

**BEFORE THE TAUPŌ DISTRICT COUNCIL
TE MIHI EXPANSION PROJECT**

Under the Resource Management Act 1991

In the matter of applications for resource consents by Contact Energy Limited under section 88 of the Act, to carry out the Te Mihi Expansion Project

**STATEMENT OF EVIDENCE OF (ALAN) ROSS BENTON (MAJOR HAZARD
INCIDENT ANALYSIS) ON BEHALF OF THE APPLICANT**

8 October 2021

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QUALIFICATIONS AND EXPERIENCE

1. My full name is **Alan Ross Benton**. I am a Director at Safety Solutions Ltd (**Safety Solutions**).
2. My evidence is given on behalf of Contact Energy Limited (**Contact**) in relation to its applications under section 88 of the Resource Management Act 1991 (**RMA**) for resource consents for the Te Mihi Power Station expansion project (**Project**).
3. I hold a Control Systems Engineering degree from Sheffield University, Functional Safety Engineer (Process Industries) accreditation from TUV Nord and Hazard and Operability Study Leader – NZQA.
4. I have worked in the field of process safety engineering for more than seven years which has included the facilitation of hazard and risk reviews and Major Hazard Facility Safety Case development work.
5. I was the Lead Engineer for the development of the Ngāwhā Power Station Major Hazard Facility (**MHF**) Safety Case which included their new power station commissioned at the end of 2020. I have led the safety assessments for both Contact's Te Huka Power Station and Wairākei Binary Plant which included overseeing the consequence modelling. I am currently working on MHF safety assessment related work for Ngāti Tūwharetoa and Mercury Energy Ltd.
6. I confirm that I have read the 'Code of Conduct' for expert witnesses contained in the Environment Court Practice Note 2014. My evidence has been prepared in compliance with that Code. In particular, unless I state otherwise, this evidence is within my sphere of expertise and I have not omitted to consider material facts known to me that might alter or detract from the opinions I express.

BACKGROUND AND ROLE

7. Safety Solutions was commissioned by Contact to undertake a major incident hazard consequence analysis of Option THI_3 for the Project.
8. Option THI_3 consists of an Organic Rankine Cycle Plant (similar to the Wairākei Binary Plant and Te Huka Power Station), consisting of up to four units located on a footprint to the south-east of the existing Te Mihi Power Station (Site THI B), with a gross output up to 165 MW. Proposed Option THI_3, if built, would use large amounts of hydrocarbon (such as n- or cyclopentane) as a working fluid in the generation process. This fluid is under elevated pressure and temperature and given its chemical properties has the potential to ignite should there be an uncontrolled release from the process.
9. Organic Rankine Cycle Plants come under the Health and Safety at Work Act (Major Hazard Facility) Regulations 2016 and Health and Safety at Work Act (Hazardous Substances) Regulations 2017 (**Regulations**) due to the use of pentane which is in the category of listed substances in the Regulations. Option THI_3 would be classed as an Upper Tier Major Hazard Facility due to the quantity of pentane. This means that a Safety Case will need to be developed and accepted by WorkSafe prior to the commissioning of Option THI_3.

10. I modelled and assessed the potential extent of harm that may arise from a major incident at the proposed Binary Plant, including the impact on people, equipment and the environment. The events modelled were based on the major hazard incidents identified for other binary power stations.
11. The findings of this assessment are presented in a report included as Appendix 11 in the Assessment of Environmental Effects (**AEE**) for the Project.
12. In preparing my evidence I have:
 - (a) reviewed the technical information in support of the resource consent applications, including the Project Description detailed in the AEE, in particular for Option THI_3;
 - (b) Supervised the preparation of, and reviewed Safety Solutions' major incident analysis included in Appendix 11 of the AEE;
 - (c) read the submissions of J and S Lloyd and S Witton; and
 - (d) read the section 42A report and associated draft consent conditions.
13. I have also reviewed the evidence of the other experts for Contact.¹

SCOPE OF EVIDENCE

14. The purpose of my evidence is to:
 - (a) assess the extent of harm that may occur in the unlikely event of a major incident hazard at the Binary Plant proposed as part of Option THI_3 of the Project, including the potential impact on people, equipment and the environment;
 - (b) respond to concerns about major incidents raised by submitters to this hearing; and
 - (c) respond to major incident hazard issues raised in the section 42A report.

EXECUTIVE SUMMARY

15. Overall, my evidence concludes that the effects of a major incident hazard arising from the proposed Option THI_3 Binary Plant will be contained within the farmland that is owned or 'controlled' by Contact and will not impact on surrounding properties and residences.
16. Although there is potential for flying debris, only an explosion of the pentane storage tank (BLEVE) with much larger volumes of stored hydrocarbon or mobile tankers have had debris known to travel more than 1km. The nearest local resident is located further than 1km from the proposed Option THI_3 Binary Plant.
17. Contact have committed, by way of a proposed condition of consent, to reducing the potential effects of a major incident hazard, including flying debris, beyond what is currently considered good practice for binary plants by at least partially mounding the pentane working fluid storage tanks.

¹Relevantly, the Brief of Evidence of Bernd Pummer dated 8 October 2021

TE MIHI POWER STATION PROPOSED EXPANSION PROJECT – MAJOR HAZARD FACILITIES

18. The Project has been described in detail in the evidence of **Mr Pummer**.
19. Option THI_3 is relevant to major incident hazard issues and the detail of this option, including the Binary Plant is as follows:
 - (a) physical location: Site THI B, located to the south-east of the existing Te Mihi Power Station. Most of Site THI B is within the Rural Environment with approximately 30% of the site located in the Industrial Environment.
 - (b) generation technology: Organic Rankine Cycle Plant (similar in process to the Wairākei Binary Plant and Te Huka Power Station, but with a larger output), consisting of up to four units with a gross output up to 165 MW.
 - (c) cooling System: Air Cooled Condenser.
 - (d) working fluid: The proposed Binary Plant may use cyclopentane or n-pentane as the working fluid. This is subject to final selection and optimisation by the equipment supplier during the development phase.
 - (e) volume of Working Fluid: The volume of working fluid is expected to be approximately 365 m³ in each of the four units. Each unit would also have a storage tank for working fluid with a capacity of approximately 175m³. This means 550 m³ of working fluid on site for each unit up to a total of 2,200 m³ for four units.
 - (f) process: The proposed Binary Plant will generate power in each of the four units by using geothermal fluids to heat the working fluid. The pressurised working fluid is boiled, creating pressurised vapour, which is used to spin turbines and the associated generator. The exhaust is then cooled back to a liquid in the air cooled condensers and returned to the start of the cycle in a closed system.

MAJOR INCIDENT HAZARD ASSESSMENT METHODOLOGY

20. Detail of the methodology I adopted for assessing the extent of harm that may occur from an unlikely major incident hazard at the proposed Binary Plant is set out in Appendix 11 to the AEE and will not be repeated in detail here.
21. In summary, the methodology involved consequence modelling which is a means of predicting the physical effects of a major incident hazard² and its impact on people, equipment, and the environment.
22. The full hazard and risk assessment process (implemented as part of the major hazard facility Safety Case, to be carried out during the design of the plant in accordance with the Regulations) includes a hazard identification and risk assessment. A risk assessment includes an assessment of both the likelihood and the extent of the consequence of a major incident hazard.

² A major incident hazard is a hazard that has the potential to cause a Major Incident. A Major Incident is an uncontrolled event that exposes multiple persons to a serious risk to their health and safety arising from exposure to a harmful substance.

23. Full analysis of the likelihood of a major incident hazard will be carried out as part of the Safety Case development and is required to be reduced so far as is reasonably practicable as per the Regulations. Contact has set a target for major incident hazard events that could result in offsite fatality to be reduced to a likelihood of a 1/1,000,000 year event.
24. The results of the consequence modelling are very conservative and represent a worst-case scenario because the consequence modelling assumes there are no buildings or geographical features, such as hills, that reduce the impact of a major incident hazard. In other words, the modelling does not take into consideration any factors, including mitigations, that will in practice reduce the consequences of a major incident hazard. The Option THI_3 Binary Plant will be located behind a hill and at a lower elevation than the existing Te Mihi Power Station and with respect to neighbours located to the north-west, which would reduce the area of impact. As will be discussed below, and in the evidence of **Mr Pummer**, in response to submissions Contact now also proposes to partially bury the working fluid storage tank as a condition of consent. This will further materially reduce the area of impact of a major incident hazard.
25. The modelling is undertaken in accordance with well accepted criteria and New Zealand and international practices and Regulations.
26. At this stage of development, the exact operating conditions (e.g., temperatures, pressures, flows) of the proposed Binary Plant have not been determined. However, Contact's existing Wairākei Binary Plant and Te Huka Power Station and tendered binary plants have similar processes, working fluid capacity, plant technology and conditions to the Binary Plant proposed under Option THI_3 at Te Mihi. The expected capacity and process conditions of the proposed Binary Plant have therefore been based on Contact's existing or tendered binary plants.
27. From the hazard and risk assessments undertaken for the existing Wairākei Binary Plant and Te Huka Power Station, the three largest, credible major incident hazard scenarios for the proposed Te Mihi Binary Plant were modelled including:
 - (a) an explosion of the pentane storage tank (BLEVE);
 - (b) fire from release of pentane from a unit; and
 - (c) explosion from release of pentane from a unit.
28. These three scenarios were modelled to represent the worst-case outcomes.

ASSESSMENT OF POTENTIAL IMPACT OF MAJOR INCIDENT HAZARD

29. The detailed results from the consequence modelling are set out in our report included in the AEE as Appendix 11 and are not repeated here.
30. The key results of the consequence modelling are presented below in **Table 1**. **Table 1** presents the maximum distances from the proposed Binary Plant at which serious harm could occur to persons in the unlikely event of a major incident hazard.

Consequence Scenario	Maximum distance to level of concern ³ (m)		
	Overpressure	Thermal Radiation	Thermal Dose
A hole in pipework leading to a pressurised jet fire	-	234	-
A large release of cyclopentane vapours leading to an explosion	186	-	-
Explosion of a cyclopentane storage tank	-	-	677

Table 1 Scenario Consequence Summary

31. Serious harm for thermal dose is considered to be where partial thickness burns (2nd degree, may blister, severe pain) can occur to an average adult. Beyond this range the effect might be considered similar to a mild sunburn.
32. 677m is the maximum distance at which serious harm could be expected to occur in the unlikely event of a major hazard incident assuming no mitigation or protections are imposed on the working fluid storage tank.
33. The nearest resident is located approximately 300 m beyond this maximum distance. This means that in the event of major incident hazard no serious harm would be expected to occur at nearby residences and facilities such as the Oruanui Pony Club and Taupō stock sale yards.
34. The modelled results are considered conservative, and an actual event is expected to be smaller than stated. However, it is not possible from this modelling to determine how much smaller.
35. The results of the sensitivity analyses demonstrate that even if the working fluid storage tank capacity increased by 50%, in the event of a major incident hazard, the area of serious harm would not include any existing neighbouring residences.
36. The area within the maximum area of serious harm (677m) includes farmland that is owned or 'controlled' by Contact via an encumbrance such that no new residential dwellings are permitted to be built and no other sensitive activities can be undertaken, unless permitted by Contact. Consideration will be given to managing the risk in this area, through awareness and appropriate emergency response plans that will be prepared during the development of the Safety Case in accordance with the Regulations.
37. As above, the maximum area of serious harm represents a worst-case scenario and is very conservative because it does not take into consideration factors, including mitigation, that will in practice reduce the consequences of a major incident hazard.

ADDRESSING POTENTIAL EFFECTS

38. As with Contact's existing binary plants, the Binary Plant proposed under Option THI_3 is required to operate under the requirements of the Regulations.

39. The Regulations require the implementation of protection systems and control measures to ensure that the risk of harm from all potential hazards are either eliminated, or failing that, minimised so far as is reasonably practicable. The Regulations require the submission of a Safety Case which must be accepted by WorkSafe for the facility to operate. An accepted Safety Case requires Contact to demonstrate (to WorkSafe) that the risks associated with the design and continued operation are very low and remain low for the lifetime of the facility. The Project proposed under Option THI_3 will fall into this regime.
40. If Option THI_3 is developed, during the Safety Case assessment stage of the plant design (as required by the Regulations) mitigation measures will be put in place to reduce the likelihood of any major incident hazard event occurring.
41. A BLEVE requires the working fluid storage tank to be heated from an external fire. The Safety Case assessments for Contact's existing binary plants firstly focused on ensuring events that could lead to a fire impacting the storage tanks are reduced. This is achieved by applying controls to minimise the likelihood of events that could lead to a fire on the plant. Existing tanks also have a spray cage to minimise the impact of an external fire. This approach will also be adopted as part of the Safety Case assessment for Option THI_3 if Option THI_3 is developed.
42. On top of these existing control methods, if Option THI_3 is constructed, the working fluid storage tanks will be located as far from potential fire sources as possible. The tanks will be orientated to make sure likely trajectory of debris will be away from populated areas.
43. In addition, the following additional conditions are proposed by Contact to minimise the harm from any major incident hazard if Option THI_3 is developed:
 - (a) Condition 26 (now Condition 27 in the Section 42A report): requires Contact to undertake a Hazardous Substances Risk Assessment (qualitative or quantitative) of the hazardous substances to be stored and used at the site associated with the Project in accordance with Standard AS/NZS4360 and provide this to the consent authority.
 - (b) Conditions 27 and 28 (now Conditions 28 and 29 in the Section 42A report): requires Contact to engage a suitably qualified person to prepare an updated Emergency Management Plan for Te Mihi Power Station (covering both the existing Te Mihi Power Station and the Project) and provide this to the consent authority for a review.
44. In my opinion the Regulations and proposed conditions are sufficient to ensure that neighbouring residences are protected from harm associated with a major incident hazard associated with Option THI_3.

RESPONSE TO SUBMISSIONS

45. I have reviewed the submissions. I have responded to those submissions specifically relating to major incident hazards below.

J and S Lloyd - 147 Oruanui Road

46. These submitters have questioned whether during a major incident hazard flying fragments could reach their residence located approximately just over 400m beyond the maximum

area of serious harm (677 m from Binary Plant), that is just over 1km from the proposed Binary Plant, causing damage or injury.

47. The modelled hazard assessment identified the area of hazard from direct effects of the event, but indirect effects are also possible from airborne debris.
48. It is impossible to accurately predict of how far debris from the BLEVE event would travel. It is therefore not possible to completely dismiss the likelihood that flying fragments could reach neighbours. However, it is extremely unlikely.
49. Two significant events relating to hydrocarbon storage include Feyzin in France 1966 which saw debris approximately 300m from the source of the explosion and San Juanico in Mexico 1984, with debris up to 1200m from the source. Both of these events involved multiple storage tanks, including spheres, with some more than 10 times the size of those proposed for the Project.
50. The most likely event for a fixed cylindrical tank is for the end dish weld to fail and for it to be projected horizontally, which would result in a smaller distance travelled by debris.
51. In addition to implementing the controls that have been imposed on Contact's existing binary plants discussed above, and in response to submissions, if Option THI_3 is constructed, Contact has committed to partially mounding the working fluid storage tank as a condition of consent.
52. Mounding will have the effect of further reducing the risk of an external fire to the storage tanks causing a major incident hazard and will also significantly reduce the area within which debris could travel.
53. Mounding is becoming common in the storage of LPG. However, there is no precedent of this for storage of pentane on a binary plant. The mounding of the tanks would be considered to exceed current good practice.
54. The aim of the Safety Case assessment (implemented as part of the major hazard facility Safety Case under the Regulations) is to reduce the likelihood of any major hazard incident (such as explosion) to what is considered so far as is reasonably practicable. Contact has set a target for major incident hazard events that could result in offsite fatality to be reduced to a likelihood of a 1/1,000,000 year event. This means that with all the mitigations in place an event is highly unlikely to occur.

S Witton - 205 Oruanul road

55. This submitter is a neighbour of Te Mihi Power Station and as stated in his submission he does not understand the consequences in the event of major hazard incident.
56. As has been discussed above, the results of the consequence modelling are a worst-case conservative estimate of the size of the area of serious harm that could arise from a credible, albeit unlikely, major hazard incident scenario. The modelling shows that events will not exceed the boundary of the property that Contact exercises control or influence over and is a significant distance from the nearest neighbouring property or public road.

57. The consequence modelling does not take into account the likelihood of events, only the potential size of the impact area due to the quantities of pentane used in the process. Contact has an obligation under the Health and Safety at Work Act 2015 and more specifically, the Regulations, to eliminate the effects of major hazard incidents, and if unable to eliminate, reduce the likelihood and potential effects so far as is reasonably practicable. This means through the design of the proposed Binary Plant Contact will be required to put in place control measures to prevent the identified major hazard incident events from occurring and they are required to continue to maintain those control measures.
58. Of all the sites I have worked with, Contact's implementation of control measures on existing plants has gone the furthest to reduce event likelihood and the potential effects of any such event.
59. In summary, the likelihood of a major incident hazard event occurring at the proposed Binary Plant will be extremely unlikely. In the event that one does occur no serious harm will occur beyond the 677m contour from the proposed Binary Plant.

RESPONSE TO COUNCIL OFFICER'S SECTION 42A REPORT

60. The section 42A Report raises no concerns about the use and storage of hazardous substances and agrees with my assessment and conclusion that "*the potential effects resulting from and [sic] incident on the adjoining properties and the general public are appropriately mitigated.*"³

Ross Benton

8 October 2021

³ Section 42A report page 18.