Rotokawa Joint Venture Limited

Evidence for Applicant

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of applications by the **Rotokawa Joint Venture Limited** to Waikato Regional Council for Resource Consents for the Rotokawa Geothermal Development

STATEMENT OF EVIDENCE OF MICHAEL STEVENS

1. INTRODUCTION

Qualifications and Experience

1.1 My name is Michael Stevens. I am employed by Mercury NZ Limited ('Mercury', formerly Mighty River Power Limited) as the Rotokawa Field Manager for the past two years. In this role, I am responsible for the management, operation, and maintenance of:

(a) the Rotokawa A Power Station (owned by Mercury);

(b) the Nga Awa Purua Power Station (owned by the Rotokawa Joint Venture (RJV) – a partnership between Mercury and Tauhara North No.2 Trust);

(c) The Rotokawa steamfield (also owned by RJV); and

(d) The Rotokawa geothermal resource.

1.2 I have worked in the geothermal generation industry for the past 16 years. I have a maintenance, operations and management background and hold a Postgraduate Diploma in Business Administration from Waikato University.

1.3 I am authorised to give evidence on behalf of RJV.

Purpose and scope of evidence

1.4 The purpose of my evidence is to introduce RJV and to provide context to its resource consent application. I will:

(a) Provide a brief overview of RJV;

(b) Provide a brief overview of Mercury – one of the two RJV partners;

(c) Describe the electricity generation activities undertaken on the Rotokawa geothermal reservoir;

(d) Illustrate the importance of electricity to society and the value placed on the reliable supply of electricity; and

(e) Discuss the overall rationale for the RJV consent application.

2. EXECUTIVE SUMMARY

2.1 RJV is a limited liability company formed between two partners - the Tauhara North No.2 Trust (TN2T) and Mercury.

2.2 RJV has worked extensively for over 15 years developing and implementing a comprehensive approach to geothermal development at Rotokawa to ensure the best chance of achieving long term sustainable use of the resource.

2.3 The Rotokawa site, and renewable geothermal generation in general, play important roles in contributing towards meeting national electricity demand, maintaining security of electricity supply, and supporting the Government's renewable generation targets.

2.4 With the start-up of Nga Awa Purua, RJV has continued to improve its understanding of the geothermal resource. RJV's resource consent application directly responds to these findings in a responsible and sustainable way – consistent with the values of both RJV partners.

2.5 Extending the steamfield towards Lake Rotokawa will provide RJV additional operational flexibility to respond to current reservoir enthalpy behaviour, and enable the construction and use of deviated wells towards desirable subsurface targets.

2.6 Securing access to more geothermal fluid will enable continued operation of the current generation assets at full capacity – maximising the site's generation of renewable electricity for the National Grid, and maximising the efficiency of the site's existing infrastructure.

2.7 Moving production away from the western reservoir area represents the best adaptive management response to observed changes, in turn, ensuring long term sustainability of the Rotokawa resource.

3. ROTOKAWA JOINT VENTURE

3.1 RJV is a limited liability company formed between two partners - the Tauhara North No.2 Trust (TN2T) and Mercury.

4. MERCURY

4.1 Mercury NZ Limited is an electricity generator and retailer that provides energy services to homes, businesses and industrial customers throughout New Zealand.

4.2 Mercury was publicly listed on the New Zealand and Australian stock exchanges in May 2013 with a large New Zealand ownership base, alongside the Government as majority owner. The company has a long heritage in renewable energy in New Zealand serving about 1-in-5 homes and businesses under the Mercury brand and other specialty brands, including the leading pre-pay product GLOBUG. Mercury also has proven capability and technical expertise in smart metering services and solar.

4.3 Our electricity generation is 100% renewable, with the hydro and geothermal power stations operated by Mercury producing enough renewable electricity for about 1 million New Zealand homes. The nine hydro stations dating back to the 1920s make up the

Waikato River Hydro System, accounting for about 10% of the country's total electricity supply that is predominantly hydro.

4.4 Lake Taupo and the eight hydro lakes provide large-scale, economic energy storage, and the nine stations are highly responsive. Mercury has 39 individual hydro generating units on the river that can quickly ramp up to meet residential and commercial demand peaks in the upper North Island.

4.5 Kaitiakitanga is a foundation to our business approach. We have a proven track-record in working with Maori landowners and through other valued and long-standing relationships in the community that help us sustainably harness natural energy resources.

4.6 Mercury led a renaissance in geothermal energy over the past decade with an innovative investment programme in partnership with local Maori land trusts, enabling the completion of three major geothermal projects in 2008 (Kawerau), 2010 (Nga Awa Purua) and 2013 (Ngatamariki). These sustainably harness natural heat deep underground, producing steady 'base-load' electricity – normally running 24/7 and are not dependent on the weather like other forms of renewable generation.

4.7 Geothermal is a distinctive strength for Mercury, and integral to New Zealand's electricity supply accounting for about 7% of the country's total electricity demand.

4.8 This reliable, renewable generation has helped displace millions of tonnes of carbon emissions every year from New Zealand's electricity supply by greatly reducing the requirement for fossil fuel based generation.

4.9 Current geothermal generation assets include:

(a) The 34 MW wholly-owned Rotokawa station;

(b) The 138 MW Nga Awa Purua geothermal power station which is 65% owned by Mercury and 35% owned by Tauhara North No. 2 Trust;

(c) A 25% shareholding in the Tuaropaki Power Company that owns the 112 MW Mokai geothermal power station near Taupo. The Tuaropaki Trust has the remaining 75% ownership of Tuaropaki Power Company. Mercury operates and maintains the station;

(d) A 100 MW wholly owned geothermal power station at Kawerau; and

(e) An 82 MW wholly-owned geothermal power station at Ngatamariki.

4.10 Mercury's capital expenditure, of more than $120 million for the current financial year, remains largely focused around an ongoing hydro reinvestment programme to improve the operational efficiency and long-term reliability of these key stations on the Waikato River along with geothermal well drilling to sustain performance.

4.11 This will deliver long-term value for the company, and support New Zealand's global competitive advantage in renewable energy that is essential to addressing the country Climate Change commitments and green growth opportunities such as the electrification of transport.

Figure 4: Location of Mercury's generation

5. RJV OPERATIONS AT ROTOKAWA

5.1 The Rotokawa Geothermal System is located about 14 km northeast of Taupo and 9 km east of Wairakei (refer Figure 5 below). The associated thermal area has a number of geothermal surface features. The energy potential of the Rotokawa geothermal system was recognised in the early 1950s and drilling has identified a large high-temperature resource of about 18 km^2.

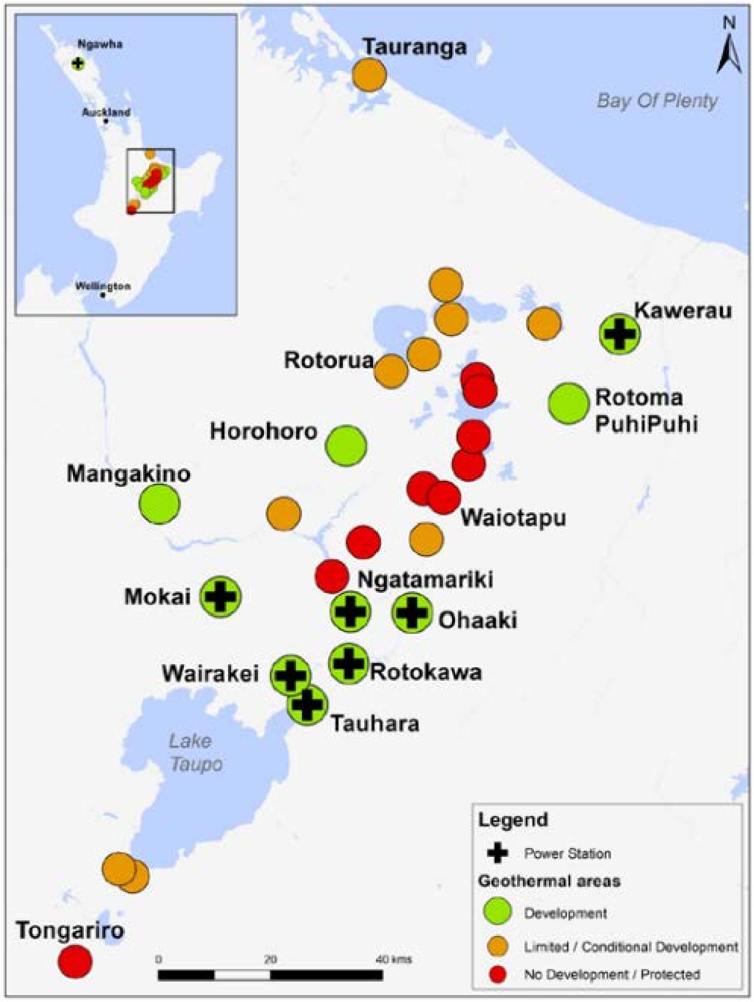

Figure 5: Location of Geothermal Systems within the Taupo Volcanic Zone (From NZGA website June 2015)

5.2 RJV holds various resource consents from the Waikato Regional Council and Taupo District Council authorising the operation and maintenance of geothermal electricity facilities at Rotokawa. These comprise:

(a) The Rotokawa A Power Station;

(b) The Nga Awa Purua Power Station and,

(c) The Rotokawa steamfield - made up of deep production, injection and monitoring wells, well heads and pipelines.

5.3 Geothermal energy production is from wells drilled to depths ranging from 2.0 to 2.5 km, with temperatures up to 337°C being one of the hottest reservoirs in New Zealand. Following use in the power stations, geothermal fluid is injected in separate wells at depths ranging from 2.5 to 3.1 km. Some 34 wells have been drilled at Rotokawa: currently 11 are operating as production wells and eight as injection wells.

5.4 The Rotokawa A power station was commissioned in 1997 and generates about 270GWh annually, providing electricity for up to 35,000 residential homes. It is a combined cycle facility where power is produced by a steam turbine followed by Ormat Energy Converters (OECs) which vaporize pentane and then use it to produce power from another turbine. Steam condensate and cooled brine from the station are combined and injected back into the geothermal reservoir. Mass flows injected at Rotokawa A are equivalent to 100% of the mass it processes, minus a small amount of non-condensable gases (which are vented to atmosphere).

5.5 The Nga Awa Purua power station is New Zealand's second largest geothermal power station in terms of generation capacity. It uses a condensing steam turbine process involving triple flashing of geothermal production fluid from reservoir pressure to lower pressures, then separation of the steam from the remaining geothermal water. The steam is cleaned, after which it expands through a backpressure steam turbine, converting steam energy to electricity. The steam from the turbine then passes into a direct contact condenser where it is cooled to liquid (condensate). The condensate is pumped to the cooling tower which forms a cooling water circuit with the direct contact condenser. Most of the steam condensate entering the cooling water circuit (excluding condensate produced by steam washing) is evaporated in the cooling tower, with the balance injected back into the geothermal reservoir. Nga Awa Purua provides enough electricity to power all homes in the urban areas of Napier and Hastings combined - with some electricity left over.

5.6 Power is transmitted from the Rotokawa A power station either to a 33kV local network transmission system or the National Grid. Nga Awa Purua connects to the 220kV National Grid.

5.7 Figure 1 shows an oblique view (looking east) of the Rotokawa Geothermal Development. Figure 2 provides a plan of the current development infrastructure at the site, and Figure 3 shows the current land ownership at Rotokawa.

Figure 1: The Rotokawa Geothermal Development

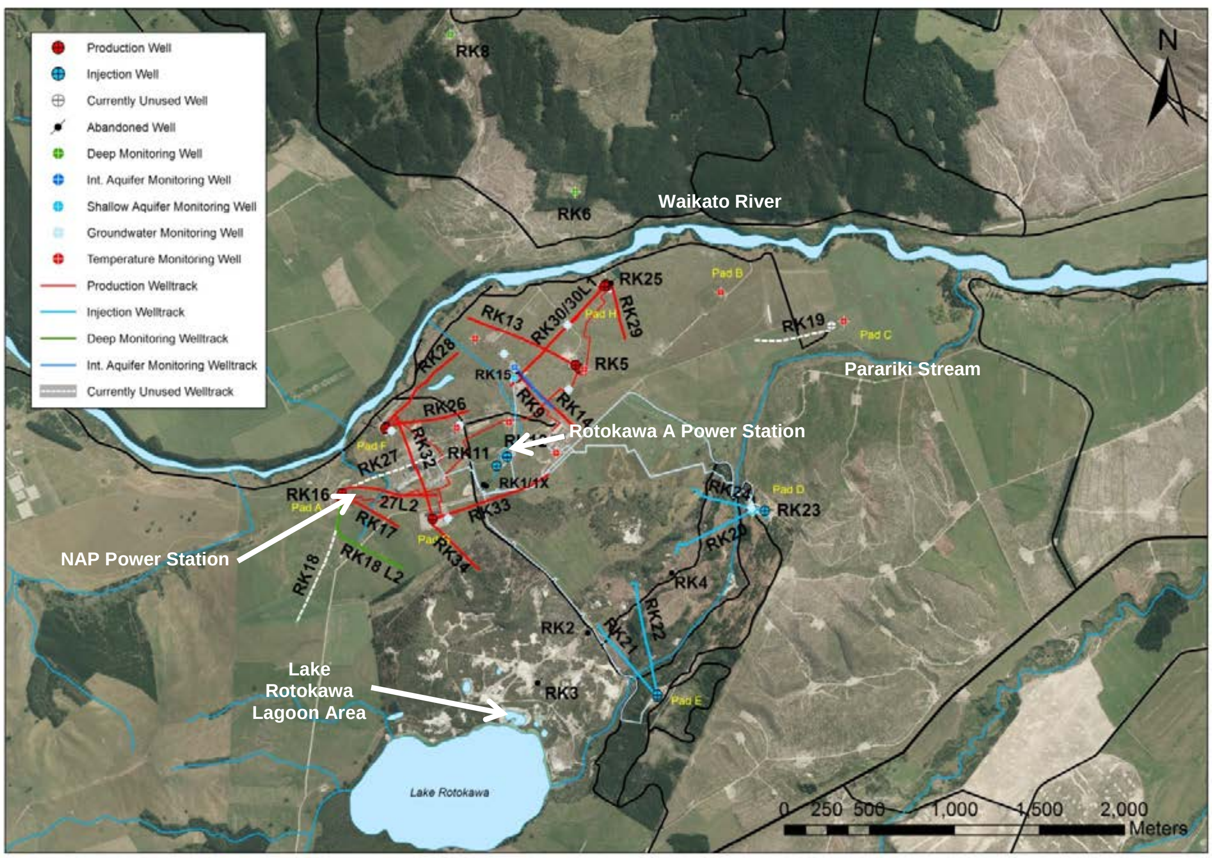

Figure 2: Rotokawa Geothermal Development Infrastructure (Wells RK1, RK1X, RK2, RK3 and RK4 are no longer in use)

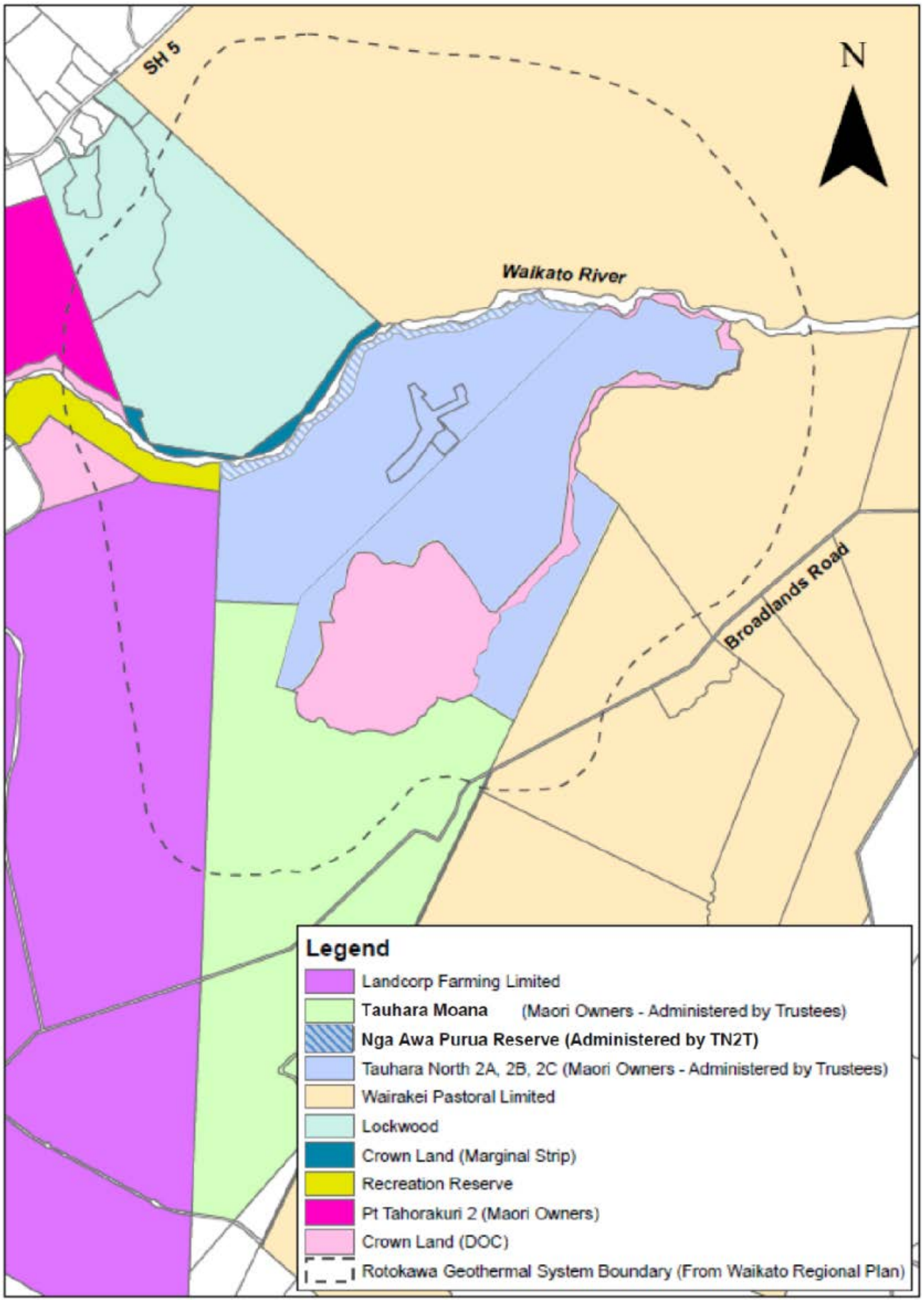

Figure 3: Land ownership at Rotokawa

5.8 All above ground infrastructure associated with the Rotokawa development is located on land owned by TN2T (apart from two small pipeline crossings over the Parariki Stream occupying land administered by the Department of Conservation (DOC)).

5.9 RJV has both surface and subsurface access rights to undertake geothermal development activities on, and under, TN2T land and Wairakei Pastoral Limited land. RJV also has subsurface rights to convey geothermal fluids via well tracks beneath the Waikato River bed (administered by LINZ) and the Parariki Stream (administered by DOC).

5.10 The joint venture partners have worked extensively together for over 15 years developing and implementing a comprehensive and sustainable approach to development at Rotokawa. This approach employs best practice sustainable geothermal development techniques such as:

(a) Injection of all available post-station fluid, providing reservoir pressure support and minimising subsidence and other surface impacts (e.g. on geothermal springs);

(b) Deep production and deeper injection – minimising the risk of cooler injectate returning to the productive reservoir;

(c) No direct discharges to the Waikato River; and

(d) Integrated and adaptive geothermal reservoir management.

5.11 Development of the resource to date has adopted a staged approach, with the 25MW Rotokawa A station commissioned in 1997 and subsequently expanded to 34 MW in 2003. Following 13 years of monitoring the reservoir response to this initial development, Nga Awa Purua power station (140MW) was commissioned in January 2010.

6. RESERVOIR RESPONSE TO DEVELOPMENT AND RATIONALE FOR THE APPLICATION

6.1 With the start-up of Nga Awa Purua, RJV has continued to improve its understanding of the geothermal resource. Some of the key observations will be described by Mr Sewell. Importantly, we have found that the reservoir is compartmentalised in nature. In other words, we have observed different responses to development at different locations across the reservoir.

6.2 Due to this compartmentalisation, we have seen pressure drawdown vary across the reservoir from a few bar up to 40 bar measured in some wells. The highest pressure drops measured have been in the western compartment wells, where a high concentration of the site's fluid production currently occurs.

6.3 We have also observed field-wide enthalpy[1] decline at an average rate of approximately 1.5% per year to the current level of ~1516 kJ/kg. The wells in the western compartment of the field are the wells with the highest decline rates. Whilst this is a relatively minor total change for the field, it is not the basis on which the plant that we installed was designed to operate. The Nga Awa Purua Power Station was designed to receive fluid with an enthalpy of 1560 kJ/kg for optimal performance and operate within a band of ~1520 kJ/kg to ~1600KJ/Kg before impacting generation.

6.4 As the enthalpy drops, additional fluid is required to maintain station design output. The current total extraction rate at Rotokawa is ~64,000 tonnes per day (t/d) compared to a maximum of 65,500 t/d provided by the current resource consent (averaged over an annual basis). An additional 10,000 t/d would provide sufficient fuel to respond to the increasing demand due to future enthalpy decline over the long term.

6.5 Due to the compartmentalisation of the reservoir, part of RJV's strategy is to reduce extraction in the areas where higher enthalpy decline is being observed and spread extraction over a larger area.

6.6 As Dr Grant confirms, extending the area of production towards Lake Rotokawa is a logical reservoir management response to what is being observed in the western compartment. He will also describe how increasing fluid take to accommodate lower field enthalpy is also sustainable, since the net take, i.e. steam consumed, will be unchanged.

[1] Enthalpy is the amount of energy contained in the reservoir fluid

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STATEMENT OF EVIDENCE OF AROHA CAMPBELL

1. INTRODUCTION

Qualifications and Experience

1.1 I am the Chief Executive Officer for the Tauhara North No. 2 Trust ("the Trust"). I have been in this position since 2006. I am also a Trustee of the Trust and was elected by the owners to this position in 1991. I am also a Trustee of the Ngati Tahu Tribal Trust, the Paeroa East 5 Trust, the 338 Ohaaki Marae Trust and Tahorakuri A1 Sec 24B.

1.2 Prior to joining the Trust full time as the Executive Officer, I worked in the timber industry for 19 years in various key positions within the supply chain and for the last six years in IT development.

1.3 As Chief Executive Officer of the Trust my key responsibilities are to provide strategic planning for the Trust, governance support, owner and descendant engagement, performance review of subsidiaries, group policies, non charitable activities and political action.

1.4 I whakapapa to Ngati Tahu from my father and to Ngati Whaoa from my mother. Both of my parents are owners in Tauhara North 3B – the block of land adjacent and south of the Tauhara North No.2 block. My connection to the Tauhara North No. 2 block is through my husband. He is an owner of the block. We also have four children and eight moko who are descendants of the Trust.

1.5 In 2015 I received the Queen's Service Medal in recognition of my services to Iwi and Maori Trusts. I was also one of three women working in geothermal awarded at the 2015 World Geothermal Conference, and more recently I won the 2016 Geothermal Special Achievement Award from the Geothermal Resources Council[1] which I will be accepting in Sacramento later this year.

1.6 I have had various guest speaking engagements, more recently the 2016 Papua New Guinea International Business Summit. I am also a member of the Waiariki Geothermal Advisory Group.

2. SCOPE OF EVIDENCE

2.1 In my evidence I will:

(a) provide a brief overview of Tauhara North No.2 Trust and Rotokawa Joint Venture.

(b) describe how Rotokawa is integral to the Trust's overall vision to ensure kaitiakitanga is maintained now and for the future generations.

(c) Outline my role in the consultation process for this consent application.

[1] The Geothermal Resources Council is an international educational association with more than 1,300 members in over 40 countries. The organisation actively seeks to expand its role as a primary professional educational association for the international geothermal community.

3. KEY CONCLUSIONS

3.1 Geothermal development on the Trust's land is instrumental in allowing tangible initiatives to be realised for the owners and their wider whanau.

3.2 The Trustees are extremely pleased with the management of the Rotokawa geothermal resource to date, and is satisfied that the future development philosophy for the resource, as proposed by the consent application, is responsible, sustainable and consistent with our mana whenua and kaitiakitanga.

3.3 The consent application enables the Trust to continue, and increase, the level of tangible benefits it gives back to its owners and their whanau and the Trust considers these benefits result in a net positive cultural impact.

4. ROTOKAWA JOINT VENTURE

4.1 As Mr Stevens has outlined, Rotokawa Joint Venture Limited (RJV) is a limited liability company formed between two partners - the Tauhara North No.2 Trust and Mercury NZ Limited (formerly Mighty River Power Limited).

4.2 The Tauhara North No. 2 Trust has a monitoring role and 50:50 share in voting in the RJV. The Trustees have made themselves fully conversant with all aspects of the Rotokawa development. This involvement is extremely important to us to monitor the well-being of the reservoir and surface features.

4.3 The Trust has put in place sound agreements and strengthened its own management capability so that we can take an active role within the joint venture partnership.

4.4 Our strong relationship with Mercury over the last 16 years has demonstrated that the company is committed to undertaking its operations in an environmentally responsible way, consistent with the principles of sustainable development.

4.5 The Trustees are extremely pleased with how the management of the Rotokawa geothermal resource has been undertaken to date and is satisfied that the future development philosophy for the resource, as proposed by the consent application, is the most responsible and sustainable way forward.

4.6 If the Trust did not have the utmost confidence in the predictions for the future well-being of the resource and its sustainable development, it would not support RJV's consent application.

5. THE TAUHARA NORTH NO.2 TRUST

5.1 The Tauhara North No.2 Trust administers, on behalf of the owners, the land to the north and east of Lake Rotokawa on which the Rotokawa A and Nga Awa Purua power stations and associated steamfield are located (Tauhara North 2 and Parariki Blocks. These are the two purple coloured land parcels on Figure 3 of Mr Stevens' evidence). These blocks of land are within the area occupied by Ngāti Tahu, and most of the owners are members of Ngāti Tahu. We currently have over 8,000 owners and descendants (including whanau trusts) listed in our owners register. A large number of the owners live in the Taupo district. About 85% live in the central North Island, while a few live as far north as Whangarei and as far south as Invercargill and a handful in Australia. The current owners are the descendants of those who were originally granted the land.

5.2 Tauhara North No. 2 Trust's Board of Trustees include Wikitoria Hepi - Te Huia (Chairperson), Che Charteris (Deputy Chairperson), Rangimarie Ngamotu, Ngahihi o te ra Bidois, Adele Barsdell, Sarah Hepi Te Huia and myself. Each of the Trustees brings important skills and knowledge that assists in the running of the Trust and its wholly owned subsidiaries.

5.3 Guiding principles in the Trust's Mission statement are to:

(a) Hold and grow the assets.

(b) Increase tangible benefits to the owners and descendants.

(c) Manage the resources in a sustainable manner.

(d) Provide excellent communications.

5.4 The Trust's values include a commitment to uphold mana at all times in all that we do, and a commitment to treat everyone with respect, dignity and truthfulness. We also strive for excellence and are committed to pursuing knowledge and ideas that will strengthen and grow Tauhara North No.2 Trust and to actively work together to protect the owners' assets.

5.5 Since the Trust's inception, it has held true to its mission and values, and has actively and sustainably grown its assets while achieving ever increasing tangible benefits.

5.6 The commercial interests of the Trust are managed by the wholly owned subsidiary Ringa Matau Limited (RML). RML has six independent directors who have been selected for their individual skills sets which include finance, geothermal, property and farming expertise.

5.7 The Trust now holds a significant equity stake in the Nga Awa Purua power station and has built up a substantial dairy farming portfolio. This includes a total of 1418 hectares of land, supporting approximately 3,000 cows which produce around one million kilograms of milk solids annually.

5.8 The Trustees declare an annual distribution and kaumatua payments[2]. In addition to these annual payments, the Trust, through its wholly owned subsidiary Charitable Company Limited (CCL), provides a variety of initiatives.

5.9 For example, CCL run three camps per year for the tamariki of the Trust. The camp age groups are 10-12 years (Kia Mau), 13-15 (Kia Tu) and 16-18 (Kia Manuwanui). The main overall theme is to "Equip them for the Future". Established in October 2011, we have seen many tamariki who have completed the camps thriving in their communities, others moved on to achieving high education and a good number have returned as camp interns and young role models.

5.10 CCL also provides education grants, available from pre-school to Secondary School, University, Polytechnic or Wananga and offers six tertiary scholarships per annum. For those who require additional support, CCL provides this service through Kip McGrath These education initiatives are to assist the descendants to gain a higher education and tertiary qualifications.

[2] Payments provided to Kaumatua aged from 60 years as an acknowledgment.

5.11 Health providers throughout Aotearoa assist CCL in servicing our owners and descendants with dental, dentures, optometrists, medical and hearing aids.

5.12 In addition, the Tangihanga grant is provided to assist whanau by alleviating some of the financial expense during times of mourning. It also benefits the Trust office to keep the share register as current as possible.

5.13 The Trust also supports the Marae in Ngati Tahu – Ngati Whaoa; they are Te Toke, Ohaaki, Waimahana and Mataarae Marae. The allocated funds are mainly used for annual maintenance programmes.

5.14 Geothermal development on the Trust's land is instrumental in allowing these benefits to be realised. The ongoing sustainable development of the Rotokawa resource as outlined in the consent application will allow the Trust to continue providing these benefits and services to its owners and their wider whanau.

5.15 As the Trust's resources increase so do these initiatives expand, and new grants are offered as the needs change of the people. One example of this is the Nga Awa Purua Environmental Ecological Project along the Nga Awa Purua Reserve[3]. The overall objective of this project is to restore this reserve land. The project is being undertaken with Ngati Tahu – Ngati Whaoa Runanga Trust. Stage one of the project was a 3 year project completed this year where the Trust provided funding towards riparian planting works. Stage 2 starts in September 2016 where the Trust has provided further funds. Other examples include the Trust's financial support of the Runanga's Te Reo Revitalisation Program since 2010 and the commissioning of a ten DVD series on the history of Ngati Tahu – Ngati Whaoa. These initiatives have only been achievable through the Rotokawa development. Further investments can also be made in other sectors to diversify the Trust's interests for the future.

5.16 For the Trust, the consent application proposed by RJV represents what is necessary to maximise resource sustainability and thereby ensure the ongoing success of the Rotokawa development. It follows that, the application also

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[3] The Nga Awa Purua Reserve is located along the northern edge of the Trust's land on the true right bank of the Waikato River. The reserve was set apart as a Maori reservation under Section 439 Maori Affairs Act 1953 (NZ Gazette 1985, page 2988) for a purpose of a place of historical cultural and recreational significance for the common use of the Ngati Tahu tribe and the people of New Zealand generally.

represents what is necessary to enable the Trust to continue to give back to its people.

6. CONSULTATION

6.1 As part of the consenting project core team, one of our tasks was to identify potentially affected parties and persons who might be interested in the development early on and to talk to them about the project.

6.2 The list of potentially affected parties included; Tauhara Moana Trust (a neighbouring maori landowning trust) and Ngati Tahu-Ngati Whaoa Runanga Trust ("the Runanga") - being the recognised iwi authority for the Rotokawa area. Consistent with the application process for the original resource consents, we identified Tuwharetoa Maori Trust Board as an interested party. That is, although we did not consider them potentially affected by the proposal, we ensured they were aware of it and fully understood it.

6.3 I was involved in consultation with these parties as discussed in more detail by Mr Jackson. I have also been involved in various consultation meetings with Department of Conservation staff over recent years regarding the prospect of development beneath the Lake Rotokawa Conservation Area (proposed Consent Area 4).

Ngati Tahu-Ngati Whaoa Runanga Trust (the Runanga)

6.4 In respect of my involvement in consultation discussions with the Runanga, it is apparent that their iwi members feel they have lost connection to Rotokawa lands as a result of historical land surveying, subdivision and land tenure processes. The Runanga also expressed some concern about potential future adverse environmental impacts associated with ongoing geothermal development. To reconcile these matters, the Runanga asked for a mitigation package from RJV to enable their iwi members to be more involved in Rotokawa activities, to acquire more geothermal knowledge, and to improve environmental and cultural values of the area, and overall be connected to it.

6.5 Providing mitigation for effects associated with historical land ownership processes presents a dilemma both for the Trust and for RJV. Both Mercury and the Trust value their relationships with the Runanga, but it is difficult to offer mitigation for perceived effects relating to events that neither party were responsible for. In addition, the Trust has always been happy for any Ngati Tahu-Ngati Whaoa member to visit Rotokawa (subject to health and safety requirements) to allow the iwi to maintain connections to the land that the Trust looks after.

6.6 However, I also support the new consent conditions that we agreed with the Runanga to provide it with an increased level of participation in future Rotokawa Peer Review Panel meetings. At these meetings monitoring data is assessed and interpreted and important decisions are made about the future management of the resource. The inclusion of these consent conditions recognises Ngati Tahu-Ngati Whaoa's statutory acknowledgment over the Rotokawa geothermal resource. It also provides the Runanga further opportunity to exercise kaitiakitanga while responding to their desire to acquire more geothermal knowledge.

6.7 Although the RJV has maintained its availability to continue discussions with the Runanga, unfortunately agreement has not been reached on their request for a mitigation package related to this consent application. I discuss this further later in my evidence.

Tuwharetoa Maori Trust Board

6.8 Consultation with the Tuwharetoa Maori Trust Board regarding the consent application has been complicated by a separate, but concurrent, Treaty settlement process between Tuwharetoa and the Crown. More specifically, the Tuwharetoa Agreement in Principle (AIP) with the Crown proposes to include the Lake Rotokawa Conservation Area as a potential cultural redress property and provide a statutory acknowledgement over the Rotokawa geothermal resource. The Trust has a submission in opposition to the AIP, which has made it difficult for all parties to separate RMA and Treaty related issues. As a result, dialogue between RJV and Tuwharetoa has been difficult to progress.

7. RESPONSE TO SUBMISSIONS

Ngati Tahu-Ngati Whaoa Runanga Trust (the Runanga)

7.1 The Runanga outline in their submission how, despite numerous discussions and sharing of information between RJV and the Runanga, RJV has not satisfied their requirements in regards to mitigation of potential environmental and cultural impacts. As mentioned earlier, unfortunately RJV does not accept that the mitigation package being sought by the Runanga is related to this resource consent application.

7.2 The Runanga's submission points out that the Runanga hold mana whenua status at Rotokawa and that the site is considered a taonga for the Ngati Tahu-Ngati Whaoa people. I agree that the Runanga has statutory acknowledgment, and the Trust, as the land owner, has mana whenua. In this respect, given TN2T's affiliation with Ngati Tahu-Ngati Whaoa, and given our role as equal share partner to the RJV, I consider this should go some way to addressing the Runanga's concerns regarding future potential environmental and cultural impacts.

7.3 The Runanga's submission also describes how the development of geothermal power generation at Rotokawa has disenfranchised Ngati Tahu-Ngati Whaoa iwi from their taonga. TN2T disagrees with this claim. As already mentioned, the Trust has never restricted Ngati Tahu-Ngati Whaoa people from accessing the Rotokawa land it has control over, provided necessary health and safety requirements are met.

7.4 The Runanga also state in their submission that the activities proposed in the RJV's application have the potential to cause adverse impacts on the cultural values of the Ngati Tahu-Ngati Whaoa people, and that the Runanga seek mitigation for these effects. I believe that the tangible benefits that tangata whenua have received to date as a result of the RJV's activities, through beneficiary payments, and other initiatives and grants as discussed earlier, generates a net positive cultural effect. The current consent application will ensure these benefits are enduring. On that basis, I believe any adverse cultural impacts will be fully mitigated, and furthermore, will be mitigated well beyond what would normally be achieved for similar types of developments.

Tuwharetoa Maori Trust Board (TMTB)

7.5 Despite the complications caused by Tuwharetoa's AIP, after the TMTB submission was received, RJV has been in contact with them and sought an opportunity to meet at any time to discuss their concerns as well as any concerns held by Ngati Hinerau, Ngati Hineure and the Tuwharetoa Hapu Forum.

7.6 Unfortunately, the Tuwharetoa Maori Trust Board has not been able to meet us.

8. CONCLUSION

8.1 Geothermal development on the Trust's land is instrumental in allowing tangible benefits to be realised for our owners and descendants.

8.2 The Trustees are extremely pleased with how the management of the Rotokawa geothermal resource has been undertaken to date and is satisfied that the future development philosophy for the resource, as proposed by the consent application, is the most responsible and sustainable way forward and is consistent with our kaitiakitanga principles and mana whenua.

8.3 The consent application also enables the Trust to continue, and increase, the level of tangible benefits it gives back, and the Trust considers these benefits result in a net positive cultural impact.

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STATEMENT OF EVIDENCE OF MISS WIKITORIA HEPI-TE HUIA

1. INTRODUCTION

Qualifications and Experience

1.1 My name is Miss Wikitoria Hepi–Te Huia and I am a Trustee of Tauhara North No.2 Trust, a position I have held since 2013. I am also the current Chairperson of this Trust, having been elected into this role in March 2015.

1.2 I am of Ngāti Tahu descent and I am a great grand-daughter of Rameka Whakahoro Henare and Hae-Hae Watene, former kaitiaki (custodians) of Orakei Korako and a grand-daughter of Herapeka Sarah Henare and Pairama George Wharekawa, the last residents and kaitiaki of Orakei Korako.

1.3 I am an owner in Tauhara North No.2 Trust.

1.4 As Chairperson of Tauhara North No.2 Trust, I have the capacity to speak on behalf of Tauhara North No. 2 Trust.

1.5 I have over 10 years' experience as a Trustee of various Maori land, marae and development trusts including Ngāti Tahu Tribal Lands Trust; Taupo Central Incorporation and Taupōnui-a-Tia College Marae working committee.

1.6 My primary background is in Management, having worked in the areas of Tourism and Iwi Social Services all my life. I have also held governance roles in both mainstream and Māori education and non-government organisations (NGOs). As an experienced sports coach and kapahaka tutor, my community involvement has been extensive within these arena, but have not been limited to them. In saying this, I consider my greatest qualification to be my whakapapa (genealogy) and my greatest achievement is that of my children. I continually strive to uphold the integrity of our cultural values and knowledge as handed down from our tūpuna.

1.7 My whanau, hapū, iwi of Ngāti Tahu belong to the central North Island and I have grown up and lived in this area for almost all of my life.

Purpose and Scope of Evidence

1.8 The purpose of my evidence is to describe the ancestral relationship that Ngāti Tahu have always had with the land and the Rotokawa resources developed for Geothermal Power.

1.9 My evidence is based on diary notes written by my mother, a daughter of Herapeka Sarah Henare and Pairama George Wharekawa; oral recollections from my mother and other whanau members and our oral and written history as handed down through the many generations before me.

1.10 I will also confirm why it is appropriate to use the geothermal resource for the benefit of Ngāti Tahu as owners and kaitiaki of the land.

2. CULTURAL SETTING AND RELEVANT HISTORY

2.1 In the 18th century the main Ngāti Tahu homestead was at Orakei Korako, about 20 kilometres north from Lake Rotokawa and it was also touted by the Department of Tourist and Health Resorts, as a tourist destination for its geothermal activities and majestic beauty. Orakei Korako is still signposted today between State Highway 1 and 5, close to the Mihi Bridge and remains a tourist destination to this day.

2.2 About 2,000 descendants of Ngāti Tahu lived at Orakei Korako during its peak, in the mid to late 18th century.

2.3 Orakei Korako was and is still known as the 'Ukaipō' or 'birthplace' of Ngāti Tahu iwi (tribe), and the boundary lines of the land over which we had ownership was decided by our first tūpuna, Tahu Matua. This ancestor climbed the highest mountain peak and pointed, as far as the eye could see, and decreed a visionary boundary line. Our iwi moved within these boundaries depending on the location of the type of food that was in season.

2.4 In June and July each year, parties would travel from Orakei Korako to Lake Rotokawa to snare the pārera (grey duck). The pārera were preserved in their own fat and taken back to Orakei Korako. Some of the pārera were also traded with other tribes for different types of food (such as seafood from the Bay of Plenty).

2.5 There were no permanent settlements around Lake Rotokawa, but temporary settlements were established during the pārera snaring season where cultivation and other activities took place.

2.6 As the pārera season was during the cold winter months, the hunting parties took advantage of the hot patches of earth and water for warmth. Mud pools and alum waters were also used to heal ailments and sores. Different pools were used for bathing, cooking and washing. The Parariki Stream may also have been used for catching fish such as Inanga, Morihaua and Kōkopu.

2.7 I have been told many stories about my people during this time. One story shared by my aunty Rangimarie Ngamotu, a younger sister of my mother, is in relation to one of our many koroua (elder-male) of that time, Paora Matenga who was out shooting pārera at Lake Rotokawa in 1867 when his gun exploded and killed him. A tapu was placed on Lake Rotokawa for five years following his death.

2.8 There is a burial ground 'Rua Hoata' in the Nga Awa Purua area. This burial ground is not affected by geothermal development, and has been protected by a reserve area. Deceased were also buried in caves along the banks of the Waikato River. Some of these burial caves are now submerged by the Aratiatia and Ohakuri lakes.

2.9 The Nga Awa Purua and Aratiatia rapids are also very important to our Ngāti Tahu people. The Nga Awa Purua rapids are adjacent to the Rotokawa site. The name of the rapids is also important to Ngāti Tahu. Many years ago the rapids were renamed Full James Rapids by a pākeha who had a boating business on the river, however our kaumātua (elders) of Ngāti Tahu successfully fought for the rapids to retain the name Nga Awa Purua. The name of the rapids has also been given to the largest and newest of the two power stations on site in recognition that it is unique to Ngāti Tahu.

2.10 In the late 18th century and early 19th century, the majority of Ngāti Tahu residing at Orakei Korako, who had survived the Black Death that swept though the settlement, moved to Reporoa. This was following pākeha settlement in the area and with the introduction of money, many of our Ngāti Tahu iwi moved to the larger settlement of Reporoa to find work. Ngāti Whaoa occupied the Reporoa region and through marriage established the link with Ngāti Tahu. Some hapū remained at and nearby Orakei Korako, moving not too far away, along the banks of the Waikato River.

2.11 Orakei Korako was taken, under the Public Works Act for the purpose of power generation. Given this proposed activity, Herapeka Sarah Henare and her husband Pairama George Wharekawa, were coerced and then evicted from their homestead Orakei Korako. On 19 January 1961, the Ministry of Works 'fire gang' took charge and torched their home, as they could do nothing but standby and watch. Thereafter, Orakei Korako was flooded for the Ohakuri hydro scheme. While this event was supposed to flood the entire Orakei Korako homestead, it did not. It was argued by an agent of the Crown in 1994 that "Orakei Korako forms part of the Lake Ohakuri lake-bed, even though it's above it." So it is well known by our Ngāti Tahu iwi that the majority of the whenua (land) of our 'Ukaipō', Orakei Korako still stands above the flood level that was promoted at that time.

2.12 When our Ngāti Tahu iwi moved, they took their marae with them. Three marae were originally sited at Orakei Korako and were relocated as the hapū moved. Tahumatua meeting house (Ohaaki Marae) is now located on the banks of the Waikato River on Piripi Road. Rahurahu meeting house (Rahurahu Marae) is located on State Highway 5 directly before the Mihi Bridge. Te Rama meeting house (Te Toke Marae) is sited south of the Ohaaki power station and north of Wairakei.

2.13 Although some of our Ngāti Tahu people have moved away from the land, they have retained a strong affiliation to the land and will always return. They have left their footprints on the land as they have moved.

2.14 A whakataukī (a unique proverb) was given by two of our kaumātua, Tete Mihinui and Kurupae Whata who have since passed on. The proverb is as follows: "Kia mau ki te whenua (hold fast to the land), Whakamahia te whenua (make use of the land), Hei painga mo nga uri whakatipuranga (for the future generations)". This proverb is also the vision of our Trust, Tauhara North No. 2 Trust.

3. MANA WHENUA

3.1 Ngāti Tahu has mana whenua status over the Tauhara North No.2 block. In the late 18^{th} century, challenges to the ownership of the land resulted in a Royal Commission rehearing. This rehearing resulted in new awards of land being made to hapū and for the Tauhara block being subdivided into three, Tauhara North, Tauhara South and Tauhara Middle. The award for Tauhara North went exclusively to Ngāti Tahu. Ngāti Whaoa is descended from Te Arawa and has obtained ownership status by marriage to Ngāti Tahu. The owners of these lands are recognised by the Maori Land Court.

4. TRADITIONAL RIGHTS AND OBLIGATIONS

4.1 The Rotokawa geothermal development is consistent with our traditional rights and obligations.

4.2 Our Tauhara North No.2 Trust logo acknowledges Ngātoro-i-rangi the first ancestor to physically use the natural resources to save his life from the snow on Tongariro Mountain. In the logo the swirls on each side of his face represent the geothermal steam, and his hands are extended to embrace all.

4.3 Our tūpuna (ancestors) have used the geothermal resource for heating, cooking and health & wellbeing.

4.4 My whakaaro (thoughts) goes back to my whakapapa, our taonga tuku iho, this includes all tangible and intangible gifts handed down from our tūpuna, such as our lands & resources, our language, our stories, our cultural values and historical knowledge and more. I believe these many gifts, the land and resource were left to us to improve ourselves and our lifestyle for the betterment of our our whanau, hapū and iwi, which will also contribute positively to our wider community and society as a whole.

4.5 Just like our tūpuna who only took the pārera during a specific season and only enough to feed their families, it is important that the geothermal resource be used in a way that it is sustainable and retained for future generations. For these reasons and more, I fully support the consent application since it will enable any improvements to the sustainability of the resource, thereby, benefiting our whanau, hapū, iwi and all future generations to come.

4.6 My belief and my inherent right as Māori and as Ngāti Tahu is to say that what is under the ground belongs to the owners of the land, as such, the geothermal resource belongs to the owners of the block, and as a trustee for our Tauhara North No.2 Trust owners and descendants, I have dedicated myself to working hard to protecting and asserting the inherent rights of our people, to protecting the resources and the many gifts as handed down from our tūpuna as outlined in pt 4.4.

5. USE OF THE LAND AND RESOURCE FOR CULTURAL BENEFITS

5.1 Historically the Tauhara North No. 2 block was covered in native bush. This was cleared for farming and for a long time the land was owned by the Crown (as confiscated land in payment of survey fees). Later it was managed for the Crown by Landcorp. In the 1980s the land was returned to the Maori owners. It was first managed by the Ngati Tahu Tribal Trust, and since 1991 it has been managed by the Tauhara North No. 2 Trust.

5.2 As farmland the land was fairly uneconomic but we recognised the value of the land in the underlying geothermal resource. The Rotokawa 1 power station has been operating since 1997. The Trust took a very conservative approach with the development of this power station because it didn’t want another Ohaaki situation. The Trust and our people learnt a good lesson from Ohaaki. If fluid is not returned to the resource, and we do not monitor it effectively, it will have the potential to be lost for our future generations. That is why the Trustees have remained conservative.

5.3 After the Rotokawa 1 power station was installed, the Trust always anticipated that further development would follow when the time was right. Once a good scientific knowledge of the geothermal resource was established through operating Rotokawa 1 for approximately 13 years, the Trust was confident in the development of Nga Awa Purua power station. Although the development of Nga Awa Purua has revealed some aspects of the resource that were not known beforehand, the Trust is confident that these are things that can be dealt with by continually adapting the development to maintain sustainability. As such, the Trust supports Rotokawa Joint Venture's consent application.

5.4 The ability for the Trust to enter into a partnership to develop the geothermal resource brings a good income to the landowners.

5.5 Tauhara North No.2 Trust provides a number of the initiatives and grants through our Charitable Company Ltd. From my perspective, we are using the resource and the land to benefit and provide for the health and wellbeing of our people - this would not be possible if we were not able to develop and use the geothermal resource. The return of income to the land owners will also have a positive influence and effect on our iwi, the wider community and society as a whole. Rotokawa Joint Venture's consent application will enable these positive influences and effects to continue.

6. CONCLUSION

6.1 Ngāti Tahu has a long and continuing association with the Tauhara North No. 2 block. Ngāti Whaoa is also associated with the land through marriage to Ngati Tahu.

6.2 As a Trustee and Chairperson of Tauhara North No. 2 Trust, I endorse the resource consent application, as it is consistent with our cultural beliefs and values and it represents an appropriate use of the geothermal resource for the betterment of the land owners and Ngati Tahu/Ngati Whaoa whanau whānui (wider tribal community).

IN THE MATTER OF the Resource Management Act 1991

AND

IN THE MATTER OF applications by **Rotokawa Joint Venture Limited** to Waikato Regional Council for resource consents for the Rotokawa Geothermal Development

STATEMENT OF EVIDENCE OF STEVEN MICHAEL SEWELL

1. **INTRODUCTION**

Summary of qualifications and experience

1.1. I am a geoscientist with over 10 years' experience in geothermal resource exploration, development, field operations and research at four developed geothermal fields within the Taupo Volcanic Zone, New Zealand, and over twenty prospects in six countries. I have expertise in the development of resource conceptual models, well targeting and resource capacity risk assessment in both volcanic and sedimentary-hosted geothermal resources. My resource management experience includes well planning, coordination of drilling and field operations and resource and environmental monitoring and reporting. I have a Bachelor of Science (Hons) degree in Geophysics from Monash University and a Post Graduate Certificate in Geothermal Energy Technology from Auckland University.

1.2. I am currently a PhD candidate at Victoria University.

1.3. I confirm that I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2014 and that I agree to comply with it. I have considered all the material facts that I am aware of that might alter or detract from the opinions that I express. I confirm that this evidence is within my area of expertise, except where I state that I am relying on the evidence of another person.

1.4. The purpose and scope of my evidence is to provide a summary of the current knowledge of the existing environment, the resource conceptual model and the effects on the geothermal reservoir from development at Rotokawa to date.

1.5 My description of the existing environment will summarise the current geoscientific knowledge of the field, the history of development, surface geothermal features and groundwater aquifers. I will describe the conceptual model, which summarises the current understanding of the ‘natural state’ of the geothermal resource, that is the state of the resource prior to geothermal development. This conceptual model forms the basis for the numerical model used in this application to make predictions of effects on the reservoir and the environment from the proposed additional 10,000 t/day fluid abstraction and the extended term of consent.

2. EXISTING ENVIRONMENT

Overview of the Rotokawa Geothermal Resource

2.1. The Rotokawa geothermal system is one of approximately 15 known high temperature geothermal systems within the Taupo Volcanic Zone (TVZ), an approximately 60 km wide zone of intense volcanic and geothermal activity which stretches from just south of Taupo to White Island. The Rotokawa geothermal system is approximately 10 km NE of Taupo and straddles the Waikato River. Figure 1 shows the current field layout with the inset showing the location of the field in the context of the North Island and TVZ. Figure 2 shows several cross-sections through the field showing the key features of the conceptual model that I will be discussing in further detail in my evidence.

Development History

2.2. The geothermal resource potential of the field was first recognised in the early 1950s. Scientific investigations were carried out in the 1960s which included chemistry sampling of the surface thermal features and resistivity surveys. These early surveys indicated high potential for development of the field and in the late 1960s and early 1970s, several exploratory wells were drilled. These wells, drilled in the south of the field near Lake Rotokawa, were approximately 1 km deep and proved sufficiently high temperatures existed in the field for geothermal production (>300°C). However, the wells had low to moderate permeability (i.e. ability to flow), and consequently between 1984 and 1986, four deeper (>2 km depth) exploration wells were drilled in different areas across the field which proved sufficient permeability and the existence of a large geothermal resource capable of supporting electricity generation.

2.3. Electricity generation of 24 MWe began on the field in 1997 with the installation of the binary Rotokawa A power plant. In 2000, Mercury and Tauhara North No. 2 Trust formed the Rotokawa Joint Venture (RJV) and generation was subsequently expanded to 34 MWe. Production for the Rotokawa A plant was initially from two deep wells, with a third well coming online in 2003 to support the additional 10 MWe of generation. Injection wells for the plant were initially relatively shallow (500 to 1000 m depth) and tapped into the intermediate aquifer, a confined, mixed groundwater and geothermal aquifer which overlies the deeper geothermal reservoir. Injection into the intermediate aquifer resulted in a build-up of pressure and in response injection was shifted to deep wells (RK16 and RK18) on the edge of the field. Injection was further shifted to a new area in the south of the field (well RK20) in 2008 following tracer testing which showed relatively fast return of injection fluid from the new deep injection location on the edge of the field back to production wells. Such a return is undesirable as it can, over time, result in cooling of the production fluid with subsequent loss of generation.

2.4. In early 2008, RJV obtained resource consents for further development at Rotokawa. This development was supported by conceptual and numerical modelling of the field. The modelling was based on the reservoir response to the Rotokawa A production from 1997 to 2007 and data from 17 wells. The Nga Awa Purua (NAP) development began in 2008 with the drilling of 10 new wells and was followed by the construction of a 138 MWe triple-flash power plant, commissioned in 2010.

2.5. In 2011, RJV was granted a consent to increase production from the field from 60,500 t/day to 65,500 t/day. Since commissioning the NAP development, three production make-up wells (RK32, RK33 and RK34) have been drilled to maintain generation.

Geology

Surface geology

2.6. The surface geology at Rotokawa is predominantly pumice alluvium and hydrothermal eruption deposits south of the Waikato River. High elevation rhyolite domes occur in the north of the field which have been built-up from repeated, slow extrusion of viscous lavas over many thousands of years. Beneath these surface layers is the Huka Falls Formation, which consists of mud-rich lake sediments, and the Parariki Breccia, a hydrothermal eruption deposit. Alteration of the minerals within these layers by the geothermal fluid in the Rotokawa area has resulted in high levels of smectite clay which results in these surface layers having very low permeability.

2.7. Below these surface layers is the volcaniclastic sediments of the Waiora Formation and further rhyolite lava layers which host the intermediate aquifer, which I will discuss in more detail later.

2.8. A deeper, low permeability smectite-clay altered zone occurs above the deep reservoir which acts to seal the reservoir from the overlying aquifers in most places. Faulting and fracturing is the main source of high permeability for the geothermal reservoir. Permeable zones for production wells mostly occur in andesite lava layers whilst most permeable zones for injection wells occur within greywacke, which is the deepest formation known within the Taupo Volcanic Zone. Permeable zones that enable flow between the reservoir and wells are relatively narrow, often only several metres thick.

Geophysics

Electrical Resistivity

2.9. Several electrical resistivity surveys have been performed at Rotokawa throughout its development. These surveys measure the ability of rock to conduct electricity and provide information on the properties of the rock. In most geothermal fields the resistivity of the rocks is dominated by high conductivity clays, particularly smectite clay. As previously mentioned, zones that are smectite clay altered are usually impermeable and form caps that impede fluid flow between the geothermal reservoir and overlying aquifers.

2.10. The resistivity surveys at Rotokawa have imaged two low permeability, smectite rich clay caps – a shallow cap that overlies the intermediate aquifer and a deeper cap that overlies the deep reservoir. Figure 3 shows a resistivity cross-section through the field and the two low resistivity clay-caps. Mapping of the deeper clay-cap can be used to give a broad indication of the possible extent of the geothermal reservoir in areas that have not yet been drilled.

Microseismicity

2.11. Microseismicity has been monitored at Rotokawa via a local network of ten seismometers since 2008 and prior to this by the regional GeoNet network of seismometers. The vast majority of microseismic events at Rotokawa have been below magnitude 2, and they occur within the deep geothermal reservoir mostly around injection wells.

2.12. A lack of any significant observed increase in pressure in the injection area means that the most likely mechanism that triggers the majority of the microseismic events is injection of cooler fluid into a very hot reservoir, which in essence causes the rock to contract thereby triggering pre-existing faults and fractures to slip.

2.13. Since deep injection was shifted to the south of the field in 2008, the vast majority of the microseismicity has been on the injection side of a NE-SW trend, roughly halfway between the injection and production wells. This appears to be due to the presence of a major geologic structure between the injection and production wells, the Central Field Fault. This fault had been previously inferred to exist from a nearly 1 km offset in the greywacke and andesite rocks between the injection and production wells. The fault appears to play a major role controlling fluid flow within the reservoir and appears to act as a barrier to fluid flow across its strike, slowing the return of injection back to production wells. It also appears to have high permeability along its strike, providing a pathway for fluid between the deep reservoir and overlying aquifers.

Microgravity

2.14. Microgravity surveys have been conducted at Rotokawa since 1997 and are used to monitor changes in mass within the geothermal system. Changes in mass, and, therefore, gravity, in geothermal systems are often related to changes in steam content, steam having a much lower density and therefore mass than water. At Rotokawa, gravity surveys undertaken since 1997 have mostly shown positive changes (increases in mass) which is most likely due to conversion of steam to water within the intermediate aquifer. This was in turn due to the relatively high rates of shallow injection occurring at the time. Since 2003, the gravity change has been relatively minor but negative, indicating the re-growth of steam since shallow injection was significantly curtailed in 2003.

Geochemistry

2.15. Geothermal systems in active volcanic areas have unique geochemistry which distinguishes them from normal groundwater. Carbon dioxide, hydrogen sulphide gases and hydrogen chloride are major components to most high temperature geothermal fluids and are derived from the magma heat source that is inferred to underlie most systems. These fluids ascend into the reservoir and boil. Boiling releases some of the dissolved gas, particularly carbon dioxide, forming a gas-rich steam. As geothermal fluid reaches shallow groundwater, it can boil further which releases more gas. Carbon dioxide-rich steam can condense and form bicarbonate rich fluids (carbonic acid) which are moderately acidic. Along with formation of bicarbonate fluid, the richly oxygenated near-surface environment allows the oxidation of the hydrogen sulphide gas which forms sulphate fluids. These sulphate fluids can be highly acidic.

2.16. The natural state geochemistry of the reservoir at Rotokawa is generally similar to other reservoirs in the TVZ, with chloride contents between 450-900 ppm and ~1% gas content, although the reservoir does have some important differences from other systems. Sampling of fluids from the early wells at Rotokawa revealed significant variation in the geochemistry from the south to the north of the field. In general, the fluid in the south of the field is higher in chloride and higher in gas and has a slightly more magmatic signature than fluids to the north of the field.

2.17. Boiling, condensation and mixing with groundwater within the intermediate aquifer produces fluids which are elevated in chloride and bicarbonate (moderately low pH carbonic acids).

2.18. The shallow 'surface aquifer' and geothermal springs at Rotokawa are mostly of mixed chloride-sulphate fluid type, particularly in the south of the field around Lake Rotokawa. Springs along the banks of the Waikato River mostly discharge bicarbonate rich fluids with low to moderate levels of chloride.

2.19. In the natural state, prior to production, the reservoir was hottest in the south, with temperatures of up to 337°C measured in RK22 prior to injection. This is the highest measured temperature within the TVZ and is amongst the highest measured temperatures for geothermal worldwide. Reservoir temperatures in the natural state were gradually cooler towards the north of the field (310°C).

2.20. Pressure in the reservoir was slightly higher than hydrostatic, which is typical of most liquid dominated geothermal systems worldwide. An approximate 10 bar difference in pressure existed between the reservoir and the overlying intermediate aquifer in the natural state. This pressure difference drives the natural fluid flow from the reservoir to the intermediate aquifer.

Surface Geothermal Features

2.21. Active geothermal features of the Rotokawa geothermal system include acid sulphate fumaroles and hot springs, steaming ground and bi-carbonate springs. The main concentration of surface activity at Rotokawa is an approximate 1 km^2 area adjacent to the northeast shore of Lake Rotokawa. Numerous hot springs also discharge into the Parariki Stream and into the Waikato River. Small patches of actively steaming ground are also found north of the Waikato River. Figure 4 shows the location of the main thermal areas (areas containing the majority of hot springs and fumaroles) and the shallow groundwater hydrology in the Rotokawa area.

2.22. Lake Rotokawa is a unique feature of the Rotokawa geothermal system. The lake covers an area of approximately 0.5 km^2 and is believed to have formed via hydrothermal eruptions which occurred around 5000 years ago. The lake is mostly recharged by rainwater, but numerous areas of geothermal input occur throughout the lake which significantly alter the chemistry of the lake and make it acidic.

2.23. The main known area of geothermal input into Lake Rotokawa is referred to as the ‘lagoon’ which is on the northeast shore of Lake Rotokawa. The lagoon consists of numerous hot springs of high chloride and sulphate, acidic chemistry and varying temperature.

2.24. The Parariki Stream drains Lake Rotokawa from its eastern edge into the Waikato River. The stream also has numerous hot springs that discharge along its banks in a number of locations. Monitoring of the Parariki Stream and Lake Rotokawa has shown that variations in flow rate, temperature and chemistry of the stream are mostly controlled by the level of Lake Rotokawa which is in turn controlled mostly by the amount of rainfall.

Groundwater aquifers

2.25. Two hydrologically separate aquifers containing mixed geothermal and groundwater occur above the deep geothermal reservoir at Rotokawa. These are the ‘surface aquifer’, which is an unconfined aquifer between approximate depths of 30 to 100m depth, and the ‘intermediate aquifer’, which is a confined aquifer that occurs approximately between 300 to 900 m depth.

2.26. The surface aquifer in most of the Rotokawa area contains mixed meteoric and geothermal water. The surface aquifer flow follows the topographic relief in the area, flowing from topographically high areas around the field and eventually draining in a northerly direction into the Waikato River. Monitoring wells south of the Waikato River within this aquifer show that it mostly contains acidic, chloride and sulphate waters with temperatures between 40°C and 90°C.

2.27. The intermediate aquifer lies beneath the surface aquifer, separated from it by an impermeable layer of clay-rich rock. The intermediate aquifer contains mixed geothermal fluid and groundwater. Groundwater recharge into the intermediate aquifer is inferred to be from topographically high areas around the field. The main geothermal input into the intermediate aquifer is considered to be in the south of the field, between Lake Rotokawa and the NAP power station. In other areas, the intermediate aquifer is hydraulically separated from the deep geothermal reservoir by another high clay content, low permeability layer of rock. The intermediate aquifer has been used for shallow injection throughout operation on the Rotokawa field although injection was significantly curtailed in 2004-5 following an increase in pressure within the aquifer.

3. CONCEPTUAL MODEL

3.1. The following section of my evidence describes the main elements of the conceptual model that were of particular importance to constructing a numerical model for the field. Figure 2 illustrates these elements in several cross-sections through the field.

Upflows

3.2. Due to the strong differences in natural state geochemistry between the north and the south of the field, there are two possible models for the deep upflow to the geothermal system: a single upflow from the south of the field which then flows towards the north of the field and is gradually diluted by a conductively heated groundwater (290°C, ~0 Cl), or two or more distinct upflows of differing chemistry and temperature across the field, at a minimum separate upflows in the north and in the south.

3.3. In terms of numerical modelling of the system, as the upflows and inferred dilution occur deep within the field, below the production and injection wells, both models can be represented as several deep upflows with temperatures between 320-340 °C.

Reservoir boundaries

3.4. The extent of the deep reservoir has been interpreted by combining magnetotelluric (MT) resistivity geophysical survey data with temperature and permeability data obtained from wells. A zone of gradually decreasing permeability around the main, high permeability reservoir has been interpreted from this approach. Outside this zone, low permeability, similar to that expected outside of highly fractured geothermal reservoirs, is interpreted to occur. The boundaries in some locations are reasonably well defined by existing wells (e.g. RK19 in the southeast was low permeability, with a conductive temperature profile indicating it is outside the geothermal reservoir), however there remain a number of areas of less certainty, particularly in the north of the field (north of the current production wells) and the south of the field (around Lake Rotokawa). These areas are mostly excluded in the reservoir model and it is therefore conservative in terms of the size of the resource.

Reservoir Base

3.5. The base of the reservoir has not yet been identified through drilling and there is no observable decrease in the number of feedzones with depth in the field. In the absence of any direct evidence of a base from the wells, the depth of microseismicity can be used to provide an indication of what depth range for the base of the reservoir is reasonable for the purposes of numerical modelling. From the microseismicity, the base of permeability is estimated to be between -3000 to -4000 masl is interpreted mostly from the fact that most of the microseismic activity at Rotokawa appears to occur at approximately the same depth as the injection feedzones, suggesting injection fluid does not sink to great depths before returning to production. There is significant uncertainty in this interpretation, at least +/- 500 m, however, in terms of the numerical modelling, setting the base to be at these depths is a conservative approach (in that it limits the reservoir volume over which production and injection fluid can flow freely) in the absence of any data to suggest a deeper base.

Permeability structure

3.6. Permeability within the reservoir is mostly associated with natural fractures within the rock. A number of datasets have shown that the reservoir has a compartmentalised behaviour, meaning that certain sectors of the reservoir have responded differently under production. This behaviour is most likely due to variations in the fracturing/permeability within the reservoir, and it is thought that this is mostly related to major faults within the field (for example, the production field fault in the western compartment of the reservoir).

Clay caps

3.7. Smectite clay zones, formed mostly through geothermal alteration, form impermeable layers or ‘caps’ to the deep reservoir and the intermediate aquifer. These caps, where they exist, prevent vertical fluid flow between the reservoir and intermediate aquifer and shallow aquifer. The depth and extent of the clay caps is interpreted from a combination of natural state well temperatures, geology and alteration from wells and MT resistivity surveys.

Aquifers and interconnections

3.8. As outlined above, two separate aquifer systems, the intermediate and shallow aquifers, occur at Rotokawa. These contain a mixture of geothermal inputs and cool, groundwater from the periphery of the field. The main connection between the deep reservoir and intermediate aquifer is thought to be in the south of the field, between the injection and production wells. The location of this connection has been inferred from natural state temperatures and MT resistivity surveys which image an absence of the deep smectite clay cap in this area. The Central Field Fault that occurs between the production and injection wells is thought to provide the main conduit for fluid flow between the reservoir and intermediate aquifer within this area.

4. EFFECTS OF DEVELOPMENT ON THE GEOTHERMAL RESERVOIR TO DATE

4.1. Between 1997 and early 2010, production from the reservoir for the Rotokawa A plant was approximately 15,000 t/day, about one quarter of the take required for the NAP plant which began operating in 2010. Consequently, changes in reservoir pressure, enthalpy and chemistry were relatively minor before the NAP plant started in 2010. Commencement of NAP operation in early 2010 induced a number of marked changes in reservoir pressure, enthalpy and chemistry. The following summarises the main changes in reservoir pressure, enthalpy and chemistry that have occurred due to development.

Reservoir Pressure

4.2. Between 1997 and 2010 the maximum measured reservoir pressure drop was around 10 bar. This pressure drop was not widespread across the reservoir but was localised around the production wells operating during this time in the centre of the field. Enthalpy and chemistry changes of the production wells operating during this time were small and insignificant.

4.3. Nearly all of the produced fluid for the Rotokawa A plant is injected and initially injection for the plant was into the intermediate aquifer between approximately 300 to 500m depth. Between 2000 and 2004, pressures within the intermediate aquifer increased significantly, and in response to this, approximately three quarters of the injection was shifted into the deep reservoir in 2005. This reduced pressure in the intermediate aquifer and provided pressure support to the reservoir.

4.4. With the start of the NAP plant in early 2010, production from the reservoir increased approximately 4-fold to around 60,000 t/day. Due to the NAP plant being a flash plant, approximately 25% of the produced fluid is lost to atmosphere, thus resulting in a net removal of fluid from the reservoir and net reservoir pressure decline.

4.5. In the first two years of NAP operations from 2010 to 2012, rates of pressure decline were initially between 6-10 bar/year, but have since stabilised to around 0.5 bar/year. This transient reservoir pressure response is typical of developed geothermal reservoirs elsewhere, a result of the geothermal system gradually approaching equilibrium with the new production and injection. Although the average pressure response of the Rotokawa reservoir to the start of the NAP plant has been roughly as expected, i.e. an initial higher drawdown rate with stabilisation over time, the pressure changes in different parts of the reservoir has not. Pressure changes within different parts of the reservoir have been highly variable, from a few bar up to 40 bar. This behaviour is often referred to as 'compartmentalisation' or a 'compartmentalised' reservoir which in essence means that the reservoir is not highly connected.

4.6. The highest pressure drops measured have been in the western compartment wells, with the lowest pressure drops in central wells located closest to areas of injection related pressure support. This is shown in Figure 5. A high concentration of production from the western compartment has likely exacerbated the effect of the compartmentalized reservoir in that area. It is therefore considered appropriate to move some production away from the western compartment in order to improve long-term sustainable use of the reservoir. The current resource consent application will facilitate this change in management.

Enthalpy

4.7. Reservoir enthalpy, which is the amount of energy contained in the reservoir fluid, is primarily a function of temperature and steam fraction (steam having a higher enthalpy than water). The combination of high reservoir temperatures and boiling within the Rotokawa reservoir means that enthalpies are on average higher than other fields within the TVZ.

4.8. Individual well enthalpies can vary significantly over time in response to changes in the steam content in reservoirs and processes that lower the reservoir temperature (for example, influx of a cooler groundwater into the reservoir). Enthalpies for the Rotokawa reservoir were initially very stable during operation of the Rotokawa A plant, averaging between 1500-1600 kJ/kg. At the start of the NAP plant, field-wide enthalpy was initially relatively stable ~1590 kJ/kg until mid-2012. Since that time, field-wide enthalpy has declined at an average rate of approximately 1.5%/year to a level of 1495 kJ/kg at the end of 2015. Whilst this is a relatively minor total change, the optimum operating enthalpy for the NAP plant is ~1520 kJ/kg and further decreases in enthalpy will likely result in generation losses.

4.9. The wells in the western compartment of the field are the wells with the highest decline rates which is likely the result of a combination of a reduction in reservoir boiling within this area over time and gradual reservoir cooling by a marginal fluid (i.e. a cooler fluid is being drawn into this area of the reservoir).

Chemistry

4.10. Changes in reservoir chemistry during operation of the Rotokawa A plant between 1997 and 2010 were relatively minor. Since the NAP plant started in 2010, chemistry changes have been pronounced and variable across the field. Analysis of the chemistry changes over time has highlighted several processes occurring within the Rotokawa reservoir. Three main zones of similar chemistry changes have been identified. Central zone wells that are closest to injection in the centre of the field show chemistry changes indicating that a proportion of the produced fluid in this area is returned from injection, with production fluids showing a loss of sulphate between injection and production. Southwest zone wells show increasing concentration of chloride which is likely the result of significant reservoir boiling. Wells in the northwest zone show significant chemical dilution which is due to the influence of marginal fluids in the northwest.

5. SUMMARY

5.1. My evidence has covered the main aspects of the conceptual model of the Rotokawa system that forms the basis of the numerical model that has been used in current resource consent application to predict the effects on the reservoir and the environment from the proposed additional 10,000 t/day fluid abstraction and the extended term of consent. My evidence has also summarised the main enthalpy, pressure and chemistry changes observed in the reservoir from the geothermal operations to date.

5.2. The Rotokawa geothermal system is, in general, typical of other high temperature geothermal systems within the TVZ, but with some exceptional features. These include the very high reservoir temperatures, high variability in chemistry in the natural state and high variability in permeability within the reservoir.

5.3. Minor changes occurred in the reservoir between 1997 and 2010 during operation of the 34 MWe Rotokawa A plant. With the start of the 138 MWe NAP plant in 2010, which resulted in a four-fold increase in production from the field, much larger changes in pressure, enthalpy and chemistry occurred within the reservoir. These changes have been varied across the reservoir.

5.4. Pressure decline rates were initially between 6-10 bar/year, but have since stabilised to around 0.5 bar/year. Pressure changes within the reservoir since 2010 have been highly variable around the field, with some parts of the reservoir having up to 40 bar drawdown whilst others having less than 5 bar drawdown. This is due mostly to the compartmentalised nature of the reservoir.

5.5. Enthalpy changes across the field have also been varied since 2010. For the first two years of NAP operation, field-wide enthalpy was relatively stable at ~1500-1600 kJ/kg. Since mid-2012 field-wide enthalpy has declined to around 1450 kJ/kg at the end of 2015.

5.6. The largest changes in reservoir pressure and enthalpy have been in the western compartment wells (RK17, RK18L2, RK26, RK27 and RK28). The higher pressure drawdown (up to ~40 bar) in this area is likely due to both the relatively high amount of production from this area and the compartmentalised nature of the reservoir. The relatively fast decline in enthalpy in this area is likely due to both changes in the amount of reservoir boiling over time and marginal recharge which has resulted in some minor cooling (up to ~10 °C) of the reservoir in this compartment.

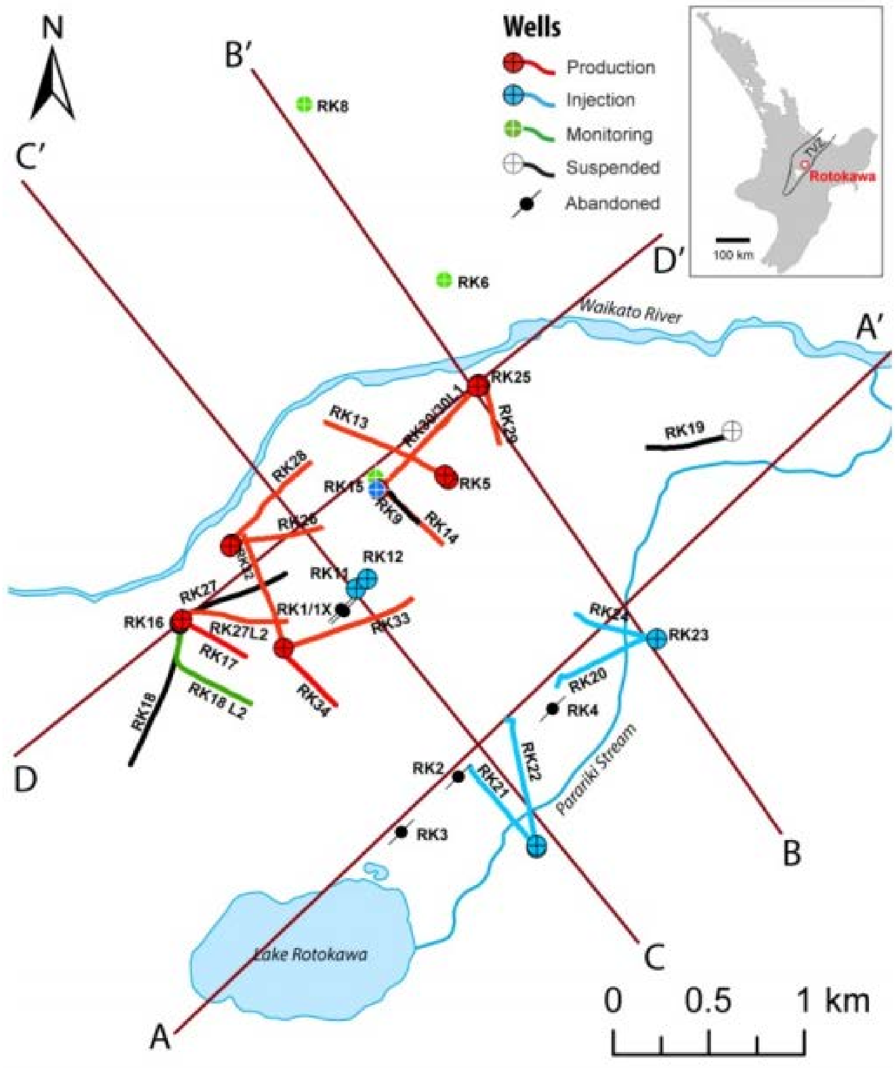

Figure 1 – Map of the Rotokawa field with production wells in red, injection wells in blue and monitoring wells in green. Black wells are abandoned wells. The location of conceptual

model cross-sections A-A’, B-B’, C-C’ and D-D’ are also shown. The inset shows the location of Rotokawa in relation to the North Island and Taupo Volcanic Zone (TVZ).

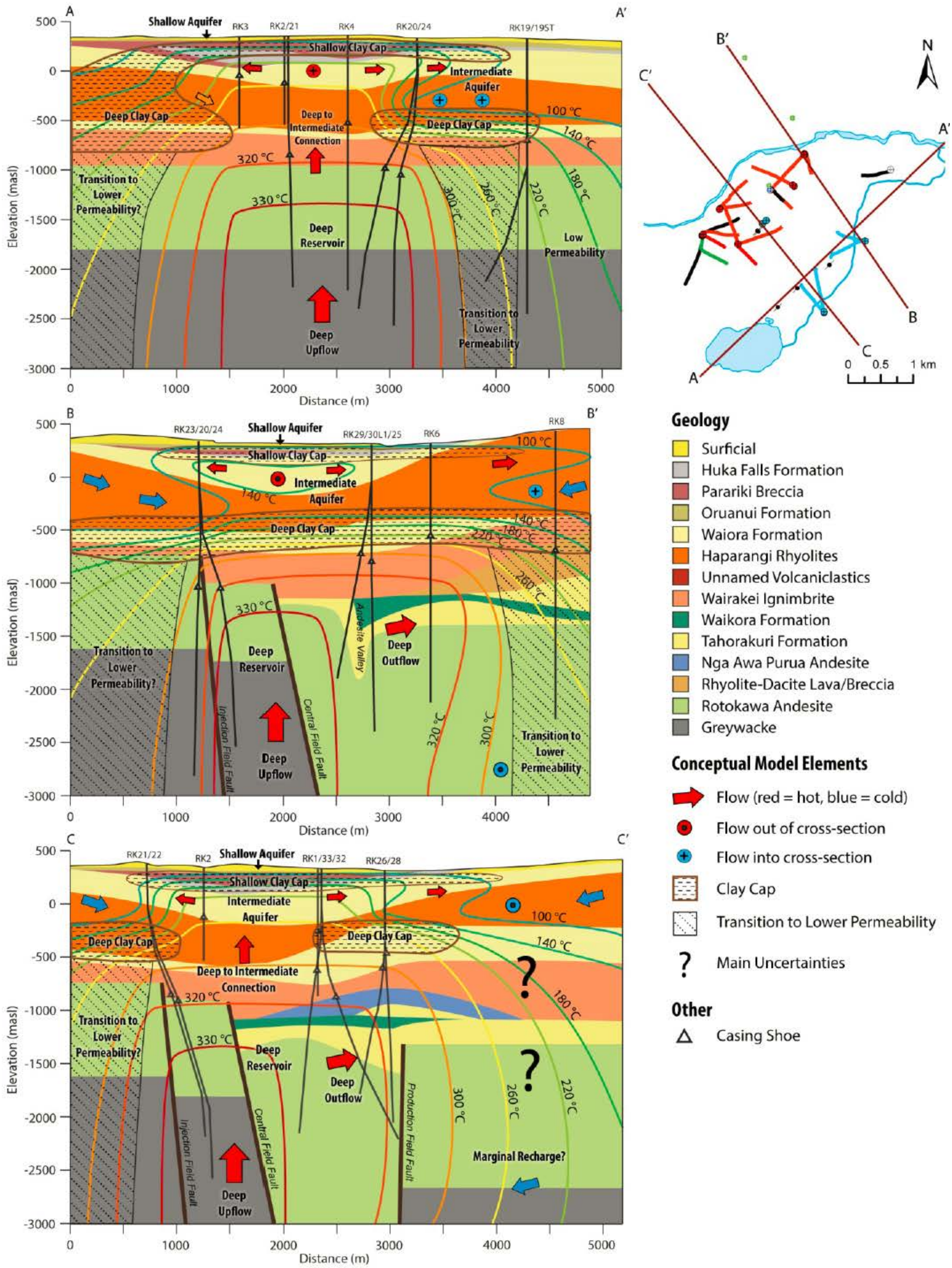

Figure 2 – Conceptual model cross-sections showing the main elements of the conceptual model and the geology. The inset and Figure 1 show the locations of the cross-sections.

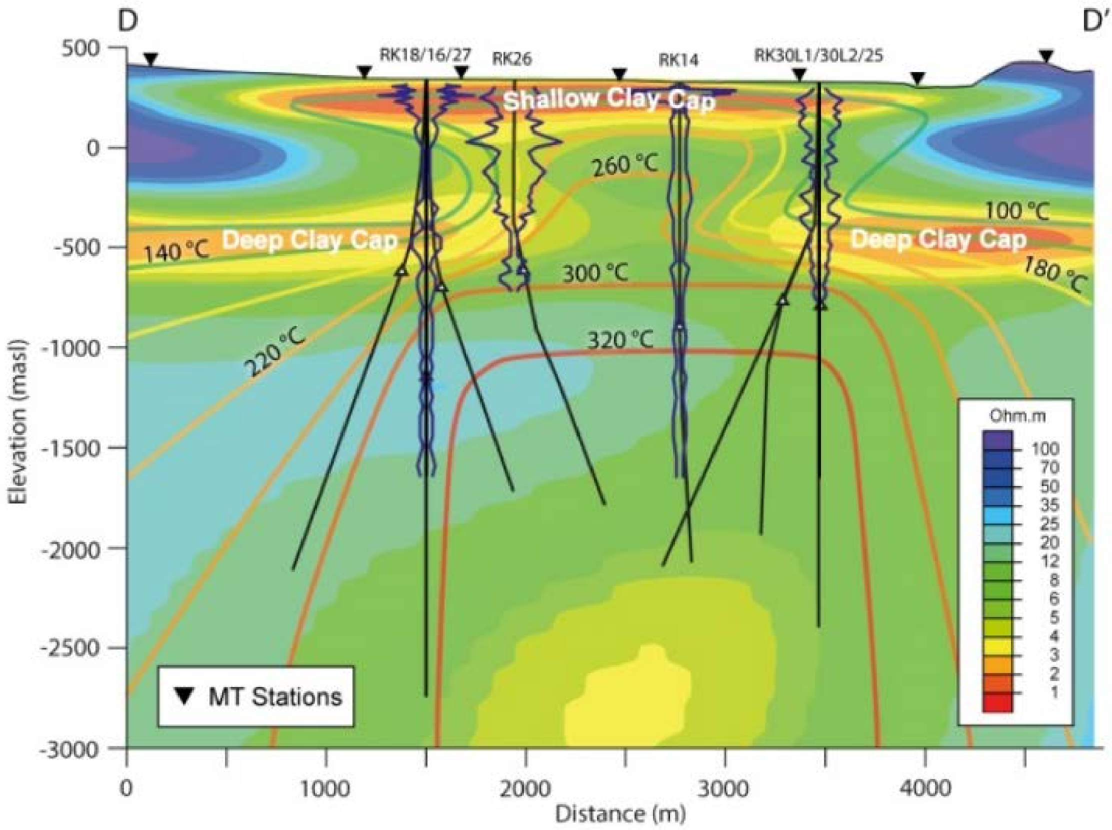

Figure 3 – MT resistivity cross-section D-D' (see Figure 1 for location) with natural state temperature and smectite content (Methylene Blue, %) logs shown in blue along well tracks.

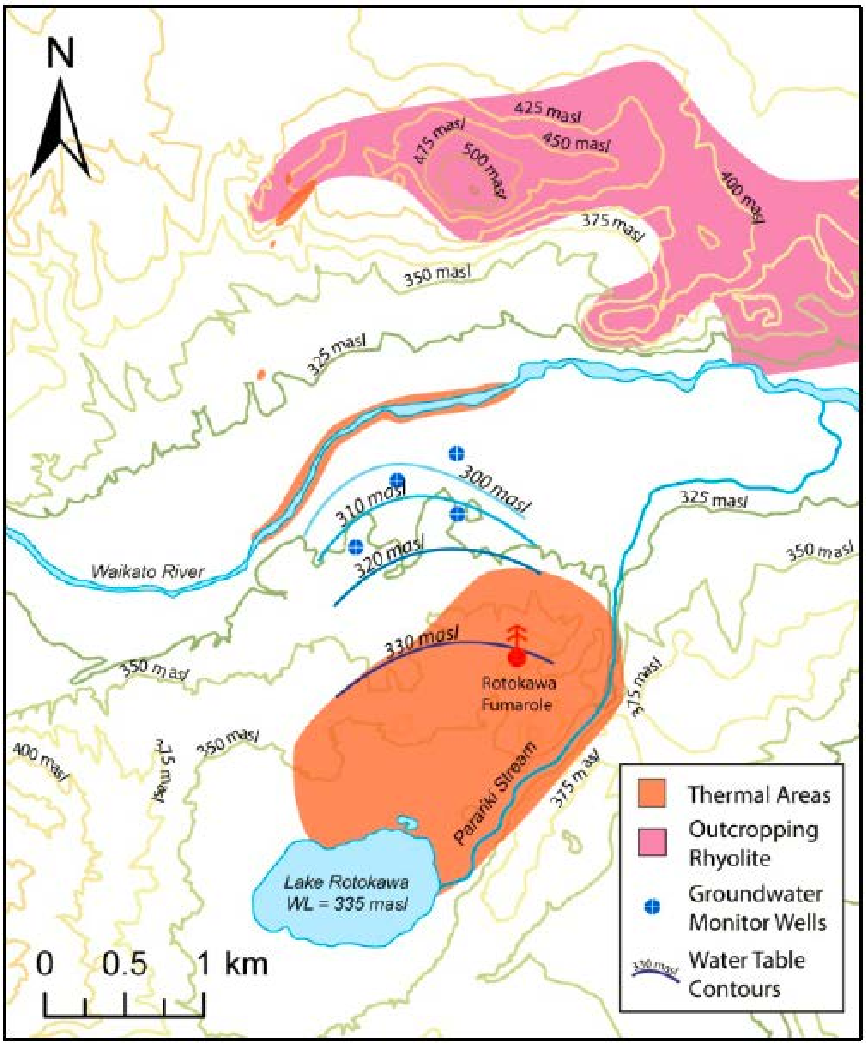

Figure 4 – Shallow groundwater hydrology in the Rotokawa area and the main areas of thermal activity. Groundwater flow in the area follows the topography with flow south of the river being from Lake Rotokawa northwards into the Waikato River. The location of the four groundwater wells that are currently monitored for changes in water level, temperature and chemistry is also shown. Highly elevated areas of outcropping rhyolite drives the groundwater flow north of the river southwards into the Waikato River.

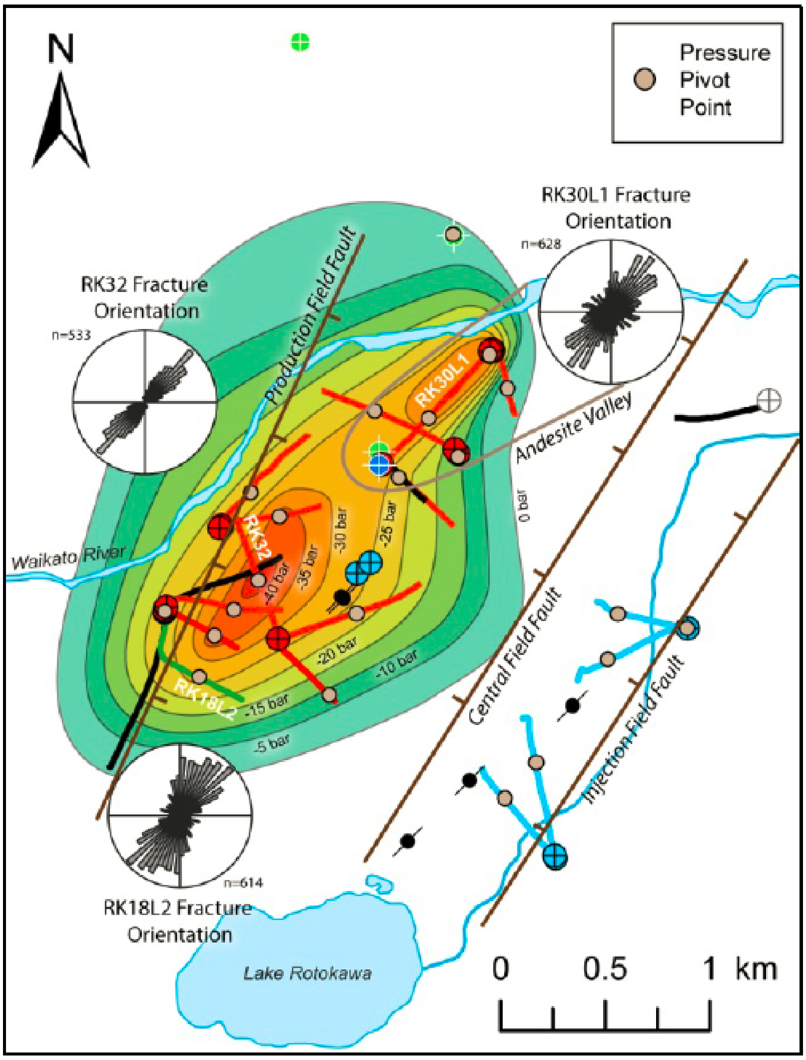

Figure 5 – Reservoir pressure in 2015 (contoured colours) overlain by the main geologic structures identified within the field at their projected surface locations. Also shown are the orientation of fractures imaged by well logs in RK18L2, RK32 and RK30L1, all of which show a dominant NE-SW fracturing trend.

APPENDIX A – REVIEW OF PROPOSED OMISSION OF THERMAL INFRARED SURVEYS

A1. BACKGROUND

A1.1. Aerial thermal infra-red (TIR) surveys utilise aircraft to survey the thermal infrared (heat) radiation from the ground. Essentially the method provides a map of surface temperatures over the area that is flown by the aircraft. The method requires calibration to a number of sites with known temperatures, ideally spanning the range of temperatures within the surveyed area. With proper calibration, the accuracy of temperature derived from TIR surveys can be as good as several degrees celsius, and the spatial resolution is typically on the order of metres.

A1.2. The existing Rotokawa consents call for aerial thermal infra-red (TIR) surveys every five years in order to monitor surface heat flow from 'all thermal areas within the Rotokawa resistivity boundary'. As part of the current consent application, a revised monitoring programme was submitted by the Rotokawa Joint Venture (RJV) with the need to perform TIR surveys removed. The main reasons for the proposed removal of TIR surveys from the monitoring programme are 1. that it is considered to be an ineffective monitoring method, 2. that the surveys are costly and time-consuming for RJV's staff to organise and run and 3. That the proposed two-yearly aerial photos and other monitoring provides better information than the five-yearly TIR surveys.

A1.3. As part of a report entitled "Rotokawa Geothermal Power Project – Geoscience Review of Resource Consent Applications" the author, Dr Brian Maunder, presents his views on the removal of TIR surveys from the monitoring program. In the report, Dr Maunder states that the aerial infrared surveys "need to be cost-effective if they are to be continued" and that they might be more cost-effective when flown by drone as opposed to fixed wing aircraft. Dr Maunder recommends that this option should be evaluated before a decision is made to cease them. The report however does not discuss the rationale for continuing the TIR surveys in terms of its utility as a tool for monitoring effects of the geothermal operations.

A1.4. I present my own views on the use of TIR surveys for the purposes of monitoring the effects of geothermal operations on the environment at Rotokawa below.

A2. POTENTIAL MONITORING APPLICATIONS OF TIR SURVEYS

A2.1. There are four possible environmental effects that I see TIR has the potential to monitor:

a) Monitoring significant changes in the total surface heat output from the system;
b) Monitoring for changes in ground temperature that might impact on geothermal habitats and vegetation;
c) Monitoring for development of new thermal areas or changes in existing thermal areas; and
d) Monitoring for hydrothermal eruption risk.

I cover these potential uses below.

Use for monitoring changes in the total surface heat flow from the system

A2.2. The vast majority of surface heat output from geothermal systems is through actively discharging thermal features. Considering this, the best way to monitor for changes in total heat output from the Rotokawa system is by monitoring heat flow from surface features where possible. TIR surveys conducted over time can measure temperature changes but they cannot measure changes in flow rates and, in my view, it is, therefore, unfit for the purposes of monitoring changes in total heat flow from the system. This is best done by directly measuring flows, chemistries and temperatures at actively discharging features at time intervals sufficient to capture any changes that might be associated with changes in the deep reservoir. The proposed revised monitoring plan submitted by RJV proposes to measure both the temperature, chemistry and flow of the main actively discharging thermal features on an annual basis. This is in my view sufficient for monitoring the changes in the overall heat output from the system.

Use as a method to monitor surface temperature changes that might impact geothermal habitats, identify changes in thermal areas or be used to monitor hydrothermal eruption risk

A2.3. The other potential use of TIR is monitoring for surface temperature changes that might identify new thermal areas as they develop (or indicate changes in existing features), that might be related to changes in geothermal habitats or might indicate an elevated risk of hydrothermal eruption. TIR may provide useful information for these purposes, however, the main issues that I see with their use is that they are run too infrequently to capture changes on a useful timescale and that other lower-cost alternatives are equally effective for monitoring purposes.

A2.4. Any significant elevation in ground surface temperatures will likely effect vegetation noting that non-geothermal vegetation is very sensitive to ground temperature and that, outside of the existing thermal areas, Rotokawa is mostly covered by vegetation. Therefore, in my view, monitoring for vegetation changes via the proposed two-yearly air photos will be as effective as aerial TIR for monitoring any significant changes in ground surface changes (i.e. changes on the order of 10s of degrees celsius over 10s of metres).

A2.5. Past experience with hydrothermal eruptions at the Wairakei geothermal field would suggest this is the case. Bromley and Hochstein (2000) in their paper entitled the "Heat transfer of the Karapiti Fumarole Field (1946-2000)" referring to four examples of aerial photos over the Wairakei field between 1946 and 2000 and the identification of newly developed thermal areas in the field state that "The resolution of these photos is sufficient to recognize clearly the area of hot ground with thermally stressed vegetation with T (0.15) >> 40 °C, an area which includes bare, steaming ground." (Note - T (0.15) is the soil temperature at ~0.15m depth).

A2.6. In addition to the aerial photos, other data being collected as part of the monitoring plan addresses monitoring of changes in thermal features, changes in thermal vegetation and hydrothermal eruption risk. These include the annual thermal feature temperature, chemistry and flow rate surveys, the annual thermal feature photography surveys, the water level and temperature in groundwater monitoring wells and the four-yearly thermotolerant vegetation surveys.

A2.7. In my view, this monitoring when combined with the two-yearly air-photos is superior to the five-yearly TIR surveys for the monitoring purposes that I have discussed here, mainly due to the increased frequency of the surveys.

A2.8. It is worth noting also that there is no direct link between hydrothermal eruptions and surface temperature. Eruptions may or may not be accompanied by surface temperature increases.

A3. COST AND LOGISTICAL ISSUES WITH TIR

A3.1. The current cost and logistics involved with running TIR surveys is also an issue for RJV. The TIR surveys are currently flown with fixed wing aircraft and are required to be flown during the night. Due to the noise associated with this, local residents must be notified about the surveys weeks in advance. Calibration sites are required to be measured during the flights, requiring personnel to be in thermal areas during the middle of the night. There is also a number of timing constraints for the surveys, they can only be flown in low-rainfall times of the year and can't be flown in cloudy, windy or foggy conditions (i.e. weather must be clear skies and low wind to fly).

A3.2. Some of these issues may be lessened if drones were to be used to conduct the surveys (i.e. cost of flying a drone should be significantly less than cost of flying a fixed wing aircraft) as suggested by Dr Maunder in his report. However, surveys via drones would probably still require similar logistics (e.g. calibration sites) and similar data processing to achieve results similar to the current surveys. It is also uncertain how much drones would actually reduce costs considering that, in my experience, the data acquisition (flying) component of the costs for TIR account for roughly less than a quarter of the total cost.

A3.3. A further issues is that flying the surveys with drones at night, which is a requirement for TIR surveys, currently appears to be prohibited. Rule 101.211 of the Civil Aviation Authority of New Zealand's rules covering unmanned aircrafts operating at night states that:

"A person must not operate a remotely piloted aircraft or free flight model

aircraft at night unless the operation is—

(1) indoors; or

(2) a shielded operation"

A4. **SUMMARY**

A4.1. There are four possible environmental effects that TIR has the potential to monitor. These are: monitoring significant changes in the total surface heat output from the system, monitoring for changes in ground temperature that might impact on geothermal habitats and vegetation, monitoring for development of new thermal areas or changes in existing thermal areas and monitoring for hydrothermal eruption risk.

A4.2. In my view, aerial TIR surveys are unsuited to monitoring for changes in the total heat output from the geothermal system that might be related to operations this purpose. The main short-coming of the TIR method for monitoring surface heat flow that I see is that it only measures temperature change, it does not measure flows.

A4.3. In my view a more appropriate method of monitoring for significant changes in surface heat flow is to measure directly the temperature and flow from the main actively discharging thermal features where possible.

A4.4. TIR surveys do appear to provide reasonably accurate measurements of ground surface temperature. They therefore may have utility in monitoring changes in surface temperature that might indicate formation of new thermal areas, changes in vegetation and/or increased risk of hydrothermal eruption.

A4.5. However, in my view, these effects are better addressed by RJV's proposed monitoring plan. In particular, the proposed two-yearly aerial photos, annual thermal feature photography combined with other regular groundwater and surface feature monitoring will provide superior information to the five-yearly aerial TIR surveys for monitoring these effects.

A4.6. The cost of aerial TIR is high relative to the other monitoring surveys. It is unlikely, in my view, that flying these surveys with drones would provide significant cost reduction relative to the current surveys. In addition, it appears that flying drones for these surveys at night is currently prohibited by Civil Aviation Authority Rules.

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of applications by the **Rotokawa Joint Venture Limited** to Waikato Regional Council for Resource Consents for the Rotokawa Geothermal Development

STATEMENT OF EVIDENCE OF DARIO JOSE HERNANDEZ

1. INTRODUCTION

Qualifications and experience

1.1 My name is Dario Jose Hernandez. I hold a Master's degree in Chemical Engineering from the Complutense University of Madrid, Spain, and a Post Graduate Master in Renewable Energy and the Energy Market. I have been employed by Mercury as Geothermal Reservoir Engineer since January 2012.

1.2 As a Reservoir Engineer, I provide technical support to the geothermal fields operated by Mercury, including Rotokawa, Kawerau, Ngatamariki and Mokai. My experience covers the following areas:

(a) Well testing design, execution and analysis of data.

(b) Reservoir monitoring, thermodynamic characterisation and design of production and injection strategy.

(c) Well drilling, planning, measurements while drilling and technical support during intervention.

(d) Numerical modelling of power plants, pipelines, reservoir and wellbore. I have collaborated in developing the Rotokawa Numerical Model and designed and run the scenarios described in this evidence.

1.3 Some of the work that I am going to describe was carried out by Dr John Burnell in collaboration with a group of geothermal geoscientists from Mercury. Dr Burnell, who currently works at the Institute of Geological and Nuclear Science (GNS), holds a PhD in Applied Mathematics from Victoria University. He has worked for more than 30 years in many research and development projects on geothermal systems. He has undertaken consulting work developing numerical models for Wairakei, Rotorua, Kawerau, Mokai and Rotokawa in New Zealand, as well as international projects in Papua New Guinea and Japan.

Purpose and scope of evidence

1.4 The purpose of my evidence is to describe the predicted effects in the Rotokawa geothermal system from different production and injection forecast scenarios.

1.5 In this evidence I will address:

(a) The modelling process;

(b) Description of the Rotokawa Numerical Model; and

(c) Numerical Model forecast results.

1.6 I confirm that I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2014 and that I agree to comply with it. I confirm that I have considered all the material facts that I am aware of that might alter or detract from the opinions that I express, and that this evidence is within my area of expertise, except where I state that I am relying on the evidence of another person.

2. EXECUTIVE SUMMARY

2.1 The Rotokawa Numerical Model was used to simulate potential impacts in the reservoir and on its thermal features associated with a proposed increase take of 10,000 tonnes per day (t/d) of fluid take across an expanded steam field area.

2.2 Seven forecast scenarios were simulated combining different amounts of total take and injection within the proposed expanded steam field area over the next 50 years.

2.3 The base case scenario represents the current consented situation with a take of up to 65,500 t/d in current Consent Area 1. Scenarios 1 and 2 represent a gradual increase over time in production (scenario 1) and injection (scenario 2) in Consent Area 4 and therefore are considered the most likely cases. Scenario 5 simulates the gradual increase of production and injection inside the current consented areas without any activity in Consent Area 4. Scenarios 3, 4 are 6 simulate an immediate increase of 10,000 t/d and provide a form of "stress test" of the scenarios 1, 2 and 5 respectively. Although not realistic due to surface facility constraints and step-changes in actual take rather than gradual, the stress test scenarios 3, 4 and 6 indicate a worst case overall effect of the proposed additional take. A more detailed description of the scenarios is presented in section 5.

2.4 I compare the impacts in the reservoir of each development option to the currently consented scenario (the "base case").

2.5 The results show that the pressure and temperature effects in the forecast scenarios do not differ significantly from the base case.

2.6 An extra pressure drop of 2 bar (average) is expected over the next 50 years, in the current production areas as a consequence of a 10,000 t/d increase in total take, in the most likely scenarios. Consent area 3 (in the north) and proposed new Consent Area 4 (in the south) show additional drops in pressure of ~10 bar in the most likely scenario and ~20 bar in the stress test scenario, over the next 50 years. This fall in pressure is consistent with the change observed in the rest of the field. To date this level of pressure drop has been observed in the existing consented area without any impact on productivity or giving rise to any issues at the surface.

2.7 In addition, the expansion of the field, and the consequential “spreading out” of production creates benefits to the deep reservoir. The distribution of the total take over a larger volume reduces the pressure decline in the current production area.

2.8 The change in pressure within the deep reservoir is transmitted up to the intermediate aquifer, which feeds the thermal features at the surface. This generates a pressure drop of 4 bar in this intermediate aquifer, under the consented base case scenario, 4.2 bar in the most likely case and 5.5 bar in the “stress test” scenarios. In turn, this translates into a predicted lower mass flow rate from the lagoon outlet. Thermal features do not stop flowing but the predicted discharge rate falls by 34% in the consented base case with an additional reduction of 6% in the most likely case and 26% additional from the base case, in the “stress test” scenario.

2.9 Under the currently consented base case scenario, production enthalpy declines by 125 kJ/kg over 50 years. Under the stress test scenarios, enthalpy declines by an additional 25 kJ/kg at the end of the simulation - equivalent to approximately 1.5% of current enthalpy values.

3. THE MODELLING PROCESS

3.1 In this section, I will provide a general description of a reservoir numerical model. Further details about the specifics of the Rotokawa Numerical Model are provided in sections 4 and 5.

3.2 A reservoir numerical model calculates the properties (pressure, temperature and steam fraction) of the fluid contained in the rock before development (the “natural state”) and in response to production and injection. This is done by using a computer program that solves the flow equations meeting the energy and mass balance in the system.

3.3 The program used to simulate the Rotokawa Numerical model is TOUGH2. TOUGH2 was developed by the Berkeley National Laboratory and is used worldwide to simulate groundwater and geothermal systems.

3.4 In order to model geothermal systems, the systems are broken down into a 3 dimensional grid of elements. The inputs required to build a numerical model are the rock properties, boundary conditions, sources and sinks (inflows and outflows) of the geothermal system. This information is gathered from geological, geochemical and reservoir engineering surveys and is included into each gridblock.

3.5 Numerical models are built in stepwise fashion. The rock properties, boundary conditions and geometry of the model are inserted in the model and then changed using manual iteration processes. Once the rock properties and boundary flows are set, the temperatures and pressures are then set to background thermodynamic conditions. The model is then run to simulate hundreds of thousands of years to approximate the geothermal system prior to any development (the “natural” or “steady” state). The model results are checked to ensure that they provide reasonable matches to the pre-production natural state temperatures and pressures, observed from drilling data. If not, the model parameters are adjusted and the model is re-run to natural state until a reasonable match is obtained.

3.6 The information gathered in the conceptual model that Mr Sewell has described constrains the inputs of the numerical model. All the inputs used in the Rotokawa Numerical Model are selected based on geoscientific data or its interpretation.

3.7 The next step in developing the model is to input production and injection data, keeping that up-to-date regularly, (every three to six months). The production and injection over the past 18 years at Rotokawa has now been simulated in the Rotokawa system. The changes in reservoir pressures are then compared against the historical changes. The calibration process is repeated until a good match of the steady state and the historical changes is achieved. With a fully calibrated model, forecast scenarios can be run to evaluate future effects of different production strategies.

4. ROTOKAWA NUMERICAL MODEL DESCRIPTION

4.1 In 2011, 18 months after the increase in production associated with the development of the Nga Awa Purua station, RJV entered into collaboration with Dr John Burnell to develop a new Rotokawa numerical model in TOUGH2. In July 2013 the TOUGH2 model was presented to the Waikato Regional Council and its Peer Review Panel and approved.

4.2 After completion, the model was transferred to Mercury and it has been updated on a regular basis with the production and injection data. Therefore, its suitability to make predictions is reassessed continuously, by comparing the model results with the measured data.

4.3 The numerical model grid covers an area of 11.6 km by 11.3 km, with 28 by 30 grid blocks in x and y direction respectively, and 16 vertical layers with a total of 13,440 primary grid blocks (as illustrated in Figure 1). The thickness of layers is between 100 and 1000 m. As Mr Sewell has explained, micro-earthquakes and lithology indicate that the base of the permeable reservoir at Rotokawa is around -4,000 m. Accordingly, the model covers a vertical range from ground surface to -4,100 m.

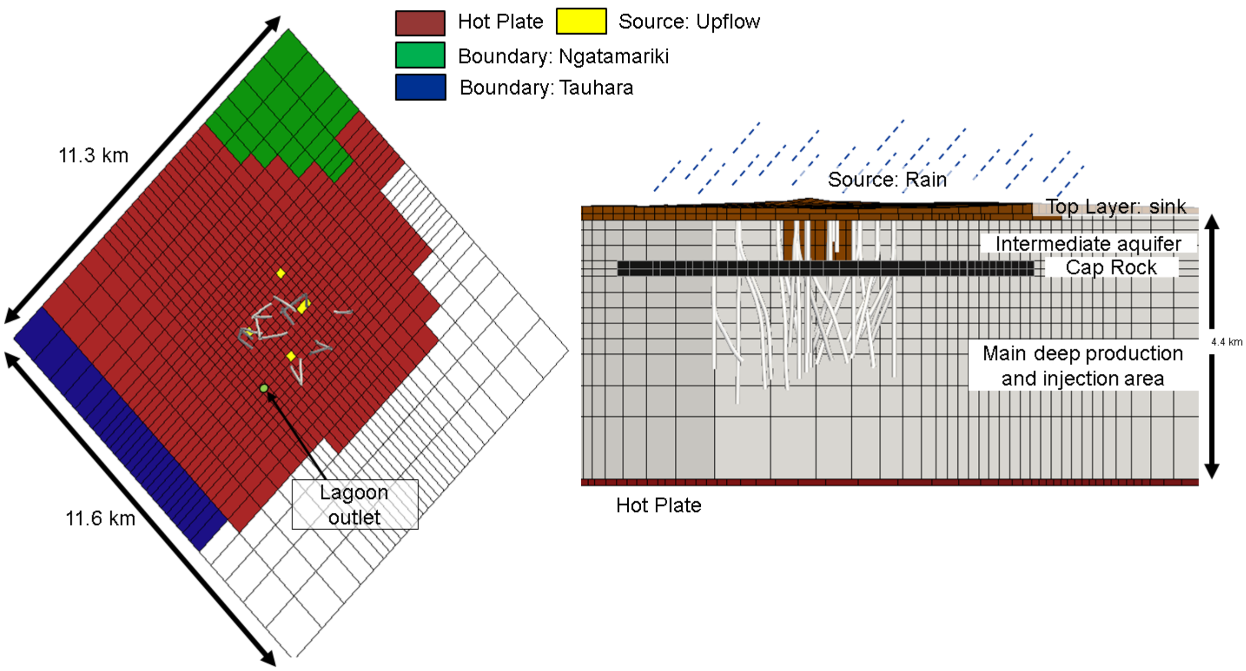

FIGURE 1: TOP AND LATERAL VIEW OF THE ROTOKAWA RESERVOIR MODEL SHOWING THE BOUNDARIES, SINK AND SOURCES. THE LINES SHOW THE GRID DISCRETISATION IN X, Y AND Z DIRECTION.

4.4 Each one of the grid elements is divided in three sub-blocks (two representing the matrix of the rock and one representing fractures, with a much larger permeability).

This is known as dual porosity and is a key element to enable modelling of the heat transfer between the rock and the fluid.

Boundary Conditions

4.5 Boundary conditions represent the edges of the model, where the changes in pressure and temperature are considered small compared to the changes in the reservoir. The boundary conditions in the Rotokawa Model are:

(a) Atmosphere: represented as one block on top of the upper layer, with CO_2 mass fraction of 100 %, pressure of 1 bar abs. and temperature of 20°C.

(b) Waikato River: a row of blocks in the upper layer with a constant pressure of 2 bar abs., temperature of 20 °C and water saturation of 100%.

(c) Tauhara and Ngatamariki systems: lateral constant temperature layers with 200 °C and 250°C respectively.

(d) Hot plate: a constant temperature hot plate is set with temperatures of 330 °C.

4.6 For production runs, constant pressure recharge blocks are added to the locations of the natural upflows. The permeability of the recharge blocks was adjusted to match the measured pressure response. The total recharge flow from these blocks is usually less than 25 kg/s over the Rotokawa production period.

Sources and Sinks

4.7 The hot upflow at the base of the model was split into four locations shown in yellow in Figure 1. The total upflow from the four locations is 150 kg/s of fluid with an average enthalpy of 1,550 kJ/kg. This amount of upflow is consistent with estimates of the total mass flow from surface heat measurements. At each upflow location, CO_2 was also injected, to simulate the existing gas fraction in the reservoir. The possibility of multiple upflow paths is consistent with the conceptual model. In general, a deeper source of fluid enters the reservoir at different locations, producing the geochemical and temperature gradient observed in the natural state.

4.8 Cold fluid is injected into the upper portions of the model, with 440 kg/s of 20 °C water to simulate rainfall, at an infiltration rate of 11 %. The regional groundwater flow in the

Intermediate Aquifer is simulated by injecting a total of 110 kg/s of 40 °C water to the east, west and south of the production field at 75 mRL.

Power Plant and Wellbore Models

4.9 In the Rotokawa geothermal field there are two operating power plants. A model that represents the operating conditions of both has been coupled with the reservoir model. This coupling allows the simulation of the fluid demand, as a function of the reservoir enthalpy. For example, if the steam fraction in the geothermal fluid decreases, the power plant would require more geothermal fluid to maintain the same electricity generation. The amount of fluid injected is updated accordingly by the model. The two power plants operating on the Rotokawa field inject approximately 75 % of total fluid take in different forms (i.e. brine, condensate), with temperature between 40 °C and 160 °C, with the majority being at 130 °C.

4.10 At each time step, the existing wells' capacity is calculated with a wellbore model. If the capacity is not enough to meet the specified target, a new production (make-up) well is automatically added. The same occurs for injection. If the required flow rate exceeds the available capacity, a new injection well is automatically added.

Thermal Features

4.11 Forecast scenarios include a single feed, wellbore model, with a depth of 300 m, which represents a generic source of the thermal features in the lagoon outlet location (see green dot in Figure 1). Given the lack of reliable historical measurements of the total flow rate, the model was calibrated to produce a relatively small amount of fluid (5kg/s) at the current state, and sufficient well head pressure to flow (between 1 and 2 bar). Coupled with the reservoir model, it provides changes in flow rate as pressure and enthalpy changes in the intermediate aquifer. It is a rough approximation and likely to represent the worst case scenario of the impact on the thermal features, because it does not include interaction with surface waters, or enough detail vertically to monitor the liquid level. Nevertheless, it does provide a coupling between changes in the reservoir and variations in this shallow well's mass flow rate.

5. MODEL SIMULATIONS AND RESULTS

5.1 The model was used to run seven forecast scenarios to quantify the effects on the reservoir and on surface thermal features associated with an additional 10,000 t/d of production and consequential increases in injection, occurring across Consent Areas 1, 2, and 3 and proposed new Consent Area 4.

5.2 The scenarios were run for 50 years starting in 2014. Figure 2, 3 and 4 show the location of simulated production and injection activities in each scenario. The scenarios were:

(a) Base case scenario: representing the current consented situation authorised by existing resource consents and land access. In the base case, total take increases gradually (according to the power plant model). Production is located in current Consent Area 1 up to the consented limit of 65,500 t/d.

(b) Scenarios 1 and 2: reflecting the scope of RJV's proposal while following the most likely future configuration of production and injection activity at Rotokawa should the resource consents sought as part of this application be granted. That is, total take also increases gradually up to an increased limit of 75,500 t/d, but unlike the base case, additional Consent Areas 3 and 4 are utilised for production (scenario 1) and production and injection (scenario 2).

(c) Scenario 5 also considers a gradual increase in production and injection, with a limit of 75,500 t/d inside the current consented area, including the most likely production from the Consent Area 3, but without any future activity in Consent Area 4.

(d) Scenarios 3, 4 and 6 are intended to reflect "worst case" scenarios. Although scenarios 3, 4 and 6 are not likely to occur in reality, they do provide a form of "stress test" of the more likely scenarios 1, 2 and 5. Instead of increasing production gradually, scenarios 3, 4 and 6 simulate an immediate fluid take rate of 75,500 t/d from day 1 of the forecast scenario. It follows that these simulations make no account of current generation facility limitations. For example, under these scenarios, more steam would be delivered to the turbine than could be used at current field enthalpy. Nevertheless, the conservatism built into scenarios 3, 4 and 6 serves to demonstrate upper bounds to any predicted reservoir changes.

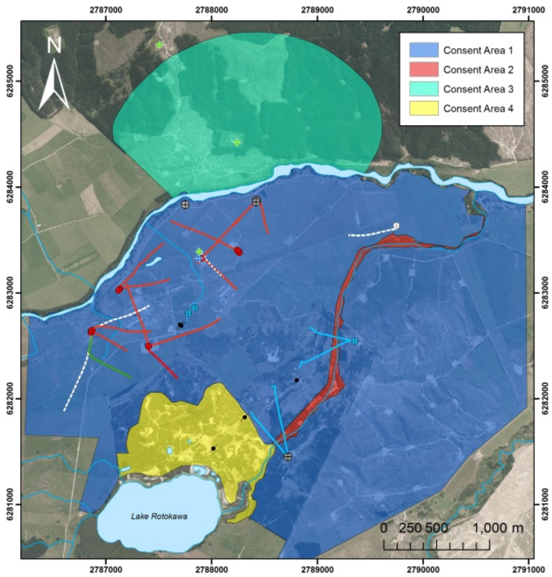

FIGURE 2: PRODUCTION WELLS (RED LINES) AND INJECTION (BLUE LINES) LOCATION FOR THE BASE SCENARIO

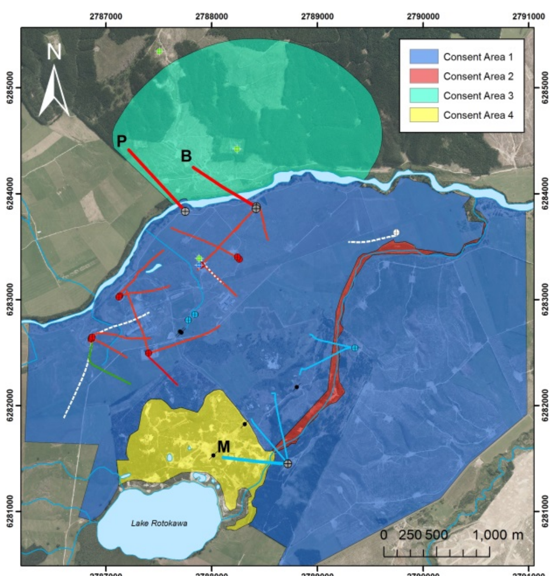

FIGURE 3 PRODUCTION WELLS (RED LINES) AND INJECTION WELLS (BLUE LINES) LOCATION FOR SCENARIO 2 AND SCENARIO 4. NEW WELLS ARE NAMED WITH A LETTER.

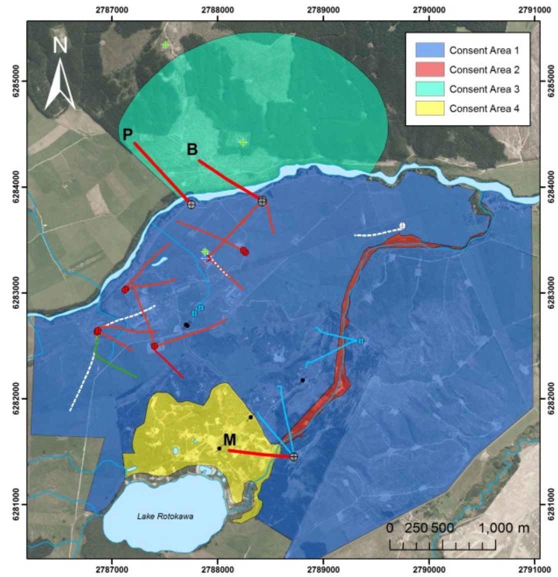

FIGURE 4 PRODUCTION WELLS (RED LINES) AND INJECTION WELLS (BLUE LINES) LOCATION FOR SCENARIO 1 AND SCENARIO 3. NEW WELLS ARE NAMED WITH A LETTER

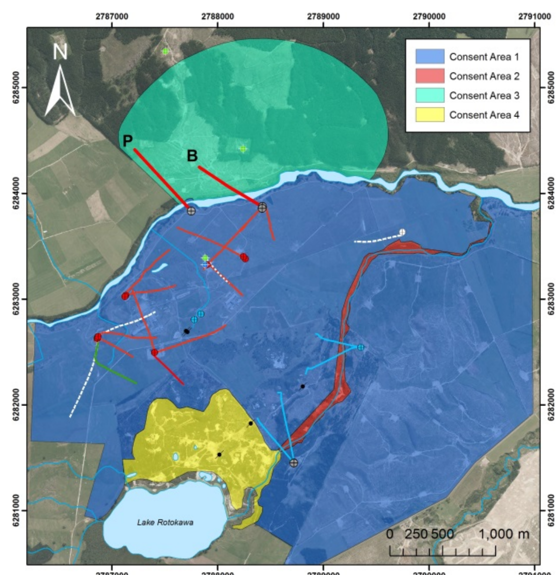

FIGURE 5 PRODUCTION WELLS (RED LINES) AND INJECTION WELLS (BLUE LINES) LOCATION FOR SCENARIO 5 AND SCENARIO 6

Results

Deep Reservoir

5.1 Figure 6 and Figure 7 compare the pressure change at -1850mRL, the main production depth, in the base case scenario (production inside the consented area), and scenario 3 (stress test, with production in consent areas 3 and 4).

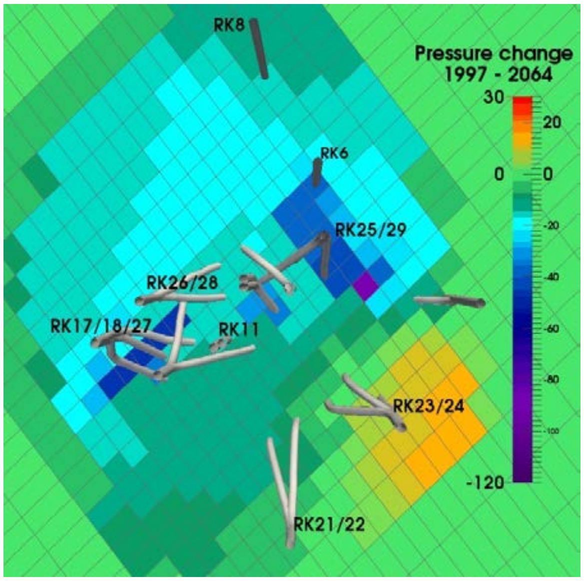

FIGURE 6 PRESSURE CHANGE IN THE BASE SCENARIO AT -1850 MRL

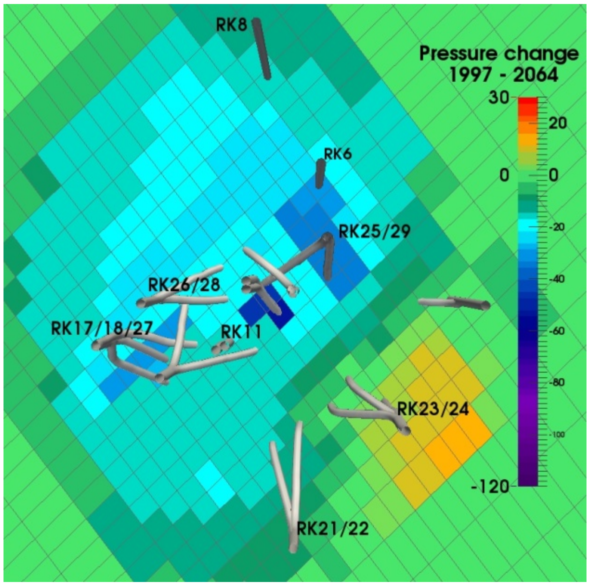

FIGURE 7: PRESSURE CHANGE IN SCENARIO 3 AT -1850MRL

5.2 These model results show how, by spreading the production out into new steam field areas, pressure drawdown values in the current production area are actually suppressed by 10 to 20 bar while the pressure drawdown in the new consented areas increases by 10 to 20 bar without exceeding the drawdown in the existing areas.

5.3 Figure 8 shows the evolution of pressure change in proposed new Consent Area 4 for each scenario at -1850mRL, and Figure 9 shows the pressure evolution in the existing production area.

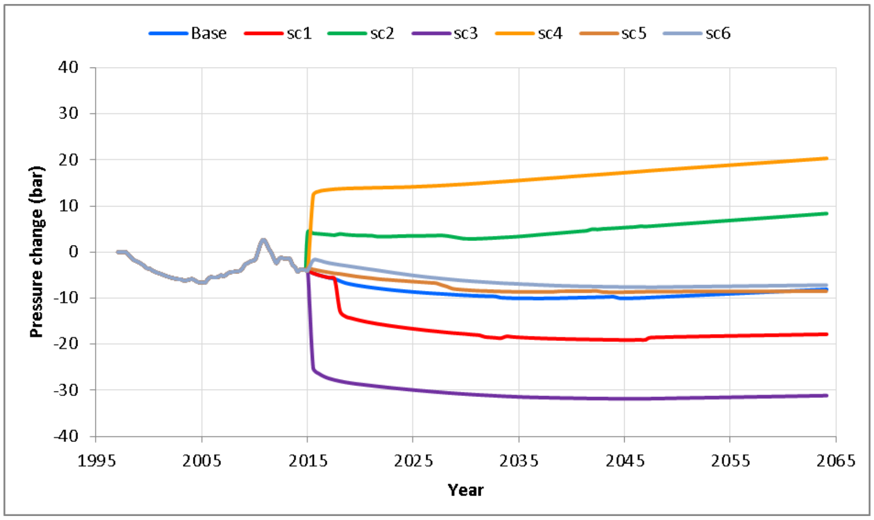

FIGURE 8: PRESSURE CHANGE AT -1875 MRL IN CONSENT AREA 4

5.4 Figure 8 shows how the pressure in Consent Area 4 decreases 5 bar in the base case scenario (blue line) in the next 50 years. The most likely production scenario (scenario 1) shows additional drop of 10 bar (red line) and a 20 bar drop is seen for the stress test for this (scenario 3, purple line). In the stress test scenario (scenario 3, purple line) the cumulative pressure drop, in Consent Area 4, after 50 years of production is 30 bar. The current production area has experienced a similar drop in pressure values without any negative impact on productivity or giving rise to issues at the surface. Scenario 5 (brown line) and 6 (grey line) show an increase in take of 10,000 t/d inside the consented area only, without production or injection in the Consent Area 4. The total pressure drop in Consent Area 4, after 50 years in scenarios 5 and 6 is the same than the base case scenario.

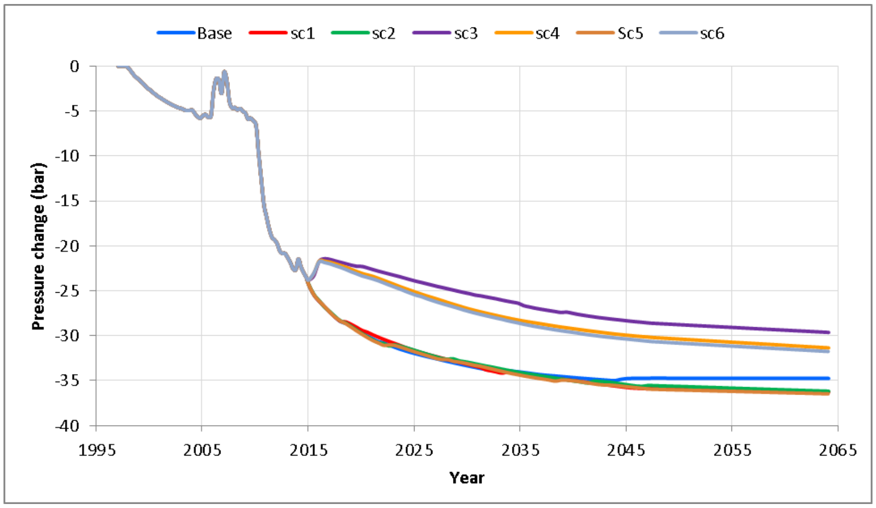

FIGURE 9: PRESSURE CHANGE IN RK18L2 AT -1500MRL

5.5 Figure 9 shows how spreading out the production (scenario 3; the purple line) equilibrates the pressure drawdown across the Rotokawa geothermal field. The proposed increased take of 10,000 t/d does not affect the stabilisation of reservoir pressure. The main changes in temperature observed are concentrated in the south (main injectors), as a consequence of the increase in brine flow rate, where injection activities already occur. The temperature in the stress test is 10 ºC to 20 ºC colder than in the base case after 50 years. This reflects a 5% change from the original temperature in the injection area only. For example, at 500 m from the injection the temperature in 50 years decreases from 200 ºC in the base case to 190 ºC in the stress test scenario.

Intermediate aquifer and surface features

5.6 In the intermediate aquifer, the change in pressure expected with the current production strategy (base case) is -4 bar versus -4.2 bar in the most likely scenario (scenario 1), and -5.5 bar in the stress test (scenario 3) after 50 years (see Figure 10). Decline in pressure and enthalpy directly translates to a decline in productivity of the thermal features.

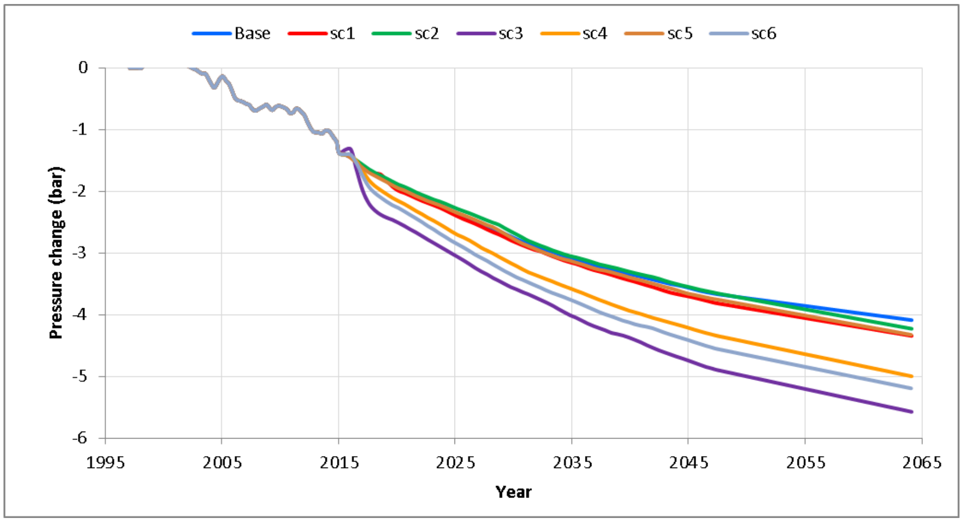

FIGURE 10: DOWNHOLE PRESSURE CHANGE OF THE LAGOON OUTLET THERMAL FEATURE

5.7 A wellbore model was calibrated to generate 5 kg/s (or 18 t/h) flow rate from the thermal features in 2014. The forecast, shown in Figure 11, indicates a decline in this flow rate from 18 t/h to 12 t/h for the currently consented base case scenario, from 18 t/h to 11 t/h (5% additional from the base case) in the most likely case (scenario 1) and from 18 t/h to 7 t/h for the stress test (28% additional from the base case).

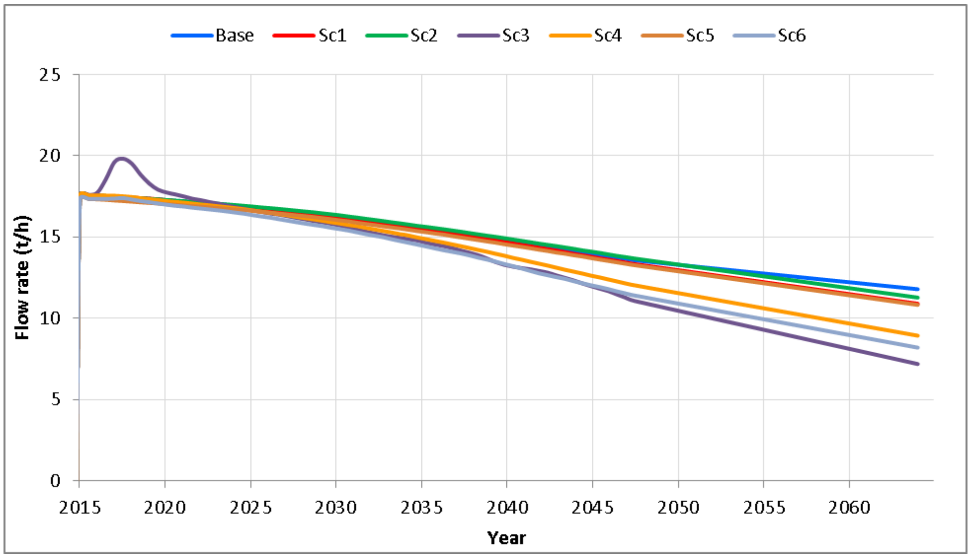

FIGURE 11: FLOW RATE OF THE LAGOON OUTLET THERMAL FEATURE. OBSERVE THAT THIS FIGURE ONLY SHOWS THE RESULTS FOR THE FORECAST PERIOD (1997-2014) SINCE NO RELIABLE HISTORICAL FLOW RATE DATA AVAILABLE.

5.8 The amount of shallow injection in the base case scenario and scenarios 1, 2 and 5 is the same since it is a function of the steam used for electricity generation. Therefore, there is no change in the intermediate aquifer temperature. In the theoretical stress tests (scenarios 3, 4 and 6) the amount of condensate injected is artificially increased in the model. That produces an additional temperature decrease of 20 ºC (or 10% of the change).

5.9 The impact of injection in the intermediate aquifer can also be assessed by looking at the enthalpy of the spring flows (Figure 12). The enthalpy decreases from 1005 kJ/kg to 968 kJ/kg in the base case scenario, to 965kJ/kg in the most likely scenarios and down to 952 kJ/kg in the stress tests (an additional 1.5% from the base case).

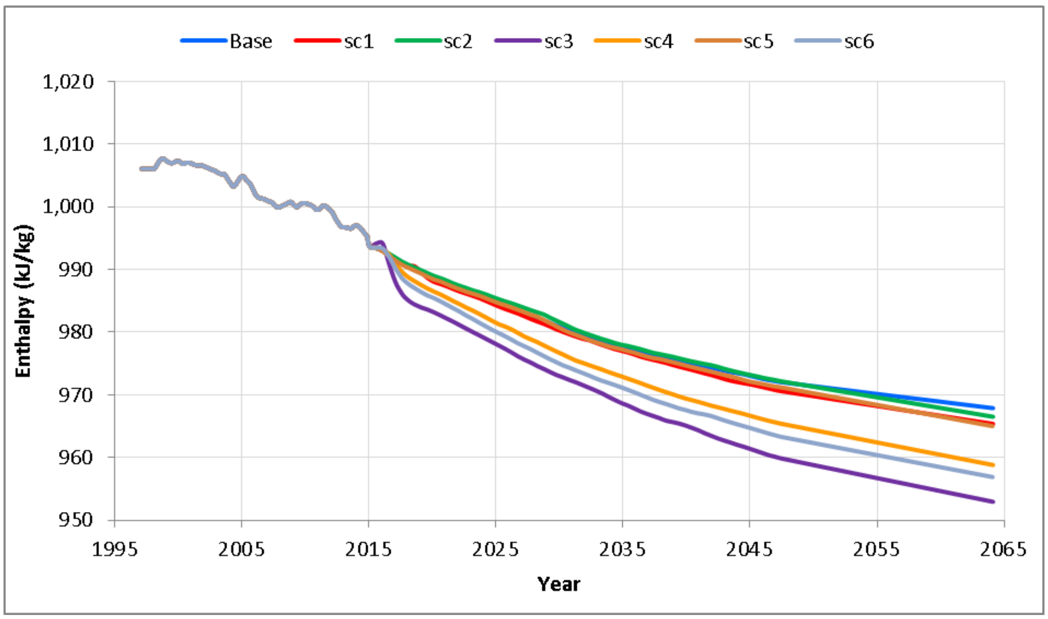

FIGURE 12: ENTHALPY OF THE LAGOON OUTLET THERMAL FEATURE

6. CONCLUSIONS

6.1 The modelling results show that the proposed extension of the consented area will be beneficial for the overall deep pressure drawdown because the total take from parts of the current production area is lowered (see comparison between Figure 6 and Figure

7) and is instead spread across a larger area. Modelled changes to reservoir parameters associated with the increase in total take, in the most likely cases (scenarios 2, 3 and 5), are very small compared to changes expected under the currently consented base case scenario. For example, in the west area (Figure 9), a total pressure drop of 37 bar is expected after 50 years, compared to the 35 bar total drop in the base case scenario.

6.2 In Consent Area 4 (Figure 8) the maximum pressure drop after 50 years of production is modelled at an additional 10 bar (in the most likely case) or 20 bar in the stress test compared to the base case. The cumulative pressure drop after 50 years in Consent Area 4 is 20 bar in the most likely scenario and 30 bar in the stress test. This impact is smaller than the pressure change currently observed in the existing production areas. To date, the drawdown in pressure in the current consented area has not resulted in noted changes in the surface features.

6.3 In the intermediate aquifer, changes in pressure and temperature might have an effect in the thermal features, but the model results indicate that the changes expected are very small, and less than minor. The model shows, in the most likely case, an additional decrease of 5% in the flow rate of the thermal features and up to 28% in the theoretical ‘worst case scenario’ stress tests.

7. REFERENCES

7.1 Resource Consent Application and AEE. December 2015

7.2 Grant, M.A., 2015 “Rotokawa model review and resource sustainability commentary” MAGAK report AEE APP 2

7.3 Hernandez D., Clearwater J., Burnell J., Franz P., Azwar L. & Marsh A. (2015). Update on the Modelling of the Rotokawa Geothermal System: 2010 – 2014; World Geothermal Congress, Melbourne, Australia.

7.4 Pruess, K., Oldenburg, C., and Moridis, G.: TOUGH2 User's Guide, Version 2.0. Berkeley: Earth Sciences Division, Lawrence Berkeley National Laboratory. (1999).

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of applications by the **Rotokawa Joint Venture Limited** to Waikato Regional Council for Resource Consents for the Rotokawa Geothermal Development

STATEMENT OF EVIDENCE OF MALCOLM ALISTER GRANT

1. INTRODUCTION

Qualifications and experience

1.1 My name is Malcolm Alister Grant. I have an ScD in Applied Mathematics from the Massachusetts Institute of Technology. I have worked in geothermal for 34 years, during which time I have worked on 76 geothermal fields, in 18 countries. I have worked on 20 fields in New Zealand. In all cases my work has been on the performance of geothermal wells, or the performance of the field as a whole, and in either case the expected behaviour in the future.

Purpose and scope of evidence

1.2 The purpose of this evidence, having reviewed the AEE, is to comment on the status, quality and adequacy of the Rotokawa Numerical Model and summarise the expected effects of RJV's proposal on the Rotokawa reservoir.

2. SUMMARY OF KEY CONCLUSIONS

2.1 In its present state, the model suitably predicts overall field behaviour and is an acceptable model for the present consenting purposes.

2.2 The model indicates that the proposal will produce negligible differences to the reservoir, and, therefore, the environmental impact of the proposal will be negligible.

3. COMMENTARY ON STATUS, QUALITY AND ADEQUACY OF THE ROTOKAWA NUMERICAL MODEL

3.1 The current simulation model is described in the evidence of Mr Hernandez.

3.2 The model has three inflow sources: deep upflow, lateral inflow and rainfall infiltration. There are corresponding outflows at constant pressure blocks at the river and ground surface.

Model calibration

3.3 Overall, the model is a good match to the natural state pressures and temperatures of the Rotokawa geothermal field.

3.4 Positive aspects of the model in terms of its match to the field are:

(a) A feature of the field is the inversion in the intermediate aquifer in nearly all wells. The model has such an inversion. Although individual well profiles differ in the quality of the match, the model replicates the general pattern of a very limited region of upflow, and inversion, into the intermediate aquifer. This behaviour of the field has major consequences for permeability between the deep reservoir and the intermediate aquifer and the model's replication of this process is well constrained.

(b) There is also a generally good match to the pressure history of the production area, although again some individual wells are not well matched, which is not uncommon. Although some individual wells are mismatched, the overall performance is reasonably well represented. This is because to achieve a good model match, it is preferable to use a wider data set that is roughly matched, rather than using a smaller, or restricted, data set with a higher quality match.

3.5 Limitations of the model include:

(a) The model has a substantial pressure rise (15-30 bar) in the injection area that is not observed, as actual changes are only a few bar. The model permeabilities in and around the injection area must be too low, even with the time-dependent increase. The observed injection area pressures indicate that some of the production drawdown has expanded into the injection area, counteracting the rise that would otherwise occur, and this is not present in the model.

(b) The enthalpy history is less well matched, and the model does not explain the wells affected by falling enthalpy. However the model does get a reasonable match to the field enthalpy.

3.6 Overall, the current status of the model match can be described as:

- Natural state temperature: good
- Natural state pressure: reasonable
- Pressure change on production: good for most production wells (RK6 & 29 are exceptions)
- Pressure change on production in the injection area: poor
- Production enthalpy: average/reasonable (some individual wells are poorly matched)
- Gravity: good match

3.7 In the present state, the model acceptably predicts overall field behaviour, but is not sufficiently accurate at detail for things such as optimal well siting.

3.8 The model is suitable for assessing the likely effects of the present resource consent applications. This is because any potential environmental effects are a consequence of the transmission to the surface, or near to the surface, of a pressure signal from production depths. These are changes within the deep production reservoir. The top of this reservoir is approximately 1000m deep, above which is the intermediate aquifer and above that the shallow aquifer.

3.9 The signal reaching the surface is determined by the average pressure change at the top of the deep reservoir, which is determined by the average field response. The pressure change at the top of the deep reservoir then propagates further upward through the intermediate and shallow aquifers, both of which spread any impact laterally. The compartments inferred within the deep reservoir do not appear to extend above the deep reservoir top as the intermediate aquifer is laterally extensive. The net effect of this is that if the model gets the pressure changes generally right, it will equally be generally right about the signal transmitted outside the reservoir that generates any impact on the external environment.

4. RJV'S PROPOSED DEVELOPMENT PHILOSOPHY AND LIKELY FUTURE IMPACTS ON THE RESERVOIR ASSOCIATED WITH THE PROPOSAL

4.1 There are two elements to RJV's proposal:

1. Extension of the area of production towards Lake Rotokawa.
2. Increase in total take.

There is also an extension of total duration by eight years but this is very minor.

4.2 The first is a logical response in reservoir management to observing adverse impacts in one part of the field, by spreading the load of withdrawal, and in particular moving away from the affected area.

4.3 The second is a means of accommodating a lower field enthalpy. The net take, i.e. steam consumed, will be unchanged. As the net take does not change there should be little effect outside the reservoir. Within the reservoir there will be an increase in flow, with greater production and injection flow, of itself this has negligible external impact.

Forecast Scenarios

4.4 Mr Hernandez describes in detail the modelled scenarios undertaken and the forecast changes to the reservoir under each scenario. In summary, scenarios include:

(a) a base case with take limited to 65,500 t/d;

(b) two expansion scenarios (1 and 2) where take increases as needed to 75,500t/d, with different locations for the flow increase;

(c) two stress tests (3 and 4) where take increases immediately to 75,500 t/d;

(d) two further scenarios (5 and 6) repeat scenarios 3 and 4 but with no use of Consent Area 4 (“DoC land”).

4.5 In all cases there is a forecast decline in enthalpy, due to injection returns. As a consequence it is necessary to increase take in order to maintain full generation load.

4.6 The effects on the reservoir are as would be expected. Expanding the area of take in scenarios 3 and 4 expands the area drawn upon, while reducing the drawdown in the existing area. Net changes within the reservoir are small, being at most a shifting around of where the pressure and temperature changes occur. These changes what would also be expected with no change to net withdrawal.

4.7 In all cases the changes above the deep reservoir are minor, as would be expected given the relatively small change in take at depth, and the convoluted path for such changes to propagate to the surface. The differences between the scenarios are small, as would be expected for what is after all a relatively small change in total take and discharge. The differences between the scenarios (1, 2, 5 and 6) are less than the inherent error in the simulation process.

4.8 One observable difference is the spread of drawdown. When production is expanded into consent area 4, the pressure drop expands into there also, while drawdown reduces elsewhere. The total effect on the reservoir is much the same but the expansion of the production well field spreads the drawdown load across a greater area.

4.9 It is worth noting that the model projections must be considered as approximate only, not precise predictions. This is acknowledged by the applicant in comments to Maunder (p11, para 3[1]) that the take might rise faster than projected. Maunder also opines: “long term predictions concerning discharge enthalpy are less certain than those for pressure”, and I support this conclusion. There remains some uncertainty about long-term field behaviour, particularly in respect of intrusions of cooler fluid.

4.10 However what is a significant conclusion, and a conclusion that is reliable, is that there is little difference between scenarios 1, 2 and 5 in the modelling results when

[1] “The Applicant has advised (email D Hernandez to B Maunder 17 March 2016) that due to model limitations, predictions of the flow rates required are approximations only and furthermore that the amount of fluid required by 2050 (corresponding to about 35 years, the maximum term of consent) could well reach 75,500 t/d assuming a fluid enthalpy of 1410 kJ/kg for both the Rotokawa 1A and NAP power stations.”

take is increased to provide constant load. The difference between these three scenarios is much less than the margin of error in the projections. That is, even if the long-term field behaviour differs significantly from the projections, the difference between the scenarios will remain small.

4.11 Based on the simulation results, the proposal has little, if any, impact outside the deep reservoir itself. It would be surprising if there were any different result. The increased take is a compensation for decreasing enthalpy and the net withdrawal (steam to the station) is held steady. Drilling and producing from Area 4, instead of the existing production area, shifts some production load but the total take is unchanged. Thus what has changed are flows within the reservoir itself but the net total has not. With pluses and minuses within the reservoir balancing out, the effect externally should be minor at most. (This observation must be slightly qualified: if the existing consents were followed production would in due course be slowly curtailed as the take limit is reached, and the proposal does represent an increase in net take, compared to this decline.)

4.12 Figures 1 and 2 below show the temperature change to 2064 at -1250m in the base case and scenarios 1, 2 & 5. It requires careful inspection to see the differences between these results. Figure 3, showing the average discharge enthalpy, similarly shows negligible difference between all the scenarios, including the stress tests.

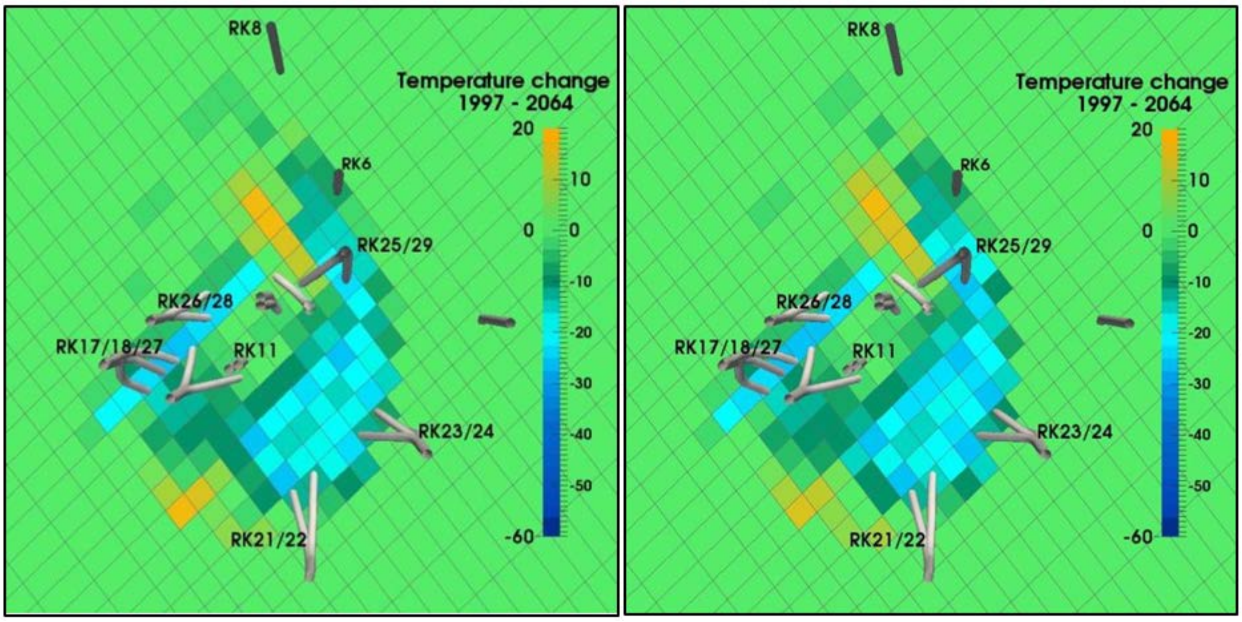

Figure 1. Temperature change 1997-2004, base case and Scenario 1.

4.13 The net effect of the additional take is to maintain steamflow – to give effect to what was originally sought and is currently consented. However the field has performed a little differently to expectation, with falling enthalpy, and this has created the need for additional mass flow. The effect within the reservoir is simply to shift more fluid around, with no net increase in take.

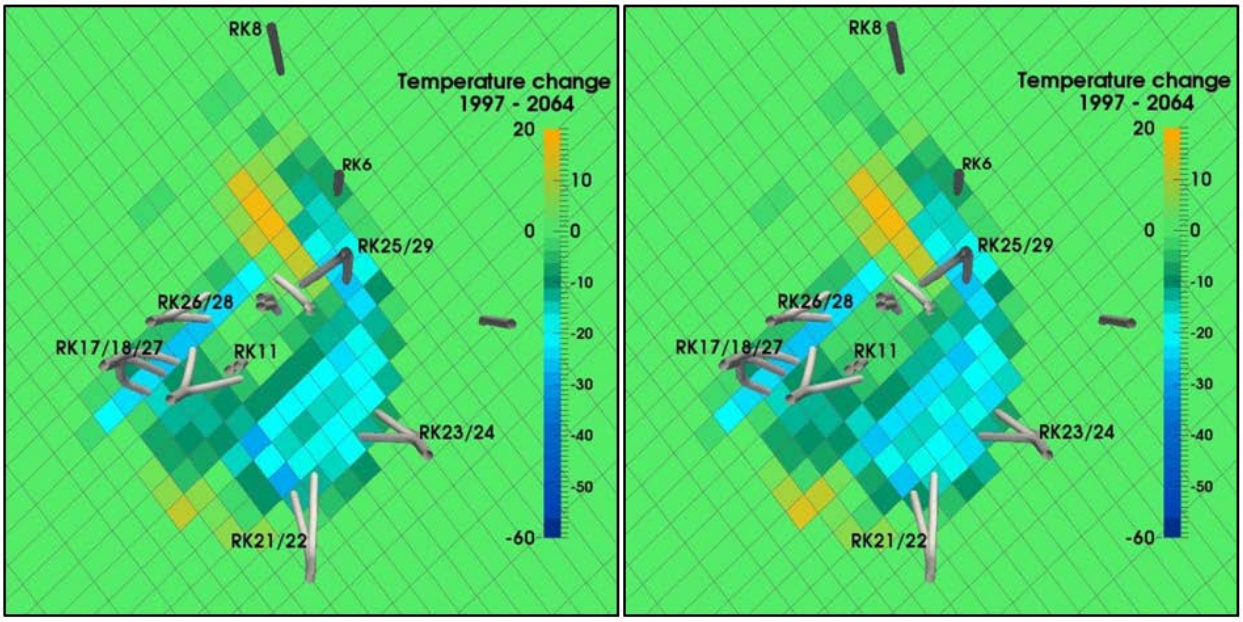

Figure 2. Temperature change 1997-2064, Scenarios 2 and 5

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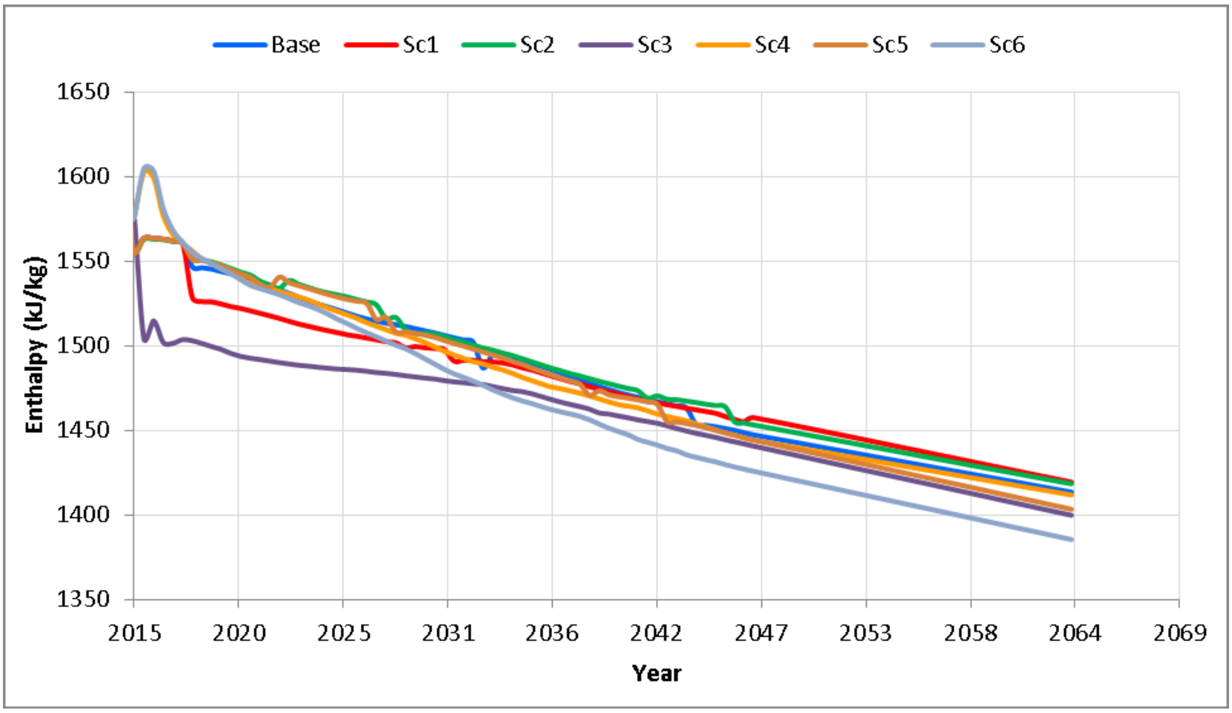

Figure 3. Production enthalpy in all scenarios

4.14 Based both upon this physical reasoning, and upon the model runs showing the same results, there is a clear conclusion that the effects of the proposal are minor indeed.

5. CONCLUSIONS

5.1 The model adequately predicts overall field behaviour in the short and medium term, and is adequate for the present consenting purposes.

5.2 The model indicates that the proposal will produce negligible differences to the reservoir, and, therefore, the environmental impact of the proposal will be negligible. This in turn illustrates the sustainable nature of the development project.

6. REFERENCES

Grant, M.A., 2015 “Rotokawa model review and resource sustainability commentary” MAGAK report AEE APP 2

Maunder, B., 2016 “Rotokawa geothermal power project Geoscience review of resource consent applications” EarthConsult report

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of applications by the **Rotokawa Joint Venture Limited** to Waikato Regional Council for Resource Consents for the Rotokawa Geothermal Development

STATEMENT OF EVIDENCE OF DR EDWARD KAZIMIERZ MROCZEK

1. INTRODUCTION

Qualifications and experience

1.1 My name is Edward Kazimierz **(**Ed) Mroczek. I am a chemist with thirty years' commercial and research experience in geothermal and environmental chemistry. I am a Senior Scientist at GNS Science in the Department of Geothermal Sciences.

1.2 I hold the qualifications of BSc (1976), BSc Hons (1977), PhD (1984), all from Victoria University of Wellington. I joined the Department of Scientific and Industrial Research in 1986 and since 1992 have been employed by the Institute of Geological and Nuclear Sciences Ltd. (GNS Science) based at the Wairakei Research Centre in Taupo.

1.3 I have worked on many projects involving reservoir chemistry and the exploration of and production from active geothermal systems in New Zealand and internationally (Japan, Philippines, Turkey, Indonesia, Uganda, Australia and Papua New Guinea).

1.4 I have published over 40 conference and peer reviewed papers, over 20 abstracts-only presentations and over 100 client reports.

1.5 Since 2003 I have been seconded to Contact Energy Ltd for 20% of my time supporting its production and reservoir chemistry programmes at four of its geothermal fields.

1.6 I was the Research Programme Leader of the GNS Science Geothermal Programme from 2002 to 2007, with responsibility for collaborative research involving more than 20 investigators from GNS, other New Zealand institutions (including the University of Auckland and Industrial Research Ltd) and international collaborators.

1.7 I was the Programme Leader from 2013 to 2015 of the GNS Waste to Wealth Programme researching the extraction of valuable components in geothermal brine.

1.8 I have been a member of the New Zealand and International Geothermal Associations since 1992 and served as Secretary for the New Zealand Geothermal Association from 1992 – 2004.

Purpose and scope of evidence

1.9 The purpose of my evidence is to:

(a) Summarise and evaluate the changes in the surface thermal feature waters and shallow groundwater composition and chemistry since the commencement of production in 1997.

(b) Assess the effect of the proposed consent increase on the surface features and shallow wells composition and chemistry.

(c) Evaluate the proposed monitoring changes for surface thermal features and shallow wells.

1.10 My evidence is set out as follows:

(a) Brief summary of geothermal chemical concepts to explain the observed composition of the Rotokawa shallow groundwater and thermal feature discharges (Section 3).

(b) Description of Rotokawa shallow groundwater and impacts due to geothermal development (Section 4).

(c) Comment on the proposed ground water monitoring plan proposed in the Waikato Regional Council (WRC) Staff Report and the issues raised by Dr Brian Maunder in his review of the RJV resource consent application for the Waikato Regional Council (Section 4).

(d) Description of the Rotokawa thermal features and impacts due to development (Section 5).

(e) Proposed changes to thermal feature and shallow groundwater monitoring (Section 6).

1.11 A summary of my evidence is set out in Section 2 below.

Expert Witness Code of Conduct

1.12 I have been provided with a copy of the Code of Conduct for Expert Witnesses contained in the Environment Court's Practice Note 2014. I have read and agree to comply with that Code. This evidence is within my area of expertise, except where I state that I am relying upon the specified evidence of another person. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

2. SUMMARY OF EVIDENCE

2.1 For the purposes of assessing the potential effects of the geothermal production on the shallow groundwater and thermal features:

(a) I have reviewed the chemical characteristics of the Rotokawa shallow ground water and thermal features.

(b) I have explained how these may change naturally or by impacts from geothermal production

(c) I have found that there were impacts on the shallow groundwater in the form of increasing chloride concentration by between 10-25 mg/L per year from 1997 to 2009. The increases were most likely in response to over pressurisation of the Intermediate Aquifer and had ceased well before the commission of the Nga Awa Purua Power Station in 2010.

(d) Subsequently beginning in 2011 there was point source contamination of the shallow groundwater in monitor well RKM1. I explain how in the context of the geothermal field the environmental impact of this is minor.

(e) The over pressurisation also activated a spring in a previously area of hot ground north east of the Rotokawa Power Station. There has been no effect of changes (flows or chemical characteristics) on the Significant Geothermal Features located at the Rotokawa Lagoon – Lake Rotokawa that can be attributed to geothermal development.

(f) The over pressurisation was solved by having the operational flexibility to move injection elsewhere in the field.

(g) I have concluded that the inclusion into the groundwater monitoring programme of the infield monitor wells RKM6, RKM7 and RKM8 is not warranted at this time.

(h) I have concluded that the effects of extensive geothermal development on the shallow groundwater and thermal features over 19 years of intensive monitoring are very small and of no consequence. Given this and supported by the mathematical modelling evidence presented elsewhere I am confident that there will be no deleterious impact on the shallow groundwater and thermal features associated with the small increased take from 65,500 tonnes per day (t/day) to 75,500 t/day.

3. GEOTHERMAL FEATURE AND SHALLOW GROUNDWATER CHEMISTRY

3.1 This section presents a brief summary of geothermal chemistry of surface feature discharges and shallow groundwater. The purpose is to set the scene for understanding the temporal chemical changes observed in the monitoring data for consideration in greater detail in Sections 4 and 5.

Key elements of Rotokawa shallow geothermal water chemistry

3.2 The composition of geothermal water and steam (generically called “fluids”) depends on the temperature, pressure, rock types and mixing with different water types. Mixing can occur naturally in shallow aquifers as well as deep within geothermal systems.

3.3 The constituents of geothermal fluid are divided into two categories, conservative and reactive. An example of a conservative constituent is chloride (Cl) as it cannot be removed from the fluid by chemical reaction. The concentration can, however, increase in response to boiling (due to evaporation) and decrease by mixing with fluids containing less Cl (e.g. rainwater) but its concentration does not change with changes with temperature. Therefore, if the Cl concentration is only slowly changing that implies that there are small amounts of mixing or boiling.

3.4 In contrast, the reactive constituents can change concentration in response to changes in reservoir temperature caused by boiling and mixing (e.g. dissolved silica precipitates due to cooling) or through reaction between water constituents and rock.

3.5 For example hydrogen sulphide gas (H_2S) is absorbed by oxygenated and steam heated water and converted to highly acidic non-volatile sulphuric acid, forming what is called an acid-sulphate water. The acid-sulphate water may also mix with the deep higher Cl geothermal fluid before discharging at the surface resulting in acidic water which is high in both sulphate (SO_4) and Cl. Rotokawa thermal features are primarily acidic (low pH) with high concentrations of both Cl and SO_4.

3.6 The shallow groundwater and surface thermal features are formed from mixtures of geothermal waters, gases and groundwaters. At Rotokawa there are three geothermal water types:- pH neutral high Cl fluids (~ 900 mg/L in the South East) similar to the waters produced by the power station production wells; low pH shallow acid-sulphate waters and waters high in dissolved carbonates. The sum of dissolved carbonates is reported as "total bicarbonate" (Total HCO_3). Acid waters are often low in Total HCO_3 as the dissolved carbonates are present as dissolved carbon dioxide (CO_2) gas which is easily lost from solution, whereas alkaline waters are often high in Total HCO3 as the dissolved carbonates are present in solution as the non-volatile bicarbonate anion (HCO_3^-).

3.7 The dissolved acid gases (CO_2 and H_2S) and sulphuric acid react with rocks to form clays such as kaolinite. This process increases the pH of water which can still contain appreciable amounts of SO_4. Kaolinite is the principal deposit (not silica sinter) in the main Rotokawa geothermal springs discharge area of the Rotokawa Lagoon.

3.8 Different ratios of these waters types, due to more or less boiling and/or mixing, result in different characteristics of the spring fluids. This means that any group of springs in close proximity can also be variably diluted with shallow groundwater and/or steam heated acid-sulphate water which can give rise to a wide range of compositions by mixing with the same deeper geothermal parent water. Many Rotokawa springs within metres of each other have different compositions.

3.9 The water composition, together in combination with reservoir engineering and geological interpretation enabled the hydrology of the Rotokawa geothermal field to be inferred; for example, there are three chemically distinct geothermal aquifers ("Shallow", "Intermediate" and "Deep"), where the cooler inflows of recharge water are occurring, where the hot upflow zone is located and enables assessment of production impacts on shallow groundwater resources and thermal springs.

Sources of data

3.10 Since 1998 annual reports list chemical and physical (flow and temperature) trend plots of shallow groundwater and thermal surface features. The most recent is the 2014-2015 Rotokawa Annual Report, discussed in more detail in the reports by Powell (2015 A & B) submitted as part of the RJV's Consent Application. The impact on geothermal groundwater and thermal features has been predicted by a numerical model (Hernandez, 2015), which uses this data. Mr Hernandez' evidence presents the model and its outputs. The groundwater trench soakage was summarised in a Mighty River Power (now Mercury) memo to the Rotokawa Peer Review Panel (Buscarlet and Jackson, 2014). A good overview of the natural features is found in the recent photographic and chemical survey (Macdonald et al., 2016), effects of groundwater in Zemansky and Mroczek (2006) and an excellent Rotokawa review was recently presented by McNamara et al., (2016; and references within). The shallow groundwater and thermal feature trend plots and detailed interpretation may be found in these publications.

4. ROTOKAWA SHALLOW GROUNDWATER

4.1 Geological data shows that the shallow groundwater aquifer is located in host rock materials that may be described as deposits containing various sized fragments ejected by a volcano. The particle sizes vary from fine sand to coarse blocks, but can include a clay or silt matrix. The ability of these materials to transmit water is expected to vary considerably, both with regard to water infiltrating in the unsaturated zone and percolating down through it to the water table aquifer and once there flow laterally through it. The shallow materials are underlain by impermeable lake sediments which mark the beginning of the deeper "Intermediate" Aquifer.

4.2 Regular monitoring at four infield monitoring wells, RKM 1 to 4, commenced in 1996, prior to the commission of the Rotokawa Power Station in 1997. The well depths range from 14 to 25 m below ground level. Additional monitoring at well RKNEC, which is located outside the geothermal consent area, commenced in 2002. The locations of these monitoring wells is shown in Figure 1 of this evidence.

Description of groundwater composition

4.3 The temporal monitoring data (temperature, water level, pH, SO4, Total HCO_3) is presented in documents supporting the RJV Application. The features of geothermal chemical data presented in Section 3 enables the characteristics of the waters present in the monitor wells at the commencement of production in 1997 to be described and understood, namely:

(a) The concentration of Cl is a proxy for the fraction of deep geothermal water in the mixture. RKM2 has the highest concentration (approx. 600-700 mg/L) while RKM1 has near zero concentration (< 5 mg/L). RKNEC composition with high Total HCO_3 (~ 225 mg/L), low Cl (66 mg/L) and negligible SO_4 (~14 mg/L) is a typical composition of a peripheral geothermal well water. An increase or decrease in Cl is indicative of more or less of deeper geothermal water fraction.

(b) The pH is inversely correlated with SO_4 and directly correlated with Total HCO_3. RKM3 has the highest SO_4 (~ 400 mg/L), lowest pH (~ 2.8) and near zero Total HCO_3. In contrast the highest Cl well RKM2 contains appreciable SO_4 (~ 200 mg/L) and Total HCO_3 (~100 mg/L) and is near neutral (~ pH 7). Both SO_4 and Total HCO_3 typically have high scatter as they are more affected by near surface processes (e.g. infiltration of rainfall).

(c) Temperatures vary between 30°C at RKM1 (near zero Cl) to ~85°C in RKM3 which has the highest concentration of SO_4. The high temperature and high SO_4 in RKM3 are correlated and are due to steam heating. Although RKM1 water composition is similar to that expected for natural fresh groundwater, the temperature exceeds what is considered normal (~ 12°C).

(d) The potentiometric water surface derived by GNS (independently of Mercury) shows the groundwater flow to be generally to the north (at roughly 45° to the Waikato River).

Changes since 1997

4.4 The chemical monitoring data shows that all the wells (except RKM1) were impacted by naturally occurring geothermal waters which pre-date the commissioning of the Rotokawa Power Station. Each well's individual response to production induced changes will vary depending on the factors discussed in Section 4.1 as well as their location with respect to the groundwater flow, geothermal wells and shallow unlined testing ponds.

4.5 The geothermal aquifers have experienced two key events: the commencement of production and injection in 1997 and increased production and injection in 2010. In 1997 the average daily consented take was 15,000 t/day which increased to 60,500 t/day in 2010 (and shortly thereafter in 2011 to 65,500 t/day) with the commissioning of the Nga Awa Purua Power Station. Injection, initially to the Intermediate Aquifer, was ~400 t/hr geothermal fluid after heat extraction.

4.6 The over pressurisation of the Intermediate Aquifer led to increases in spring flow (Section 5.13) which was managed by reducing injection to 200 t/hr by May 2005 and shift to deeper injection in the South East. Shallow injection at ~250 t/hr has been used to attempt to minimise external casing corrosion of wells, and whilst not used for this purpose since around September 2015, corrosion mitigation through shallow injection may be required into the future.

4.7 RKM2, RKM3 and RKM4 all increased steadily in Cl by between 10-25 mg/L per year. This is good evidence of impact on the geothermal fluids (Section 3.3) due to the Rotokawa development. The monitor wells are down gradient of the production wells and unlined ponds or in close proximity to them.

4.8 The increase in Cl ceased in RKM2 sometime around 2002, in RKM3 in 2005 and in RKM4 in 2009. No data is available to assess the reason for the cessation which may be due to a reduction in surface testing discharges in the period after commissioning in 1997 but also due to the reduction in 2005 in Intermediate Aquifer injection from 550 t/hr to 200 t/hr. The concentration of Cl in the Rotokawa Geothermal Power Station injection fluid (geothermal water + condensate) was about 500 mg/l, close to that already naturally present in the shallow unconfined reservoir. So any progressive mixing of the two fluids would result in mixture only changing slowly over time. Condensate (zero Cl) injection in the Intermediate Aquifer commenced only in 2010 after the commissioning of the Nga Awa Purua station.

4.9 Importantly there was no impact observed due to the commission of the Nga Awa Purua station. However in 2011 the RKM1 Cl increased from ~ 5 to 1200 mg/L Cl accompanied by a 2 m water level increase coincident with an Cl increase in RKM4 from ~ 330 to 600 mg/L. A Mercury memo (dated 23/4/14) to the Rotokawa Peer Review Panel suggests the increase was due to soakage in an unlined trench located less than ~ 50 m (directly up-gradient) from RKM1. The increase in RKM4 was unexplained but ascribed to unrelated reservoir effects or possibly historical soakage. It is my view that the increase in RKM4 may be related to the trench soakage near RKM1. A cursory inspection of the data suggests the observed increase in Cl at

RKM4 is approximately matched by the expected decrease in SO_4 given the concentrations in RKM1.

4.10 The large Cl increase observed in RKM1 suggests a direct flow without any dilution by local groundwater. The most recent data (July 2015) shows that the RKM4 Cl has deceased to previous levels, while that in RKM1 has not. Modelling by Mercury suggests a direct line to RKM1 and then onto the river: a not unexpected result, given the close location of the trench to RKM1.

4.11 The impact on the shallow geothermal reservoir shown by the monitor bores prior to the RKM1 spike is minimal, in the context of being located in the bounds of the geothermal field and given the naturally occurring impact prior to development. It is my opinion also that at RKM1 the effects are now very localised given that the quantity of trench soakage has decreased (Mason Jackson communication 10/8/16) and the changes observed at RKM4 and in the Waikato River seep known as the Sunset spring.

4.12 The RKM4 Cl and SO_4 concentrations have decreased and are presently at typical background levels. The Mercury memo (dated 23/4/14) suggests that the spike at 800 mg/L (sampled March 2013) in the Sunset spring may be related to the trench soakage (via RKM1). The sample collected in March 2012 (approximately 1 year after the concentration increase in RKM1 was observed) was 330 mg/L (below average). By March 2014 the concentration spike observed in March 2013 had decreased back to 470 mg/L typical of historical values; even though the Cl levels of RKM1 at that time still remained high. Either the spike observed in 2013 is unrelated to the soakage or the reduction in soakage means that expected dispersion, mixing and dilution, as the fluid flows away from the point source, rapidly reduces concentrations to near typical background. Yearly samples do not offer any resolution for seasonal effects nor progressive changes related to effects over shorter time periods.

4.13 There are no potable water wells in the Rotokawa consent area that are affected by this impact and the only environmental consequences would be increased levels flowing to the Waikato River. Even at worst case of 10,000 t/day (0.12 m^3/s) directly to river, rather than groundflow, the dilution by the large flow of the Waikato River (mean flow ~ 160 m^3/s) means that typical production well concentrations are diluted 1400x down to natural ambient levels.

Impact on Proposal on Shallow Geothermal Groundwater

4.14 It is my opinion that the RJV proposal to increase the geothermal take from 65,500 t/day to 75,500 t/day will not have a detrimental impact on the shallow groundwater, and no greater than that already observed since production commenced in 1997. Most of this minor change occurred prior to the commissioning of Nga Awa Purua in 2010, most likely due to injection into the shallow Intermediate Aquifer. Scenario modelling presented by Mr Hernandez shows that the predicted aquifer pressure declines are very similar to baseline (no increase in take). As the AEE submitted with the RJV application explains, the small pressure decline in the geothermal aquifers will have minimal effect on the pressure in the fresh groundwater aquifer. This is because of the pressure – moderating effect of Lake Rotokawa. The Lake Rotokawa water level maintains the groundwater pressure above the geothermal field so that any pressure decline in the geothermal aquifers is buffered by recharge from the lake. This is probably why the four fold increase in take in 2010 caused no discernible change in shallow groundwater quality, as monitored by the monitor bores, with the exception of the recent localised RKM1 contamination by nearby trench soakage which in itself has little environmental impact.

Groundwater Monitoring Plan

4.15 In his evidence, Mr Mason Jackson presents a Table of groundwater monitoring matters agreed and those that are not agreed between the RJV and WRC Staff. The staff recommendation calls for quarterly (3 – monthly) monitoring of infield wells as well as outfield groundwater wells. I support this increased emphasis in the monitoring of the fresh water resources and this has also been accepted by RJV. The recommended increased outfield monitoring is also supported in the geoscientific review undertaken by Dr Maunder (Maunder, 2016) where he is of the opinion that the greatest risk of the geothermal production is to the fresh groundwater resources utilised by users on the periphery of the geothermal field.

4.16 I also support Dr Maunder’s recommendation, and the staff recommendation to sample the new outfield wells quarterly until baselines are well established. My experience in monitoring is that resolution is lost is when sampling is undertaken with less frequency. However once the baseline has been seasonally established then reducing the frequency to six-monthly is acceptable.

4.17 However in my opinion there is no need to increase sampling frequency from six monthly to quarterly of the infield wells RKM1-RKM4 and outfield well RKNEC as recommended by the WRC staff. For these wells, long (20 year) and well established monitoring records exist which can be used to assess whether future changes are within control limits. Dr Maunder shares the the view that six-monthly sampling frequency is adequate for well-established monitoring records.

4.18 The WRC staff and RJV have also agreed to sample other existing infield wells RKM6, RKM7 and RKM8 with WRC recommending these be sampled quarterly. I share Dr Maunder's view that there needs be a clear sampling objective apart from sampling wells simply because they exist. In my opinion the objectives of monitoring the shallow groundwater are adequately served by wells RKM1-RKM4 (and Waikato River Sunset Spring). The monitoring of these shallow wells showed that there was little impact on the unconfined shallow aquifer in response to the over-pressurisation of the Intermediate Aquifer.

4.19 All three of the "new" wells (RKM6, RKM 7 and RKM 8) proposed to be added to the sampling programme are hot and well above 100°C, which presents difficulties and greatly increases the expense in collecting representative samples. RKM8 penetrated only into the shallow unconfined aquifer, already well served by wells RKM1-RKM4. It is very hot and the latest 2010 temperature survey showed this well to be 160°C at 80 m depth. Of the two remaining wells RKM7 is impermeable and may not give representative aquifer samples (Lim, 2008A) while in RKM6 airlifted water samples were collected and were identified as being either reinjection water from RK20 or deeper reservoir water (Lim, 2008B). So RK6 fluid appears not to be representative of the Intermediate Aquifer fluids.

4.20 Therefore it is my opinion that regular monitoring of these wells is not warranted or required. However I would recommend that consideration be given to undertaking pressure and temperature surveys in these wells followed by downhole sampling to adequately characterise the reservoir fluids to give a snapshot of the resource at this time.

5. ROTOKAWA THERMAL FEATURES

Description of the Monitored Features

5.1 Rotokawa has extensive surface geothermal features comprising boiling springs, hot pools and fumaroles. The location of the geothermal features being monitored is shown in Figure 2 of this evidence. Figure 2 also shows additional features RJV proposes to add to its photographic monitoring programme.

5.2 The significant geothermal area is located in the south of the field and comprises 1 ha of discharging springs ("Rotokawa Lagoon") which feed into the shallow acidic Lake Rotokawa. Lake Rotokawa drains into Parariki Stream which flows on to the Waikato River. One Lagoon spring (New West Spring), Parariki Stream at the Lagoon outlet, a spring at the head of Parariki Stream (Parariki Spring) and at the confluence with the Waikato River are all monitored.

5.3 North of the Lagoon a large crater is sampled as is the Rotokawa Fumarole at the top of nearby hill. A seep in the Waikato River (Sunset Spring discussed in Section 4.12) and Toby/Ed's Spring is located just north-east of the Rotokawa Power Station.

5.4 Many features have been regularly monitored since 1994, well before the commissioning of the Rotokawa Station in 1997. This is a vital aspect of monitoring as the natural variation can be compared to changes observed after the commencement of production.

5.5 Data also exists (historical and recent) for many other features that are not regularly monitored.

5.6 The important factors which give the natural water features their chemical characteristics are given in Section 3. As for fumaroles, as the pressurised hot geothermal water rises, it boils and steam is formed. The steam can travel independently of the boiled water. At higher elevation, above the water table the steam discharges in fumaroles but can also condense and form highly acidic water in the ground and in pools and depressions. As this water flows naturally to lower elevations it variably mixes with the rising geothermal waters resulting in the wide range of observed compositions of the thermal features at Rotokawa (Section 3).

Impact of the Thermal Features to Geothermal Development

5.7 Springs are sensitive to geothermal development. The springs at the famous Geyser Valley at Wairakei ceased discharging within 10 years of the commencement of production. Similarly, many features were severely impacted at Rotorua (but declined over a longer time period) due to over exploitation of the resource.

5.8 The chemical and physical changes that can occur are well understood and would be easily recognised in the monitoring undertaken to date. Typically, a decline in deep aquifer pressures caused by withdrawal of fluid causes spring flows to reduce and a reduction in the proportion of the deep geothermal component (e.g. Cl) with a corresponding increase in the shallow component (e.g. SO_4). Lowering pressures may induce boiling which can maintain temperatures but eventually temperatures may decline and the spring becomes extinct or becomes a hot pool of highly acidic steam condensate with little to no deep water component.

5.9 Conversely contamination of spring source aquifers by reinjection fluid would similarly be recognised (the contamination of RKM4 inferred to be from trench soakage is a good analogue, Cl and pH up; SO_4 down, Sections 4.10 - 4.11).

5.10 The confounding issue is that thermal features do naturally change and can cease discharge; for example, the Lagoon discharges have naturally lost considerable silica (compared to the conservative Cl) which can block fluid flow to the surface. Therefore, in assessing impacts, comparison of a number of features or an integrated measurement (e.g. total Lagoon flow to the Lake) is of more value than specifically focussing on this or that individual feature. A case in point is the cessation in 2000 of flow in the originally monitored Lagoon West Spring. No other nearby pools suffered reduced flow or abnormal changes in composition at that time. Hence I infer that the change was unrelated to geothermal development which is supported in hindsight by the lack of any other progressive changes to date.

5.11 Mr Hernandez states that the Lagoon thermal feature flow will decrease by 34% caused by a pressure drop of 4 bar in the Intermediate Aquifer. Mr Hernandez' model does not take into account the effect of the surrounding groundwater on the predicted flow at the surface so the predicted decrease is worst case. I expect that the buffering of shallow pressure by Lake Rotokawa will result in an increased proportion of the shallow acidic component (paragraph 5.8) rather than a reduction in total flow. An increase in cold fresh groundwater component which would have a greater detrimental impact, is not expected in this location.

5.12 As long as springs keep flowing the silica concentrations will not be affected by Mr Hernandez' small predicted enthalpy decline of 125 kJ/kg in the Intermediate Aquifer. This is because the dissolved silica in the spring waters is at the concentration expected at the surface discharge temperature. The discharge concentration is not controlled by the higher dissolved silica concentrations found in the hotter deeper reservoir waters where the enthalpy decline is predicted to occur.

5.13 Since the discharges are already very acidic, an increase in the acid component will have little impact on the Lagoon and spring character and chemistry of the fluids. The springs are not actively depositing silica sinter (paragraph 6.2) and minor declines in silica will similarly have little impact on the character of the springs. Correlating the changes in Lagoon flow and composition against measured Intermediate Aquifer pressures and model predictions would be an important aspect of assessing the impacts of production.

5.14 There are other impacts on the Lagoon springs that are unrelated to geothermal development. The Lagoon was periodically flooded by the Lake which was remediated by lowering the Lake level in 2013. Mr Duncan Graham (GNS Science) who has monitored the Lagoon area since 1997 reports that severe flooding occurs from higher ground which brings debris onto and into the Lagoon springs ("perhaps 6 times a year"). The debris is clearly seen in the monitoring photographs of New West Pool. This could potentially severely affect an individual feature but is unlikely to stop flow from the Lagoon as a whole nor change the chemical characteristics.

5.15 The monitoring data for the Lagoon – Lake Rotokawa – Parariki features (temperature, pH, Cl, SO_4) shows little change or deleterious trends as a consequence of geothermal development at Rotokawa. Similarly the Crater water and more surprisingly the Rotokawa fumarole shows no trends as a consequence of geothermal development. Although in the latter case the fumarole steam composition has large scatter and is unlike that of the deep reservoir gas composition due to natural modification as it flows to the surface.

5.16 Nevertheless development has impacted on surface features north east of the Rotokawa Power Station where injection over pressured the Intermediate Aquifer resulting in the discharge of a hot spring in an area of previously hot ground (Toby/Ed's Spring). The spring ceased flowing in 2006 after reinjection into the Intermediate Aquifer was reduced (paragraph 4.6). The composition of the waters is acid water and more similar to the Lagoon springs and unlike that of the reinjection water at that time. The Cl has been slowly trending downwards (900 mg/L in 2002 to 800 mg/L in 2015)

5.17 The last spring monitored is the Waikato River seep "Sunset Spring". This spring composition has higher scatter due to effects of the river and cannot be sampled at high river flows. A spike in March 2013 was attributed to contamination by trench soakage (Section 4.12) but this is not conclusively proved. The trends support no impact from geothermal development on this spring composition.

5.18 To date there have been no detrimental effects on the natural thermal features and it is my opinion that the RJV proposal to increase the geothermal take from 65,500 t/day to 75,500 t/day will not have any additional deleterious changes for the same reasons as for the shallow geothermal groundwater discussed in Section 4.15. The long uninterrupted monitoring record gives high confidence that no effects have occurred to date and sets a stringent bench mark for the future. The unintended injection into the Intermediate Aquifer caused Toby/Ed's Spring to discharge to the north but fortunately with no adverse effects on the significant geothermal area in the south.

5.19 It is instructive that this over pressurisation was able to be solved because of consents which allowed the injection to be redirected deeper to the south-east. As this example shows, geothermal development can give rise to different responses to those anticipated. In my opinion the key to tackling adverse surface effects, in the remote possibility should they arise, is in having the operational flexibility in how and where production and injection is managed.

6. COMMENTS ON CHANGES PROPOSED TO THE GEOTHERMAL FEATURES MONITORING PROGRAMME

6.1 Mr T Powell recommended changes to the Geothermal Features Sampling Programme (Powell, 2015 B) in his report that forms part of the AEE for this application. I assess these individually in turn. Ideally the features chosen for monitoring should give a good geographical coverage over the consent area and preferably initially be actively flowing, high Cl springs (i.e. deep feeding) with little mixing with shallow surficial (acidic or fresh) waters. In contrast, at Rotokawa the significant features are all in relatively close proximity concentrated in the South, primarily in the Lagoon area but also Parariki Spring and are a mix of deep Cl water and shallow acid-SO_4 waters. Some features are stagnant and are therefore impacted by evaporative effects.

6.2 There is one misconception in Mr Powell's report in that he states the Rotokawa springs are actively depositing sinter. This is not strictly correct as the fluids are relatively low in silica and too acid for this to occur subaqueously. However, subaerial silica deposition does occur where water is able to further cool and be concentrated by evaporation; for example at the Lagoon outlet. The primary deposit around the Lagoon area is kaolinite clay.

6.3 Sampling Recommendations

(a) Continue yearly sampling of the Waikato River seep, Sunset Spring. I agree that this is an important spring to sample for monitoring groundwater contamination. At times of high trench soakage, the RJV may consider an increased sampling frequency.

(b) Discontinue yearly sampling of Toby/Ed's Spring in favour of photographic surveys. I agree with this recommendation, as utilising stagnant features for monitoring is not good practise as the composition can be highly influenced by surficial effects unrelated to the geothermal effects (e.g. evaporation or dilution by rainwater).

(c) Discontinue sampling of Crater Spring. I agree with the recommendation to discontinue sampling Crater Spring. The composition is similar to the other acid springs and is essentially a stagnant feature that may be hazardous to sample.

(d) Continue sampling the West Pool, Parariki Spring and the Lagoon Outlet. Mr Powell suggests that all these three features be sampled even though there is "some similarity in composition between West Pool and Parariki Spring" and to guard against springs "shifting or drying out". I would concur with these suggestions and strongly support the flow rate measurement from the Lagoon as this is a simple way to integrate all the Lagoon area flows and average composition. This is perhaps the most important and most useful measurement from the Lagoon. The New West Pool composition and the Parariki Spring are of the same acid-SO_4-Cl water type but are distinct from each other. It is the Parariki Spring and the Parariki Stream at the Lake outlet (compared on an annual basis) that appear to be of very similar composition (based on Cl and SO_4). This is perhaps not unexpected.

(e) Discontinue monthly Parariki Stream sampling (at Lake outlet and Waikato River confluence) for Cl and SO_4 and flow in favour of only annual measurements. Mr Powell suggests that annual sampling with flow rate measurements would be sufficient to detect longer term changes. What the monthly sampling and flow measurements have done is show a dramatic seasonal effect on concentrations and flow. The concentrations are inversely correlated with flow (e.g. fresh water runoff dilutes the geothermal waters) but, as Mr Powell's graphs show, more dissolved solids are transported at higher flows. I would suggest that reducing the measurement frequency to quarterly would result in little loss of data resolution for inferring longer term changes. However, given the large seasonal effects, I am of the opinion that decreasing the sampling and flow measurement frequency further would require proof (e.g. sensitivity analysis from mathematical modelling) that these would be able to detect longer term changes as the more frequent sampling.

(f) Discontinue annual chemical monitoring of the Rotokawa fumarole but continue with the photographic survey. In my opinion monitoring of the fumarole should be abandoned altogether. Mr Powell points out the composition of the fumarole steam has not shown any trend over the last 18 years. This is surprising as one of the well-known longer term consequences of geothermal production is degassing of the geothermal reservoirs resulting in declining gas concentrations. However, my point is that unlike for maintaining spring flows, there is no economic production response that could be implemented if the gas concentrations were to either increase or decrease. There is no point to the monitoring effort except for general interest.

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APPENDIX – FIGURES

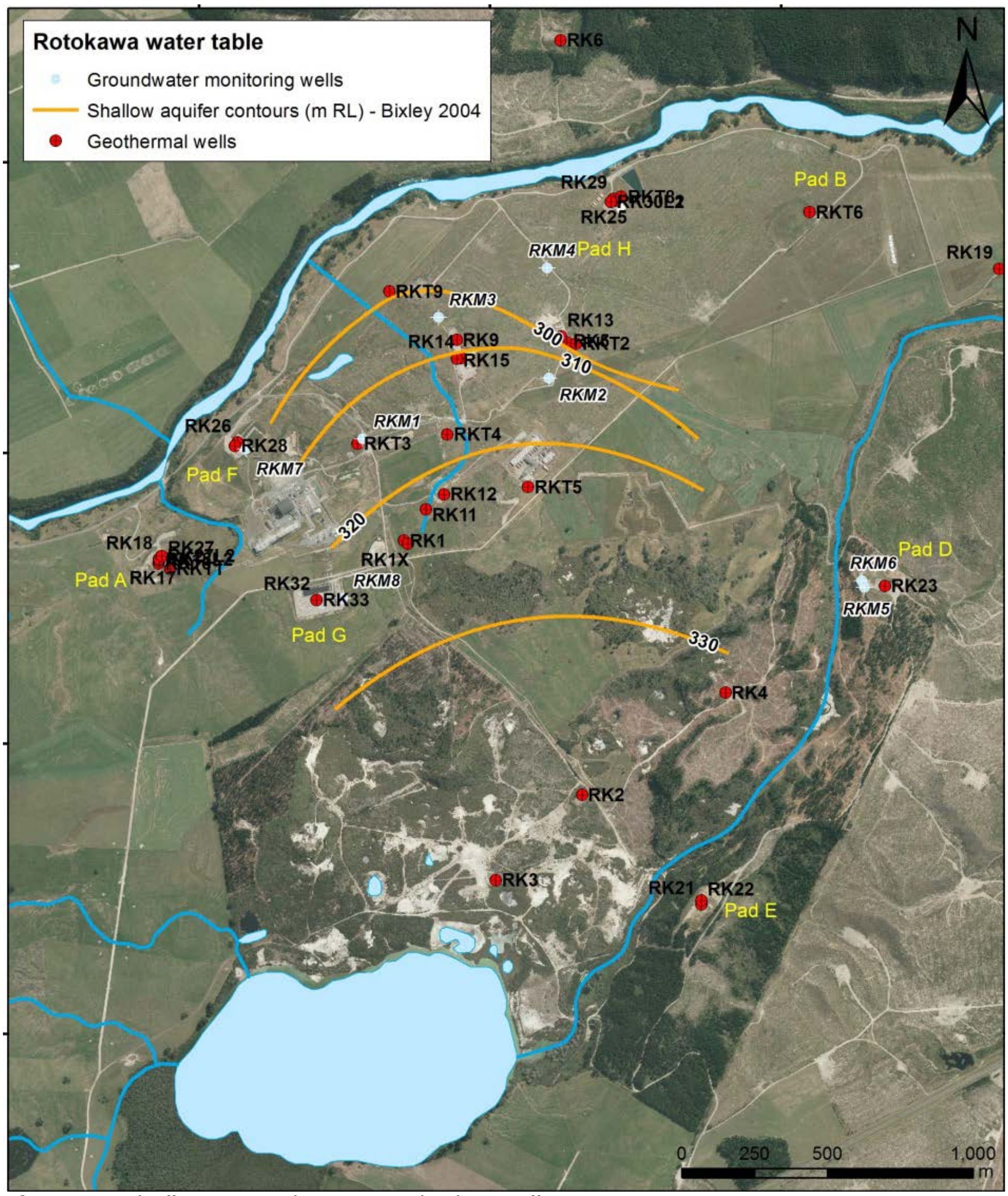

Figure 1: Shallow groundwater monitoring wells

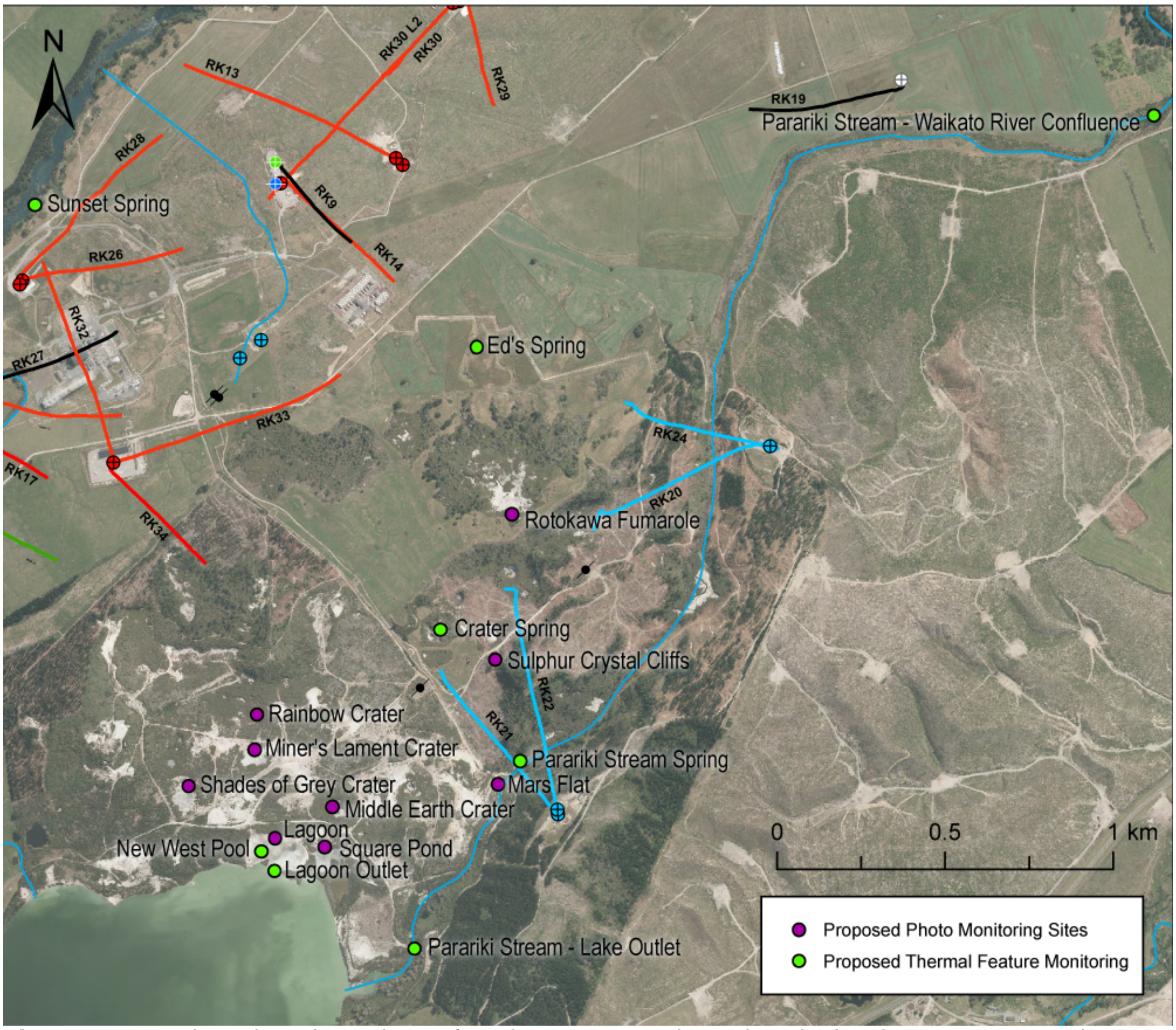

Figure 2: Map of Monitored Geothermal Surface Features (green) and other features proposed to be added to photographic records (purple).

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of applications by the **Rotokawa Joint Venture Limited** to Waikato Regional Council for Resource Consents for the Rotokawa Geothermal Development

STATEMENT OF EVIDENCE OF STEVEN MICHAEL SEWELL

1. INTRODUCTION

1.1. My qualifications and experience are set out in my first brief of evidence.

Purpose and scope of evidence

1.2. The purpose and scope of this second statement of evidence is to provide an overview of the potential effects of ground level changes, commonly referred to as subsidence, from the proposed activities. My evidence will include:

(a) an overview of the historic ground level changes that have occurred at Rotokawa due to geothermal operations;

(b) the subsidence modelling undertaken to predict potential ground level changes from the proposed activities; and

(c) (c) the potential effects of the predicted ground level changes with particular focus on the potential impact on Lake Rotokawa and thermal features in the lagoon area on the northwest shore of Lake Rotokawa.

2. HISTORIC SUBSIDENCE AT ROTOKAWA

Overview of subsidence at geothermal fields

2.1. Many cases of man-made changes in ground level have been documented due to extraction of groundwater, oil and gas, mining, dam construction and geothermal operations around the world. This has most often been ground subsidence, which is the ground level moving down over time. A less common occurrence is ground inflation, where the ground surface rises, which may occur due to local increases in subsurface pressure. Ground level changes due to geothermal operations are typically in the range of tens of centimetres but ground level changes of several metres have been documented in a number of geothermal fields in New Zealand and overseas.

2.2. Ground level changes induced by geothermal operations arise due to both changes in subsurface pressure and temperature. Net abstraction of fluid from geothermal reservoirs typically results in reservoir pressure decreasing with time. This causes the pore space within the rock layers to contract and/or compact, causing the overlying ground surface to sink. If pressure increases occur, for instance in injection areas, then ground inflation can occur. Cooling of rock in injection areas can also result in subsidence. In this case, the cooling causes the rock itself to contract.

2.3. The amount of subsidence that occurs due to a temperature or pressure change is dependent on the material properties of the rock within and above the zone where the temperature and pressure changes are occurring. Some rocks, such as highly porous sediments or ductile clay-rich rocks, are prone to compaction whereas other stronger rock types, such as lavas, resist compaction. As a result, subsidence can vary significantly across a geothermal field and local subsidence anomalies can arise due to local variations in rock properties.

2.4. Changes in ground level generally only become an issue when the changes are large enough to place stress on man-made structures and thereby cause structural damage. Subsidence in some geothermal fields has been large enough to cause minor structural damage to buildings. Subsidence may also alter the drainage of surface water bodies causing water ponding and changing the course of rivers, streams, canals and irrigation channels.

2.5. Subsidence generally occurs in a ‘bowl’ shape, Figure 1 shows a schematic diagram of this. Structural damage most commonly occurs in regions where the subsidence causes compression or extension of the ground. Ground tilt, the change in ground levels per horizontal distance, develops in the region between the margins of the bowl and its centre. This generally causes less structural damage, but can impact on the drainage of surface water bodies.

Historic subsidence at Rotokawa

2.6. Ground levels have been monitored at Rotokawa since 1997 via a local network of levelling benchmarks. Field-wide surveys have been performed approximately every four years since 1997 with partial surveys often on a two-yearly interval. The levelling benchmark network has expanded significantly over time in response to expansion of field operations.

2.7. Figure 2 shows a graph of ground levels over time at a selection of benchmarks for each survey from 1997 to 2015. Over the entire monitoring period from 1997 to 2015, net subsidence has occurred at Rotokawa with maximum total subsidence values of up to 220 mm. Although the net change has been subsidence, a period of inflation did occur from 1997 to 2004 when ground levels rose by up to 50 mm. This was due to increasing pressure in the intermediate aquifer as a result of a relatively high amount of shallow injection occurring over this time. In 2005, the majority of injection was shifted to the deep reservoir which resulted in a decrease in pressure within the intermediate aquifer and consequently, since 2005, ground inflation has ceased.

2.8. Figure 3 shows a map of the net change in ground levels from 1997 to 2015 at Rotokawa. The main area of subsidence (and inflation) at Rotokawa is a relatively small area, approximately 1 km by 1 km, between the two power plants centred on the location of the shallow injection. A broader subsidence bowl covering the entire field also occurs where rates of change have been more subdued.

2.9. Subsidence rates, measured in mm/year, have varied over time, with the highest rates of up to 46 mm/year occurring between 2004 and 2007. Since 2007, subsidence rates have slowed significantly. The most recent levelling surveys at Rotokawa conducted in 2013 and 2015 have shown maximum subsidence rates to be ~10 mm/year, approximately one quarter of the rate observed between 2004 and 2007.

2.10. Although ground level changes have been relatively small at Rotokawa and structural damage due to subsidence has not been documented and is highly unlikely, there is some potential for subsidence to impact on the thermal features in the lagoon area of Lake Rotokawa. This is a unique situation that arises due to the relatively small differences in water levels between the lagoon and the lake itself. Subsidence has the potential to change the relative water levels between the lake and lagoon with the potential for water to flow from the lake to the lagoon, thereby changing the geothermal environment in that area.

2.11. The Parariki Stream drains Lake Rotokawa and the head of this stream ultimately controls the water level in the lake. Therefore, the relative difference in water level between the head of the Parariki Stream and the lagoon is what determines whether or not the lagoon will flood.

2.12. Removal of logs from a collapsed log culvert near the head of the Parariki Stream in March/April 2013 and 2014 by the Department of Conservation allowed the stream to flow more freely and resulted in a 10-20 cm lowering of the Lake Rotokawa water level. Figure 4 shows this change in lake level. Prior to this, there was little difference between the lake level and the lagoon water levels and in strong southerly winds, water from the lake did occasionally flow into the lagoon. It follows that a future change in water level between the lagoon and the head of the Parariki Stream in the order of 10-20 cm could potentially cause the lagoon area to be flooded.

2.13. The difference in water level between the lagoon and the head of the Parariki Stream controls whether or not the lagoon will flood. Consequently, it is the tilt that is induced by subsidence that determines whether or not subsidence will affect the lagoon area. Subsidence itself without any tilt across the lake would be unlikely to cause any issues.

2.14. Historical subsidence in the Lake Rotokawa area has thus far caused tilting across the lake of around 0.25 mm/100 m per year. If this rate of tilt continues for the next 50 years, the lagoon will be approximately 5 cm lower relative to the lake outlet into the Parariki Stream. This is less than half the 10-20 cm drop in Lake Rotokawa’s water level that was observed after removal of logs from the Parariki Stream. Therefore, the current rate of tilt would not result in inundation of the lagoon.

3. SUBSIDENCE MODELLING

Modelling Process

3.1. The Rotokawa Joint Venture contracted GeoMechanics Technologies to construct a geomechanical model in order to predict ground level changes due to the proposed additional abstraction from the reservoir and the longer timeframe for this resource consent application. The process of modelling subsidence generally follows three steps which I will now outline.

3.2. First, the area to be modelled is divided into small blocks and the blocks are assigned rock property values based mostly upon the geology of the area. Two rock properties control the amount of subsidence or inflation that occurs due to changes in pressure and temperature, namely rock compressibility and thermal expansivity respectively.

3.3. For the Rotokawa model, rock compressibility values were initially assigned based on available measurements that had been previously made on cores from Rotokawa. Where measurements were not available, values from similar rocks in other geothermal fields in New Zealand were used.

3.4. The next step in the subsidence modelling process is to calibrate the model using available levelling survey data. Subsurface temperature and pressure changes are input into the model and are usually taken directly from reservoir numerical models. If a reasonable match between the modelled level changes and the measured level changes is not obtained, then the modeller adjusts the rock properties and the model is re-run. This process is repeated until a satisfactory match between measured and modelled level changes is obtained.

3.5. For the Rotokawa subsidence model, GeoMechanics Technologies chose to calibrate the model with levelling data between 2009 and 2013, omitting levelling data before this period. This was done for several reasons: the first being that levelling survey data prior to this period did not cover the entire field and significant gaps in the data occurred; secondly the level changes prior to 2009 were mostly inflation and therefore unrepresentative of the subsidence that had occurred since 2009; and thirdly, the production and injection locations and volumes were significantly different before and after 2009.

3.6. The relatively short calibration period for the model is not ideal and this does increase the uncertainty in the predictions of future level changes from the model. However, given the rates of subsidence were higher over the calibration period compared to the most recent subsidence rates observed between 2013-2015 in the levelling surveys, it is more likely that the model will over predict the level changes. For this reason, the model is more likely to be conservative in terms of assessing potential effects from subsidence.

3.7. The final step in the modelling process is to use the model to predict changes in ground level at some point in the future. Subsurface temperature and pressure changes are input into the model from reservoir numerical model simulations. By doing this, different production and injection scenarios can be simulated and the resultant changes in ground levels predicted.

3.8. Four different production and injection scenarios were run in the subsidence model for Rotokawa to assess the potential subsidence-related impacts of the proposed increase in take from the reservoir. These were the base case scenario which simulates no change to the current production and injection, and the three 'stress test' scenarios which simulate an additional 10,000 tonnes per day take. The stress test scenarios assume an unrealistic instantaneous change in production rates starting in mid-2015 and are therefore conservative in that they represent the absolute maximum amount of change in production from the reservoir.

3.9. The three stress tests vary only slightly in the location of production and injection. Case 3 has 1000 tonnes per hour of production from beneath the new consent area near Lake Rotokawa, Case 4 has injection of 1000 tonnes per hour in the new consent area near Lake Rotokawa and Case 6 has no production or injection within the new consent area.

3.10. The time period for all four of the simulations was 50 years from mid-2015 to 2064.

Summary of modelling results

3.11. The match between measured and modelled level changes for the calibration period for the Rotokawa model was considered good. The model reproduced the main subsidence bowl matching approximately the magnitude of the level changes and the general shape and location of the subsidence bowl.

3.12. The differences in modelled subsidence between the four scenarios were relatively minor. The maximum predicted additional subsidence in at the end of the modelled period (50 years) for the base case was approximately 700 mm compared with approximately 800 mm for the three stress tests. Maximum subsidence for all three stress tests were within 50 mm of each other.

3.13. Predicted maximum subsidence rates over the 50-year time period were also similar, for the base case this was 14 mm/year compared with 17-18 mm/year for the three stress tests. Again these are relatively minor differences.

3.14. The predicted size, shape and location of the subsidence bowl is very similar between the base case and stress tests. In all cases the maximum subsidence values occur in the region between the two power plants where the current measured maximum values of subsidence occur.

3.15. The predicted tilt in the Lake Rotokawa area from the subsidence model for the base case is 0.44 mm/100m per year compared with 0.50-0.54 mm/100m per year for the three stress tests. The differences in tilt between the scenarios are negligible and overall the tilt rates are similar to the current rate of tilt in the Lake Rotokawa area of 0.25 mm/100m per year.

3.16 Given 400 m of separation between the lagoon and the Parariki Stream outlet the predicted tilt values suggest that after 50 years the lagoon will be ~9 cm lower than the lake outlet for the base case and ~10-11 cm for the stress tests. That is, the model predicts the lagoon area will be approximately 1-2 cm lower due to the proposed increased take compared to the base case.

4. POTENTIAL SUBSIDENCE RELATED EFFECTS OF THE PROPOSAL

4.1. Given the differences in modelled subsidence and tilt rates between the base case and the stress tests are negligible, the model predicts that additional subsidence effects due to the proposal will be negligible.

4.2. In all cases, the predicted level of subsidence is minor compared to subsidence observed in other areas around the world. The level of subsidence is highly unlikely to cause any damage to the built environment in the area or impact on the surface hydrology of the area.

4.3. Predicted tilt values for the Lake Rotokawa area suggest that after 50 years the lagoon area will be approximately 9 cm lower than the current level for the base case and 10-11 cm lower for the three stress tests relative to the lake outlet into the Parariki Stream. Therefore, the additional risk of inundation of the lagoon area from the proposal is negligible.

4.4. In all cases, the predicted change in relative water level between the lagoon and the lake outlet is approximately 10 cm which is the approximate drop in water level in the lake that was observed following the removal of logs from the Parariki Stream in 2013. It follows that, in 50 years the difference between the lake and lagoon water levels will be approximately what it was prior to removal of the logs and therefore risk of inundation of the lagoon due to subsidence is overall very low.

5. PROPOSED SUBSIDENCE MONITORING

Levelling surveys

5.1. The proposed monitoring of surface levels is two-yearly precision levelling surveys alternating between full and partial surveys. This timing of surveys is sufficient to capture changes in ground levels occurring over time due to subsidence.

5.2. The levelling benchmark network at Rotokawa was significantly expanded in 2013 and 2015 and now adequately covers the entire field including proposed future areas for production and injection.

Lake Rotokawa and lagoon water levels

5.3. In addition to the ground level surveys, levelling measurements have previously been taken of the water levels of six thermal features and Lake Rotokawa. This was last undertaken in 2011 and will be continued on a four-yearly basis.

5.3. The water level of Lake Rotokawa is also proposed to be monitored on a monthly basis utilising an existing staff gauge in the southern part of the lake, and a flume has been set up to monitor the flow from the lagoon into Lake Rotokawa.

5.4. Together, these datasets will allow any changes in relative water level between the lake and the lagoon to be adequately monitored. The two to four yearly timing of levelling surveys would be sufficient to enable mitigation actions to prevent inundation of the lagoon in the unlikely event that it was under threat of flooding.

6. SUMMARY

6.1. Historic subsidence at Rotokawa has been relatively minor with levelling survey data acquired between 1997 and 2015 showing a maximum net subsidence of approximately 220 mm has occurred, mostly in a 1 x 1 km area between the two power plants.

6.2. Subsidence rates appear to have slowed significantly between 2009 and 2015 despite increased take from the reservoir with the start of the NAP plant in 2010.

6.3. A subsidence model for the Rotokawa area has been constructed and calibrated using available data constraints. The model obtains a good match with the levelling data between 2009 and 2013.

6.4. The model predicts that there will be a very minor increase in the total subsidence due to the increased abstraction from the reservoir. The maximum predicted increase in total subsidence is ~100 mm.

6.5. The model predicts that the proposed increase in take will result in approximately 1-2 cm of additional change in the relative water level between Lake Rotokawa and the lagoon.

6.6. Given the model predictions, the change in subsidence related effects from the proposed increased abstraction is negligible. The risk of inundation of the lagoon area on the NW shore of Lake Rotokawa.

6.7. The proposed monitoring of ground levels across the field and water level monitoring in the Lake Rotokawa area are adequate to monitor for any subsidence related effects that may occur due to the proposed additional take.

6.8. As subsidence occurs slowly, over the course of many years, the two to four yearly scheduling of the levelling surveys will enable mitigation actions in the unlikely event that subsidence related tilt threatens to inundate the lagoon area.

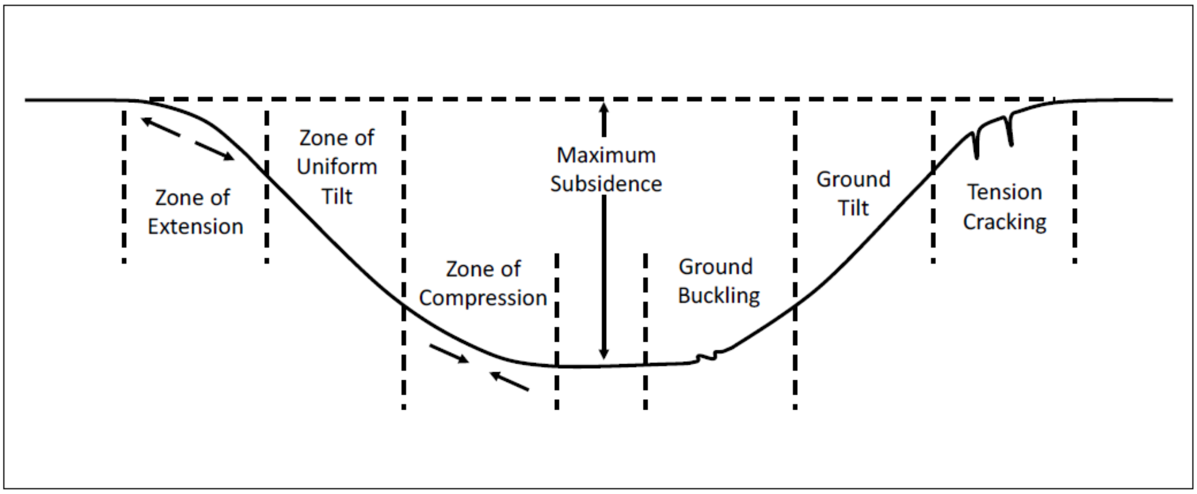

Figure 1 – Schematic diagram of a subsidence bowl.

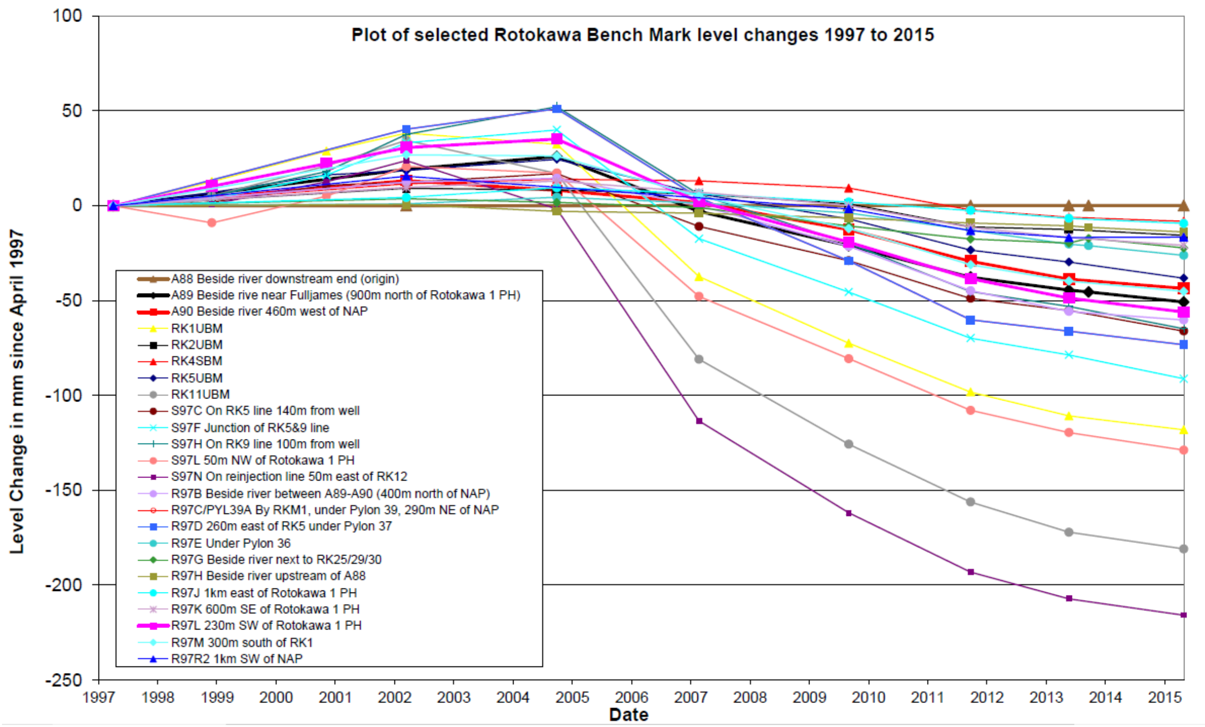

Figure 2 – Plot of ground level change for selected benchmarks at Rotokawa from 1997 to 2015. A period of inflation (increase in ground levels) occurred between 1997 and 2004 most likely due to relatively high levels of shallow injection. Following a large reduction in the amount of shallow injection, subsidence has occurred since 2004. Subsidence rates have declined over time as seen by the relatively small changes in level between surveys in 2011 and 2015.

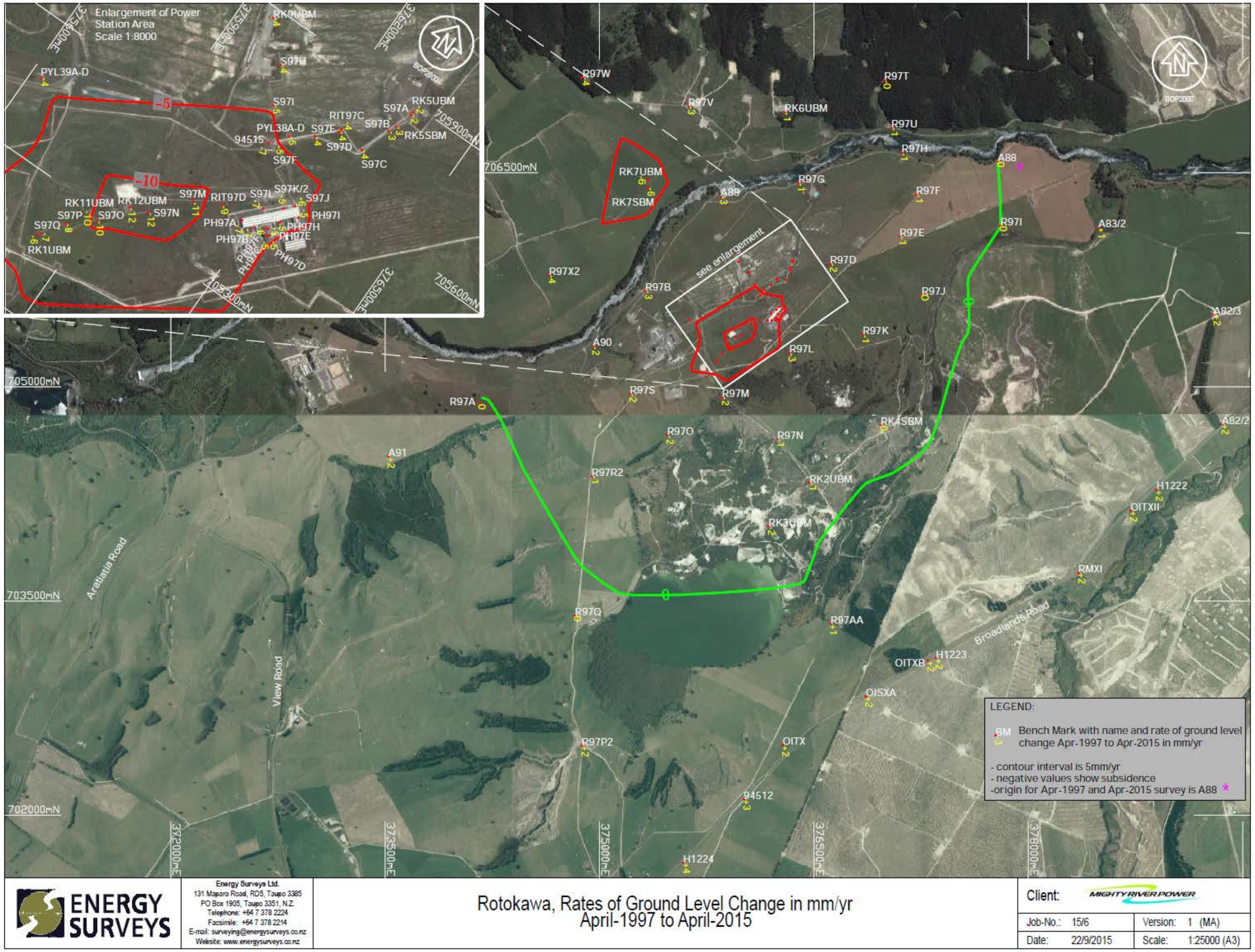

Figure 3 – Net subsidence rates (mm/yr) at Rotokawa between 1997 and 2015. The inset shows the main area of subsidence between the two power plants. N.B. the benchmark (red dots) network has been expanded significantly since 1997.

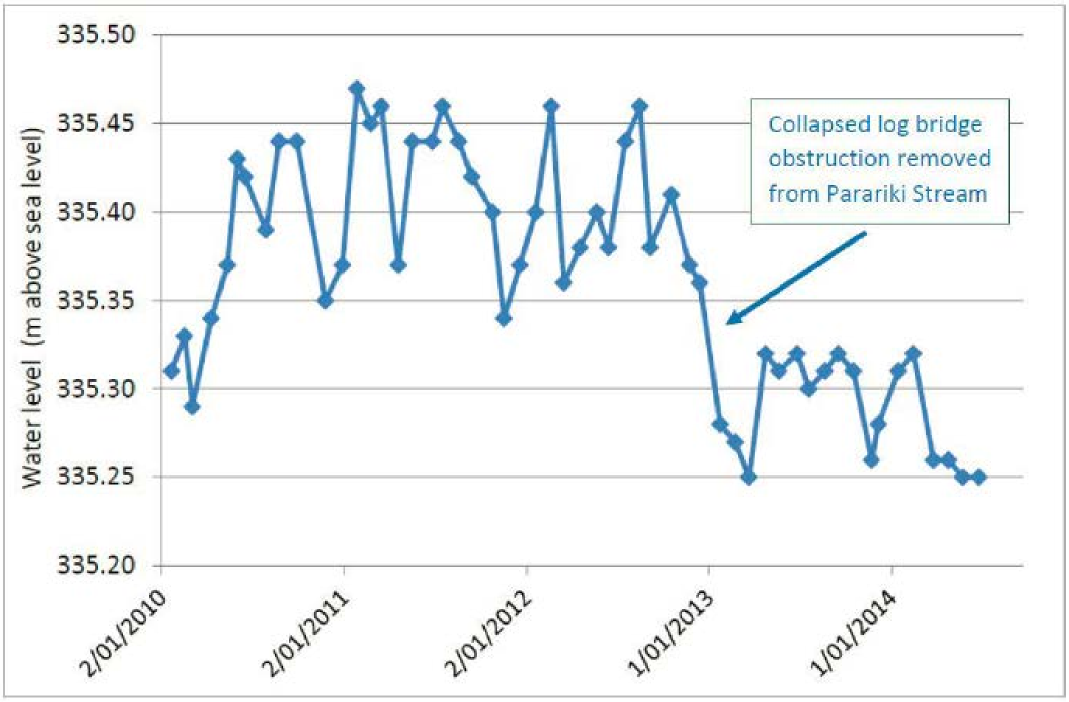

Figure 4 – Water level of Lake Rotokawa between 2010 and 2014 as measured at a staff in the southern part of the lake. A drop in water level of around 10-20 cm occurred in 2013 due to removal of logs from the Parariki Stream.

IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of applications by the **Rotokawa Joint Venture Limited** to Waikato Regional Council for Resource Consents for the Rotokawa Geothermal Development

STATEMENT OF EVIDENCE OF MASON DARYL JACKSON

1. INTRODUCTION

Qualifications and experience

1.1 My name is Mason Daryl Jackson. I am employed by Mercury NZ Ltd (Mercury) as Consents and Compliance Manager. In this role I am responsible for provision of in-house environmental management, consenting and compliance services for operational geothermal power stations at Rotokawa, Mokai, Ngatamariki and Kawerau and for the Waikato Hydro Power Scheme.

1.2 I hold a Master of Science Degree (Earth Science) and a Post Graduate Diploma in Environmental Management.

1.3 I have worked for Mercury (formerly Mighty River Power) since 2005 and have been in my current role for the company since September 2013. Before joining Mercury, I worked for approximately five years as a Resource Officer for the Waikato Regional Council.

Before that I was employed as Regional Environmental Manager for Anchor Products (now Fonterra).

1.4 During my time at Mercury I have worked on various consenting projects including:

(a) Marsden B Re-Powering;

(b) Nga Awa Purua geothermal power station;

(c) Turitea wind farm;

(d) Ngatamariki geothermal power station;

(e) Puketoi wind farm.

1.5 My role when working on these projects has included consultation with Council staff, local communities, tangata whenua, government agencies, interest groups and submitters.

1.6 My work with Waikato Regional Council mainly involved processing resource consent applications within the energy sector.

1.7 My role on the current Rotokawa Joint Venture (RJV) consenting project has been to provide management and technical support in the following areas:

(a) Project consultation and communications with neighbours and stakeholders, tangata whenua and submitters. In this regard, I note that these activities also involved others from Tauhara North No.2 Trust and Mercury. It follows that I have not been directly involved in all consultation undertaken;

(b) Management of RJV's technical experts and review of their effects assessments and hearing evidence;

(c) Preparation and production of the AEE;

(d) Liaison with Council officers and their technical advisor;

(e) Management of consultation information; and

(f) Preparation of draft proposed consent conditions.

1.8 I am very familiar with the site and surrounding areas through numerous visits and work conducted there during my time with Mercury and prior to that as Waikato Regional Council's Monitoring Officer for this site. I am also aware of the environment and community within which these applications fall.

Purpose and scope of evidence

1.9 The purpose of my evidence is to describe the approach RJV took to preparing the application and to consultation during the consenting project and to present a set of proposed draft consent conditions should resource consents be granted.

1.10 Section 2 of my evidence describes some of the technical aspects associated with the project that have influenced the consenting process. In doing so, I describe the approach undertaken to identify, assess and understand the potential environmental effects of the proposal.

1.11 In Section 3, I describe the consultation undertaken in relation to the proposal. In doing so, I :

(a) describe the approach undertaken by RJV to identify any potentially affected or interested parties;

(b) outline the steps undertaken to understand and resolve concerns raised by stakeholders, to integrate their feedback into our environmental assessments, to validate potential effects, and to avoid, remedy or mitigate such effects; and

(c) discuss outcomes achieved through consultation.

1.12 Section 4 of my evidence describes the draft set of consent conditions proposed by RJV. In this regard I :

(a) summarise the overall philosophy underpinning the structure and content of the conditions;

(b) describe the methods used to develop the conditions; and

(c) comment on specific conditions of interest, particularly where they relate to an outcome of consultation.

1.13 I am authorised to give this evidence on behalf of RJV.

2. CONSENTING APPROACH – TECHNICAL ASPECTS

2.1 Mr Stevens has described the rationale for this consent application, however, to achieve the best consenting outcome it is important that the scope, or consent envelope, is appropriate to ensure balance between resource sustainability, RJV's requirements and effects on the environment and local community. In this case, RJV has focussed on historical geoscience data collection and on-going data review and interpretation to optimise the consenting project scope. This has been an iterative process that has occurred over the last two years or so using in-house reservoir modelling and geoscience expertise.

2.2 Ultimately this internal pre-application assessment phase has informed what RJV considers is the most responsible and sustainable development adaptation option available in light of recent observed changes to the Rotokawa reservoir following the commissioning of Nga Awa Purua.

2.3 In terms of consenting, it was important at the very outset to identify potential impacts associated with the final proposal. It was equally important to recognise the type of concerns the proposal may present for various stakeholders.

2.4 Existing relationships and previous experiences with key Rotokawa stakeholders such as the Department of Conservation, Ngati Tahu-Ngati Whaoa Runanga Trust and Wairakei Pastoral Limited has informed our understanding of their likely concerns. On this basis, the key aspects we identified early on included impacts on;

(a) reservoir sustainability;

(b) geothermal surface features;

(c) subsidence;

(d) groundwater quality;

(e) ecology; and

(f) cultural values.

2.5 A number of these potential impacts mirror the matters that RJV and its individual joint venture partners themselves needed to consider before committing to this proposal – particularly those kinds of impacts that could put RJV's current generating assets, investment and reputation at risk, such as adverse effects on reservoir sustainability, subsidence and geothermal surface features. To this end, the management of effects and commercial imperatives are actually aligned.

2.6 Another key consideration during the formulation of effects assessment reports, and in particular, communication of results and conclusions, was acknowledging the very technical nature of information needed to assess and predict impacts. This type of information can be a challenge for stakeholders to understand and comprehend so it was important that technical aspects were set out clearly, logically and without unnecessary jargon.

2.7 Following the confirmation of likely geothermal reservoir impacts, and from there, the consenting project scope and likely areas of concerns held by stakeholders, the next step in the consent process was to quantify and confirm these effects. In this regard, various technical experts were provided with the proposal details and modelling results and asked to assess the potential impacts in their fields of expertise. Through combining the results and recommendations proposed by these experts, we were also able to refine certain aspects – such as monitoring. None of the experts involved in the effects assessment exercise identified any potentially significant adverse effects associated with the proposal.

2.8 The results of the effects assessments were then used in consultation and later to support the application documentation.

3. CONSENTING APPROACH - CONSULTATION

3.1 RJV recognises that consultation is a key component to consenting.

3.2 The overall approach taken has been consistent with the notion of maintaining RJV's "community licence to operate". That is, consultation with potentially affected parties and other stakeholders has and will remain an integral component of this consent process and of future site operations.

3.3 The consent project team adopted a consultation programme which was based on the following core principles:

(a) Early identification of parties who may be affected by the project (“affected parties”);

(b) Early identification of parties who may be interested in the project (“interested parties”);

(c) Level of consultation to be commensurate with the scale and nature of the application;

(d) Preparation of consultation material that introduces the project and outlines the consenting process for affected and interested parties;

(e) Obtaining feedback, concerns and suggestions from affected and interested parties;

(f) Preparing a range of technical, environmental and resource studies that inform affected and interested parties of the impacts expected on them (if any);

(g) Establishing factual information from independent experts prior to continuing discussions about detailed matters of environmental effects;

(h) Remaining open to allay any relevant concerns, and;

(i) Being readily available throughout the course of the project and the consent process to any party who wishes to meet to discuss the project.

3.4 At the outset of the consenting project, we considered the following to be affected parties:

(a) Ngati Tahu-Ngati Whaoa Runanga Trust (the Runanga);

(b) Te Arawa River Iwi Trust (TARIT);

(c) Department of Conservation (DOC);

(d) Wairakei Pastoral Limited (WPL);

(e) Landcorp;

(f) Lockwood Trust Partnership;

(g) Contact Energy Limited;

(h) Tauhara Moana Trust; and

(i) New Zealand Equestrian Centre.

3.5 Other parties we identified as interested parties included the Tuwharetoa Maori Trust Board and the Tuwharetoa Settlement Trust (i.e. parties not directly affected by the application but having a general interest in it). This was consistent with the approach taken during the application for the current resource consents granted in 2007.

3.6 Consultation with the parties identified was undertaken by various members of Tauhara North No.2 Trust and Mercury - representing the Rotokawa Joint Venture.

3.7 Waikato Regional Council staff were also kept abreast of project developments on an ongoing basis.

3.8 A collaborative approach to consultation was promoted - particularly with key stakeholders. In this respect, relevant assessments of environmental effects were presented in draft form to solicit feedback. This process of collaboration worked particularly well with the Runanga, DOC and WPL. Checks were able to be made on whether the right effects were being addressed, whether the monitoring and mitigation proposed was adequate and whether or not there were aspects of the proposal that needed further consideration or review before being finalised.

3.9 The approach taken to consultation also strived to ensure information was readily available to people and in a form such that any party could identify how the proposal might affect them. The consultation carried out was predominantly done via phone calls and face to face meetings with power point presentations given at most meetings held.

3.10 Consultation information was presented in various forms, including a one-page summary document, an eight page summary presentation and other information and presentation slide packs tailor-made for individual stakeholders and/or in response to specific stakeholder information requests or queries.

3.11 In early January 2016, full copies of the AEE and supporting technical documents were also provided to the Runanga, DOC, WPL and Tuwharetoa Maori Trust Board.

4. DETAILS AND OUTCOMES OF CONSULTATION UNDERTAKEN

Waikato Regional Council

4.1 Initial discussions with Waikato Regional Council staff regarding the proposal began in September 2014. Various meetings and discussions have been held through the course of the project with Council staff, and since October 2015, with their technical advisor Dr Brian Maunder.

4.2 From initial consultation undertaken with the Waikato Regional Council, RJV was able to conclude the following:

(a) That the scope of various environmental effects assessments being carried out were commensurate with the nature and scale of the proposal. Other than undertaking some additional reservoir modelling work (to assess effects of a scenario where proposed Consent Area 4 is not utilised), it was generally agreed by staff that the level of technical work to support the applications was appropriate.

(b) That the parties RJV had identified as being affected by the proposal were agreed by Council staff except for Tuwharetoa entities. RJV considered Tuwharetoa and associated entities to be interested in the application but not affected by it. Initially, Council staff had not decided whether Tuwharetoa entities would be affected parties, but were considering it in light of separate Treaty agreement negotiations occurring between Tuwharetoa and the Crown that potentially involved the Lake Rotokawa Conservation Area.

4.3 Over the latter part of this consultation process, we have also discussed what consent conditions might be appropriate in the event the consents are granted and what monitoring should be undertaken. These discussions have progressed to the point where general agreement on the consent conditions (as expressed in the Officer’s report) has been reached. I will cover this in more detail later.

Ngati Tahu-Ngati Whaoa Runanga Trust (The Runanga)

4.4 Preliminary discussions with the Runanga regarding RJV’s consenting plans began on 9 September 2014. Pre-lodgement consultation hui were later held on 24 September, 13 October and 9 November 2015. The Runanga executive met in early November 2015 to discuss RJVs application and were supportive of the proposal in principle, however, were keen to explore various related matters further with RJV including:

(a) More opportunity for the Runanga to be involved in geothermal management;

(b) Further input into the final monitoring programme; and

(c) A mitigation package.

4.5 Post lodgement hui on 26 January, 3 February, 19 February and 18 March 2016, and various phone conversations during early 2016, were held to discuss these matters further. In summary, the outcomes of these discussions were;

(a) With respect to the Runanga's request to be more involved in the management of the Rotokawa resource, the Runanga, RJV and Waikato Regional Council agreed on various changes to the proposed consent condition suite that enable this to occur to the Runanga's satisfaction. I discuss the particulars of these agreed new consent conditions later in my evidence.

(b) In respect of the Runanga having further input into the monitoring programme, RJV and the Runanga met on 9 November 2015 where the reasons for RJV's proposed changes to the monitoring programme were discussed in more detail. Runanga staff indicated they were satisfied with the opportunity to better understand the monitoring programme and did not request any changes to it.

(c) In respect of the mitigation package requested by the Runanga, as Aroha Campbell has discussed, unfortunately agreement has not been reached.

Department of Conservation (DOC)

4.1 In accordance with the current resource consents, RJV meets at least annually with DOC to discuss various operational and compliance matters. From DOC's perspective, the Rotokawa Conservation Area is an important site for geothermal conservation and preservation of geodiversity. It is actively managed by DOC staff (assisted by some RJV funding). In DOC's view, Rotokawa is a very good example of conservation and development working well and sustainably together.

4.2 For over three years now, RJV has been signalling to DOC that it would like to seek resource consents and land access approval for sub-surface geothermal development activities beneath the Lake Rotokawa Conservation Area. These consents and access approvals are to secure additional adaptive management options to reduce risk for the development and the resource as a whole, while achieving a more sustainable development overall. Throughout this time, DOC has been very constructive, co-operative and open minded to this prospect, but also very clear that:

(a) no significant infrastructure should be placed above the ground surface within the Conservation Area;

(b) no significant impacts on thermal surface features (including Lake Rotokawa and the Parariki Stream) and thermo-tolerant vegetation should occur; and

(c) the best practice geothermal development philosophy should be maintained to ensure resource sustainability.

4.3 Early reservoir and surface feature modelling results were presented and discussed with DOC staff on 23 July 2014. At this point, DOC was satisfied that the proposal and likely future impacts met their requirements, and that RJV should progress with more detailed effects assessments for further consultation.

4.4 At the July 2014 meeting, concession requirements for sub-surface access to Conservation land were also discussed. In this respect, DOC noted that the Lake Rotokawa Conservation Area would potentially be included in Tuwharetoa's imminent Agreement in Principle with the Crown. For this reason, DOC confirmed they could not process any concession application relating to this area until the outcomes of Tuwharetoa's Treaty settlement were confirmed. However, DOC also advised that this should not be a reason to halt the resource consent application process.

4.5 Following the completion of RJV's effects assessments, more focussed consultation meetings were held with DOC on 13 October and 2 November 2015 to discuss the outcomes of this work. DOC's specific concerns were limited to subsidence, the potential for a reduction in pressure in the deep reservoir and/or intermediate aquifer affecting surface features, and monitoring.

4.6 DOC accepted that the absolute amount of subsidence predicted isn't large, but was concerned about the amount of differential subsidence, or tilt, predicted relative to the low level of tolerance the northern lake edge has before thermal features in the lagoon area and vegetation there become inundated. Mr Sewell's evidence discusses this risk in detail, concluding that overall it is very low. DOC has also acknowledged there are mitigation options available (e.g. further lowering of lake outlet invert level) in the event the assessment of this risk proves inaccurate.

4.7 DOC's concern that a reduction in pressure in the deep reservoir and/or intermediate aquifer could affect surface features largely relates to its concern around using models to predict future behaviour of geothermal features given the complex mix of variables controlling them. Mr Hernandez acknowledges that the surface feature modelling undertaken does not account for natural plumbing beneath these features and overall is an approximation, but he also considers the model is appropriate in this instance since it is a conservative approach to use, and provides a good way of correlating changes in the reservoir and variations in shallow mass flow rates.

4.8 DOC also considered the modelled reduction in the lagoon feature flow to be more than minor if it were to occur and that on-going monitoring is important to confirm any actual changes and impacts. RJV has installed a flume and implemented additional monitoring of the flow rate from the lagoon for this purpose.

4.9 DOC staff have provided helpful feedback on RJV's proposed monitoring programme throughout the consultation process. RJV has adopted most of DOC's monitoring suggestions and requests (e.g. additional surface feature monitoring). I understand that DOC is happy with the monitoring programme contained in RJV's application (refer Appendix B of the DRAFT SMP).

Wairakei Pastoral Limited (WPL)

4.10 A full suite of the draft technical reports was provided to WPL on 10 November for their review. Various e-mail and phone call discussions were then undertaken with WPL's consultants (Jacobs). WPL's key concern about the application was the potential for the ongoing development to adversely affect fresh groundwater resources peripheral to the Rotokawa geothermal system. WPL was also interested in potential water quality effects in the Waikato River and geothermal resource sustainability in general.

4.11 Following the exchange of additional requested information, Jacobs indicated (on behalf of WPL) that the proposed on-going geothermal development were unlikely to cause any concerns to WPL's current and future farming plans – particularly in respect of groundwater quality. Minor queries related to the proposed future management of the geothermal resource and overall sustainability of the resource were also addressed.

Landcorp

4.12 RJV spoke to Mr Ross Shepherd on 12 November to discuss the proposal. Landcorp, the tenant and dairy farm operator of various WPL landholdings confirmed it is reasonably comfortable that the proposal will not impact Landcorp's farming operations. Mr Shepherd advised that, unlike previous consenting processes relating to the Ngatamariki site, Landcorp didn't need to be involved in the discussions between RJV and WPL.

Lockwood Trust Partnership

4.13 RJV met with representatives of the Lockwood Trust Partnership on 24 November 2015. No concerns were expressed about the proposal.

Contact Energy

4.14 A summary information pack was provided to Contact Energy on 1 October 2015 and an offer was extended to discuss the proposal further if required. On 14 January 2016 Contact Energy indicated they had no concerns with the application.

Tauhara Moana Trust

4.15 A summary of the application was provided to Mr Topia Rameka from Tauhara Moana Trust on 1 October 2015 and an offer was extended to discuss the proposal further with the Trust if they required. Mr Rameka advised he was to pass on the information to the Tauhara Moana Trustees for their consideration. No further feedback was received from the Trust.

Tuwharetoa Maori Trust Board (TMTB)

4.16 A summary document was sent to TMTB on 8 October 2015 along with an offer from RJV to discuss further if required. This offer was made to TMTB as an interested party to the application. On 3 November 2015, RJV representatives met with TMTB's in-house environmental planning team. At the hui, RJV presented a pre-circulated set of slides comprising a more fulsome summary of the application and predicted effects. Following the hui, TMTB requested that RJV:

(a) provide further information on any potential impacts on the Waikato River, the Pueto Stream, Parariki Stream and geothermal surface features;

(b) engage with the Tuwharetoa Hapu Forum (THF) about the application; and

(c) provide TMTB with a copy of the AEE when it was finalised.

4.17 On 14 December 2015, RJV provided TMTB with a detailed information pack focussed on potential effects on local waterways and geothermal surface features as requested, and a copy of the AEE was provided on 5 January 2016. However, RJV did not seek consultation hui with Tuwharetoa Hapu Forum (THF).

4.18 As mentioned by Mrs Campbell, consultation with TMTB was complicated by Tuwharetoa's Treaty settlement process occurring at the same time. This was partly why RJV did not initially pursue additional discussions with THF. To do so would have compromised Tauhara North No.2 Trust's submission in opposition to Tuwharetoa's Agreement in Principal (AIP) with the Crown. It was also RJV's understanding that the THF was the entity set up to negotiate with the Crown in respect of Tuwharetoa's Treaty claim, and was not an entity that could be affected in an RMA sense. This position was later confirmed via correspondence received by RJV from Waikato Regional Council staff.

4.19 During the time between February and May 2016, various e-mails and phone conversations were had between RJV and TMTB regarding consent process updates.

4.20 On 5 May 2016, prior to the start of notification, TMTB wrote to RJV highlighting various concerns regarding the consultation and consent processes. The letter included:

(a) a request that Ngāti Tūwharetoa marae / hapū and economic authorities be given the opportunity to review and submit on the applications should they wish (in this respect, I note that notification decisions are not made by RJV);

(b) a note to advise that the Lake Rotokawa Conservation Area is one of the potential cultural redress properties included in the AIP between Ngāti Tūwharetoa hapū and the Crown (in this respect, I understand the AIP is still not finalised, nor beyond challenge, and as a consequence, Lake Rotokawa Conservation Area is yet to be confirmed as a cultural redress property). In any case, RJV acknowledges that any resource consents that may be granted for activities within the Lake Rotokawa Conservation Area cannot be exercised until access has been agreed with the landowner);

(c) a further request to consult with THF and relevant hapu (in this respect, for reasons explained earlier, RJV's response had, at that time, not changed from when TMTB originally made this request); and

(d) a request for RJV to undertake an assessment of the cultural impacts on Tuwharetoa as a result of the proposal.

4.21 Due to the complexities and alternate viewpoints associated with the Tuwharetoa AIP, RJV decided not to undertake a specific assessment of cultural effects on Tuwharetoa, which it did not consider to be a potentially affected party. RJV instead relied on advice from TN2T and the Runanga regarding cultural matters - as it had done for earlier Rotokawa consent applications.

Tuwharetoa Settlement Trust

4.22 Representatives from RJV met with Mr Dylan Tahau from the Tuwharetoa Settlement Trust to talk about the application on 3 November 2015. This discussion was held with the Settlement Trust as an interested party to the application. Mr Tauhau confirmed that Tuwharetoa has an interest in the Rotokawa area. It lies on the Tuwharetoa migration pathway from their waka and was visited by Tuwharetoa people as part of their general movements around the region. Mr Tahau also confirmed that the Settlement Trust is unlikely to take an active role in RJV's consent process, but would support TMTB in any involvement they might have.

New Zealand Equestrian Centre

4.23 An RJV representative met with the site manager at the New Zealand Equestrian Centre to talk about this application. The manager expressed no concerns. I note that the Equestrian Centre submitted in support of the resource consent application, but that the submission was not accepted due to it being late.

TARIT

4.24 A summary information pack was provided to TARIT on 3 November and an offer was extended to discuss the proposal further if required. TARIT responded on 4 November thanking RJV for keeping TARIT informed. No concerns were expressed about the application.

5. RESPONSE TO SUBMISSIONS

Tuwharetoa Maori Trust Board

5.1 A key concern expressed in TMTB's submission is that Ngāti Hinerau, Ngāti Hineure and the Tūwharetoa Hapū Forum were not consulted.

5.2 In response, on 8 July 2016, RJV informed TMTB that it would make themselves available at any time to meet and discuss the concerns outlined in their submission. RJV also requested that TMTB arrange for representatives from THF and Ngati Hinerau and Ngati Hineure to attend and take part in the discussions. From RJV's perspective, one of the key objectives of this requested hui was to determine what specific effects were of main concern, since the scope of TMTB's submission was very wide ranging.

5.3 Through July and August 2016 I followed up with TMTB a number of times asking of any updates or confirmations regarding potential hui dates and to offer any assistance in hui arrangements. I also indicated RJV's willingness to host the hui at the Rotokawa site if that suited. As of 4 August, advice from TMTB staff was that the invitation from RJV to meet was put to their hapu and the Tuwharetoa Hapu Forum, and that TMTB was awaiting their direction. At the time of preparing this evidence, no further hui had been held nor any hui dates confirmed.

Ngati Tahu-Ngati Whaoa Runanga Trust (the Runanga)

5.4 The Runanga outlines in its submission how, despite numerous discussions and sharing of information between RJV and the Runanga, RJV has not satisfied their requirements in regards to mitigation of potential environmental and cultural impacts. As mentioned earlier in my evidence, and in Mrs Campbell's evidence, unfortunately the mitigation package being sought by the Runanga has not been agreed between the two parties.

5.5 I do not discuss RJV's response to the outstanding matter of mitigation, but instead refer to evidence already presented by Mrs Campbell in regard to mitigation of cultural impacts.

6. CONSENT CONDITIONS

6.1 It is important that the conditions of consent enable a development that is commercially viable in this Development Geothermal System. To this end RJV has worked collaboratively with staff from Waikato Regional Council to develop appropriate consent conditions for the Rotokawa development.

6.2 In large measure, the conditions proposed by RJV are the same as the current Rotokawa conditions, which have served RJV and the community well since they were originally granted in 2007. Their general structure is also the same as the consents used for the Ngatamariki, Wairakei, Te Mihi, Ohaaki and Tauhara II geothermal developments within the Waikato region.

6.3 The conditions which provide for the use of the resource at the same time ensure adverse effects will be avoided, remedied or mitigated. They address a wide range of matters including:

(a) Geothermal system management.

(b) Effects on Significant Geothermal Features.

(c) Effects on groundwater.

(d) Earthworks.

(e) Erosion and sediment control.

(f) Drilling and testing.

(g) Kaitiakitanga and community consultation.

6.4 Of particular importance are the conditions which address system management, as the management of the geothermal reservoir lies at the core of the proposed development.

Central to these conditions is the requirement for the development to be managed in accordance with a System Management Plan (SMP). The SMP is a "living document" in that it will be amended and updated to respond to any changing circumstances as the development proceeds and it can be used to ensure that an appropriate response to any effect is implemented. A SMP was initially implemented at Rotokawa in 2010. That plan was subsequently revised and updated in 2014. The SMP included as part of the current application utilises the latest scientific data and modelling results, and incorporates proposed future resource development philosophies and processes consistent with RJV's consent application.

6.5 Apart from a few minor changes with respect to future monitoring, which I address in Table 1 below, RJV accepts the consent conditions as proposed.

Table 1: Monitoring matters not agreed between RJV and Staff

Monitoring Parameter[1]	**Staff Report Recommendation**	RJV Response
Thermal Infrared Monitoring (TIR)	Staff do not agree with RJV's proposal to remove TIR, but are open to more discussion on the matter.	In his evidence, Mr Sewell presents further information in support of RJV's request to remove future TIR survey requirements. Overall, RJV considers that; additional 2-yearly aerial photos, more frequent and wider scope of ecology monitoring, and wider scope of thermal feature monitoring being offered, will provide a more robust and meaningful way of monitoring changes in surface heat flow than TIR. For these reasons, RJV's request to remove future TIR survey requirements remains.
Groundwater Monitoring Programme	Include new General Condition 13 which; • Specifies the objectives for the monitoring programme to be; o to identify extent of geothermally influenced groundwater, and o to identify any impact on privately owned bores; • requires a review of the	RJV agrees with the objective of the groundwater monitoring programme be designed to identify any impact on privately owned bores, but has concerns about this suggested new condition and overall seeks for it to be deleted. Reasons and relief are discussed below; 1. Identifying the extent of geothermally influenced

[1] **Refer Annexure 1 of this evidence (Schedule Two of the General Conditions)**

Monitoring Parameter[1]	Staff Report Recommendation	RJV Response
	programme after 6-months to assess whether these objectives are addressed; and • requires the programme to be reviewed every time the SMP is reviewed.	groundwater is not a reasonable objective in the context of the proposed activity. To achieve this objective, numerous additional wells will need to be drilled and monitored which would be extremely costly. It is also not clear why knowing the extent of geothermally influenced groundwater is important for understanding future potential effects. Relief: Remove any requirement for the groundwater monitoring programme objectives to include identifying extent of geothermally influenced groundwater. 2. RJV considers the condition, as proposed, does not provide for evolution or changes to groundwater monitoring programme objectives through time. For example, there may be other aspects that change over time that the groundwater monitoring programme can be used for. Relief: Relocate the intent of this condition as one of the mandatory requirements of the SMP. This way, the objectives can be reviewed at any time, and as a minimum, every 4 years. It also addresses the staff recommendation to require a review of the groundwater monitoring programme every time the SMP is reviewed. Refer Annexure 2 for suggested change to General Condition 3.4. 3. With regards to the suggested 6-month review of the groundwater monitoring programme, RJV does not consider it likely that after 6 months we will know whether the objectives of the programme are addressed. Relief: Delete the requirement for a 6 month review in favour of reviews as and when the SMP is reviewed, and/or as provided for by General Condition 5.5 (reproduced in Annexure 2).

Monitoring Parameter[1]	Staff Report Recommendation	RJV Response
Groundwater well monitoring frequency	Prescribes a 3-monthly monitoring frequency of for all infield and outfield groundwater monitoring wells until background variability can be established (as summarised below); • In-field groundwater (RKM1-RKM4, RKM6-RKM8 and RKNEC) – 3 monthly water level, temperature and chemistry. • Out-field groundwater (periphery wells) – 3 monthly chemistry.	RJV partly accepts and partly opposes this recommendation as follows; • As recommended by Dr Mroczek, RJV considers 3-monthly monitoring of in-field wells RKM1-RKM4 and RKNEC is unnecessary. For these wells, a long (20 year) monitoring record exists which already provides well established background variability. • As recommended by Dr Mroczek, RJV accepts to “characterise” infield wells RKM6-RKM8 via one-off pressure and temperature surveys followed by downhole sampling but considers regular monitoring of these wells is not warranted. • RJV accepts to monitor chemistry of out-field groundwater wells (subject to securing third party access) on a 3-monthly basis until background variability can be established.
Frequency of Parariki Stream Monitoring	Staff have accepted RJV’s proposal to reduce Parariki Stream monitoring frequency from monthly to annually (as detailed in the AEE).	As recommended by Dr Mroczek, RJV will reduce the Parariki Stream monitoring frequency to quarterly (i.e. more frequent than the minimum annual frequency originally suggested by RJV and agreed by staff)

6.6 Annexure 1 of my evidence provides RJV’s suggested revised monitoring programme following receipt of the Staff Report. Changes to monitoring recommended by staff are highlighted as tracked changes. Annexure 2 includes General Conditions 3.4 and 5.5 along with suggested amendments as discussed in Table 1 above.

6.7 In the remainder of this section I will address specific consent conditions, with particular emphasis on how they address the key concerns raised by the Runanga.

6.8 As discussed earlier, the Runanga, RJV and Waikato Regional Council agreed on various changes to the proposed consent condition suite that enable additional opportunity for the Runanga to be involved in the Peer Review Panel process. These changes are denoted by yellow highlighted text in the proposed conditions at Annexure 1 of my evidence. More specifically the changes now include:

(a) A requirement for RJV to provide the Runanga a copy of its annual compliance report.

(b) A requirement to provide an invite to the annual peer review panel meeting be sent to the Runanga.

(c) The Peer Review Panel to prepare an annual report including the Panel's opinion and recommendations regarding:

- the Consent Holder's Annual Report;
- any observed or future predicted adverse environmental effects associated with the Consent Holder's activities;
- the overall health and sustainability of the Rotokawa geothermal resource; and
- any other matter relevant to the Panel's role.

(d) An advice note that supports all the above and clarifies objectives and limitations of the Runanga involvement.

7. CONCLUSION

7.1 RJV's iwi consultation process was complicated by separate Treaty related processes occurring at the same time. Despite these unique circumstances, RJV has made a significant effort to ensure the level of consultation undertaken with affected and interested tangata whenua (both the Runanga and TMTB) has been appropriate and commensurate with the scale and nature of this proposal.

7.2 Through the consultation activities with other stakeholders a general level of comfort and agreement has been reached with these parties. The consent conditions recommended by the Council Officers also ensure the concerns of all submitters will be addressed.

ANNEXURE 1: Proposed Monitoring Programme

SCHEDULE TWO – ROTOKAWA MONITORING PROGRAMME

GEOTHERMAL WELLS

LOCATIONS	MEASUREMENT TYPE	MEASUREMENT FREQUENCY
Every new well	3 temperature and pressure surveys with well closed	One at well completion and Two before discharge unless otherwise agreed by the Waikato Regional Council after taking advice from the Peer Review Panel.
Every well	Caliper survey for corrosion monitoring	After first discharge then a minimum of once every two years thereafter unless otherwise agreed by the Waikato Regional Council after taking advice from the Peer Review Panel.
Wells not used for production or reinjection unless otherwise agreed by the Waikato Regional Council after taking advice from the Peer Review Panel.	Pressure and temperature survey, or where capillary tubing is installed, pressure only.	Annually
Wells not being used for production or reinjection unless otherwise agreed by the Waikato Regional Council after taking advice from the Peer Review Panel.	Record wellhead pressure and well status (shut, open, bleeding, etc)	Well head pressure – Monthly Well Status – Continuously
Production wells	Mass flow rate from groups of wells, wellhead pressure and temperature from individual production wells	Daily
Production wells	Water and gas chemistry sampled at surface	Annually
Production wells	Discharge characteristic (mass flow rate and enthalpy)	On first discharge then at the request of the Waikato Regional Council on the advice of the Peer Review Panel
Reinjection wells	Mass flow rate, wellhead pressure and temperature	Daily

SHALLOW MONITOR WELLS

LOCATIONS	MEASUREMENT TYPE	MEASUREMENT FREQUENCY
Shallow groundwater monitor wells within the field (RKM1-RKM4, RKNEC)	• Water level • Temperature at 1m below water level • Chemistry	6-monthly

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Where practicable, characterise monitor wells RKM6-RKM8 within the field.	• Pressure / Temperature Survey • Downhole Chemistry Sampling	One-off
Subject to access rights being obtained, at least 4 groundwater periphery wells (refer to the System Management Plan for names and locations)	• Chemistry	3-monthly

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GROUND LEVEL

LOCATIONS	MEASUREMENT TYPE	MEASUREMENT FREQUENCY
The benchmark network in the Rotokawa field as approved by the Waikato Regional Council.	• Levelling survey to detect and measure subsidence / tumescence.	Every two years alternating between full surveys and partial surveys.

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AERIAL PHOTOGRAPHY

LOCATIONS	MEASUREMENT TYPE	MEASUREMENT FREQUENCY
Lake Rotokawa Thermal Area	• Aerial photography survey of Rotokawa Area	Every two years alternating between full surveys and partial surveys.

GEOTHERMAL SURFACE FEATURES

LOCATIONS	MEASUREMENT TYPE	MEASUREMENT FREQUENCY
At locations specified in the surface feature monitoring plan contained within the System Management Plan and any other feature as required by the Waikato Regional Council after taking advice from the Peer Review Panel.	• Temperature, Chemistry, Flow (where possible), and/or Photograph and Field Description (details confirmed within the System Management Plan)	Annually
Lagoon Outlet	• Flow	Monthly

STREAMS RECEIVING GEOTHERMAL WATER

LOCATIONS	MEASUREMENT TYPE	MEASUREMENT FREQUENCY
Parariki Stream near its exit from Lake Rotokawa and near its confluence with the Waikato River	• Flow rate, Temp, pH, chemistry	3-Monthly

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LAKE ROTOKAWA

LOCATIONS	MEASUREMENT TYPE	MEASUREMENT FREQUENCY
Near the outlet of the Lake	• Water Level	Monthly

FLORA AND FAUNA

LOCATIONS	MEASUREMENT TYPE	MEASUREMENT FREQUENCY
Rotokawa thermal area (6 transects)	• Thermotolerant vegetation and soil temperature survey	4-yearly
Rotokawa thermal area	• Mapping (from aerial photography and walk-through survey)	4-yearly
Rotokawa thermal area (Approximately 20 locations)	• Photograph	Annually

MICROGRAVITY

LOCATIONS	MEASUREMENT TYPE	MEASUREMENT FREQUENCY
Covering the area within the Rotokawa resistivity boundary	Microgravity	12-yearly

SEISMIC

LOCATIONS	MEASUREMENT TYPE	MEASUREMENT FREQUENCY
At fixed locations as approved by the Waikato Regional Council on the advice of the Peer Review Panel	Seismometer	Continuous

TRACER TESTS

LOCATIONS	MEASUREMENT TYPE	MEASUREMENT FREQUENCY
In wells selected by the	Injection of a chemical or	As required by the Consent Holder,

Consent Holder, or by the Waikato Regional Council on the advice of the Peer Review Panel.	isotope contained in Schedule THREE or otherwise approved by the Waikato Regional Council	or, in the event of an unexpected geothermal fluid break-through event (e.g. to the ground surface or into adjacent fresh groundwater), following any request by the Waikato Regional Council after taking advice from the Peer Review Panel.

ANNEXURE 2: Conditions Referenced in Table 1 of This Evidence

CHANGES TO GENERAL CONDITIONS RE: GROUNDWATER MONITORING

3.4 The System Management Plan is to include;

(a) objectives for the groundwater monitoring programme; and
(b) as a discrete part, a Geothermal Discharge Strategy, the conditions relating to which are set out in General Condition 4.

5.5 The Consent Holder may, at any time, propose to the Waikato Regional Council changes to the Monitoring Programme. An alteration in the Monitoring Programme described in Schedule TWO may be approved by the Waikato Regional Council if, after taking advice from the Peer Review Panel, in its view the Monitoring Programme is no longer appropriate or necessary but requires an increase or decrease in the type, frequency and location of any part of the Monitoring Programme.

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IN THE MATTER of the Resource Management Act 1991

AND

IN THE MATTER of applications to the Waikato Regional Council by **ROTOKAWA JOINT VENTURE LIMITED** for resource consents in relation to increased fluid take and steamfield expansion at the Rotokawa Geothermal System.

STATEMENT OF EVIDENCE OF ANDREW MICHAEL COLLINS, PLANNER, ON BEHALF OF ROTOKAWA JOINT VENTURE LIMITED

12 SEPTEMBER 2016

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1. INTRODUCTION

Qualifications and experience

1.1 My full name is Andrew Michael Collins. I am a Director of Harrison Grierson Consultants Limited, a multi-disciplinary consulting company with six offices throughout New Zealand. I hold the position of General Manager Planning for our company, a position that I have held since 1 January 2005. I have an overview role for approximately 40 resource management planners, urban designers and landscape architects, based across all of our offices. I am based in Tauranga.

1.2 I have a Bachelor's Degree in Regional Planning (with First Class Honours) from Massey University in Palmerston North, completed in 1987. Since then I have had some 29 years planning and resource management experience. I have worked as a planner in both the public and private sector, mainly the latter. I am a full member of the New Zealand Planning Institute and also a Member of the Resource Management Law Association of New Zealand. I am currently President of the Bay of Plenty Branch of the Property Council and am on the National Board of the Property Council.

1.3 During my career, I have been involved in a large number of resource consent, designation, and plan making processes relating to both district and regional issues, and as a result have been involved in many local authority and Environment Court hearings. In my current role as General Manager Planning for Harrison Grierson, I undertake planning work for a wide range of clients throughout New Zealand. This work is typically of a strategic planning, project management, policy analysis or resource consent-related nature, and is undertaken for numerous local authority, government, utility and developer clients throughout the country.

1.4 Over the last few years, I have been closely involved with the geothermal policy provisions in the Bay of Plenty Regional Policy Statement (on behalf of Mighty River Power, as then named) and in the Waikato Regional Policy Statement (on behalf of Mighty River Power and the Rotokawa Joint Venture). This work involved participation in geothermal caucus groups, evidence at Council hearings and involvement in appeal mediation processes. Over the last 10 years, I have been closely involved with numerous other energy sector projects (consents and policy), mainly through the central and upper North Island. These have included geothermal, hydro and thermal (gas) electricity generation projects. As a result, I have developed a good understanding of the energy policy framework applying in New Zealand, the relevant parts of which I will discuss later in this evidence.

Expert witness Code of Conduct

1.5 I confirm that I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2014 and that I agree to comply with it. I confirm that I have considered all the material facts that I am aware of that might alter or detract from the opinions that I express, and that this evidence is within my area of expertise, except where I state that I am relying on the evidence of another person.

This evidence

1.6 I have been engaged by the Rotokawa Joint Venture (**RJV**) to provide planning evidence in relation to its applications for resource consents for increased geothermal fluid take and steamfield expansion at the Rotokawa Development Geothermal System. I was not involved in the preparation of the resource consent application nor any of the consultation undertaken.

1.7 To better understand the issues involved, I visited the site on 4 August 2016 accompanied by Mason Jackson, who is the Consents and Compliance Manager at Mercury. I visited the Nga Awa Purua geothermal power station, the Lake Rotokawa Conservation Area on the northern side of Lake Rotokawa and sections of the Parariki Stream.

1.8 After my evidence summary (section 2), my evidence addresses:

(a) RJV's existing operations and consents at Rotokawa (section 3)
(b) Application and activity status (section 4)
(c) Section 104 of the Resource Management Act 1991 (section 5)
(d) Issues raised in submissions (section 6)
(e) Environmental effects (section 7)
(f) Relevant planning provisions (section 8)
(g) Other relevant matters (section 9)
(h) Regional Council staff report (section 10)
(i) Statutory evaluation under the RMA 1991 (section 11)
(j) My planning conclusion (section 12).

2. SUMMARY OF EVIDENCE

2.1 There are three components of these applications by RJV in relation to its Rotokawa geothermal steamfield activities, namely:

- Extension of the abstraction area to include Consent Area 4;
- Increase in abstraction volume by 10,000 tonnes per day; and
- Rationalisation of consents and extension of expiry dates by 8 years.

2.2 This evidence explores issues raised in submissions and the statutory requirements of section 104 and Part 2 of the Resource Management Act. Following my analysis, which draws upon the conclusions of the other technical experts, I am of the opinion that actual and potential environmental effects have been thoroughly addressed, including cumulative effects with regards reservoir sustainability. Potential adverse effects can be adequately avoided, remedied and/or mitigated with assurance in this regard provided via a comprehensive suite of proposed conditions which provide for a rigorous adaptive management approach.

2.3 I am of the opinion that the application is fully consistent with the provisions of the National Policy Statement for Renewable Electricity Generation and the operative Waikato Regional Policy Statement and Waikato Regional Plan.

2.4 The application is fully consistent with central government's national policy directions as stated in the New Zealand Energy Efficiency and Conservation Strategy (2011-2016) and the New Zealand Energy Strategy (2011-2021).

2.5 Based on an overall evaluation of Part 2 Resource Management Act considerations, I am of the opinion that the application achieves the sustainable management purpose of the RMA and that the granting of consents sought is appropriate subject to the comprehensive conditions proposed.

3. RJV'S EXISTING OPERATIONS AND CONSENTS AT ROTOKAWA

3.1 The evidence of other witnesses fully describes the land ownership within the area that comprises the Rotokawa geothermal system, and explains the existing operations on the Rotokawa geothermal system, namely the Rotokawa A and the Nga Awa Purua power stations and associated steamfield infrastructure. Rather than duplicate the other evidence, I simply note that the current ownership pattern and the nature and history of the existing development on the

Rotokawa system is comprehensively described in the *draft Rotokawa System Management Plan* (**SMP**) that is attached to the RJV resource consent application (**RCA**).

3.2 In addition, in Appendix D of the SMP, there is a schedule of the existing consents held, which include:

- two land use consents from Taupo District Council (one for each of the power stations and their ancillary structures, well drilling and other activities);
- two resource consents from Waikato Regional Council (**WRC**) for water takes from the Waikato River;
- 21 resource consents from the WRC for geothermal steamfield activities (geothermal takes, injection, discharges to land and air). These consents are also summarised in section 1.5 of the Assessment of Environmental Effects (**AEE**). Of the 21 consents, there are 16 consents relating to Consent Areas 1 and 2 (south of the Waikato River) and five consents relating to Consent Area 3 (north of the Waikato River).

4. APPLICATION AND ACTIVITY STATUS

4.1 As set out in Part A of the RCA, there are three main components to the application:

(a) ***Consent Area 4*** - RJV seeks consent to expand the sub-surface component of the site's steamfield to include a new area, which is shown as "Consent Area 4" in Schedule 1. This area corresponds with the geothermal reservoir lying under the Crown land that comprises the Lake Rotokawa Conservation Area[1]. While it is proposed that there be geothermal wells deep under the surface, there will be no surface structures or activities in this area other than monitoring.

(b) ***Increase abstraction volume*** - RJV seeks to increase abstraction of geothermal fluid from the Rotokawa system (combination of Consent Areas 1, 3 and 4) by 10,000 tonnes per day – from the consented average 65,500 tonnes per day up to an average 75,500 tonnes per day.

1 The RJV has not yet secured sub-surface access rights to proposed Consent Area 4. These will be sought separately via a concession process under the Conservation Act.

(c) ***Rationalisation of consents and extend expiry dates*** – RJV seeks to rationalise the WRC consents in place by replacing 19 existing consents (those with expiry dates expire in January 2043) with 11 new consents (to expire in 2051, 35 years from date of consent). This rationalisation and the consents sought is clearly set out in Table A in section 5 of the RCA[2]. The existing consents provide a "consented baseline" of effects up to 2043. The AEE and evidence of others addresses the 8 year consent extension sought.

4.2 The two land use consents from Taupo District Council and the two resource consents from WRC that relate to the take and use of water from the Waikato River - as referred to in paragraph 3.2 above - and two resource consents for structures in, on or under waterways and significant geothermal features are all unaffected by the current RCA. These are not part of the consent rationalisation proposal. The rationalisation relates solely to the 19 geothermal steamfield consents from WRC. In my opinion, the proposed rationalisation of the consents into the 11 consents sought makes good sense and is consistent with the integrated management of the geothermal resource.

4.3 Section 6.5.3 of the AEE sets out the 11 consents sought[3] and specifies the Waikato Regional Plan rules that determine the activity status of each application. In summary, RJV seeks:

- 2 water permits (for production and well testing purposes)
- 8 discharge permits (injection, air discharges, stormwater, condensates, wastewater, drillings muds and fluids)
- 1 land use consent (earthworks and drilling activities)

4.4 I note that the relevant rules of the Waikato Regional Plan are set out in full in section 6.5.3 of the AEE. I agree with the assessment in the AEE that three of the applications are controlled activities and the remainder are discretionary activities and so, by applying the "bundling" approach, the applications should be assessed overall as a discretionary activity.

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2 I note that the application as lodged sought to replace 21 existing consents with 12 new ones. However, post-lodgement Mercury has withdrawn the land consent application relating to structures. The existing land use consents 116573 and 124483 will remain unchanged.

3 As noted above, section 6.5.3 actually describes the 12 consents sought at the time of lodgement. However, with the post-lodgement withdrawal (on 14th July 2016) of the land consent application relating to structures, there are now 11 consents sought. The existing land use consents 116573 and 124483 will remain unchanged.

5. SECTION 104, RESOURCE MANAGEMENT ACT 1991

5.1 Section 104 of the Resource Management Act 1991 (**RMA**) states:

104 Consideration of applications

(1) When considering an application for a resource consent and any submissions received, the consent authority must, subject to Part 2, have regard to –

(a) any actual and potential effects on the environment of allowing the activity; and

(b) any relevant provisions of—

(i) a national environmental standard:
(ii) other regulations:
(iii) a national policy statement:
(iv) a New Zealand coastal policy statement:
(v) a regional policy statement or proposed regional policy statement:
(vi) a plan or proposed plan; and

(c) any other matter the consent authority considers relevant and reasonably necessary to determine the application.

5.2 I address submissions in section 6, effects on the environment in section 7, relevant planning provisions in section 8, and other relevant matters in section 9 of my evidence. In section 11, I will return to my section 104 evaluation and also address Part 2 RMA matters.

6. ISSUES RAISED IN SUBMISSIONS

6.1 There have been four submissions received within time, and one late submission*, as follows:

- Tauhara North No. 2 Trust (**TN2T**) (support)
- Wallace Niederer (NZ Equestrian Centre) (support *)
- Department of Conservation (**DOC**) (neutral)
- Ngati Tahu – Ngati Whaoa Runanga Trust (neutral)
- Tuwharetoa Maori Trust Board (oppose)

6.2 The TN2T submission fully supports the application and considers the application represents good adaptive management and will ensure the long term sustainability of the resource. The submission also refers to the tangible social and economic benefits of the geothermal resource use for its owners and their descendants.

6.3 Mr Niederer's submission supports the application provided that the Equestrian Centre's deep well is not affected in quality or quantity terms.

6.4 The DOC submission provides no details but I understand that DOC supports the proposed changes to conditions, particularly as they relate to the monitoring regime.

6.5 The Ngati Tahu – Ngati Whaoa Runanga Trust submission is expressed as a neutral one although it notes the Rotokawa geothermal resource is a taonga with associated high cultural values. It notes yet-to-be-resolved concerns regarding mitigation of potential environmental and cultural impacts. That said, the submission indicates that the submitter does not wish to be heard.

6.6 The Tuwharetoa Maori Trust Board submission claims mana whenua status and expresses concern over lack of consultation. It also notes that the Rotokawa geothermal resource and Lake Rotokawa are taonga with associated high cultural values, particularly for Ngati Hinerau and Ngati Hinuere. The submission notes that the Lake Rotokawa Conservation Area is one of the potential cultural redress properties included in the Agreement in Principle between Ngati Tuwharetoa hapu and the Crown (a process which is ongoing). The submission refers to effects on:

- the geothermal reservoir
- surface geothermal features (including from subsidence)
- surface water
- cultural values and Ngati Tuwharetoa interests.

6.7 I wish to comment briefly now on the matter of consultation while the other issues above are addressed in the next section of my evidence. Section 5 of the AEE outlines the consultation undertaken with 11 parties, including the Tuwharetoa Maori Trust Board, prior to the application being lodged. The evidence of Mr Jackson and Aroha Campbell outlines the consultation undertaken post-lodgement with the Tuwharetoa Maori Trust Board and the Ngati Tahu – Ngati Whaoa Runanga Trust. I note that the RMA does not require consultation to be undertaken with any party. There is no mandatory requirement in this respect.

6.8 The Fourth Schedule to the RMA sets out the information required in applications for resource consent. Clause 6(1) states that an AEE must include:

(f) identification of the persons affected by the activity, ***any consultation undertaken****, and any response to the views of any person consulted:*

6.9 Clause 6(3) of the Fourth Schedule then states:

(3) To avoid doubt, subclause (1)(f) obliges an applicant to report as to the persons identified as being affected by the proposal, but does not—

(a) oblige the applicant to consult any person; or

(b) create any ground for expecting that the applicant will consult any person.

6.10 I have not been involved in any of the consultation processes but, having read the evidence of Mr Jackson and Ms Campbell, I am of the opinion that RJV has taken a responsible approach to consultation which is commensurate with the scale and nature of this proposal. The conditions proposed respond appropriately to the issues raised through the consultation process and in submissions received, as I shall further discuss in the next section of my evidence.

7. ENVIRONMENTAL EFFECTS

Effects envelope

7.1 Section 4 of the RCA expresses the view that the "envelope of effects" to be assessed is limited to:

(a) The additional and cumulative effects arising as a result of the expansion of subsurface geothermal activities into Consent Area 4 (beneath the Lake Rotokawa Conservation Area), including drilling, testing and geothermal production (fluid abstraction), injection and monitoring activities – only those effects over and above those already occurring or consented.

(b) The additional and cumulative effects arising as a result of the proposed 10,000 tonnes per day increase in geothermal fluid take from the reservoir as a whole (Consent Areas 1, 3 and 4).

(c) Any actual and potential effects associated with the extension of the consent term from 2043 to 2050 (or 2051 if consented is granted for 35 years from the date of consent as sought).

7.2 Section 4 of the RCA also notes that there will be no increase in generation capacity at the two existing geothermal power stations (as the increased abstraction referred to in (b) above will just enable them to operate as already designed and consented, to compensate for reducing enthalpy). There is also no increase sought in terms of consented injection volumes or air discharges.

7.3 I agree with the scope of the "effects envelope" to be assessed as set out in Section 4 of the RCA. In summary, between 2016 and 2043, the additional and cumulative effects to be considered are those set in paragraph 7.1 (a) and (b) above as other effects are within the "consented baseline" provided by the existing consents. Between 2043 and 2051, the overall effects of the rationalised suite of consents may be considered (by comparing the modelled effects as they will exist in 2043 with the modelled effects in 2050). I note the modelling scenario is based on the year 2050 which supports a 34 year consent term but, based on the evidence of Dr Grant there seems little reason why a 35 year consent term to 2051 should not be granted.

Economic effects / positive effects

7.4 Section 4.1 of the AEE refers to a range of economic effects associated with renewable generation of electricity, including significant benefits to:

- JV partners and their owners (beneficial owners, shareholders, Crown)
- Local community and economy
- New Zealand's electricity market and its security of supply
- The public generally through offsetting the need for generation using fossil fuels.

7.5 The granting of the consents sought will enable RJV to maintain full generation capacity over the long term while also providing the best outcome for the health of the Rotokawa geothermal resource (having regard to its status as a 'Development Geothermal System'[4]).

Cultural effects (including mauri and kaitiakitanga effects)

7.6 Section 4.2 of the AEE addresses cultural effects and refers to the role that the TN2T plays as both kaitiaki and JV partner. The SMP, and the associated independent peer review panel, ensures the sustainable and efficient use of the Rotokawa geothermal resource (discussed in the next section). There are no

4 Refer Method 9.1.1 of the Waikato Regional Plan, as discussed later.

additional surface activities or structures beyond what is already consented and so the proposal does not impact in any physical sense on existing culturally valuable sites, geothermal features or ecosystems.

7.7 I note that RJV proposes a new condition[5] for the land use consent for "well drilling, roading and related earthworks" that will ensure that any well tracks:

- pass no less than 500 metres below the Waikato River
- are outside the vertical boundaries of a 30 metre buffer zone around any waahi tapu site (such as the Rua Hoata rock shelter site)
- are outside the vertical boundaries of a 50 metre buffer zone around Lake Rotokawa and any other Significant Geothermal Water Features as identified in the Waikato Regional Plan.

7.8 I also note that the existing land use consent for "well drilling, roading and related earthworks" and the existing discharge permit for the discharge of muds and fluids to land both contain conditions[6] which are to be retained that ensure that ground surface drilling locations (well heads) and discharges shall be no closer than:

- 100 metres from any significant geothermal feature (50 metres for discharges)
- 20 metres from the bed of the Waikato River or Parariki Stream
- 30 metres from any waahi tapu
- 100 metres from any existing dwelling.

7.9 The above buffer distances - together with the very comprehensive monitoring programme for geothermal surface features, flora and fauna in the Rotokawa thermal area, groundwater and surface water features such as the Parariki Stream, as required by the General Conditions that apply to all consents[7] – will ensure that any adverse cultural effects (such as effects on the mauri of these features) will be minimal.

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5 Refer to proposed condition 3 on page 25, Appendix 9 (Proposed consent conditions) in Part C of the RCA/AEE. In the s42A report, this is in Schedule K (page 52).

6 Refer to condition 10 on page 23 and condition 14 on page 27, Appendix 9 (Proposed consent conditions) in Part C of the RCA/AEE. In the s42A report, these are in Schedules J and K (pages 50 and 53-54).

7 Refer pages 42 to 47, Appendix 9 (Proposed consent conditions) in Part C of the RCA/AEE. In the s42A report, this is in Schedule M, General Conditions (which includes Schedule Two – Rotokawa Monitoring Programme on pages 70-72).

7.10 In addition, as a result of post-lodgement discussions with the Ngati Tahu-Ngati Whaoa Runanga Trust, the applicant proposes some further amendments to the General Conditions, specifically:

- Amended condition 1.8, new condition 1.9 and an amended condition 1.12 (previously 1.11) in the 'Peer Review Panel' conditions in section 1[8]; and
- a new advice note at the start of the 'Kaitiakitanga and community' conditions in section 2[9]; and
- condition 3.12 in the System Management Plan conditions[10].

7.11 The effect of these requested amendments is to enable the Ngati Tahu-Ngati Whaoa Runanga Trust more involvement in the processes relating to the consent holder's Annual Report and the Peer Review Panel's review, meeting and recommendations relating to that Annual Report. I support the changes to the abovementioned conditions in section 1 and 3.

7.12 Finally, on the matter of cultural effects, I note the following statements in the evidence of Ms Campbell[11] (bold emphasis added):

> *"I believe that the tangible benefits that tangata whenua have received to date as a result of the RJV's activities, through beneficiary payments, and other initiatives and grants as discussed earlier, generates a* ***net positive cultural effect****. The current consent application will ensure these benefits are enduring. On that basis, I believe any adverse cultural impacts will be fully mitigated, and furthermore, will be mitigated well beyond what would normally be achieved for similar types of developments."*

Reservoir sustainability / cumulative effects

7.13 Sections 4.3 and 4.4 of the AEE address the numeric reservoir modelling process and the modelling scenarios (including stress test scenarios) that have been run, and resource sustainability. The reservoir modelling has been peer reviewed by Dr Grant (MAGAK)[12] and also independently peer reviewed for the WRC by Dr Maunder (Earth Consult Limited). Furthermore, evidence has been presented to this hearing by Dr Grant for RJV. I defer to their expertise and conclusions that the effects of the changes proposed by the application (namely the extension to include Consent Area 4 and the increased abstraction volume

8 Refer Schedule M (General Conditions) of s42A report, page 58.
9 Refer Schedule M (General Conditions) of s42A report, page 59.
10 Refer Schedule M (General Conditions) of s42A report, page 61.
11 Refer paragraph 7.4 of Ms Campbell's evidence.
12 Refer Appendix 2 in Part C of the RCA/AEE.

and consent duration) are no more than minor. They agree that the effect within the reservoir is simply to shift more fluid around, with no net increase in take[13].. I note Dr Grant's conclusion that *"the model indicates that the proposal will produce negligible differences to the reservoir and, therefore, the environmental impact of the proposal will be negligible. This in turn illustrates the sustainable nature of the development project"*[14] .

Ground movement effects (subsidence / tilt)

7.14 Sections 4.5 and 4.6 of the AEE address subsidence modelling and effects. The subsidence modelling has been undertaken by GeoMechanics Technologies[15] and peer reviewed by Powell Geoscience Limited[16]. It has also been independently peer reviewed for the WRC by Dr Maunder (Earth Consult Limited).

7.15 During my site visit I noted the potential vulnerability of the geothermal features within the Rotokawa Conservation Area (particularly in and around the lake-edge thermal lagoon) should future subsidence occur to an extent that causes inundation by the cooler waters of Lake Rotokawa. I defer to the expertise and conclusions of the respective experts that the incremental risk posed by the proposed increased extraction rate is very small. Specifically I refer to the evidence of Steven Sewell where he states[17] *"Given the differences in modelled subsidence and tilt rates between the base case and the stress tests are negligible, the model predicts that additional subsidence effects due to the proposal will be negligible"*.

7.16 Further comfort may be gained from the comprehensive monitoring, review and adaptive management regime required by the General Conditions[18]. If any unanticipated effects were to occur, these conditions would ensure that they would be detected and appropriately managed.

Geothermal surface feature effects

7.17 Section 4.7 and 4.8 of the AEE address geothermal surface features and the thermal modelling undertaken for a range of scenarios (including stress test scenarios). These sections also address groundwater and terrestrial ecology.

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13 Refer paragraph 4.13 of Dr Grant's evidence.
14 Refer paragraph 5.2 of Dr Grant's evidence.
15 Refer Appendix 3 in Part C of the RCA/AEE.
16 Refer Appendix 4 in Part C of the RCA/AEE.
17 Refer paragraph 4.1 of Mr Sewell's evidence.
18 Refer pages 28 to 47, Appendix 9 (Proposed consent conditions) in Part C of the RCA/AEE. In the s42A report, these are in Schedule M.

7.18 I note that the General Conditions that apply to all existing consents, and which will apply to the rationalised suite of consents if granted, contain:

- condition 12.1 that requires the remediation or mitigation of any significant adverse effects on any significant geothermal features[19]; and
- Schedule 2 that sets out a very comprehensive monitoring programme for, amongst other things, geothermal surface features, flora and fauna in the Rotokawa thermal area, groundwater and surface water features such as the Parariki Stream[20].

7.19 I refer to the evidence of Dr Mroczek who concludes, based on over 19 years of intensive monitoring, that the effects of geothermal development on the shallow groundwater and thermal features in Rotokawa have been very minor. Based on this and on the modelling undertaken, he concludes that the proposal will have no adverse effects on shallow groundwater and thermal features[21].

8. RELEVANT PLANNING PROVISIONS

National Policy Statement for Renewable Electricity Generation 2011

8.1 Section 104(1)(b) of the RMA requires Council to have regard to the National Policy Statement for Renewable Electricity Generation (**NPS-REG**). This specifies that the development, operation, maintenance and upgrading of renewable electricity generation, and its benefits, are 'matters of national significance'.

8.2 The objective of the NPS-REG is:

> *To recognise the national significance of renewable electricity generation activities by providing for the development, operation, maintenance and upgrading of new and existing renewable electricity generation activities, such that the proportion of New Zealand's electricity generated from renewable energy sources increases to a level that meets or exceeds the New Zealand Government's national target for renewable electricity generation.*

8.3 The Government's national target is 90% of electricity generation from renewable energy sources by 2025, as set out in the New Zealand Energy Strategy 2011-2021. This application does not seek to increase renewable

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19 Refer page 39 of Appendix 9 (Proposed consent conditions) in Part C of the RCA/AEE. In the s42A report, this is in Schedule M (page 68).

20 Refer pages 42 to 47, Appendix 9 (Proposed consent conditions) in Part C of the RCA/AEE. In the s42A report, this is in Schedule M, General Conditions (which includes Schedule Two – Rotokawa Monitoring Programme on pages 70-72).

21 Refer paragraph 2.1 of Dr Mroczek's evidence.

generation capacity, but rather to utilise the existing generation capacity at Rotokawa A and Nga Awa Purua power stations to the fullest extent possible (and for 8 years longer). I note that the evidence of Michael Stevens for RJV concludes that *"securing access to more geothermal fluid will enable continued operation of the current generation assets at full capacity – maximising the site's generation of renewable electricity for the National Grid, and maximising the efficiency of the site's existing infrastructure"*[22]*.* In my opinion, this is fully consistent with the NPS-REG objective. It follows that if the application is not granted, then the amount of renewable electricity generated from existing generation assets will gradually decline. This outcome would, in my opinion, be contrary to the NPS-REG objective.

8.4 Policy A of the NPS-REG is:

> ***Recognising the benefits of renewable electricity generation activities***
>
> *Decision-makers shall recognise and provide for the national significance of renewable electricity generation activities, including the national, regional and local benefits relevant to renewable electricity generation activities. These benefits include, but are not limited to:*
>
> *a) maintaining or increasing electricity generation capacity while avoiding, reducing or displacing greenhouse gas emissions;*
> *b) maintaining or increasing security of electricity supply at local, regional and national levels by diversifying the type and/or location of electricity generation;*
> *c) using renewable natural resources rather than finite resources;*
> *d) the reversibility of the adverse effects on the environment of some renewable electricity generation technologies;*
> *e) avoiding reliance on imported fuels for the purposes of generating electricity.*

8.5 In my opinion, the application is fully and very clearly consistent with Policy A of the NPS-REG. It enables renewable electricity generation capacity to be maintained at optimum levels (clause a), thereby also maintaining the current contribution to security of electricity supply (clause b). The adaptive management approach that underpins the Rotokawa SMP enables adverse effects to be detected early and then remedied, or reversed, consistent with clause (d). Finally, the renewable electricity generated is fully consistent with clause (e) of Policy A in that it offsets the need for gas or coal fuelled electricity to be generated elsewhere.

8.6 Policy B of the NPS-REG is:

22 Refer paragraph 2.6 of Mr Steven's evidence.

Acknowledging the practical implications of achieving New Zealand's target for electricity generation from renewable resources

Decision-makers shall have particular regard to the following matters:

a) maintenance of the generation output of existing renewable electricity generation activities can require protection of the assets, operational capacity and continued availability of the renewable energy resource; and

b) even minor reductions in the generation output of existing renewable electricity generation activities can cumulatively have significant adverse effects on national, regional and local renewable electricity generation output; and

c) meeting or exceeding the New Zealand Government's national target for the generation of electricity from renewable resources will require the significant development of renewable electricity generation activities.

8.7 Policy B of the NPS-REG is very relevant to this application as it reinforces the need to maintain the operational capacity of existing renewable electricity generation assets and it notes in clause (b) that *even minor reductions* can have significant cumulative effect on our renewable generation outputs. In my opinion, the application is fully and very clearly consistent with Policy B of the NPS-REG.

8.8 Policy C1 of the NPS-REG is:

Acknowledging the practical constraints associated with the development, operation, maintenance and upgrading of new and existing renewable electricity generation activities

Decision-makers shall have particular regard to the following matters:

a) *the need to locate the renewable electricity generation activity where the renewable energy resource is available;*

b) logistical or technical practicalities associated with developing, upgrading, operating or maintaining the renewable electricity generation activity;

c) the location of existing structures and infrastructure including, but not limited to, roads, navigation and telecommunication structures and facilities, the distribution network and the national grid in relation to the renewable electricity generation activity, and the need to connect renewable electricity generation activity to the national grid;

d) designing measures which allow operational requirements to complement and provide for mitigation opportunities; and

e) adaptive management measures.

8.9 Policy C of the NPS-REG is also very relevant to this application. The proposed conditions are comprehensive and are an excellent example of both mitigation measures and adaptive management. For example, the Peer Review Panel conditions, kaitiakitanga conditions, SMP conditions, monitoring and review conditions (sections 1, 2, 3, 5 and 7 Schedule M respectively) all epitomise a robust adaptive management approach.

8.10 In summary, this application is fully consistent with the above NPS-REG objective and policies. The adaptive management approach (consistent with Policy C) will enable the existing generation capacity at Rotokawa A and Nga Awa Purua power stations to be utilised to the fullest extent possible (consistent with Policy B) resulting in the national, regional and local benefits as described by Policy A. This is precisely the type of project that the NPS-REG aims to support.

Operative Waikato Regional Policy Statement

8.11 The Waikato Regional Policy Statement (**RPS**) became operative in May 2016. Section 6.4 of the AEE addresses relevant provisions in the RPS relating to energy, geothermal and built environment topics. I adopt that discussion for the purpose of my evidence. Some of the most relevant provisions are set out below.

8.12 Te Ture Whaimana o Te Awa o Waikato – the Vision and Strategy for the Waikato River arose from settlement of the claims of Waikato-Tainui against the Crown in relation to breaches of the Treaty of Waitangi. The Vision and Strategy deemed by the Waikato-Tainui Raupatu Claims (Waikato River) Settlement Act 2010 and the Ngati Tuwharetoa, Raukawa, and Te Arawa River Iwi Waikato River Act 2010 to be part of the RPS, which cannot be inconsistent with it. The Vision and Strategy is set out in section 2.5 of the RPS. Objective 3.4 of the RPS is:

> ***Health and wellbeing of the Waikato River***
> *The health and wellbeing of the Waikato River is restored and protected and Te Ture Whaimana o Te Awa o Waikato (the Vision and Strategy for the Waikato River) is achieved.*

8.13 I consider this objective, and the Vision and Strategy for the Waikato River, to be relevant as the Rotokawa geothermal reservoir is within the Waikato River catchment and there is connectivity between the groundwater and surface water systems. I note that there is no change proposed to the already-consented water takes from the Waikato River and structures within Waikato River tributaries. I consider the comprehensive suite of conditions and the SMP with its robust monitoring, review and adaptive management measures are consistent with the outcomes sought by the Vision and Strategy, including the following objectives:

a) health and well-being of the Waikato River
g) avoidance of cumulative effects on the Waikato River; and
m) application of both maatauranga Maaori and the latest available scientific methods.

8.14 I refer to the evidence of Ms Campbell which she notes[23]:

> *"As the Trust's resources increase so do these initiatives expand, and new grants are offered as the needs change of the people. One example of this is the Nga Awa Purua Environmental Ecological Project along the Nga Awa Purua Reserve. The overall objective of this project is to restore this reserve land. The project is being undertaken with Ngati Tahu – Ngati Whaoa Runanga Trust. Stage one of the project was a 3 year project completed this year where the Trust provided funding towards riparian planting works. Stage 2 starts in September 2016 where the Trust has provided further funds".*

8.15 In my opinion this is a good practical example of how this application is able to indirectly support initiatives that are consistent with the Vision and Strategy.

8.16 The relevant parts of Objective 3.2 of the RPS are:

> ***Resource use and development***
> *Recognise and provide for the role of sustainable resource use and development and its benefits in enabling people and communities to provide for their economic, social and cultural wellbeing, including by maintaining and where appropriate enhancing …*
>
> *c) the availability of energy resources for electricity generation and for electricity generation activities to locate where the energy resource exists*;

8.17 I consider the application to be fully consistent with this objective. It will deliver benefits as discussed in paragraphs 7.4 and 7.5.

8.18 The relevant parts of Objective 3.3 of the RPS (bold emphasis added) are:

> ***Decision making***
> *Resource management decision making is holistic and consistent and:*
>
> *d) adopts a precautionary approach, including the use of* ***adaptive management****, where appropriate, towards any proposed activity whose effects may be significant or irreversible but are as yet uncertain, unknown or little understood;*

23 Refer paragraph 5.15 of Ms Campbell's evidence.

f) *has regard to the potential for **cumulative effects** from activities;*

g) *is based on the **best available information**, including mātauranga Māori;*

8.19 I consider the application fully consistent with this objective in that it is founded upon robust science, modelling, monitoring and independent peer review. This is the best information available. This has triggered an adaptive management response to provide flexibility to draw geothermal fluids from a new part of the reservoir (Consent Area 4), and 10,000 tonnes per day more fluid overall, while drawing less from other parts of the reservoir, to maintain existing generation capacity in a more sustainable manner. The Peer Review Panel and kaitiakitanga conditions proposed will continue to ensure that cumulative effects will be monitored and responded to having regard to the best available, and independently reviewed, information.

8.20 Objective 3.5 of the RPS is:

Energy

Energy use is managed, and electricity generation and transmission is operated, maintained, developed and upgraded, in a way that:

a) *increases efficiency;*

b) *recognises any increasing demand for energy;*

c) *seeks opportunities to minimise demand for energy;*

d) *recognises and provides for the national significance of electricity transmission and renewable electricity generation activities;*

e) *recognises and provides for the national, regional and local benefits of electricity transmission and renewable electricity generation;*

f) *reduces reliance on fossil fuels over time;*

g) *addresses adverse effects on natural and physical resources;*

h) *recognises the technical and operational constraints of the electricity transmission network and electricity generation activities; and*

i) *recognises the contribution of existing and future electricity transmission and electricity generation activities to regional and national energy needs and security of supply.*

8.21 Similar to my earlier analysis and comments in relation to the NPS-REG, it is also my opinion that this application is fully consistent with this objective. The granting of the consents sought will maximise the efficiency of the existing generation assets and provide for the national, regional and local benefits of renewable electricity generation. Not only is the project consistent with this objective, the granting of the consent sought will assist the Region to achieve this objective.

8.22 Objective 3.17 of the RPS is:

> ***Geothermal***
> *Sustainable management of the Regional Geothermal Resource is promoted by:*
>
> *a) ensuring integrated management of geothermal systems;*
> *b) allocating some of the geothermal resource for take, use and discharge in a way that enables current energy needs and the reasonably foreseeable energy needs of future generations to be met, while avoiding, remedying or mitigating significant adverse effects on the Regional Geothermal Resource; and*
> *c) protecting some characteristics of the Regional Geothermal Resource from significant adverse effects.*

8.23 The above objective is to be achieved by a number of policies in the RPS, the most relevant ones being Policies 9.1, 9.2 and 9.3.

8.24 Policy 9.1 of the RPS is:

> ***Sustainable management of the Regional Geothermal Resource***
> *Sustainably manage the Regional Geothermal Resource in a way that provides for multiple uses and the extent and variety of the region's geothermal features including by:*
>
> *a) classifying geothermal systems for management based upon:*
> *i) system size;*
> *ii) the vulnerability of Significant Geothermal Features to extractive uses; and*
> *iii) existing uses;*
> *b) managing the effects of development and use of land and non-geothermal water on the Regional Geothermal Resource; and*
> *c) allocating some of the Regional Geothermal Resource for protection and some for take, use and discharge.*

8.25 This policy is implemented by Method 9.1.1 of the RPS which specifies that the region's geothermal systems shall be classified in the Waikato Regional Plan (**WRP**) as Protected, Research, Limited Development or Development Systems. In the WRP, Rotokawa is classified as a Development Geothermal System. My evidence will address this in more detail shortly.

8.26 Policy 9.2 of the RPS is:

> ***Significant Geothermal Features***
> *Recognise that some geothermal features are significant and provide the appropriate level of protection for these features within different geothermal systems.*

8.27 In relation to Development Geothermal Systems, this policy is implemented by Method 9.2.3 of the RPS which specifies that regional and district plans shall ensure, amongst other things, that:

> *a) significant adverse effects on Significant Geothermal Features in Development Geothermal Systems from take, use or discharge of geothermal energy and water are remedied or mitigated;*

8.28 Policy 9.3 of the RPS is:

> ***Development Geothermal Systems***
> *Development Geothermal Systems shall be managed in a way that enables large-scale use and development of geothermal energy and water and:*
>
> *a) promotes efficient use of the geothermal resource;*
> *b) recognises and allows for controlled depletion of energy so as to provide for the energy needs of current and future generations;*
> *c) takes an integrated management approach, including through:*
> *i) the development of a System Management Plan for each Development Geothermal System;*
> *ii) establishing a peer review panel for the purpose of assisting the consent authority to manage the system; and*
> *iii) the development and imposition of appropriate resource consent conditions;*
> *d) requires reinjection/injection of the geothermal water from large-scale takes remaining after use;*
> *e) provides for small and medium-scale use and development that is not inconsistent with any approved system management plan; and*
> *f) avoids, remedies, or mitigates adverse effects on other natural and physical resources including overlying structures.*

8.29 In my opinion, this proposal is consistent with the RPS's Geothermal objective and policies. As a development geothermal system, Rotokawa has been recognised as a suitable location for electricity generation. The modelling undertaken in support of this resource consent application has shown that the proposal is sustainable in the long term, with changes in predicted reservoir pressure, temperature and enthalpy all sustainable over the modelled 50 year period. This will allow the continued use of geothermal energy and water from the Rotokawa Geothermal System to generate much needed base load electricity for current and future generations, as envisaged by clause (b). The application proposes an integrated management approach including a Peer Review Panel, an SMP, and comprehensive consent conditions, all as envisaged by clause (c). Reinjection continues to be a key element of the management strategy of the proposal and the SMP, consistent with clause (d) and there is a robust framework in place to avoid, remedy and mitigate adverse effects, consistent with clause (f).

Operative Waikato Regional Plan

8.30 The Waikato Regional Plan (**WRP**) became operative, for the most part, in September 2007 and then subsequently - between 2008 and 2012 - four significant variations have also become operative. Chapter 2 (Matters of Significance to Maori) and Chapter 7 (Geothermal Module) are the most relevant chapters for this application.

8.31 In Chapter 2, section 2.2.3 introduces Waikato-Tainui's rohe and its special relationship with its tupuna (ancestor) - the Waikato River - from the Huka Falls to its mouth. Then, section 2.2.5 introduces Ngati Tuwharetoa's rohe and its special relationship with their various taonga including Lake Taupo, the Waikato River and geothermal areas. In section 2.2.5.2 there is the following statement:

> *"Waikato Regional Council recognises and acknowledges that Ngati Tuwharetoa are tangata whenua of their rohe. Waikato Regional Council also recognises and acknowledges the important physical, spiritual, cultural, social and economic values held by Ngati Tuwharetoa in regard to the natural and physical resources in their rohe".*

8.32 Objective 2.3.2(b) is:

> *"Tangata whenua able to give effect to kaitiakitanga".*

8.33 Kaitiakitanga is defined in Part 1 of the RMA as:

> *"Kaitiakitanga means the exercise of guardianship by the tangata whenua of an area in accordance with tikanga Maori in relation to natural and physical resources; and includes the ethic of stewardship:"*

8.34 There are two policies in section 2.3.3 and 25 implementation methods in section 2.3.4 of the WRP to give effect to the above objective. I note that the applicant has consulted with the following other tangata whenua groups as part of preparing this application:

- Ngati Tahu-Ngati Whaoa Runanga Trust
- Tauhara Moana Trust
- Tuwharetoa Maori Trust Board
- Tuwharetoa Settlement Trust
- Te Arawa River Iwi Trust.

8.35 The submitters' witnesses are better placed than me to comment on the exercise of their kaitiaki role in relation to this application. That said, for the reasons expressed in paragraphs 7.6 to 7.12 of my evidence (cultural effects), I do consider that the applicant has demonstrated a genuine respect for the important role of kaitiakitanga and has responded with appropriate suggestions for mitigation measures and conditions. The evidence of Ms Campbell and Wikitoria Hepi-Te Puia makes it abundantly clear how important they regard their kaitiaki role.

8.36 Chapter 7 contains the objectives and policies that relate to the management of the geothermal resource of the Waikato Region.

8.37 In accordance with the policies and methods in the Regional Policy Statement, the WRP identifies the region's large geothermal systems as Development, Limited Development, Research or Protected Geothermal Systems. In this way, it achieves overall sustainable management of the regional geothermal resource while allowing controlled depletion of specified Development Systems. Rotokawa is a Development Geothermal System, as set out in Table 1 within Policy 1 of the WRP.

8.38 The most relevant objectives and policies for this application are:

> ***Objective 2***
> *In Development Geothermal Systems, significant adverse effects on Significant Geothermal Features arising from the take of geothermal energy and water to be remedied or mitigated within the Regional Geothermal Resource.*
>
> ***Objective 5***
> *In Development Geothermal Systems, adverse effects on other natural and physical resources including overlying structures (the built environment), such as those resulting from subsidence and land instability, arising from the take, use, and discharge of geothermal energy or water to be avoided, remedied or mitigated.*
>
> ***Objective 8***
> *Increased knowledge about the Regional Geothermal Resource, and better understanding of the effects of using the resource and effects of other activities on the resource.*
>
> ***Policy 1 - Identification of Geothermal Systems*** (relevant part only)
> *Promote the sustainable management of the Regional Geothermal Resource by identifying Geothermal Systems for different uses in accordance with the categories in Section 3.7.2, Policy Three of the Regional Policy Statement, as follows:*

***(A) Development Geothermal Systems**, where the take, use and discharge of geothermal energy and water will be allowed while:*

- *remedying or mitigating significant adverse effects on Significant Geothermal Features; and*
- *avoiding, remedying or mitigating adverse effects on other natural and physical resources including overlying structures (the built environment).*

Policy 3 - Management of Use and Development in Development Geothermal Systems

Control the depletion of energy in Development Geothermal Systems through stepped production based on reservoir modelling that:

- *considers the capacity of the system as a whole; and*
- *considers the reasonably foreseeable needs of present and future generations; and*
- *promotes efficient management and use of the system.*

Policy 4 - Integrated System Management of Development Geothermal Systems

Each Development Geothermal System shall have an up to date approved System Management Plan that defines the objectives to be achieved in relation to the System having regard to the relevant policies in the RPS.

Policy 6: Significant Geothermal Features in Development Geothermal Systems

Where significant adverse effects on Significant Geothermal Features in Development Geothermal Systems are to be remedied or mitigated, the remediation and mitigation may include:

- *the take and return of geothermal water being managed to remedy or mitigate significant adverse effects on those Significant Geothermal Features affected, or*
- *adverse effects on features of the same or similar type (defined in the glossary) being remedied or mitigated to an extent commensurate with the adverse effect being caused ('like for like' mitigation).*

8.39 In my opinion, the three components of these applications – being the extension of the abstraction area to include Consent Area 4; the increased abstraction volume by 10,000 tonnes per day; and the rationalisation of consents and extension of expiry dates by 8 years – are all consistent with the above objectives and policies given the categorisation of Rotokawa as a Development Geothermal System. Extensive reservoir modelling has been undertaken that supports the controlled depletion proposed (consistent with Policy 3) and the Rotokawa system is being carefully managed under a robust System Management Plan (consistent with Policy 4) which is subject to regular scrutiny by an Independent Peer Review Panel process. I understand the conclusions of the respective technical experts for RJV and WRC – underpinned by extensive monitoring and modelling – to be that the proposal will not give rise to any significant effects on SGF's nor any more than minor effects on any other natural and physical resources (consistent with Policies 1 and 6 and Objectives 2 and 5).

Operative Taupo District Plan

8.40 As this application only involves new sub-surface activities, and as all existing and proposed surface activities are already covered by existing land use consents from Taupo District Council, then the Taupo District Plan is not relevant for this hearing.

9. OTHER RELEVANT MATTERS

New Zealand Energy Efficiency and Conservation Strategy 2011-2016

9.1 The New Zealand Energy Efficiency and Conservation Strategy 2011-2016 ("**NZEECS**") contributes to the delivery of the Government's energy priorities set out in the New Zealand Energy Strategy as discussed below.

9.2 The NZEECS is a strategy prepared in accordance with the Energy Efficiency and Conservation Act 2000. Under the Energy Efficiency and Conservation Act 2000, the NZEECS is to promote energy efficiency, energy conservation and renewable energy in New Zealand[24].

9.3 Of relevance to RJV's application, the NZEECS provides objectives and targets, including those for the electricity system. The objective for the electricity system is "an efficient, renewable electricity system supporting New Zealand's global competitiveness." Its associated target is consistent with the NZES being:

> *"by 2025: 90 percent of electricity will be generated from renewable sources, provided supply security is maintained."*

New Zealand Energy Strategy 2011 – 2021

9.4 The New Zealand Energy Strategy (**NZES**) is a non-statutory document which sets out the Government's direction with respect to energy matters.

9.5 The goal of the NZES is to make the most of New Zealand's abundant energy potential, for the benefit of all New Zealanders. The strategy aims to achieve this through environmentally-responsible development and efficient use of the

24 Energy Efficiency and Conservation Act 2000, sections 8 and 9.

country's diverse energy resources so that the economy grows powered by secure, competitively-priced energy.

9.6 In my opinion, granting the consents sought by RJV would be consistent with the guidance and directions of both the NZES and the NZEECS which are relevant considerations under section 104(1)(c) of the RMA.

Environmental Management Plans

9.7 Subject to considering evidence from submitters that I have not received yet, I am of the opinion (based on the cultural effects and environmental effects section of my evidence above) that the granting of the consents sought by the RJV will not be inconsistent with the Environmental Management Plans of Ngati Tahu-Ngati Whaoa, Ngati Tuwharetoa or the Te Arawa River Iwi. This conclusion draws on the evidence of others in the RJV team that the incremental effects above the consented baseline will be either negligible or minor. I consider the comprehensive suite of conditions and the SMP with its robust monitoring, review and adaptive management measures will be consistent with the kaitiakitanga outcomes sought by these plans.

10. REGIONAL COUNCIL STAFF REPORT

10.1 I have reviewed the Council's s42A report and I agree with the analysis and evaluation comments set out in the report. Section 9 of the report suggests relatively minor changes to the conditions of consent proposed by the applicant. Mr Jackson responds to these suggested changes in his evidence, drawing upon the conclusions of Mr Sewell and Dr Mroczek. Mr Jackson provides specific alternative wording (relief sought) in his evidence. The areas of disagreement relate to:

- Thermal infrared monitoring condition;
- Groundwater monitoring conditions;
- Groundwater well monitoring frequency;
- Parariki Stream monitoring frequency.

10.2 I have reviewed the amendments requested by Mr Jackson and consider that they are appropriate and provide for a balanced and robust approach to monitoring.

11. STATUTORY EVALUATION

Section 104 matters

11.1 In paragraph 5.1 of my evidence I set out the wording of section 104(1) of the RMA which requires the Hearing Committee to consider the application and submissions received and, subject to Part 2 of the RMA, have regard to:

- Actual and potential effects on the environment
- Relevant planning provisions
- Other relevant matters.

11.2 I have used section 104(1) as the framework for the structure of my evidence in that:

- Submissions were addressed in section 6;
- Effects on the environment were addressed in section 7;
- Relevant planning provisions in the NPS-REG, RPS and WRP were addressed in section 8;
- Other relevant matters such as the NZEECS and NZES were discussed in section 9

11.3 I conclude that the issues raised in submissions have been addressed in the technical evidence of other expert witnesses.

11.4 The actual and potential effects on the environment have also been thoroughly addressed in the AEE and in the technical evidence of other expert witnesses, and I have drawn on their respective conclusions to reach my own conclusion that, having regard to the consented "effects envelope", the incremental and cumulative effects potentially associated with this application are no more than minor. Assurance in this regard is provided via a comprehensive suite of revised conditions that would apply to the rationalised consents.

11.5 I am of the opinion that the application is fully consistent with the provisions of the NPS-REG, the RPS, WRP for reasons that I have explained throughout my evidence.

11.6 Finally, in terms of section 104 matters, the application is fully consistent with central government's national policy directions in the NZEECS and NZES.

Part 2, RMA

11.7 Section 5 of the RMA provides that the purpose of the Act is to "promote the sustainable management of natural and physical resources". Section 5(2) of the RMA states:

> *"In this Act, sustainable management means managing the use, development and protection of natural and physical resources in a way, or at a rate, which enables people and communities to provide for their social, economic and cultural wellbeing and for their health and safety while –*
>
> *(a) sustaining the potential of natural and physical resources (excluding minerals) to meet the reasonably foreseeable needs of future generations; and*
> *(b) safeguarding the life-supporting capacity of air, water, soil, and ecosystems; and*
> *(c) avoiding, remedying, or mitigating any adverse effects of activities on the environment".*

11.8 I consider that the application is consistent with the sustainable management purpose of the Act as set out in section 5. Specifically, approval of the applications sought will enable the existing power stations to be run to their design capacity rather than being under-utilised, and this additional renewable electricity generated will assist the regional and national community to provide for its collective social, economic and cultural wellbeing[25] and health and safety. This is because electricity is a fundamental enabler for all aspects of modern life. This proposal's contribution to the nation's current and future electricity needs will be realised while:

(a) Being fully consistent with the sustainable management of the region's geothermal resources (as development and use of the "development systems" can be regarded as being at one end of a spectrum which extends through a range of other more protective geothermal classifications to the fully "protected systems" elsewhere in the region);

(b) Meeting the reasonably foreseeable needs of future generations as above;

(c) Safeguarding the life-supporting capacity of geothermal surface features and their ecosystems (assured by comprehensive monitoring and other conditions);

25 Refer paragraph 7.4 of Ms Campbell's evidence.

(d) Avoiding, remedying and/or mitigating other adverse effects on the environment, such as on built structures and existing activities and users.

11.9 Turning now to the Section 6 matters of national importance that the Hearing Panel is required to “recognise and provide for”, I consider that the relevant matters for this application are:

- The protection of areas of significant indigenous vegetation and significant habitats of indigenous fauna: [section 6(c)];
- The relationship of Maori and their culture and traditions with their ancestral lands, water, sites, waahi tapu, and other taonga [section 6(e)].

11.10 For all the reasons set out earlier in my evidence, I consider that the proposed consent conditions (with their adaptive management, modelling, monitoring, consultation and independent peer review requirements) do recognise and provide for the above section 6, RMA matters.

11.11 I also consider that the application is fully consistent with the section 7, RMA matters, the relevant ones being:

- Kaitiakitanga [section 7(a)]
- The efficient use and development of natural and physical resources [section 7(b)]
- Maintenance and enhancement of the quality of the environment [section 7(f)]
- The benefits to be derived from the use and development of renewable energy [section 7(j)]

11.12 Kaitiakitanga is a core principle for the Trustees of the Tauhara North No. 2 Trust (RJV partner) as addressed in the evidence of Ms Campbell and Ms Hepi-Te Puia. The application proposes the efficient use of the Rotokawa geothermal resource (natural resource) while maximising the efficient use and full capacity of the sites’ existing infrastructure (physical resources). This enable a wide range of benefits to be provided, consistent with section 7(j) of the RMA.

11.13 Section 8 requires that all parties exercising functions and powers under the RMA in relation to managing the use, development, and protection of natural and physical resources shall take into account the principles of the Treaty of Waitangi (Te Tiriti o Waitangi).

11.14 Finally, drawing from the expert technical evidence presented by other witnesses on which I rely for my own conclusions, it is my opinion that the proposal (and the consent conditions) will ensure sustainable management of the Rotokawa geothermal system and that this taonga will be safeguarded and its mauri maintained – that is, having regard to its context as a Development Geothermal System. Consultation with tangata whenua has been undertaken and meaningful commitments have been made by the applicant to ensure sustainable, integrated management. I believe that the above is consistent with the principles of the Treaty of Waitangi (Te Tiriti o Waitangi) and, therefore, consistent with section 8 of the RMA.

12. PLANNING CONCLUSION

12.1 In conclusion, I consider that extending the steamfield into Consent Area 4 will provide RJV with operational flexibility to apply an adaptive management approach (moving production away from the consented western reservoir area) in response to current reservoir enthalpy behaviour. Furthermore, securing access to more geothermal fluid (average 10,000 tonnes per day extra) will enable continued operation of the existing generation assets at full capacity, an outcome that is consistent with the:

- NPS-REG
- New Zealand Energy Strategy
- objectives and policies of the Waikato RPS and Regional Plan as they relate to this development system and
- purpose and principles of the Resource Management Act 1991.

Andrew Michael Collins
12 September 2016