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

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| In the matter of | the Resource management Act 1991 |
| And | |
| In the matter of | resource consent applications by Contact Energy Ltd in respect of the proposed Te Mihi Geothermal Power Station. |

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# BRIEF OF EVIDENCE IN CHIEF BY BRUCE WILLIAM LANG GRAHAM

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## 1. Introduction

1.1. My name is Bruce William Lang Graham. I hold the qualifications of BSc, MSc in Chemistry, and a PhD. I am a member of several professional bodies, including the Clean Air Society of Australia and New Zealand, and am a Fellow of the New Zealand Institute of Chemistry.

1.2. I am a self-employed consultant with over 30 years experience in the field of environmental science, including an extensive range of activities in the area of air quality. This experience was developed through working for many years as a Scientist in the New Zealand Department of Health, the Chemistry Division of DSIR, and the Institute of Environmental Science and Research (ESR). I left ESR in 1995 to work for 2 years as a Principal Scientist with Opus International Consultants, before establishing my own independent consultancy in 1997.

1.3. My work in air quality has included the design and operation of air monitoring programmes, monitoring and control of process emissions, and environmental impact assessments. Since the introduction of the Resource Management Act 1991 I have been involved with impact assessments of the air discharges from a wide range of industries, including: pulp and paper mills, thermal and geothermal power stations, timber mills, dairy companies, steel mills, foundries, mines and quarries, incinerators, boilers, and asphalt plants.

1.4. I have previously been involved in the following activities of specific relevance to the current application:

i) Peer reviewer and technical advisor to Environment Waikato for the Rotokawa II geothermal power station developments (2007).
ii) Peer reviewer and technical advisor to Environment Waikato for the Poihipi and Tauhara power station developments (1996-97).
iii) Technical advisor to Environment Bay of Plenty for air quality monitoring, modelling and assessment studies in Rotorua (1992-2008).
iv) Technical advisor to Environment Bay of Plenty for odour monitoring, modelling and assessment studies in relation to the emissions from the Tasman pulp and paper mill and geothermal power plant (1992-2008).
v) Technical advisor to several regional councils in relation to a variety of odour sources, including compost plants, intensive chicken farming, piggeries, and wastewater treatment plants (1997-2008).

1.5. I have been provided with a copy of the Code of Conduct for Expert Witnesses in the Environment Court Consolidated Practice Note 2006 and have read and agree to comply with that Code. Except where I state that I am relying upon the specified evidence of another person, my evidence in this statement is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions which I express.

## 2. Scope

2.1. My evidence addresses the following matters:

- Background information on the exposure criteria used in assessing the potential effects of hydrogen sulphide emissions from the proposed Te Mihi power station.
- Comments on the Contact Energy assessment of air effects for the power station.
- The proposed consent conditions.

2.2. This evidence is based on a review of the Te Mihi proposal that I carried out last year for Environment Waikato. A copy of this report is attached to my evidence as exhibit BG1. (Note: the report is labelled as a draft. It was never finalised due to the call-in of the Te Mihi consent applications).

2.3. In addition, my evidence draws on the following reports produced by Dr Craig Stevenson on behalf of Contact Energy:

- Geothermal Power Stations. Air & Environmental Services Ltd, July 2007.
- Cumulative Effects with the Proposed Expansion of Te Mihi Power Station. Air & Environmental Services Ltd, August 2007.
- Further Analysis of Monitoring Data & Dispersion Modeling Predictions (Response to s92 request). Air & Environmental Services Ltd, September 2007.

## 3. Exposure Criteria for Hydrogen Sulphide

3.1. The air contaminant of most interest for this application is hydrogen sulphide. This is responsible for the characteristic odour that most people would associate with geothermal areas, but at high concentrations it is also a highly toxic gas.

3.2. In the past, hydrogen sulphide emissions from New Zealand geothermal power stations have been monitored and assessed against an air quality guideline of 70 $\mu g/m^3$, averaged over periods of 15 minutes to 1 hour. This guideline was first adopted about 20 years ago, and I understand that was on the basis of protecting against odour effects. Health effects were believed to only occur at much higher concentrations. However, our established views about 'acceptable' exposure levels are gradually changing as a result of more recent research, especially over the last ten or so years. I therefore considered it appropriate to carry out a review of the health effect information before proceeding with the review of the Te Mihi assessment.

3.3. My review of the information on health effects and exposure criteria can be found in the draft report prepared for Environment Waikato (Exhibit BG1). In the interests of brevity I will not reproduce all of that information here. However, a simple summary is given in the attached Exhibit BG2, which shows the concentrations associated with specific health effects, and also the range of recommended exposure criteria.

3.4. Some of the key points from the review are as follows:

i) The lowest concentration for observed effects in humans — bronchial constriction in asthmatics — is 2800 $\mu g/m^3$, over 30 minutes.
ii) Animal studies (not shown in the chart) suggest significant nasal irritation and cell damage are likely to occur in humans from prolonged (70-90 day) exposures at 7000 $\mu g/m^3$.
iii) The above studies have been used by government agencies in the United States, and by the WHO's International Programme for Chemical Safety, to develop a recommended limit of 100 $\mu g/m^3$, for 24-hour exposures.
iv) Longer term (90-day, annual or lifetime) exposure limits of 2 to 30 $\mu g/m^3$ have also been proposed.
v) The reported odour thresholds for hydrogen sulphide vary widely, but the New Zealand air quality guideline of 7 $\mu g/m^3$, can be taken as a nominal threshold value. (The odour threshold is the concentration at which 50% of people can just detect the odour).

vi) The historical geothermal guideline of 70 µg/m$^3$ is 10 times this odour limit, which is consistent with the Ministry for the Environment's recommendations for odour control in low sensitivity areas.

3.5. On the basis of the review, I concluded that the geothermal guideline of 70 µg/m$^3$ should be retained. This is still an appropriate guideline for protection against odour effects, and is comfortably below the health-based limits noted above, after adjusting for the different averaging times.

3.6. It should be noted that as an odour-based guideline, the 70 µg/m$^3$ level should not be seen as an absolute limit, never to be exceeded. It simply represents a point above which odour nuisance may occur.

## 4. Review of the Assessment of Effects on Air Quality

4.1. My review of the assessment of effects on air quality is detailed in the report referenced in paragraph 2.2 above. The following notes provide a very short summary of my findings.

4.2. The methodology used by Dr Stevenson for the assessment was consistent with current practice in New Zealand for this type of work. In addition, the use of the CALPUFF model coupled with local meteorological data ensures that the results can be taken as having a reasonably high level of accuracy and relevance.

4.3. I am generally in agreement with Dr Stevenson's assessment of the potential effects from the power station emissions. In respect of hydrogen sulphide, I would summarise the key findings as follows:

i) The current emissions from the Wairakei plant have a noticeable impact on hydrogen sulphide levels in the surrounding area, although this has not resulted in any significant number of odour complaints. The planned phase-out of the Wairakei station will virtually eliminate these localised impacts.
ii) The potential impacts from the Te Mihi plant are expected to be much lower than those for Wairakei because of (a) the much greater dispersion characteristics of the proposed site, and (b) the greater buoyancy of the plant discharges.
iii) The only significant impacts from the Te Mihi plant will be well within the site boundaries. The predicted impacts at the nearest residences are expected to

be comfortably below the guideline level of 70 µg/$m^3$. This indicates that the geothermal odour may be slightly more noticeable at these locations than at present, but the frequency with which this happens is unlikely to cause any concerns.

iv) The cumulative effects from the Te Mihi plant and other existing and proposed power stations are expected to result in an overall increase in the ambient levels of hydrogen sulphide across the wider Taupo/Wairakei area. However, the only effect of any significance might be a slight increase in the frequency with which people notice the geothermal odour.

## 5. Proposed Consent Conditions

5.1. I have reviewed the proposed consent conditions, as put forward by Mr Stephen Daysh on behalf of the Applicant. Some of these conditions were discussed and agreed in a meeting between myself, Dr Stevenson and Mr Pummer (Contact Energy) on 22 May 2008. I am generally in agreement with the proposed conditions, but would particularly like to emphasise the points noted below in relation to proposed consent number 116789 (Te Mihi discharges to air).

5.2. An emission limit for the hydrogen sulphide discharges (condition 1) is important because the assessed effects were based on a specific emission rate. Any significant variation from this rate would result in corresponding changes in the ambient impacts. The requirement, under condition 4, for annual testing of the emissions will also provide an appropriate check on any such variations.

5.3. A properly designed and operated ambient monitoring programme for hydrogen sulphide is also important. Past experience has shown that the human perception of odour in geothermal areas is not especially reliable because of the desensitising effects of hydrogen sulphide. As a result, ambient monitoring data will be an essential resource for the investigation of any complaints about odour, should they arise.

5.4. The ambient monitoring specifications proposed in condition 3 allow for a reasonable degree of flexibility in the selection of monitoring sites and monitoring methods. The rationale for this flexibility, and the preferred 'final' approach, are clearly explained in paragraphs 232 to 236 of Dr Stevenson's evidence, on the basis of our discussions on 22 May.

## 6. Conclusion

6.1. In conclusion, I would simply note that, should the Board decide to grant consents, I am generally in support of the conditions proposed by Mr Daysh.

**Exhibit BG1**

(Te Mihi Geothermal Power Station – Review of the Assessment of Effects of Discharges to Air. Graham Environmental Consulting Ltd, Auckland. Draft report prepared for Environment Waikato, October 2007)

**Exhibit BG2: Hydrogen Sulphide Human Health Effect Levels and Exposure Criteria**