

**BEFORE THE HEARING PANEL**

**IN THE MATTER** of the Resource Management Act 1991

**AND**

**IN THE MATTER** of Proposed Plan Change 8 to the Operative Rotorua District Plan

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**STATEMENT OF EVIDENCE OF KELVIN RAYMOND BERRYMAN  
ON BEHALF OF ROTORUA LAKES COUNCIL  
(Fault rupture hazard)  
Dated 13 March 2026**

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## **INTRODUCTION**

1. My full name is Kelvin Raymond Berryman. I am an advisor on hazard, risk and resilience and the director of Berryman Research & Consulting Limited.

### **Qualifications and experience**

2. I obtained a PhD degree from Victoria University of Wellington in 1989. I am a member, and elected life member, of the New Zealand Society for Earthquake Engineering and I am a member of the Geoscience Society of New Zealand. I am a current elected member of the Advisory Board for the Global Assessment Report of the UN organisation for disaster risk and resilience. From 1974 to 2020 I worked for GNS Science and predecessor organisations on geological hazard and risk research and on many applied projects. In 2020 I left GNS Science and have continued my work in natural hazard and risk studies as Berryman Research & Consulting Ltd. I have over 50 years of experience working on natural hazards and risks, predominantly concerning active faults in New Zealand and globally.
3. In 2003 a report from the Ministry for the Environment provided risk-based guidance on building on or close to active faults in New Zealand (Kerr et al., 2003). Although I was not an author of this report, I supported it as a GNS Science research leader. Earlier (in 1987) I was involved in a Planning Tribunal case as an expert witness contesting Wellington City Council's decision to allow conversion of a building sited on the Wellington fault from warehouse to apartments (Moss, 1987). Since that time, I have been involved in many hearings and consenting applications throughout New Zealand.
4. For the past 2 years I have provided advice to Rotorua Lakes Council (Council) on refinement of active fault rupture hazard information in the New Zealand active fault database. These studies have supported development of Plan Change 8 (Natural Hazards) (PC 8).

**Code of conduct**

5. I have read the Environment Court Code of Conduct for expert witnesses contained in the Environment Court Practice Note 2023 and agree to comply with it. I confirm that the opinions expressed in this statement are within my area of expertise except where I state that I have relied on the evidence of other persons. I have not omitted to consider materials or facts known to me that might alter or detract from the opinions I have expressed.

**Scope of evidence**

6. My evidence includes some background on the development of risk-based criteria to apply to active faults for land use planning. I also respond to questions raised in submissions about the mapping of specific fault traces in the NZ Active Faults Database and my conclusions about these faults from subsequent studies.
7. In addition, I provide background information about:
  - (a) The 'attributes' recorded about faults in the NZ Active Faults Database.
  - (b) The level of uncertainty associated with specific 'attributes', which may have implications for how the rules are refined.
  - (c) The risk-based approach set out in the Ministry for the Environment's *Planning for Development On or Near Active Faults: A guideline to assist resource management planners in New Zealand* (2003) (MfE Guidelines).
  - (d) How this risk-based approach aligns with principles underpinning the management of other hazards in the Building Act 2004 and specifically to Loading Code NZS 1170.5. The risk-based approach is also consistent with the 2025 release of an updated National Policy Statement for Natural Hazards (MfE, 2025) (NPS-NH).

8. My evidence also recommends areas for potential refinement of the rule framework in the District Plan in relation to unknown and possible faults and 2-storey dwellings in keeping with a risk-based and proportionate approach to managing risk and the matters raised in submissions.

#### **EXECUTIVE SUMMARY**

9. My evidence explains how fault rupture hazard information for the Rotorua District has developed over time and is now represented in the NZ Active Faults Database. It also outlines the MfE Guidelines on development on or near active faults and how this guidance is based on a risk-based approach that aligns with seismic design practices. The approach distinguishes between greenfield and already-developed areas, reflecting differences in potential exposure and opportunities to avoid placing development across active fault traces.
10. In response to matters raised in submissions regarding specific mapped fault traces, this evidence explains that:
  - (a) there is a high degree of certainty regarding the presence and continuation of the fault along the Lake Ōkāreka peninsula;
  - (b) fault avoidance zones are wider in locations where the surface expression of the fault is less well defined, resulting in greater uncertainty about the precise location of the trace; and
  - (c) in the Waipa Valley area, parts of the mapped feature are classified as possible in terms of tectonic origin and have long recurrence intervals, with implications for how the fault rupture hazard should be managed.
11. In response to broader concerns raised in submissions about the treatment of uncertainty and achieving a proportionate approach to managing risk, this evidence recommends refinements to the rule framework. These include:

- (a) enabling permitted activity pathways for construction of buildings of lower importance (Category 1 and 2a) where faults are classified as possible or unknown;
- (b) applying consistent treatment for one- and two-storey residential buildings within Building Importance Category 2a; and
- (c) supporting additional permitted pathways for development on existing sites where recurrence interval thresholds are consistent with the MfE Guidelines.

## **FAULT RUPTURE HAZARD IN ROTORUA**

12. Within Rotorua District there are many active geological faults that disrupt the landforms of the district. Fault movement, and associated earthquakes larger than approximately magnitude 6, occurs essentially instantaneously with relative movement that may be up to 2-3 metres. An example near the Rotorua District occurred in 1987 as surface rupture, with up to 2.5 m displacement, on the Edgcumbe fault and was associated with a magnitude 6.3 earthquake. Fault rupture breaks the ground and if buildings are located where the fault ruptures there is high likelihood of serious damage and potential collapse.

## **INFORMATION ON FAULT RUPTURE HAZARD**

### **GNS Mapping of fault hazards**

13. Two major district-wide studies to map fault hazards have been undertaken by GNS Science for the Council in 2010 and 2025. The latter used updated topographical information using LiDAR technology and is intended to supersede the former. The latter study also included a review of recent local and site-specific studies. With the advent of 1 m resolution LiDAR for the 2025 study, the limitation of mapping active faults due to heavy vegetation cover has largely been overcome. The 2025 study is consistent with the NZ Active Fault Database managed by GNS Science (now Earth Sciences New Zealand).

## NZ Active Faults Database

14. The NZ Active Faults Database has developed and evolved over many years. As a database it began with a systematic New Zealand-wide coverage in 1983 as a map-based compilation based on interpretation from aerial photos and field surveys (Officers of NZ Geological Survey, 1983) to which I was a contributor. But mapping of active faults in New Zealand goes back as far as Alexander McKay's observations of the 1888 rupture of the Awatere fault in Marlborough (McKay, 1890). In 1995 the first digital database as such was published with many attributes listed (Beanland, 1995). Sarah Beanland was the principal author although I was one of the initiators of the project.
15. Currently, active faults in the Rotorua district are first mapped as to the confidence that they are indeed active faults (the Tectonic Origin criteria) with a 4-fold ranking through definite, likely, possible and unknown. Thinking of quantiles of confidence, we can assume that definite and likely mean the feature is 50% or more likely to be an active fault and possible and unknown features are less than 50% likely to be an active fault.
16. In some instances, the phase 'extended' has been used to signify the fault has been extended along the line of a feature where it is no longer visible (usually because of recent landscape modification such that it is no longer visible in LiDAR imagery). Usually the 'extended' designation is only applied to faults of certain or likely tectonic origin (refer to paragraph 26 commenting on the submission related to the fault at Acacia Road, Lake Ōkāreka).
17. A second criterion of fault description is the complexity of the fault at the ground surface and thus the width of the fault avoidance zone according to the MfE Guidelines. The descriptors for this criterion are 'well-defined, distributed, and uncertain'. The use of the term 'uncertain' has caused confusion because it has often been confused with the Tectonic Origin

criteria. What is 'uncertain' is the width or complexity of the fault trace, not uncertain as to whether the feature is an active fault [paragraph 26].

18. Although much of the fault hazard information incorporated in the NZ Active Fault Database has been collected from aerial photograph and now LiDAR imagery, and regional field studies, the attributes of Tectonic Origin and Recurrence Interval have been informed from many site field studies in the district.
19. Where key information is currently lacking to establish the parameters for risk assessment then cost-effective site investigation (alongside other geotechnical hazards) can often be achieved at subdivision scale and this can often be achieved at previously developed sites as well.

#### **MANAGEMENT OF RISK UNDER MINISTRY FOR THE ENVIRONMENT GUIDELINES**

20. The MfE Guidelines on development on or near active faults provides guidance on how to identify 'Fault Avoidance Zones' (FAZs) and applies a risk-based framework for development within FAZs based on consideration of the recurrence interval of the fault, building importance and whether the building occurs in a previously developed or greenfield site. A residential timber-framed single storey dwelling, for example, (Building Importance Category 2a) is identified as acceptable for fault recurrence intervals of >2000 years in previously subdivided or developed sites and >3500 years in greenfield sites. A structure with special post-disaster function, in contrast (Building Importance Category 4), is only acceptable where the fault recurrence interval for the fault is greater than 20,000 years.

#### **Risk Management Within Broader Risk Management Practices**

21. In New Zealand, buildings are designed to meet the Ultimate Limit State (ULS) in NZS 1170.5, which corresponds to a life-safety performance objective. The design philosophy incorporates an implicit margin of safety

beyond the ULS through ductility, overstrength, and capacity design requirements, such that collapse is unlikely at higher levels of shaking. This implicit performance level is commonly described as the Collapse Avoidance Limit State (CALS). This is about 1.5 times the more frequently referred to Ultimate Limit State (ULS). Normal residential buildings are classified as Building Importance Category (BIC) 2 structures and the ULS is set at 10% probability of exceedance in 50 years. Thus, the CALS for BIC 2 residential structures is about 1 in 2,500-year return period (Canterbury Earthquakes Royal Commission 2011).

22. The MfE Guidelines are attached in a policy sense to risk treatment embedded in NZS 1170.5. The risk-based engineering perspective is presented by King et al (2003) where the authors explained BIC levels for a range of structures and how fault rupture recurrence intervals were aligned with BIC's. These comments are the back-drop to the fault avoidance policies adopted by the Council in land use planning rules of the District Plan.
23. The recurrence interval information contained within the NZ Active Fault Database provides a useful starting point to assess which active faults should be avoided in the layout of a new residential development. Adopting a risk-based approach indicates there will be circumstances where faults with high activity rates put people at unacceptable levels of risk and should be avoided. Therefore, it is critical for a new major development to avoid building across an active fault, consistent with the MfE Guidelines .

#### **PROPOSED PROVISIONS OF PC 8**

24. PC 8 proposes to remove the outdated fault mapping from the District Plan. Otherwise, it essentially proposes to retain the existing approach to managing the fault rupture hazard in the main part of the District Plan but apply this to a defined 'fault rupture hazard area' rather than a mapped overlay. Rules NH-R1 to NH-R3 would continue to require

consent for most new buildings (excluding buildings of low importance). Replacement of an existing building within the same footprint would remain a permitted activity. These rules are also proposed to be extended to the Lakes A Zone. Fault rupture hazards would continue to be addressed at subdivision through general performance standards, and the proposed policies would clarify this approach.

## **EVALUATION OF SUBMISSIONS ON FAULT RUPTURE HAZARD**

### **Mapping of specific faults**

25. Submissions on these proposals raise the following concerns about the information to support the management of the fault rupture hazard for specific active fault traces, which are addressed in this evidence.
26. Submitters question the level of certainty about a fault affecting the Acacia Road peninsula, at Lake Ōkāreka. For example, Euan and Joanne Campbell state that existing reports are inconclusive (12.1); R&B Property Group state the justification for extending the fault line through Acacia Road is neither transparent nor scientifically substantiated (54.1).
27. The fault can be seen on the opposite side of Lake Ōkāreka and, judging by its continuity to the south, it is certainly a continuous feature including along the length of Acacia Road peninsula (Figure 1).



*Figure 1: Continuation of Fault from Acacia Road Peninsula to the north side of Lake Ōkāreka.*

28. Lake Ōkāreka Community Association considers it inequitable to impose definitive rules based on uncertain evidence. It does not dispute the location of a fault (with respect to the fault identified over Acacia and Pryce Roads) but states that the fault location and recurrence interval are not confidently established and seeks a different approach to management of this fault (21.4).
29. As noted above in (paragraph 26) there is certainty that the fault extends along Acacia Road to the end of the peninsula. At present there is no data to ascribe a definite recurrence interval for this strand of the fault. The submission uses the terminology of uncertain but this is uncertainty in the fault complexity, not uncertainty in the fault's existence.
30. The Tarawera Residents Association questions why the fault avoidance zone that crosses the intersection of Alexander and Spencer Roads, at

Lake Tarawera, is substantially larger than most of the other fault avoidance zones on the map and asks what the evidence is for this (30.2).

31. The fault avoidance zone is wider at the intersection of Alexander and Spencer Roads because the fault is less well defined as to its exact location. Therefore, the buffer zone is drawn wider to accommodate the uncertainty in fault complexity. The recurrence interval of this strand of the Crater Lake fault has been determined to be Recurrence Interval IV, so there is no restriction for residential buildings.
32. Red Stag Investments seeks that the District Plan be sufficiently nuanced to handle instances where the data within that database is acknowledged to be of low confidence or high uncertainty, stating that it must contain mechanisms to address such situations fairly and efficiently (20.3). Red Stag Investments seeks an alternative rule approach for instances, such as at its site in Waipa, where there is no surface expression of the fault on the property.
33. The fault maps are drawn based on surface expression but, in the area of concern at the entrance of the Waipa Valley, it is acknowledged that the FAZ is wider to reflect the uncertainty in the complexity of the fault. In the low-lying area of the Waipa valley the part of the fault is mapped as possible with respect to fault origin with a recurrence interval of more than 7,000 years. This means there is no constraint under the MfE Guidance. For this reason I support the proposal in the Section 42A Report for possible faults not to be regulated for BIC 1 and 2a.
34. The submission also states that, due to the nature of the site (such as deep alluvial or organic deposits), standard intrusive investigation techniques (such as trenching) may be scientifically impractical or inconclusive for the purpose of verifying the location and activity of the fault trace (20.4).
35. Regarding the lack of continuity of faults across the valley floor at the Red Stag Investments site, the age of the valley floor (which was initially

formed when the ancestral Lake Rotorua occupied this valley) has quite some age (probably more than 20,000 years), but the area has been heavily modified during the history of the Waipa industrial site from the 1960's.

### **Opportunities to Refine the Rule Framework**

36. I consider that the issue of the need to refine the rule framework to address issues of uncertainty in the fault mapping raised by Red Stag Investments should be given further consideration (20.3).
37. In its submission, the Bay of Plenty Regional Council understands the difficulty of applying a rule framework where some of the underlying active fault mapping is uncertain (FS 45.38). Meanwhile, the Natural Hazards Commission acknowledges that there is uncertainty associated with mapping active faults, but this should not be used as a reason to change the definition or provisions for Fault Rupture Hazard Areas (FS 22.17).
38. The terminology of 'uncertain' is addressed above (paragraph 17). The tectonic origin criteria use the terminology of definite, probable, possible and unknown, whereas 'uncertain' pertains to the complexity of the surface rupture pattern and thus the width of the FAZ.
39. The approach taken in the establishment of the MfE Guidelines in 2003 could be described as precautionary stemming from incomplete data, including limitations on mapping active faults based largely on interpretation from aerial photographs such that areas of heavy vegetation made it difficult to discern the extent of surface faulting. At that time field investigation of active faults were developing but were much more limited than today.
40. Despite the much more consistent aerial coverage of active faults many of the criteria for describing active fault activity have not changed. Because of this, elements of the active fault coverage in the Rotorua area

currently continues to be precautionary whereas the guiding principles recently released in the NPS-NH (MfE, 2025) calls for a risk-based and proportionate approach.

41. Considering the excellent topographic coverage that now exists, it would seem overly precautionary to have possible and unknown features included as active faults for the purpose of land use planning and building consents. I consider that features that have a lower likelihood of being an active fault (designated as unknown and possible as to their tectonic origin) should no longer need to be avoided in the proposed fault rupture hazard area for buildings of lower importance, including single family residential construction in existing developed areas. In my view, it would however be reasonable to require further investigation of the fault where multiple residential units or higher building importance levels are associated with a development, noting the escalation of risk when there are more people exposed to the potential hazard.
42. I therefore support providing additional permitted pathways for development on existing sites where the recurrence interval is consistent with the thresholds in the MfE Guidelines, recognising the lower level of exposure and the more limited opportunities for avoidance that apply in already-developed areas compared with greenfield subdivision.
43. I also consider that there may be other opportunities to improve fairness and efficiency as sought by Red Stag Investments, in particular, in relation to 2 storey residential buildings. This may also go some way to address the concerns of submitters affected by fault avoidance zones, in terms of opportunities for future development of their properties
44. In 2003 with the promulgation of the MfE Guidelines a distinction was made between 1 storey and 2 storey residential buildings in Building Importance Categories (BIC) 2a (1 storey buildings) and 2b (2 storey buildings). With recent revisions to NZS 1170.5 on earthquake design requirements in 2010 and 2025, it seems overly precautionary to require

longer fault recurrence for 2 storey residential buildings. I recommend that there should be no distinction in the management of residential buildings in categories BIC 2a and 2b.

45. In considering applications for greenfield residential development, for example in the context of a subdivision, decision-makers may also consider aligning the acceptable recurrence interval with that used for the CALS threshold for BIC 2 residential structures (i.e. reducing the current criterion from >3,500 years to >2,500 years). However, this should be approached with caution where multiple residential units would be exposed to the potential hazard, given both the opportunity in greenfield settings to avoid the risk and the increased consequences associated with the exposure of multiple units.

## **CONCLUSION**

46. The principles of risk management embedded in MfE Guidance for building on or near active faults continues to be valid and in general is aligned with the 2025 NPS-NH and with many of the submissions to PC 8. My recommendation is to modify some rules that aligns with more recent research, including:
  - (a) bring all detached residential buildings of 1 and 2 storeys into the same BIC 2a category;
  - (b) recognise the difference in risk and opportunities between 'in fill' or building on existing sites compared to new greenfield subdivision by supporting additional permitted pathways for the former where the recurrence interval is consistent with the 2003 MfE Guidelines.
  - (c) where the fault origin of features in the proposed fault rupture hazard area are classified as possible or unknown then there should not be a restriction from a fault hazard standpoint for BIC 1 or 2a construction.

47. In addition, in the context of decisions on subdivision where avoidance cannot reasonably be achieved, decision-makers may consider aligning the acceptable recurrence interval for residential development with the CALS threshold for BIC 2 residential structures (i.e. > 2,500 years rather than > 3,500 years). However, this should be applied with caution where multiple residential units would be exposed to the potential hazard, given the increased consequences associated with higher numbers of people and dwellings being located near an active fault.

**Kelvin Raymond Berryman**

**Dated 13 March 2026**

## BIBLIOGRAPHY

- Beanland, S. (1995). The North Island dextral fault belt, Hikurangi subduction margin, New Zealand. *PhD thesis, Victoria University of Wellington*. 341 pp.
- Canterbury Earthquakes Royal Commission. (2011). *Interim Report: Recommendations on Engineering Design, Building Performance and the Earthquake Commission*. Canterbury Earthquakes Royal Commission, Wellington.  
(Accessed via: <https://canterbury.royalcommission.govt.nz/Interim-Report-Contents>)
- GNS Science. (2010). *Active Fault Hazard Assessment for the Rotorua District*. GNS Science Consultancy Report 2010/182. Prepared for Rotorua Lakes Council.
- GNS Science. (2025). Letter to Rotorua Lakes Council re: Active fault mapping and Fault Avoidance Zones for Rotorua Lakes District: an update [14 March 2025]. GNS Consultancy Report 2025/02 LR.
- Kerr, J., Nathan, S., Van Dissen, R., Webb, P., Brunson, D., & King, A. (2003). *Planning for Development on or Near Active Faults: A guideline to assist resource management planners in New Zealand*. Ministry for the Environment, Wellington, New Zealand.
- King, A., Brunson, D., & Cousins, J. (2003). *Engineering implications of active faults and fault avoidance zones*. In: Proceedings of the 2003 NZSEE Conference. New Zealand Society for Earthquake Engineering.
- McKay, A. (1890). *On the Amuri Earthquake of September 1st, 1888*. Geological Survey of New Zealand, Government Printer, Wellington.
- Ministry for the Environment. (2025). *National Policy Statement for Natural Hazards 2025*. Ministry for the Environment, Wellington, New Zealand.
- Moss, P. (1987). *Wellington City Council v. The Warehouse Conversion Proposal: Evidence to the Planning Tribunal on Wellington Fault Hazard*. Planning Tribunal, Wellington, New Zealand.
- Officers of the New Zealand Geological Survey. (1983). *Late Quaternary Tectonic Map of New Zealand* (2nd ed.). New Zealand Geological Survey Miscellaneous Series Map 12. Department of Scientific and Industrial Research, Wellington.