

**BOARD OF INQUIRY
TE MIHI GEOTHERMAL POWER STATION PROPOSAL**

In the Matter of the Resource Management Act 1991

And

In the matter of resource consent applications by Contact Energy Limited
in respect of the Te Mihi Geothermal Power Station Proposal

REBUTTAL EVIDENCE OF CHRISTOPHER JOHN BROMLEY

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Introduction.

1. My name is Christopher John Bromley. I am a geothermal scientist with an MSc (Hons) degree in geophysics from Victoria University. I am employed by GNS Science, at the Wairakei Research Centre, as a geothermal consultant and senior research scientist. I refer the Board of Inquiry to the statement of my qualifications and experience in my evidence in chief. I reaffirm my commitment to comply with the code of conduct for expert witnesses in the Environment Court.
2. The purpose of this brief of evidence is to respond to an issue raised by Dr Watson (giving evidence for Waikato Regional Council) regarding the potential for adverse effects to result from rising reservoir pressures on the Tauhara Field as a result of the additional reinjection for which Contact is seeking consent.
3. Dr Watson's concern is that raising pressures in the Taupo area too rapidly may cause adverse effects, including accelerating subsidence, because of steam zone quenching causing initial pressure decline. I agree that this is a factor to be considered in future system management (I would class the risk as small but real) and therefore some caution is advised.
4. As with a number of geothermal reservoir issues, however, it depends on the specific circumstances. During the Environment Court hearings in 2005 regarding geothermal policies in the Waikato Region, two eminent geothermal scientists giving evidence to the Court, Drs Rick Allis and Karsten Pruess, discussed the effects on steam zone pressure of injected water and agreed a joint statement. In short, either effect is possible (pressure support or pressure reduction), depending on the situation.
5. The same issue was discussed at some length in the appeals heard by the Environment Court in late 2006 and early 2007 relating to Contact's Wairakei resource consents. I identified the risk identified by Dr Watson in my evidence at those hearings, as indeed did he. The solution adopted by the Court to address this issue along with the other uncertainties of management of the System was to put in place an adaptive management regime, guided by a specified hierarchy of objectives. I believe that this approach, which keeps options open, is the best way to deal with these uncertainties.

6. In this case, it is important in my view to distinguish between *targeted* injection of cooler water directly into or adjacent to a steam zone, and *remote* injection into an underlying liquid aquifer causing rising pressures and resaturation of a steam zone from beneath.
7. The former could cause local transient pressure reduction due to direct condensation of steam. However, steam is mobile and surrounding steam will flow into the depressurized local zone rapidly to equalize the pressure. If the steam zone is large (eg The Geysers Field in the USA, or Larderello, Italy) the local pressure reduction effect of injected water may not be noticeable. If the steam pocket is small, the local transient pressure reduction effect might be more important. This was the particular situation Dr Watson expressed concern about in the 2006 hearings. In either case, the pressures will begin to rise once the steam zone is fully saturated with liquid. For a small steam pocket this will take a shorter time than for a large steam zone.
8. The second case of resaturation from beneath the steam zone caused by *remote* injection is closer to the situation expected at Taupo from additional Wairakei injection for at least the next few years. Here, the temperature is not so important because of the injection remoteness. It is the pressure effect that pushes local fluid up into the overlying steam zone, resaturating it. Transients in steam upflow will be caused by a reduction in thickness of the boiling zone. If the steam zone is discharging (through bores or fractures) the net effect could be an initial drop in its pressure. Again, this will stimulate more boiling which could help buffer any pressure changes. In general, this second mechanism is less likely to produce significant steam pressure reduction in a small steam pocket associated with a subsidence bowl, than the first mechanism.
9. While I identified targeted injection close to a subsidence zone as a possible subsidence mitigation measure in my evidence in chief, that option depends in practice on construction of a bridge across the Waikato River as part of the East Taupo Arterial Road project to enable geothermal water to be transported to the reinjection site(s). Mr Stephenson noted in his evidence in chief that construction of the project is currently anticipated to be complete in 2012. By then the results of the subsidence investigation project discussed in my evidence in chief will be available and will enable a better assessment of the risks Dr Watson has identified.

10. I therefore support Mr Brockelsby's suggested solution regarding the potential adverse effects of increased injection on subsidence, relying on the Peer Review Panel to assess whether or not the rate of increase of pressure in the Taupo area (caused by Wairakei reinjection) is having adverse effects or not, and whether or not it needs to be limited. They have the ability to recommend adjustments, if necessary, to relative flowrates in distributed injection bores, or surface discharge, under the existing adaptive discharge management scheme.
11. In my view, this approach is preferable to imposing a maximum liquid pressure increase rate through consent conditions. Given the current state of knowledge, specification of a maximum rate at this point would be somewhat arbitrary as it could not be related to the risk of adverse effects.

CJ Bromley