BEFORE THE ENVIRONMENT COURT
AT WELLINGTON

ENV-2015-WLG-024

IN THE MATTER	of the Resource Management Act 1991
AND	
IN THE MATTER	of applications for resource consent by Site 10 Redevelopment Limited Partnership and Wellington City Council in respect of the area known as Site 10

EVIDENCE OF RICHARD ANTHONY REINEN-HAMILL ON BEHALF OF SITE 10 REDEVELOPMENT LIMITED PARTNERSHIP AND WELLINGTON CITY COUNCIL

2 JULY 2015

Simpson Grierson
Barristers & Solicitors

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INTRODUCTION

Qualifications and experience

1. My full name is Richard Anthony Reinen-Hamill.

2. I hold the qualifications of a Bachelor of Engineering (Honours), a Master of Civil Engineering specialising in fluid mechanics and sediment transport and a certificate of competence in multi-hazard risk assessment. I am a Fellow of IPENZ and a member of the New Zealand Coastal Society, a technical group of IPENZ. I have completed the Making Good Decisions training assessment and certification programme for Resource Management Act 1991 ("**RMA**") Decision-Makers.

3. I am a Senior Coastal Engineer and Director of Tonkin & Taylor Ltd ("T&T"), Environmental and Engineering Consultants in Newmarket, Auckland. I have more than 27 years' experience in hydraulic and coastal engineering, including four years at the Dutch Hydraulic and Coastal Research Institute (Delft Hydraulics).

4. I have undertaken and assisted in coastal erosion and inundation hazard assessments and provided coastal hazard advice on regional, district and individual lot scales, for many territorial local authorities and regional councils, including coastal hazard assessments for Canterbury (2015), Northland (2014) and the Hawke Bay (in progress).

5. I have been involved in numerous RMA hearings (Council, Environment Court and Board of Inquiry), most recently for Tasman District Council on overtopping and inundation assessment for an Environment Court hearing and for Hawke's Bay Regional Council for an erosion and inundation assessment. I was principal author for the Victorian State Government Coastal Hazard Guideline (2012) and was principal reviewer of the first edition of the MfE guidance manual on planning on coastal hazard and climate change. I am currently assisting DOC on a guidance document for the NZCPS.

6. Of specific relevance to this matter is my involvement in the Wellington City Council sea level rise options analysis (T&T, 2013[1]) examining the risks of sea level rise around the Wellington Region. I have also worked with Council, CentrePort, and KiwiRail, on inundation and overtopping assessments for their

[1] T&T (2013) Sea level rise option analysis. Tonkin & Taylor Ltd Report 61579.002 for Wellington City Council, June 2013

seawalls within Wellington Harbour, including the design analysis of the seawall in close proximity to this location. I am currently evaluating tsunami impact forces on the proposed air traffic control tower in Lyall Bay. I consider I know this area and the issues relating to coastal inundation well.

Code of conduct

7. I confirm that I have read the Code of Conduct for Expert Witnesses contained in the Environment Court Practice Note 2014 and that I agree to comply with it. I confirm I have considered all the material facts that I am aware of that might alter or detract from the opinions that I express, and that this evidence is within my area of expertise, except where I state that I am relying on the evidence of another person.

Background

8. My initial role was to peer review the Natural Hazard Assessment report prepared by Beca[2].

9. I have since reviewed the memorandum prepared by Dr Iain Dawe (20 February 2015) on behalf of Wellington City Council and prepared a response to a section 92 request from Wellington City Council for further information dated 10 March 2015 regarding sea level rise. This is attached to this brief of evidence as **Appendix A**.

10. I have subsequently reviewed the site specific assessment of the site carried out by Dr Michael Revell of NIWA and included in his statement of evidence.

SCOPE OF EVIDENCE

11. I have been asked by the Applicants to review the findings of Dr Sharpe, Dr Dawe and Dr Revell in respect of the issue of sea level rise and its effects at the proposed building site over the life of the building, and to present my own conclusions in respect of the appropriate ground floor level for the proposed building on Site 10 in light of sea level rise, storm surge and wave run up.

[2] Sharpe, R (2014) Site 10 – Kumutoto Natural Hazards Assessment. Beca report dated 22 October 2014

12. I have also been asked to provide evidence on the issue of tsunami hazard at the proposed building site.

13. The key conclusions from my evidence are:

(a) A building platform level of 2.5 m WVD is suitable to avoid coastal inundation resulting from 1%AEP joint probability storm surge and waves in addition to 1 m of sea level rise.

(b) Tsunami preparedness is important, but the configuration of the harbour entrance significantly attenuates tsunami wave heights at this location.

ASSESSMENT ON SEA LEVEL RISE, STORM SURGE AND INUNDATION

Sharpe Report

14. I have reviewed Dr Sharpe's report with regard to the issue of sea level rise and inundation of the proposed building site. I note that this was prepared prior to the modelling work completed by NIWA (as outlined in Dr Revell's report).

15. Dr Sharpe provides information from a number of historic studies from 1993 to 2002 to establish a 1%AEP storm surge of 1.7 m WVD-53 and used his expert judgement to assess the local wave height adjacent to the site of 0.3 m. He concludes that there is a low likelihood of inundation within the first 50 years of the building's life, but that the likelihood increases as a result of sea level rise for the following 50 year period.

The Dawe Report

16. I have reviewed Dr Dawe's report with regard to the issue of sea level rise and inundation of the proposed building site. Like Dr Sharpe's report, the Dawe report was prepared prior to the modelling work completed by NIWA (as outlined in Dr Revell's report).

17. Dr Dawe has used a "building-block" approach to determine his design water level. This is a conventional, but typically conservative, approach to provide a credible upper bound of possible levels and is frequently used by coastal hazard practitioners, including myself, to provide a first-order assessment. Dr Dawe uses the NIWA (2009) calculated 1%AEP storm surge at the port tide

gauge of 1.32 m WVD-53 and adds 1 m of sea level rise, wave activity of 0.1 m, an allowance for increased intensity of storm events and an allowance for the difference in sea level rise from 1953 to the present of 0.2 m to derive a design ground floor level to be 2.7 m WVD.

18. As outlined in my response to the section 92 request, I do not support the addition of 0.2 m proposed by Dr Dawe to take into account the historic rise in sea level from 1953 to the present as this is taken into account in the analysis of NIWA by using measured values.

19. I prepared my response to the section 92 request also without the benefit of the Revell Report. In this, I noted (in summary) that:

(a) the establishment of minimum ground floor levels should be based on the addition of the combined 1%AEP storm tide and set up with 1.0 m of sea level rise and an allowance for sea surface fluctuations of 0.2 m.

(b) wave run-up effects are not relevant to include in an assessment of inundation levels for the development, which is situated some 39 m landward of the wharf edge.

(c) the total inundation level would be 2.67 m WVD-53 (1.47 m WVD-53 storm surge + 0.2m tidal fluctuations + 1.0m SLR) based on the more up-to-date information in the NIWA 2013 report that supersedes their earlier report.

(d) avoiding the potential risk of intermittent inundation could be managed by either raising the ground floor to a level of at least 2.67 m WVD-53 (i.e. 2.67 m above mean sea level) or ensuing that through hard landscaping or building design (such as a bund around the building entrance) sea inundation could not enter the building at this level.

The Revell Report

20. Dr Revell has carried out a site specific assessment at the proposed site using an updated assessment of extreme water level and a combination of a wave growth model (SWAN) and a model that takes into account the localised effects of refraction and diffraction to provide more detailed information of the local wave climate adjacent to the site. The results of the water level and wave height were then combined to provide the joint-probability of water level and waves for present day and future climate change effects of an additional 1.0 m sea level rise and a 20% increase in wind speed.

21. This site specific assessment is more detailed and specific to the site than either of the reports of Dr Dawe and Dr Sharpe as it contains information on local wave climates and water levels. In my opinion, this is to be preferred over the first order assessment presented in the earlier reports .

22. The modelling carried out by Dr Revell shows wave heights at this location are very small, with a maximum significant wave height of 0.153 m and that the majority of inundation results from storm surge effects. He determined a maximum wave run-up level of 2.41 m above WVD-53 for a 1%AEP event with 1 m sea level rise and 20% additional wave energy based on the joint probability of a water level of 2.32 m WVD and a run-up level reached by 2% of the waves ($R_{u2\%}$) derived from a wave height of 0.048 m.

23. This results in a lower level than the "building block" approach that both Dr Dawe and I used, which is to be expected given the updated information and the joint probability approach.

24. In reviewing Dr Revell's selection of wave run-up formula, I note that he has used an equation that is specifically for coastal dikes and embankment seawalls. As the shoreline at this location is more representative of an armoured rubble slope, I have checked the run-up level based on eqn. 5.10 of the guidance manual appropriately entitled "The Rock Manual[3]". This formula is more appropriate for rock armoured slopes that the equation used by Dr Revell. I have evaluated run-up for the 0.048 m wave height. Using eqn. 5.10 of the Rock Manual results in a $R_{u2\%}$ height of 0.17 m above the still water level. I note that this run-up level provides an average trend from physical model studies and therefore is not over-conservative. Adding this run-up to the design water level results in water levels of 2.49 m WVD-53 rather than the 2.41 m WVD-53 as calculated by Dr Revell.

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[3] CIRIA (2007). The Rock Manual. The use of rock in hydraulic engineering (2nd Edition). CIRIA C683, UK.

ASSESSMENT ON TSUNAMI HAZARD AT SITE 10

25. In section 3 of the Natural Hazard Assessment, Dr Sharpe addresses the issue of tsunami hazard at Site 10. He refers to the August 2013 update to the Geological and Nuclear Sciences Ltd's 2005 review of New Zealand's exposure to tsunami[4], which estimates that a tsunami will reach a height of 6.2 m (50 percentile) above the sea level at the time in the inner harbour area every 500 years on average. Dr Sharpe concludes that:

(a) A tsunami with a 500-year return period height has a probability of occurrence that is reasonable when designing for safety.

(b) An inundation of 6.1 m above New City Datum would inundate completely the ground floor of the proposed building to around the first-floor level for a short period of time.

(c) The underground carpark would inevitably be completely flooded.

(d) Extensive damage to the non-structural items ('fit-out') in the ground floor of the building would be expected.

(e) The horizontal loads on the wharf and building structure from this rapid inundation are likely to be significantly less than the similar loads associated with a 500-year return period design earthquake. The structural integrity of the building is unlikely to be affected unless it takes a direct hit from debris such as a boat as big as a commercial fishing vessel, tug or harbour ferry. Damage to non-structural elements would be comparable to the earthquake event considered above. People unable to move to a higher level in the building, or inland, would be at risk of drowning.

26. Dr Sharpe notes in mitigation of the risks associated with a 500-year tsunami event, that:

(a) as a non-residential building, people will not be in occupation for 24 hours a day.

(b) secondary structures on the ground floor of the building will fail before they can impose significant loadings on the primary structure.

[4] GNS (2013) Review of tsunami hazard in New Zealand (2013 update). GNS Science Consultancy Report 2013/131, August 2013.

(c) removing ground floor staff and patrons to upper levels will mitigate risk to human life.

(d) there are few mitigation options for the underground car park, however, there are unlikely to be many people at risk at the time, particularly if there has been a warning.

27. Dr Sharpe concludes that "*The risk to occupants from this design-level tsunami is therefore unlikely to be any greater than that which would apply to other waterfront properties in the Wellington CBD.*"

28. I agree with the conclusions of Dr Sharpe, but believe that the return period for a tsunami with a nearshore wave height of 6.1 m is well in excess of 500 years.

29. The GNS (2013) report provides a conservative upper bound for tsunami height within Wellington Harbour. The information provided in that report is based on the highest values within an area that includes the open coast as well as the inner harbour (refer Figure 1, Appendix B) and that due to the shape of the harbour and the narrow harbour entrance there would be wave attenuation within the harbour, lowering the wave height at Kumutoto.

30. The fact that the narrow entrance to Wellington Harbour is likely to attenuate the flow was identified by Dr Dawe[5] and as shown in the Figure 2 **attached** to my evidence. This figure shows that for this event the upper bound tsunami height at the shoreline is 12 m. If this height was placed on the curves provided by GNS in Figure 1, it would be in excess of the 2500 year 84% percentile on the open coast. Based on the results shown in Figure 2, a tsunami with a height of 12 m on the open coast reduces to a tsunami height of around 2 to 4 m at Kumutoto.

[5] Officers direct referral report (s87F) for the two notified resource consent applications submitted to Greater Wellington Regional Council which form part of the North Kumutoto Precinct Project

CONCLUSIONS

31. Based on my assessment of the studies done by both Dr Dawe and Dr Revell and my analysis of local wave run-up, I recommend a minimum design water level of 2.50 m WVD-53 to represent the local level from a 1%AEP storm surge and wave event and 1.0 m sea level rise.

Richard Reinen-Hamill
2/7/2015

Appendix A: Response to S92 request

Tonkin & Taylor

Job No: 30819
20 March 2015

Willis Bond and Co. Ltd
PO Box 24137
WELLINGTON

Attention: Rosalind Luxford

Dear Rosalind

Technical review of coastal inundation hazards

1 Purpose

Willis Bond and Co. Ltd commissioned Tonkin & Taylor Ltd (T&T) to review the Natural Hazard Assessment report prepared by Beca (2014), the memo prepared by Dr Iain Dawe (20 February 2015) and the S92 request to form a view on the likely ground floor level to reduce risk of inundation. This report was prepared by Mr Richard Reinen-Hamill, a senior coastal engineer in the Natural Hazards team. His short Bio is attached to this letter.

2 Assessment

The Beca (2014) provides a range information on extreme water levels and identified that a building with a ground floor level of 2.5 m WVD-53 would have a low likelihood of periodic inundation in the second 50 year period of the buildings life under extreme sea-level events in combination with sea level rise of 1 m.

Dr Dawe uses the NIWA (2009) calculated a 1%AEP storm surge at the port tide gauge of 1.32 m WVD-53 and adds 1m of sea level rise, wave activity of 0.1 m, an allowance for increased intensity of storm events and an allowance for the difference in sea level rise from 1953 to the present of 0.2 m to derive a design ground floor level to be 2.7 m WVD.

We do not support the addition of 0.2 m proposed by Dr Dawe to take into account the historic rise in sea level from 1953 to the present as this is taken into account in the analysis of NIWA by using measured values.

The establishment of minimum ground floor levels should be based on the addition of the combined 1%AEP storm tide and set up with 1.0 m of sea level rise and an allowance for sea surface fluctuations of 0.2 m as recommended by Bell and Hannah (2012). Wave effects including run-up are only relevant in close proximity to the seawall and typically only extend 5 to 10 m from the coastal edge and are therefore not relevant to include in an assessment of inundation levels for development situated some 39 m landward of the wharf edge.

The combined 1%AEP storm tide level and wave set-up at this location is 1.47 m WVD-53 based on the NIWA (2013) report from an assessment at Oriental Bay. We note levels increase to 1.48 m WVD-53 along the Wellington Petone Motorway, but this is a more exposed location to the present site. This suggests wave set-up of around 0.15 m when compared to the NIWA (2009) assessment of storm surge, which appears in the right order of magnitude.

Therefore we assess the total inundation level to be 2.67 m WVD-53 (1.47 m WVD-53 storm surge + 0.2 m tidal fluctuations + 1.0 m SLR) which is in the same order of magnitude as calculated by Dr Dawe. Should further site specific assessment reduce this level based on local factors, it is possible that the lower level could be applied.

3 Mitigation

Avoiding the potential risk of intermittent inundation could be managed either by raising the ground floor to a level of at least 2.67 m WVD-53, or by ensuring that through the hard landscaping or building design that sea inundation could not enter the building at this level and that building materials would not be damaged by periodic inundation. In the situation of hard landscaping which creates a bund around the building entrance, it may be necessary to consider processes to remove stormwater that could collect within any bunded area.

4 Applicability

This report has been prepared for the benefit of Willis Bond and Co. Ltd with respect to the particular brief given to us and it may not be relied upon in other contexts or for any other purpose without our prior review and agreement.

Tonkin & Taylor Ltd

Environmental and Engineering Consultants

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Richard Reinen-Hamill

Senior Coastal Engineer

Appendix A: CV of Richard Reinen-Hamill

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Appendix A: CV of Richard Reinen-Hamill

Richard Reinen-Hamill, BE, ME - Senior Coastal Engineer, Director

Richard has over 27 years experience in coastal engineering and natural hazards, including the consideration of climate change effects on coastal hazards. He is the Business Leader for Natural Hazards for Tonkin & Taylor Ltd, a specialist environmental and engineering consultancy. He has specialist training on multi-hazard natural risk assessments. He has undertaken and assisted in coastal hazard assessments and provided coastal hazard advice on regional, district and individual lot scales for many territorial local authorities and regional councils, including coastal hazard assessments for Wellington City Council for Canterbury Regional Council (2015), Northland Regional Council (2014) and the Hawke Bay Regional Council.

Richard has been involved in numerous RMA hearings (Council, Environment Court and Board of Inquiry), most recently for Tasman District Council on overtopping and inundation assessment for an Environment Court hearing and for Hawkes Bay Regional Council for an erosion and inundation assessment. He was principal author for the Victorian State Government Coastal Hazard Guideline (2012) and was principal reviewer of the first edition of the MfE guidance manual on planning on coastal hazard and climate change. He is currently assisting DOC on a guidance document for the NZCPS.

He is very familiar with the Wellington coastal environment, with both consent level and detailed design studies and assessments on the open coast and within Wellington Harbour.

Expertise

Core competencies include:

- Coastal inundation hazard assessments
- Climate change effects on sea level rise
- Coastal processes
- Coastal protection design
- Coastal protection evaluation
- Mitigation option development
- Master planning

Experience

Examples of relevant projects:

- **Wellington Sea Level Rise Hazard Assessment**
  Evaluation of the extent and consequences (environmental, social and economic) of coastal inundation taking into account a range of projected sea level rise changes. Development of GIS tools and assessment criteria.
- **Island Bay Coastal Protection Design**
  Conceptual and detailed design of coastal protection to protect road infrastructure along the Island Bay shoreline
- **Wellington to Petone Seawall**
  Emergency response to assist in repairing failed sections of seawall, including conceptual design of remedial options and site inspections followed by consent level and detailed design of long term protection works.
- **CentrePort Seawall remediation**
  Technical analysis of extreme wave and water level for design of coastal protection works to repair the seawall damaged by seismic shaking.

- **Gallagher Appeal**
  Technical expert advising Tasman District Council on inundation and overtopping assessment of a natural and armoured coastline, including evidence preparation and attendance at Environment Court
- **Tauranga Tsunami Evacuation Study, NZ**
  A comprehensive tsunami inundation study for Tauranga City to develop evacuation route planning as part of risk reduction planning.
- **Oriental Bay preliminary to detailed design**
  Technical studies to design the award winning beach and control structures at Oriental Bay within the Wellington Harbour. Other components included the design of coastal structures, design of submarine outfalls, assessment of hydrodynamic and sediment effects, public consultation and resource consent.
- **Mexted Appeal, Mahunga**
  Expert witness for Hawkes Bay Regional Council on coastal erosion and inundation hazard assessments for a proposed subdivision.
- **New Plymouth Coastal Walkway**
  Coastal engineering design for the award winning coastal walkway including coastal process assessment, rock revetment design and overtopping assessments in a high energy wave environment.
- **Onehunga Foreshore Enhancement - Consent level design**
  Consent level and detailed design for a 7 hectare reclamation and soft coastal edge to provide an improved recreational amenity and access to the community of Onehunga. The project included reclamation design, coastal edge design, a high quality pedestrian bridge and stormwater.
- **Mokihinui Coastal Protection Options**
  Evaluating coastal processes in the vicinity of the Mokihinui River outlet and consent level design of coastal protection works to protect the community from wave attack. Preparation of reports and evidence for Council Hearing and Environment Court.
- **Ocean Beach Dunedin**
  Evaluation of coastal processes and development of options to manage current and future coastal erosion hazards along Ocean Beach, Dunedin including adaptive management options.
- **Ruby Bay Coastal Protection**
  Evaluation of causes of existing erosion and inundation problems. Identification of long-term hazard management strategies taking into account existing conditions and climate change effects and detailed design of coastal protection works.
- **Seawall Construction Guidelines for Tauranga Harbour**
  Development of design standards and construction guidelines for Tauranga Harbour when hard engineering solutions are appropriate.
- **Victorian coastal hazard guideline, Australia**
  Preparation of a coastal hazard guide to assist in the understanding of coastal hazards and climate change and the consideration of hazards in a risk management framework.
- **Technical review of Natural Coastal Policy Guidelines, NZ**
  Technical reviewer and advisor to Department of Conservation on their Guideline for natural hazard provisions of the New Zealand Coastal Policy Statement, 2010.

Qualifications

Certificate in Multi Hazard Risk Assessment, University of Twente, 2014
RMA: Making good decisions, 2005
ME, fluid mechanics, University of Auckland. 1989
BE (Hons), Civil, University of Auckland, 1985

Richard Reinen-Hamill is currently a member of:
Institution of Professional Engineers New Zealand (IPENZ) (Fellow),
New Zealand Coastal Society.

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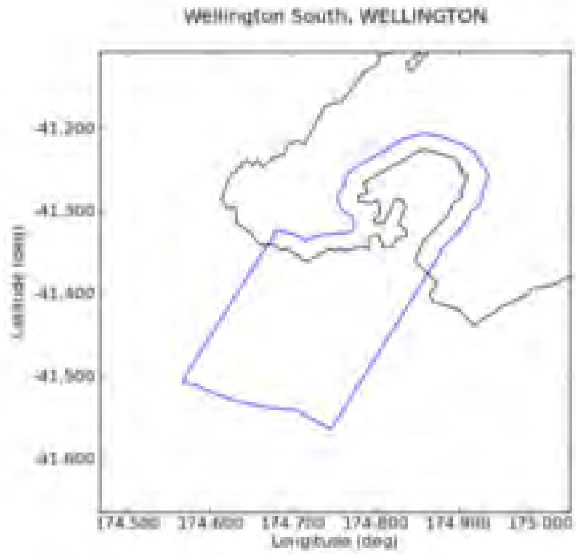
Appendix B: Extract from GNS publications

Wellington



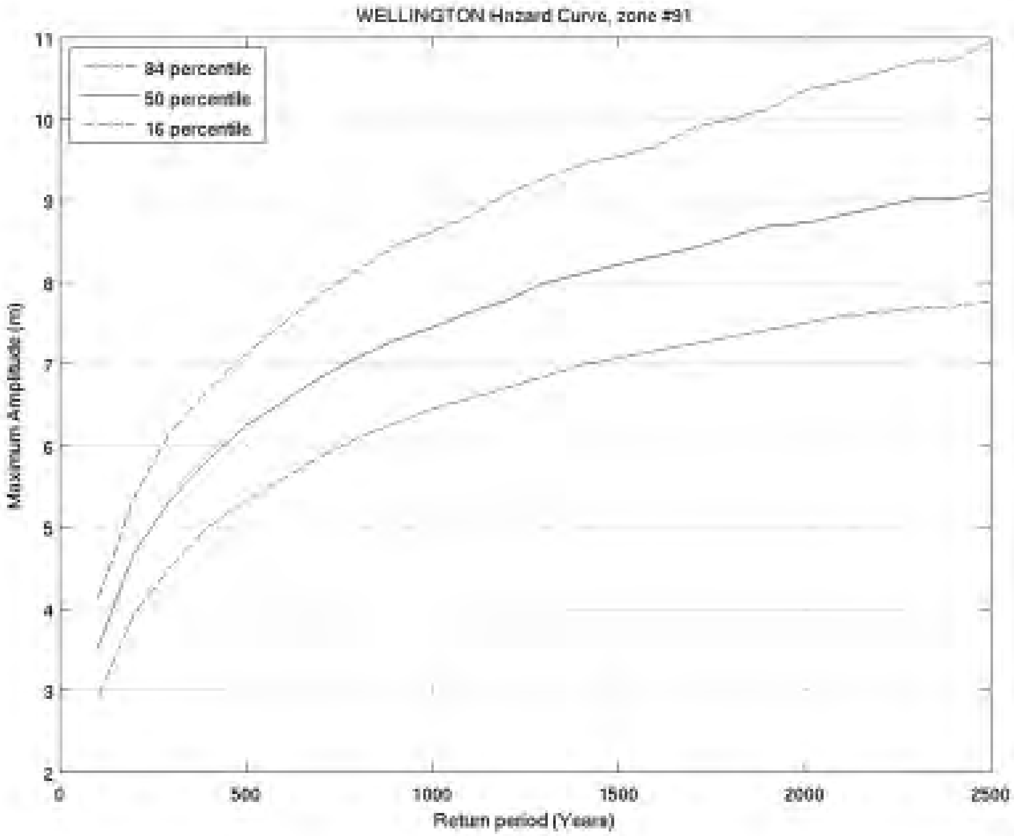


Figure 1 Extract from GNS (2013[6]) showing maximum tsunami elevations for the open and harbour shores of Wellington

[6] GNS (2013) Review of tsunami hazard in New Zealand (2013 update). GNS Science Consultancy report 2013/131, August 2013

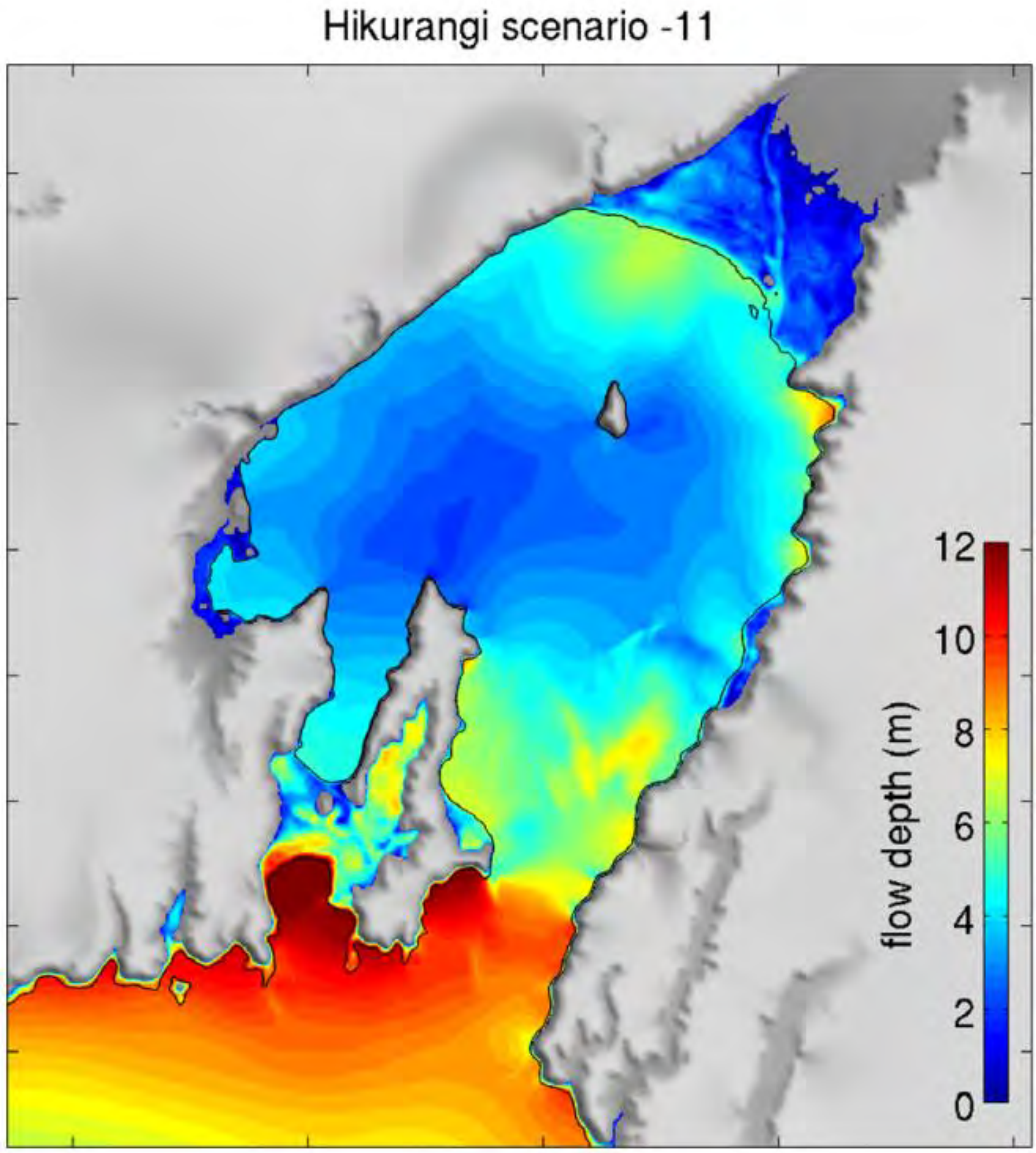


Figure 2 Maximum flow despth for the Hikurangi interface rupture scenario (Source: GNS, 2014[7])

[7] GNS (2014) Investigation on the effects of earthquake complexity on tsunami inundation hazard in Wellington Harbour. GNS Science Consultancy Report 214/198, July 2014.