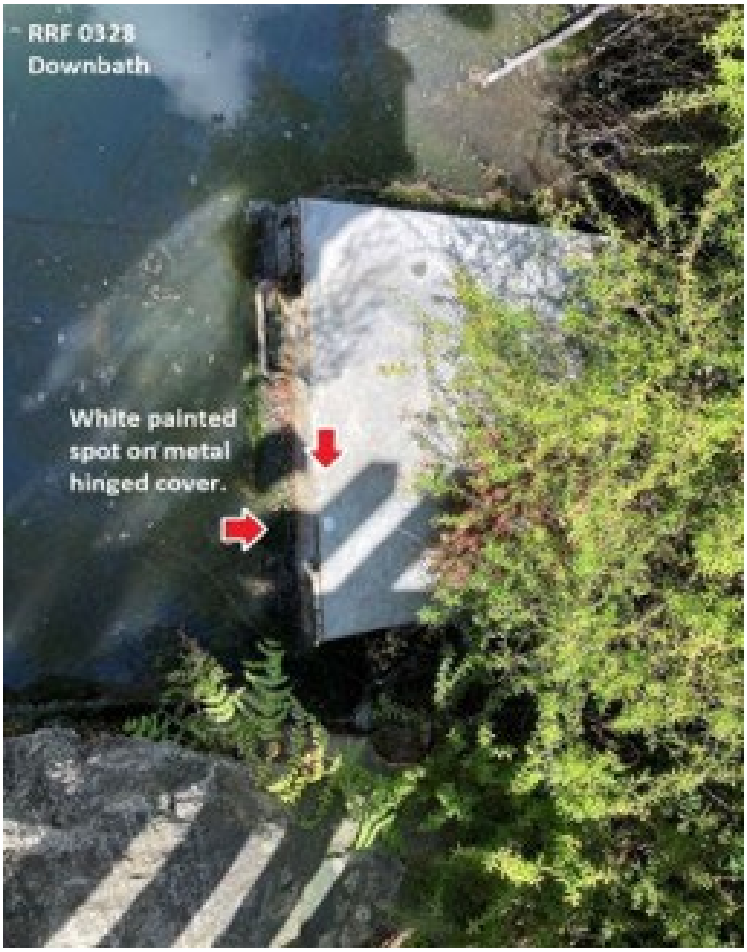
RRF0076 Te Horu current datum

RRF0079 Wairoa current datum

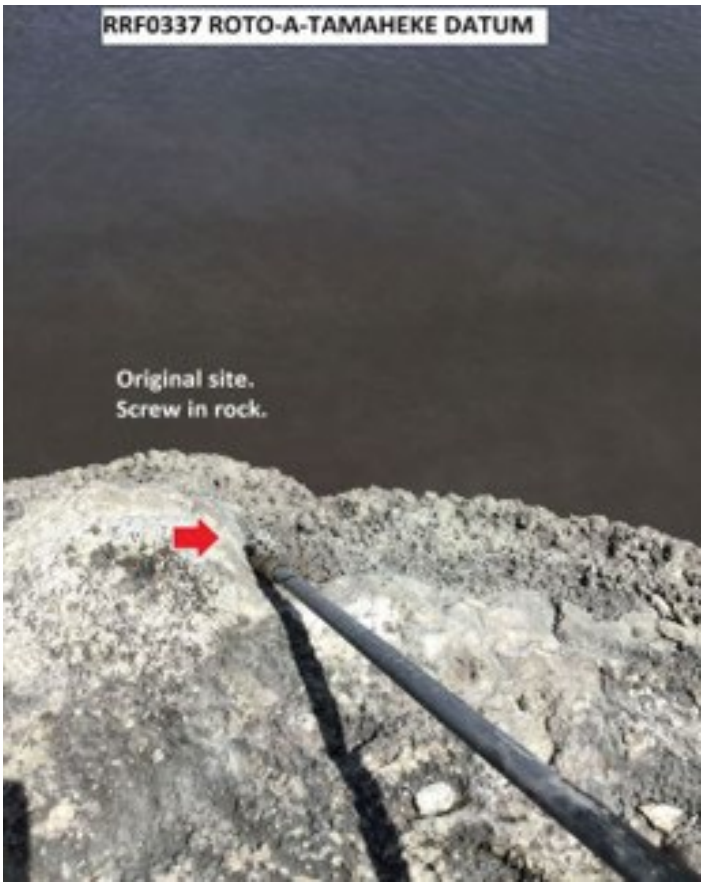
RRF0081 Puapua current datum



RRF0283 Korotiotio current datum



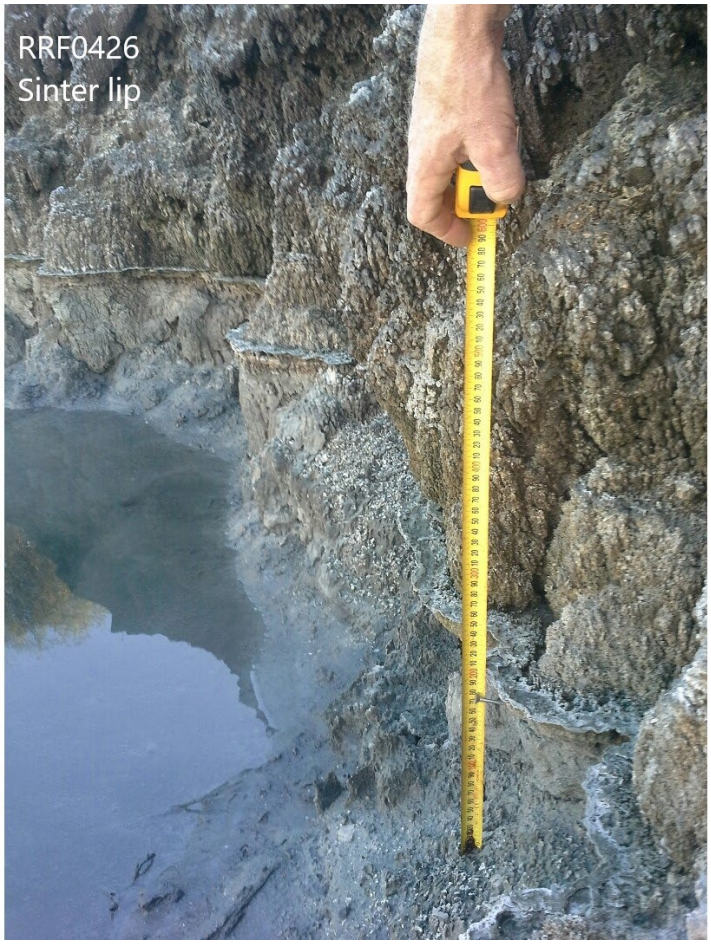
RRF0328 Downbath current datum



RRF0337 Roto-a-tamaheke old datum

RRF0337 Roto-a-tamaheke current datum

RRF0351 Ororea current datum



RRF0426 Unnamed feature old datum (sinter lip).

RRF0426 Unnamed feature current datum (front nail – red circle). Back-nail was installed and surveyed already for backup.

RRF0529 Ngararatuatara current datum

RRF0529 Ngararatuatara backup datum

RRF0601 Kuirau Lake current datum

RRF0624 Soda Spring old datum (sinter lip)

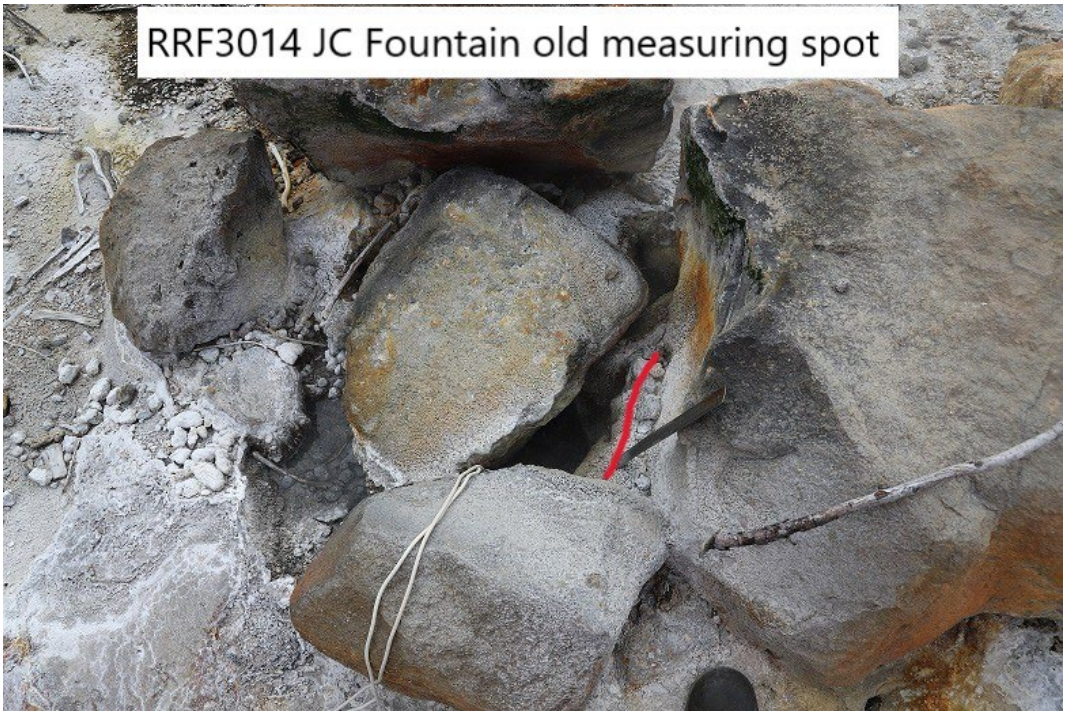
RRF0624 Soda Spring current datum (sinter lip)

RRF0650 Kuirau Spring current datum

RRF0653 Tarewa Spring current datum

RRF0657 Waiariki Parekaumoana current datum

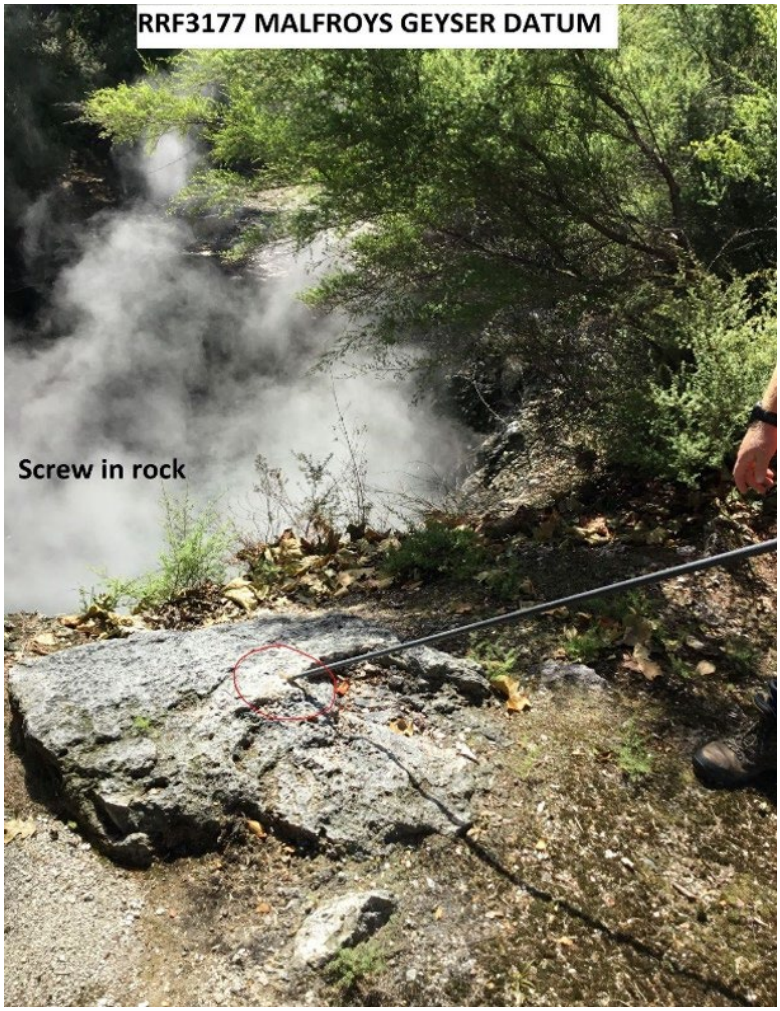
RRF0715 Mayors Mouth current datum



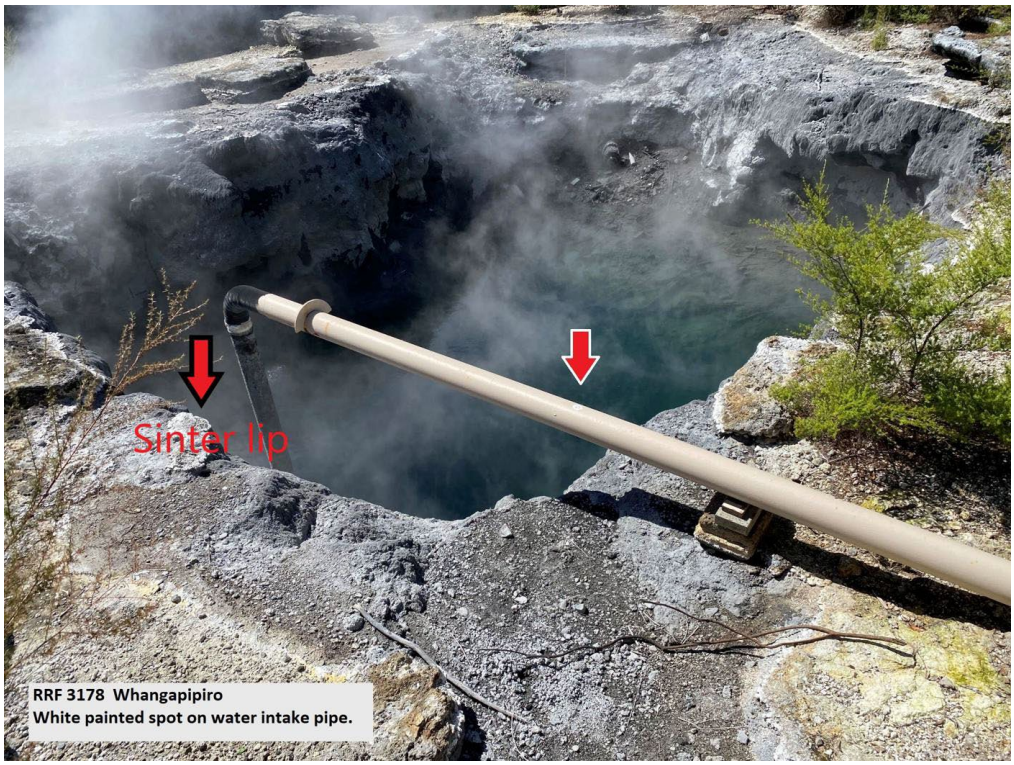
RRF3014 JC Fountain old datum (along the red line)

RRF3014 JC Fountain current datum

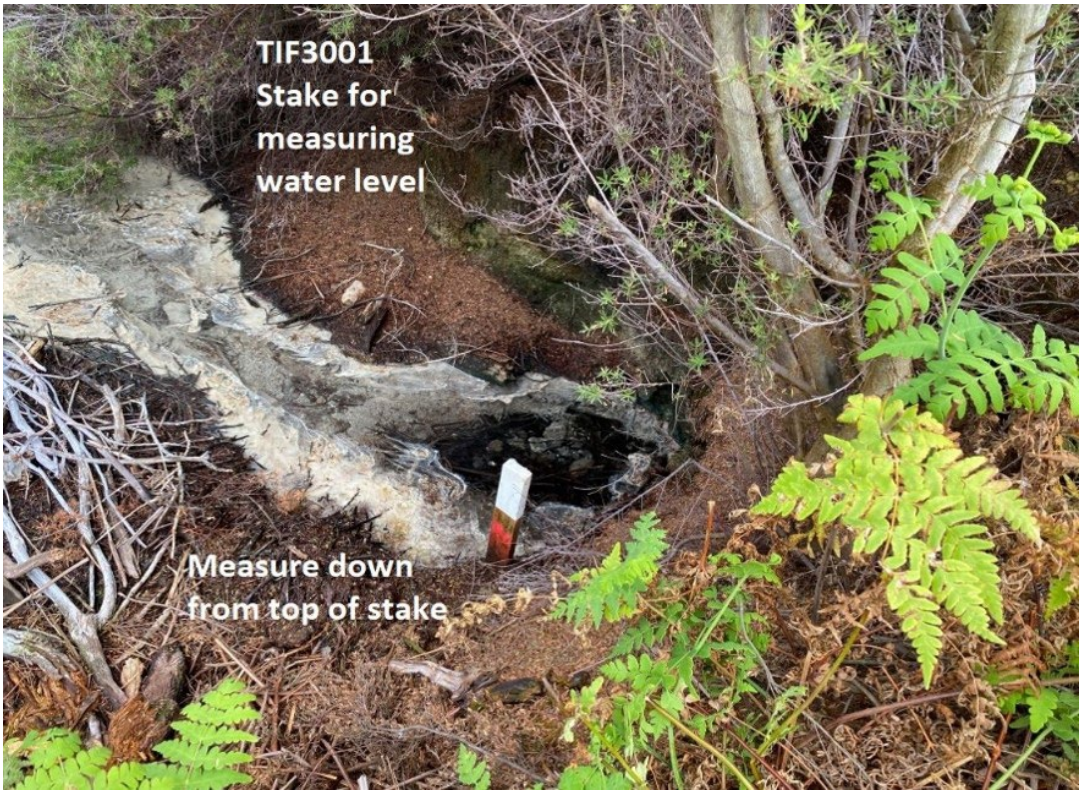
RRF3175 Postmasters Pool current datum



RRF3177 Malfroys Geyser current datum.



RRF3178 Whangapipiro / Rachel Spring old datum (sinter lip) and new datum (top of pipe).



TIF3001 Wharetata Bay current datum

TIF3016 Parengarenga Bay current datum