TAUPO, NEW ZEALAND: DIRECT USE OF A LOW TEMPERATURE RESOURCE

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1 KEY WORDS

low temperature reservoir, downhole heat exchangers, space heating, regulations

2 ABSTRACT

This paper reviews the development and future of the hot groundwater resource in Taupo. A significant proportion of the township is underlain by hot groundwater There is also a very shallow, very low pressure steam resource Some commercial premises, motels and several hundred households use the resource. Most households use very low output downhole heat exchangers in shallow groundwater bores. Relatively low temperatures that are declining, poor permeability, and new government regulations discourage much further development of this shallow geothermal resource.

3 RESOURCE

Taupo township is on the edge of the Wairakei-Tauhara geothermal field (Figure 1). Rainfall on the flanks of Mount Tauhara, a dormant dacite volcano, infiltrates the surface pumice and volcanic ash deposits draining through it into the lake and upper Waikato river The groundwater is heated by steam migrating up from the deep reservoir Drawdown in the deep reservoir caused by production for the Wairakei Power Station created an expanding steam zone and a three to five fold increase in heat flow to the surface This appeared to peak about 1980 and it has been declining since then. The groundwater temperatures appear to be declining only in the northern part of Taupo township which infers that there might be two shallow geothermal systems (DSIR 1988)

There is a large region of surface thermal activity on the northeastern edge of town consisting of thermal vegetation, steaming ground and fumaroles. A few hydrothermal eruptions have also occurred in this area This land has been used for recreation, industry, or left rural.

The groundwater is slightly mineralised and unsuitable for potable use Aquifer conditions are difficult to determine because of internal flows in bores The pumice and ash layers appear to act as a series of aquifers and aquitards. However, the data does suggest that there have been only small changes in downhole pressures over the last forty years with the exception of a small area of drawdown to the northwest (DSIR, 1988)

4 HISTORY OF USE

The original Maori used the hot water springs for bathing and cooking. European settlement was from the 1860s onwards with the development of several big hotels that had bathing complexes attached As the town is at the junction of several major roads, together with a number of notable scenic attractions that include the geothermal activity, it has always drawn many visitors

At the end of the Second World War the town was a hamlet of less than 750 residents and a lot of small holiday homes. Large forestry plantations, and to a lesser extent new power stations on the upper Waikato, provided the impetus for growth Housing started being built on areas that were underlain by hot water Several bores had been drilled before the war, but the first domestic hot water bore appears to have been drilled in 19.50

In the sixties and seventies, a lot of housing was erected in the hot areas A large ridge behind the housing had many active thermal areas so this area was used for industrial development and reserves. Many houses had hot water bores put down. At one stage, ten to twenty wells a month were being drilled for householders. An energy crisis in the early seventies and government encouragement to use alternate energy resources gave additional incentive to the push to convert to geothermal for domestic heating. It is estimated that up to 1000 bores, including steam soakholes had been drilled by 1987.

The Department of Scientific and Industrial Research (DSIR) had a research centre at Wairakei associated with the power station development Some of the scientists there took an interest in the shallow geothermal resource but it was very much on an ad hoc basis for many years Temperature surveys were done on many wells just after they were drilled and the springs were regularly monitored. No concerted research was done on the resource however, until the late seventies. By this time, major changes had occurred so there was little baseline information.

In the early eighties, there were concerns over changes in the behavior of the geysers in Rotorua The decline in surface activity was attributed to the large drawoff by inefficient domestic and commercial geothermal bores in the city Punitive regulations were brought in, forcing a lot of bores to be abandoned and others to have more efficient heat exchanger set ups The whole issue in Rotorua, has been very contentious and has still not been fully resolved

A number of the regulations that were used for Rotorua were then enforced on the Taupo bores They involved regular inspections with fees, restrictive construction and maintenance practices, and the possibility of royalties. Under the new rules, bores have become prohibitively expensive and uneconomic where temperatures and permeability are low The only relief for Taupo boreowners was that a bore had to be hotter than 70°C to be covered by the regulations Because of the temperature decline, a lot of bores are now under the threshold temperature hence outside the legislation. Figure 2 shows the temperature decline of a typical bore. The main permeability for this bore is about 30m depth

Since the regulations came into effect in 1989, very few new bores have been drilled Those that have are generally in the cooler parts of the reservoir where the regulations don't apply. It is believed some wells have also been drilled in the hotter areas without proper authorisation.

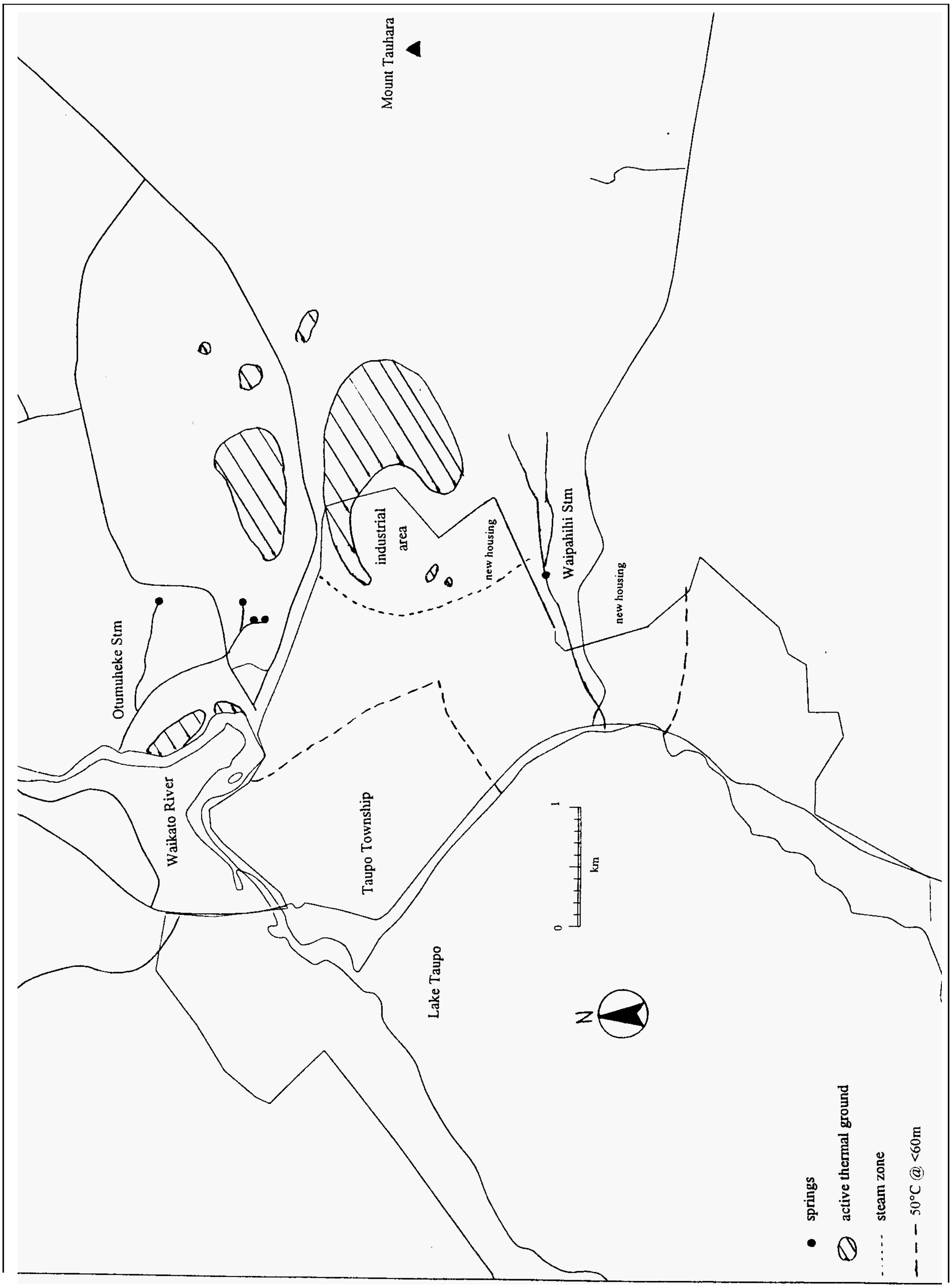

Figure 1: Map of Taupo and surroundings

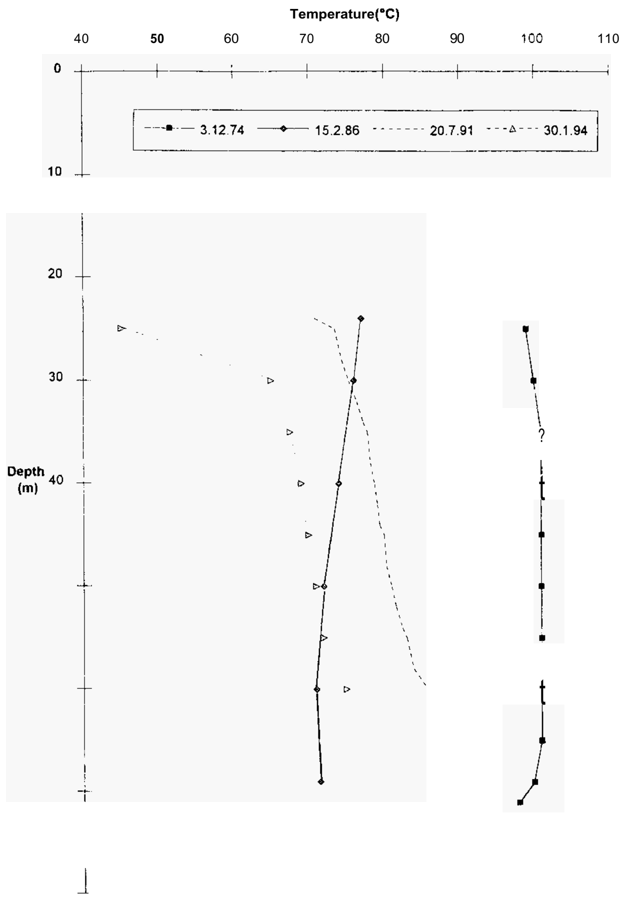

Figure 2: Historical temperature changes in typical bore

5. SPRINGS

There are two major hot water streams in Taupo and they have their origins from hot water springs and seeps. The larger one, the Otumuheke, is to the north of the town and flows into the upper Waikato river. The Waipahihi flows from the southern part of the thermal area into the lake.

Springs at the head of both streams are used for outdoor hot water swimming complexes. Approximately 80% of all geothermal energy use in Taupo is used at these swimming pools (Curtis, 1988). Both pools use air spraying as a means of reducing the temperature of the spring water for direct use in bathing pools. The municipal baths at the head of the Otumuheke also have large heat exchangers so the main pools can be filled with chlorinated water. This minimises the health risk from amoebic meningitis that has been a problem in some NZ hot pools

Changes to the long term rainfall patterns, together with changes in the surface flux of steam to the surface have meant that the spring flows and temperatures in the Otumuheke springs have become more erratic The diminished water flow at the springs has also meant that the grass on the golf course above the springs has been suffering heat stress from the hotter ground temperatures. Unpublished monitoring has shown that the flow at one of the springs responds rapidly to rainfall and to a lesser extent, atmospheric pressure The heat supply from the springs dropped so much over the winter of 1993 from the lack of rain that a deep bore had to be drilled to provide an additional fluid supply for continued operation of the pool.

6. WATERBORES

The permeability of the wells in the surface deposits is generally fair to very poor. Most of the bores are actually located in areas of very poor permeability. The temperatures and pressures are such that none of the shallow bores discharge, or can be stimulated to discharge two phase fluid. Tests have indicated that the permeability is associated with narrow layers (Morris 1993). There 1981). Figure 3 shows the downhole profiles of three bores less than 100m apart. If one considers isothermal conditions as indicative of internal flows between permeable zones, then the profiles indicate discrete, poorly connected aquifers.

The bores are usually of a very simple construction. A *75* or 100mm diameter steel pipe **is put** down 20 to 30m as a liner. The well is drilled open hole down to a depth of 40 to 80m. A copper U bend heat exchanger with polybutylene pipes to the surface is placed in the hole and connected to the domestic water supply. The water that is heated in the heat exchanger is used for domestic hot water or space heating. The system is often set up so that thermosiphoning or pumped recirculation can be utilised.

Output of the bores is low, typically 1 to 5 kW under normal operating conditions (Morris, 1993). Recirculation allows for an increased storage capacity by increasing the volume of hot water. The maximum outlet temperature of the water is 45-85°C, usually about 10°C lower than the downhole temperatures around the heat exchanger. Because the maximum potential output of the bores **is** so low, they need to be simple. Installation of equipment to improve the efficiency cannot usually be economically justified.

Some bores have two downhole heat exchangers, one for hot water, the other for space heating. Some have a downhole pump or airlift that supplies a pool. However, there is not enough permeability in most wells to make these options generally viable.

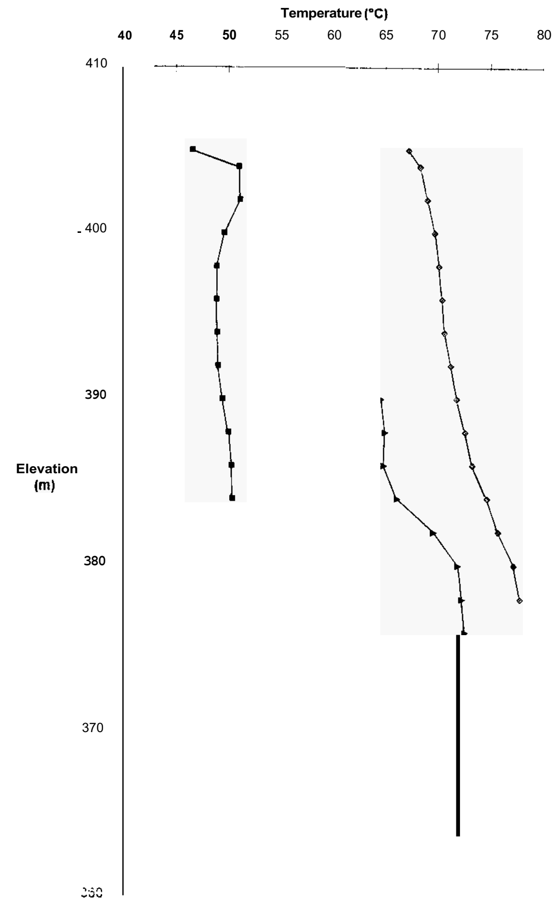

Figure 3: Downhole profiles of 3 adjacent bores

7 STEAM

Around the industrial area of Taupo, there is a very shallow, very low pressure steam resource The steam has been a major obstacle to development in parts of Taupo, particularly the industrial area Underground cables and pipes are corroded in the hot ground and sewage has been cooked by the heat However, there has been very few problems with hydrogen sulphide gas and they have all been of a minor nature

Figure 4 shows the temperature profile in one of the few wells that is open to both steam and groundwater zones The well is on the edge of an area of transient thermal ground and was discharging steam during the survey. This well was cold (<30°C) until 1988 and occasionally reverts to this state for several weeks or months at a time. Conditions in the bore appear to be related to surface activity more than fifty metres away

Very little research has been done on the shallow steam, which does not appear to he sourced from the directly underlying ground water The steam flow is dependant on weather and atmospheric pressure, so a long period of fine (high pressure) weather can cause the discharge to stop The steam **is** probably migrating long distances through unconsolidated packed pumice layers capped by clays or siltstones Cuttings and excavations support this explanation

Rain runoff is normally disposed of by soakholes in Taupo **A** typical house would have 2 or 3 soakholes, each 0 5 to 0 7Sm diameter and two to five metres deep Soakholes constructed in parts of town subsequently vented steam and some householders have utilised this steam supply. Most have put heat exchangers such as coils of pipe in the soakholes and connected the pipes to their domestic water so that heat can be used in the same way as hot water bores. Others have put a collection pipe on the top of a soakhole and use the steam directly in radiators or surface heat exchangers

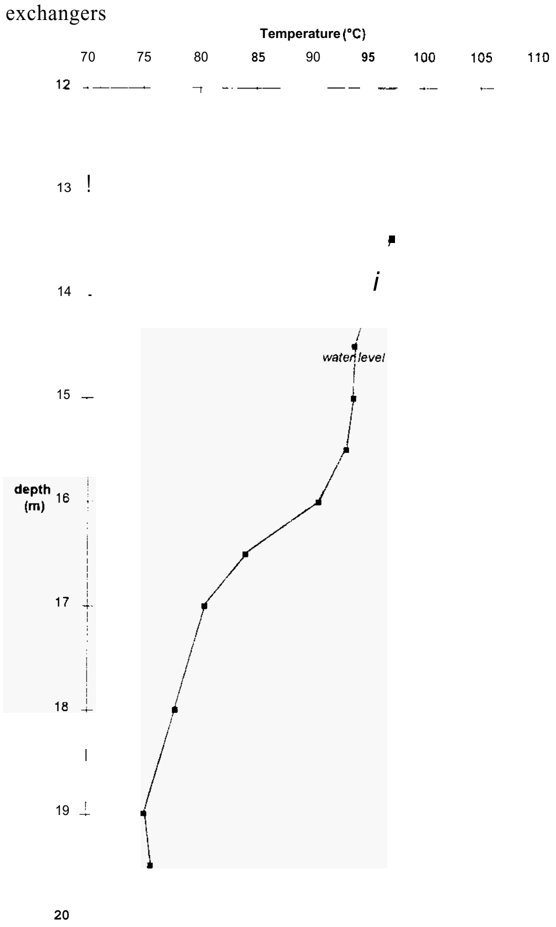

Figure **4:** Temperature profile in a bore discharging steam

8 REGULATORY ENVIRONMENT

For the purposes of resource management, all naturally heated water hotter than 30°C is considered geothermal The threshold for specific safety legislation relating to geothermal wells is a downhole temperature of greater than 70°C. If any fluid brought to the surface is greater than 70°C, including that from the secondary side of a downhole heat exchanger, this is also considered geothermal and comes under the geothermal safety legislation (Chief Geothermal Inspector, 1992, pers comm).

Almost all geothermal work was covered by the Geothermal Energy Regulations which first came out in 1961 and were subject to a number of additions and alterations, particularly in the last 10 years At the end of 1992, the regulations were moved substantially unaltered into the Health, Safety and Employment legislation. The Geothermal Inspectorate, which enforces the safety aspect of the legislation is also bringing in a Code of Practice for wells less than 150m deep

The prescriptive regulations and Code of Practice are seen by many in Taupo as the death knell of domestic geothermal development The new regulations mean that wells have to be fitted with master valves and have cemented casings if they are likelv to encounter conditions of over 70°C. The cost of meeting these conditions makes the bores uneconomic.

An example of the regulatory overkill is that the process of lifting a heat exchanger in a 71°C bore is considered drilling work This means that comprehensive details have to be supplied to an office 150km away and consent obtained before the work can start What used to be a simple two person job that took ten minutes has now become an excessively bureaucratic exercise In the face of this paperwork, people now often work outside the law

The government is investigating the possibility of charging all geothermal energy users a royalty for the use of the energy At present, only bore owners in Rotorua pay royalties, but the legislation is in place to charge everyone. Discussion papers have been circulated about possible charging regimes The Taupo domestic bores will probably escape being charged royalties because the regional government consider them permitted activities, hence outside possible royalty charges (WRC, 1991).

9 FUTURE

With the declining temperatures. it is probable that there will be little new drilling in the peripheries of the hot water zone. This covers the bulk of the existing housing. However, a lot of new housing is going up in the hot region where ground water temperatures of 80° to 100°C are present at less than 60m depth. There **is** also steam present in this area that could be used (see Figure 1)

Domestic geothermal energy supply would he ideal for the new housing Curtis (1988) estimated that only 4% of the natural heat flow was used. The output from DHEs in existing bores in the area is typically 5kW. The permeability is good so it **is** likely that there would be little interference between closely sited bores At the present housing density, it would be possible to supply the two hundred houses in the area with a renewable, reliable and efficient energy supply. However, it would require legislative changes that are not planned (Chief Geothermal Inspector, 1992-93, pers comm).

Putting the homes on geothermal energy would also lower air pollution and greenhouse gas emissions This is because the alternatives for space heating in Taupo are electricity, natural gas and firewood The marginal demand for electricity in New Zealand is met by burning gas or coal in thermal power stations. Natural gas is reticulated to the suburbs. With Taupo surrounded by plantation forests, firewood is very accessible. Many homes have a wood burning enclosed fire for space heating. These are relatively efficient but pollution is a problem on still, frosty nights.

The regional council, which is responsible for the management of resources in the area, wants domestic use of the thermal groundwater to continue (WRC, 1991) This will help reduce the thermal load from hot groundwater on the lake and upper Waikato. Because of their negligible impact on aquifer pressures, downhole heat exchangers will be preferred to downhole pumps. Along with the present bores, the council wishes to see the development of larger bores feeding group heating schemes similar to those in Rotorua. None of these have been developed yet. Results from earlier tests (Pan 1984) indicate that it is unlikely that sufficient heat will be available to make such schemes economic. The regulatory framework is not conducive to such developments either.

There is speculation that New Zealand will again be in an electricity shortfall situation within the next few years. If and when this happens, there could be another surge of geothermal development. Unfortunately, because of the problems outlined above, it is unlikely to stimulate increased domestic geothermal use in Taupo.

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