

Literature Review – Natural Hazards

Summary of Literature produced since 2010 on natural hazards which has implications for urban growth and land use – to inform a review of the 2010 Heretaunga Plains Urban Development Strategy.

March 2016
HBRC Plan No. 4790
HBRC Report No. SD16-02

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Policy

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EXECUTIVE SUMMARY

1. The Heretaunga Plains is at risk of numerous natural hazards. Those of particular relevance are flooding, earthquake, tsunami and coastal erosion and it is important that up-to-date hazard information is taken into account during each review of HPUDS so we understand and plan for these changes.
2. There is a significant amount of research that has been undertaken at both a regional and national level on natural hazards. The literature review summarises research released post 2010 and will provide a better understanding of the key outcomes and results of this research.
3. While the information contained in this literature review may not result in changes to the HPUDS document itself, it is important that there is a good understanding of this information so when it comes to implementing parts of HPUDS, natural hazards can be thoroughly investigated and mitigated or in some instances avoided, prior to development taking place.
4. For example, the literature review could be used to inform decision makers on where further investigations may be required prior to development decisions being made, i.e. the liquefaction maps may change TLA current guidance for the minimum types of site investigations required for any proposed new building work in certain locations. Where intensification may be occurring the local council may decide an appropriate response to a tsunami hazard is to develop community response plans and clear evacuation routes for residents together with the local community. In more extreme cases, new development may need to be avoided in areas subject to a high likelihood of natural hazards.

PURPOSE

5. The purpose of this report is to carry out a review of key documents, released post 2010, which contains natural hazard information that is relevant to the Heretaunga Plains, and provide a summary of the key outcomes of these documents. The literature reviewed has been selected on the basis of HPUDS TAG recommendations set out in the project brief titled "*Heretaunga Plains Urban Development Study: Natural Hazards*".

DOCUMENTS REVIEWED

For the purposes of this literature review, the key documents reviewed include:

- a) *Hawke's Bay Regional Council, May 2011, Hawke's Bay: Tsunami Inundation Model Preliminary Results: Tangoio to Cape Kidnappers.*
- b) *GNS Science Consultancy Report, May 2011, Fault Avoidance Zone Mapping for Wairoa District, Napier City and surrounds.*
- c) *Brendan Morris Consulting Limited, May 2011, Hawke's Bay Joint Hazard Strategy for Local Authority Land-Use Planning*

- d) *Paul D Komar & Erica Harris, November 2014, Hawke's Bay New Zealand: Global Climate Change and Barrier Beach Response.*
- e) *Parliamentary Commissioner for the Environment, November 2014, Changing Climate and Rising Seas: Understanding the science.*
- f) *GNS Science Consultancy Report, January 2015, Active Fault Mapping and Fault Avoidance Zones for Hastings District environs.*
- g) *GNS Science Consultancy Report, June 2015, Update of the Hawke's Bay 10 Year Hazards Research Plan.*
- h) *Parliamentary Commissioner for the Environment, November 2015, Preparing New Zealand for Rising Seas: Certainty and Uncertainty.*
- i) *Hawke's Bay Regional Council, January 2016, Hawke's Bay Hazard information Portal.*

COMMON ABBREVIATIONS in this report

CDEM	Hawke's Bay Civil Defence Emergency Management (CDEM)
HBRC	Hawke's Bay Regional Council
HDC	Hastings District Council
NCC	Napier City Council
PCE	Parliamentary Commissioner for the Environment
RPS	Regional Policy Statement

SUMMARY OF LITERATURE

Hawkes Bay Joint Hazard Strategy for Local Authority Land-Use Planning, May 2011

6. The Hawke's Bay region is subject to a wide range of hazards, meaning the management of natural hazards is a significant issue for the region. Currently the treatment of similar hazards and their associated risks vary considerably between TLAs within the region, and there is a lack of integration between CDEM planning, district plans, regional plans and the Regional Policy Statement.
7. In order to address these issues, a Hazard Strategy was jointly developed by the 5 local authorities within the Hawke's Bay Region. The Joint Strategy aims for a more coordinated approach between councils when dealing with hazards, and to provide a clear framework to achieve better integration and consistency in hazard management across the region.
8. The strategy contains a summary of the current land use planning versus best practice, for six natural hazards being: river flood, coastal erosion/inundation, earthquake, tsunami, landslide and volcanic.

9. The strategy contains a number of general recommendations such as linking RMA policies with emergency management activities, and incorporating best practice concepts for land use planning into district and regional plans.
10. The strategy then goes on to provide hazard specific recommendations on the approach to land use planning in Hawke's Bay. Of particular note, the strategy suggests moving to a regional approach via the RRMP for river floods and focusing on a whole of catchment approach. It recommends incorporating set back distances from active faults and using best practice when planning for natural hazards.
11. The strategy recommends avoidance over mitigation for greenfield areas and suggests restricting the location of critical facilities and the protection of evacuation routes in tsunami zones. Other recommendations include retiring large areas of greenfield land around active faults and restricting intensification of development in high risk areas.

Hawke's Bay 10 Year Hazards Research Plan, June 2015

12. Research into hazards that affect the region has been undertaken by HBRC for the past 30 years. Currently hazard research directions are identified in a 10 year Hawke's Bay Hazards Research Plan which seeks to mitigate regional risk by commissioning ongoing science and research which leads to a greater understanding of the hazards which can affect the region.
13. In 2015, HBRC updated the 10 Year Hazard Research Plan to identify and prioritise what hazards research needs to be undertaken for the region. A summary of scheduled projects which relate to the Heretaunga Plains is provided in Table 1 below:

Table 1: 10 Year Hazard Research Plan

Projects	Year(s) project will be undertaken
Review liquefaction risks and establish geotechnical database for Hawkes Bay	2013 - 2015
Fault line mapping review work – Hastings and Wairoa	2015 -2017
Earthquake research – active faults and earthquake sources in Hawke's Bay	2015 - 2017
Hazards and impacts/consequences modelling of earthquake and tsunami – primarily through the Riskscape programme	2015-2019
Update earthquake ground motion model for Hawke's Bay	2014-15
An update of ground shaking behaviours, presented as loading code soil types on maps	2016-2017
Vertical land deformation from a subduction plate boundary earthquake event	2018-2019
Tsunami frequency and magnitude research	2019-2020
Remobilisation of volcanic ash	2020-2021
Climate change implications for other hazards (50 years) – including extreme weather events, coastal hazards, tsunami, etc.	2021-2022

Wave inundation forecasting	2022 - 2023
Assess joint occurrence of high sea levels and high river flows. river sea interface – interactions and hazards posed (esp. for Wairoa)	2023 – 2024
Consequences based coastal erosion model (perhaps for Riskscape)	2023 –2024
River – coastal transition systems	2024-2025
Maximum credible weather events – wind	2024 – 2025
Extension of the severe weather database	2025 – 2026
Managed retreat scenarios	2025 – 2026

Hawke's Bay: Tsunami Inundation Model Preliminary Results: Tangoio to Cape Kidnappers, May 2011

14. In 2011, HBRC developed a Tsunami inundation model for the Tangoio to Cape Kidnappers coastline. Tsunami wave heights ranging from 1 m to 10 m were tested in the model, with inundation extents being presented for a wave height of 5 m for the worst case distant source tsunami, and a wave height of 10 m for the worst case near source tsunami. This model was used together with the worst case scenarios from several other inundation models to inform the tsunami inundation extents contained on the Hazards Portal discussed below.
15. The following figures were contained in the report and show a sample of maximum depth reached for the wave heights of 2 m, 5 m, 6.6 m, and 10 m.

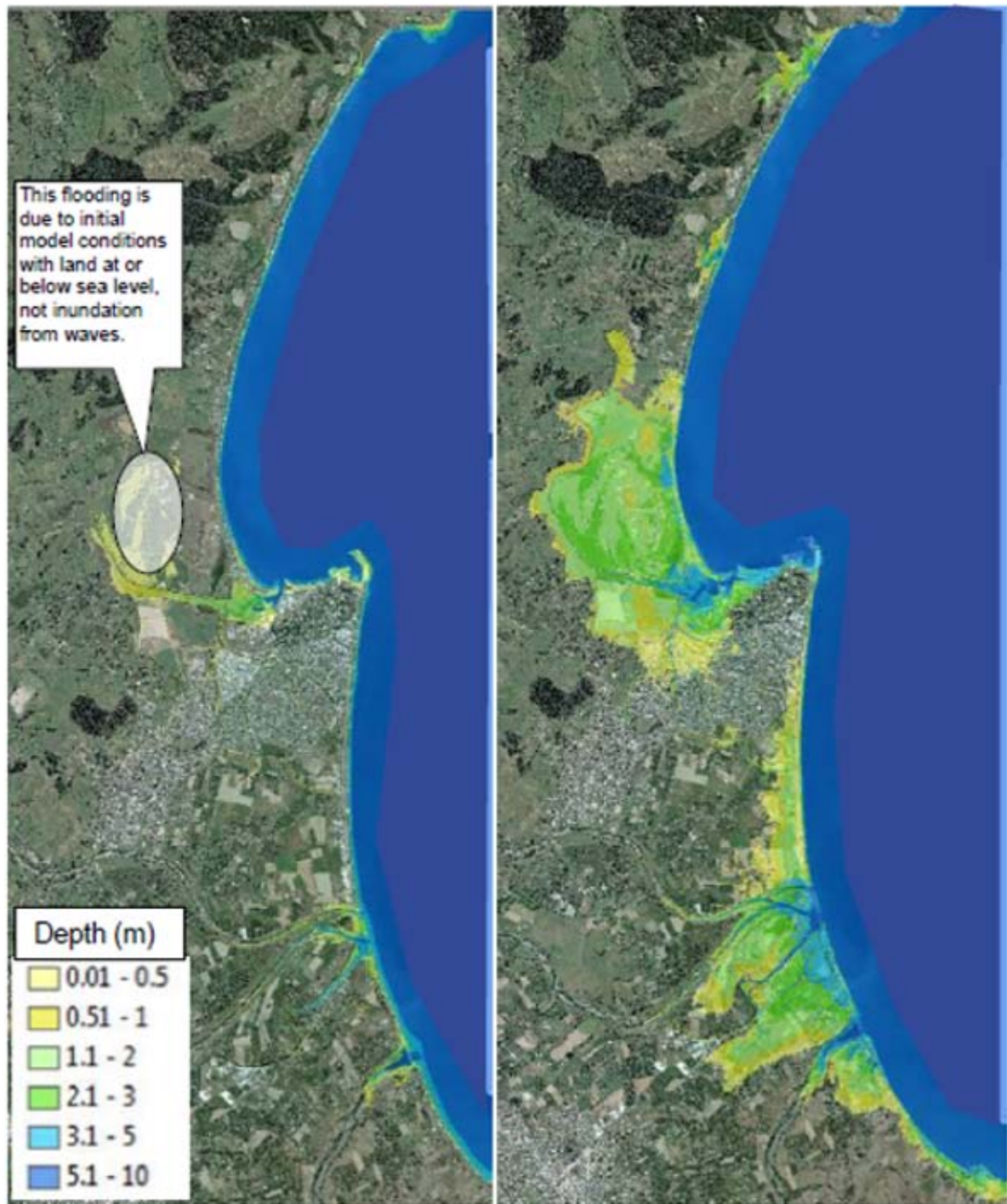


Figure 1: Inundation from 2m wave

Inundation from 5m wave

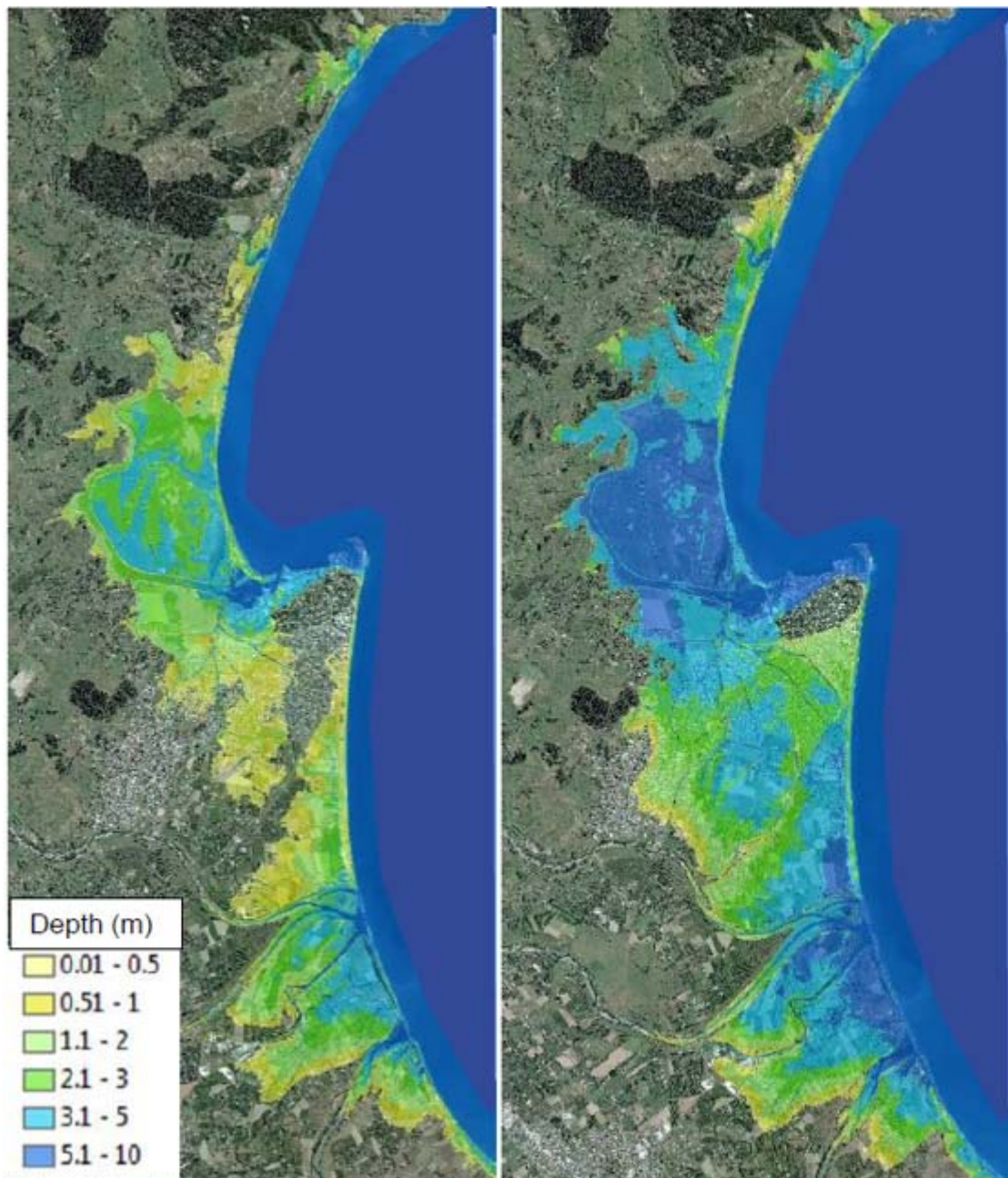


Figure 2: Inundation from 6.6m wave

Inundation from 10m wave

Hawke's Bay: Global Climate Change and Barrier Beach Response, Nov. 2014

16. The report on Global Climate Change and Barrier Beach Response for Hawke's Bay was written by Paul Komar November 2014 (otherwise known as the 'Komar Report'). The report focused on the coastal area between Tangoio and Clifton particularly looking at the hazards associated with this part of the coastline and its associated management. A summary of the key aspects of the Komar report is detailed below:

Tectonic setting

17. The coast of Hawke's Bay is one of the most seismically active regions of New Zealand, and has a history of subduction earthquakes occurring within the area.
18. It is important to have an understanding of the tectonic setting and its relevance to the range of natural hazards impacting on the Hawke's Bay coastline. Although rare, Komar predicts that the greatest future hazard comes from a major earthquake and accompanying tsunami.
19. In context, the tectonic setting in Hawke's Bay is very similar to that along the coasts of Sumatra and Japan. Both areas provide recent examples of the extreme hazards of subduction earthquakes and tsunami.

Erosion

20. While there are a few parts of the Clifton to Tangoio coastline where the shoreline is stable (e.g. Marine Parade beach), most of the coastline is eroding. Komar predicts that in the next century, sea level rise in combination with increased wave heights and storm intensities will significantly impact on the gravel barrier ridge protecting this part of the coast.
21. Solely due to sea level rise, Komar predicts a 10 – 15 m retreat of the beach along the Tangoio to Clifton coastline by 2100. When combining sea level rise with more intense storms and higher wave heights, Komar advises that the Bay View shoreline cell¹ could retreat 15 to 20 m, with the northern end of the Haumoana cell potentially retreating 30 m.
22. In addition to shoreline retreat, there is increased likelihood of 'over wash' events during major storms which could occur along the beach in the Haumoana cell. Here the total water levels could potentially exceed the low elevations of the gravel ridges leading to flooding of low lying inland properties and infrastructure.
23. In Komar's view, these increased effects from erosion and flooding will most likely occur gradually over the next 25 plus years.

Inundation - storm surge events

24. The changing water levels and elevations of tides combined with storm surges are a major factor in causing coastal erosion and flooding. Komar (2014) predicts that with rising sea levels, and increasing wave heights generated by a 1% AEP storm, total water levels by 2100 will be:
 - 2 m above the present day levels on the Bay View cell shoreline; and
 - 1.5 m above the present day levels on the Haumoana cell shoreline.

¹ Littoral cell: All coasts are divided into natural compartments called littoral cells. Each cell contains a complete cycle of sedimentation including sources, transport paths, and sinks. The presence of sand on any particular beach depends on the transport of sand within the cell.

25. This essentially doubles the increased contribution by the rise in sea levels acting alone.
26. Komar also undertook an extreme scenario in which the most severe event and hazard was based on a combination of an extreme tide elevated by a 100 year surge, together with extreme swash run up levels from waves generated by a severe storm. The result represents a rare occurrence (likely return period much longer than 100 years) that while extreme in its components, is still possible.
27. The predicted outcome was total water levels of 4 m and 3.5 m above the present day levels on the Bay View and Haumoana cell shorelines, respectively. This extreme scenario represents a worst case storm event faced on the coast and would result in over wash of the gravel barrier beaches along the entire length of the Haumoana cell shoreline and at least the southern half of the Bay View shoreline.

Sea level rise

28. Rising sea levels increase the likelihood and severity of erosion and inundation along the coast. While experts agree that future sea levels will keep rising, the rate and magnitude of the predicted sea level rise differs.
29. Komar concludes that by the year 2050 sea level could be expected to be 30 cm above its elevation in 2000, by the year 2100 a sea level rise of 90 cm is considered likely in Hawke's Bay. However, Komar notes that in an extreme high assessment case, sea levels could have an increase of 50 cm by 2050 and 130 cm by 2100.

Changing Climate and Rising Seas, 2014

30. In November 2014, the Parliamentary Commissioner for the Environment (PCE) released her report on the changing climate and rising seas. The report contains a comprehensive explanation around the science of sea level rise and updates future projections for sea level rise.
31. The PCE report uses the latest sea level rise projections from the Intergovernmental Panel on Climate Change (IPCC). The IPCC projections reflect a consensus view of hundreds of experts in the field, and cites thousands of scientific papers. A key question discussed in the report is how much will the sea rise around New Zealand by 2050 and 2100, the key findings in the PCE report are summarised below:

How much will the sea rise by 2050?

32. Around the world the average sea level has risen by about 20 cm in the last century². The PCE report signals that a rise of a further 30 cm by the middle of the century is now inevitable and will occur regardless of action taken to reduce greenhouse gas emissions³.
33. An extract from the PCE report reads that *"while a 30 centimetre rise may not sound like much... in New Zealand, the impact will be significant at a national level and potentially devastating for some land owners"*, it goes on to conclude that *"a rising sea will be with us for a long time to come, and one way or another we will have to adapt"*.

² PCE officials advise that the exact number is 19 cm from 1901 to 2010

³ PCE officials advise that the 30 cm rise by 2050 is relative to a base year of 1990. The exact range for this is 17 – 38 cm.

34. The PCE report highlights that a sea level rise of 30 cm will be most noticeable during severe storms. It is during these storms that greater wave breaking heights, and higher swash run up levels on beaches, occur exacerbating erosion and inundation. Flooding is further exacerbated when a storm surge coincides with a high tide, and especially so if the high tide is one of the 'king' tides that occur a few times a year.
35. With storms increasing in frequency and intensity over the next 100 years, it is likely that a 30 cm rise in sea level will have significant consequences for parts of the country and New Zealand will need to adapt.

How much will the sea rise by 2100?

36. After 2050, the predicted rise in sea level becomes increasingly dependent on the actions the global community takes to reduce greenhouse gas emissions. If the global community responds appropriately then in the second half of the century sea level rise will slow.
37. While the PCE report does not formally specify a sea level rise projection out to 2100 or beyond, it does refer to the IPCC's 'Business as Usual' scenario which predicts that mean sea level will be 1 m higher in 2100 than it is now⁴, and will continue to rise for several centuries.
38. However, debate continues on longer term sea level rise projections contained in the IPCC report. For example, the PCE report states that ninety sea level rise experts are now estimating a sea level rise of up to 1.2 m in 2100 using the same IPCC's 'Business as Usual' scenario.
39. By way of comparison, the coastal hazard studies underpinning coastal hazard zones in the Regional Coastal Environment Plan were based on sea level rise figures of 0.5 m by 2100.

Preparing New Zealand for Rising Seas: Certainty and Uncertainty, Nov. 2015

40. In November 2015, the Parliamentary Commissioner for the Environment (PCE) released her report on preparing New Zealand for rising seas. This report follows on from her earlier 2014 report *"changing climate and rising seas"*, and aims to increase understanding of how sea level rise will affect New Zealand.
41. The subtitle of the report 'certainty and uncertainty' is deliberate with the PCE noting that it is certain the sea is rising which will lead to more flooding on low lying land near the coast, erosion of many beaches, and possibly saltier coastal groundwater. However, it is uncertain how rapidly the sea will rise, how different coastal areas will be affected, and how we should prepare.
42. An interesting observation from the PCE is that sea level rise is incremental, and will unfold slowly for a period before accelerating. While it is important to start planning for sea level rise, the PCE notes that there is enough time to plan and do it well, and that haste in planning for sea level rise is not needed.
43. However, the PCE notes there are several aspects of planning for sea level rise that should be done with urgency, in particular, the granting of consents for greenfield development. New suburbs and expensive infrastructure should be viewed as long term investments and should not be built on vulnerable coastal land.

⁴ Relative to a base year of 1990.

44. The report contains the latest IPCC projections for sea level rise based on 'very high greenhouse gas emissions' and 'stringent mitigation' which reflects discussions in the PCE's previous report. It then goes on to discuss how climate change is expected to exacerbate rainfall, winds and storms in New Zealand, and how the rising sea level will increase the severity of coastal flooding, erosion and salt water intrusion into groundwater. To put this into context, it is expected that as the sea level rises, exceedances of today's '100 year events' will occur more and more often. For example in Wellington, once 30 cm of sea level rise occurs, a 100 year event is expected to happen once a year, if the sea level rises to 50 cm the 100 year event will happen twice a month, increasing to 3 times a week if the sea level rises to 60 cm.
45. The report contains regional land elevation maps for a number of areas around New Zealand including Hawke's Bay. The maps indicate that Napier has a significant amount of low lying land with around 8,000 homes lying less than 150 cm above the spring high tide mark, and the airport lying less than 50 cm above the spring high tide mark. Areas that are both low-lying and close to the coast are most vulnerable to sea level rise due to the effects from coastal flooding and rising groundwater. It is noted however, as discussed in Paragraph 77, the coastal hazard mapping currently being undertaken by Tonkin and Taylor will provide far more meaningful maps of areas at risk of coastal hazards due to the effects of sea level rise.
46. The report contains eight recommendations to the Government, with the first seven aiming to improve Government direction and advice given to councils around sea level rise. The last recommendation relates to assessing the economic and fiscal implications of sea level rise.

Fault Avoidance Zone mapping for Wairoa District, Napier City and surrounds, May 2011

47. In May 2011, GNS provided HBRC with a map of active faults and fault avoidance zones for the Wairoa District, Napier City and surrounds. This summary will focus on Napier City and surrounds given its relevance to HPUDS.
48. As discussed in paragraph 61, there are no mapped active fault traces within the bounds of Napier City. Instead GNS reconsidered the role and effects of the 1931 Hawke's Bay earthquake, which caused major damage in Napier and Hastings. By looking at surface demolition related to the fault GNS was able to broadly map the Awanui Fault across the Heretaunga Plains between Bridge Pa and Awatoto. While the Awanui Fault should be considered as an active fault GNS advise that is not possible to accurately map a relevant Fault Avoidance Zone.
49. While GNS recognises that the Awanui Fault cannot be mapped with sufficient accuracy and certainty to be of use in terms of planning purposes, the report does go on to advise that if any critical structures are to be sited along the axis of the deformation from the Awanui Fault, in the future, then fault deformation should be considered as a potential hazard to the life of the building.
50. The report also specifically recommends that when assessing low-lying parts of Napier City (such as Awatoto) it is critical to consider the ground conditions for buildings sited in areas that were uplifted above sea level as a result of the 1931 earthquake. Such land will be prone to increased levels of seismic shaking damage (including liquefaction) in strong earthquake events from nearby fault sources including the offshore subduction zone.

51. Figure 3 shows the map of vertical deformation and surface faulting (thick red lines) related to the 1931 Hawkes's Bay earthquake. Uplift is shown in orange and subsidence in green.

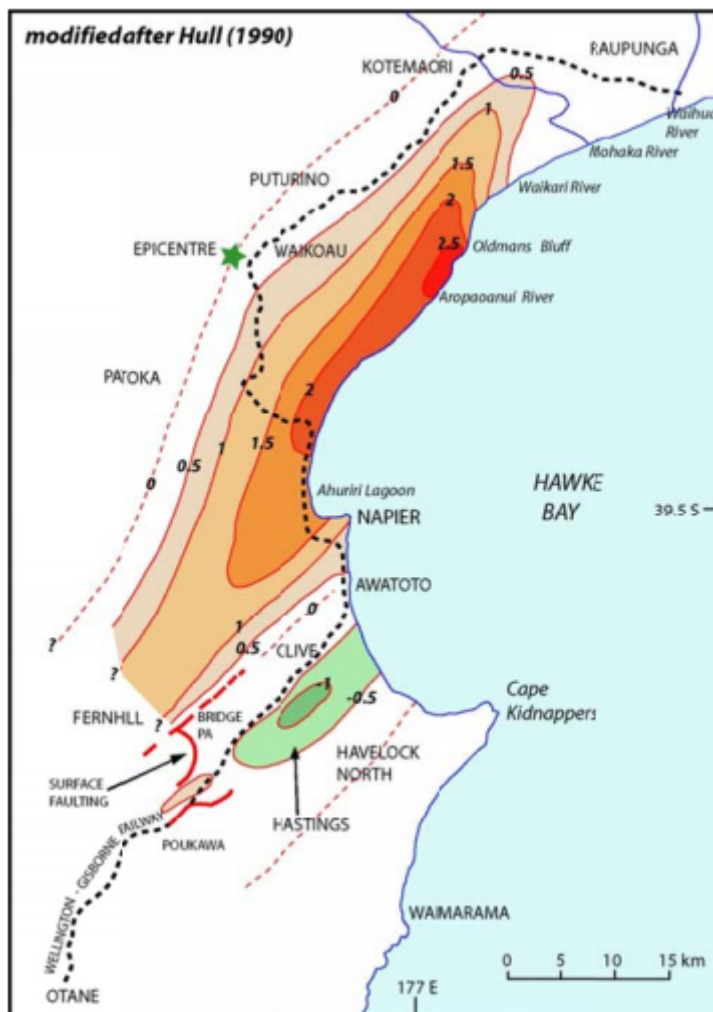


Figure 3: vertical deformation and surface faulting from the 1931 Hawkes Bay earthquake.

Active Fault Mapping and Fault Avoidance Zones for Hastings District environs, Jan. 2015

52. In January 2015, GNS provided HBRC with an update of active fault line work and fault avoidance zones for the Hastings District. This District is traversed by sets of active strike-slip, reverse and normal faults that pose a surface rupture hazard to buildings and infrastructure.
53. The report provides maps which are suitable for use across the Hastings District and GNS recommends that these fault traces be incorporated into district planning maps, where possible in order to set rules for setback distances from active faults to require consideration of active fault guidelines. This information could also be used to inform choices of development locations and design of future developments.
54. The report contains significant information about fault lines and the methodology behind fault line mapping. As shown in Figure 4 below, the Hastings District contains four broad morphotectonic zones of active faulting, these are identified as the Axial Ranges zone, the Hawke's Bay Syncline, the Poukawa-Heretaunga trough and the eastern or Coastal Ranges.

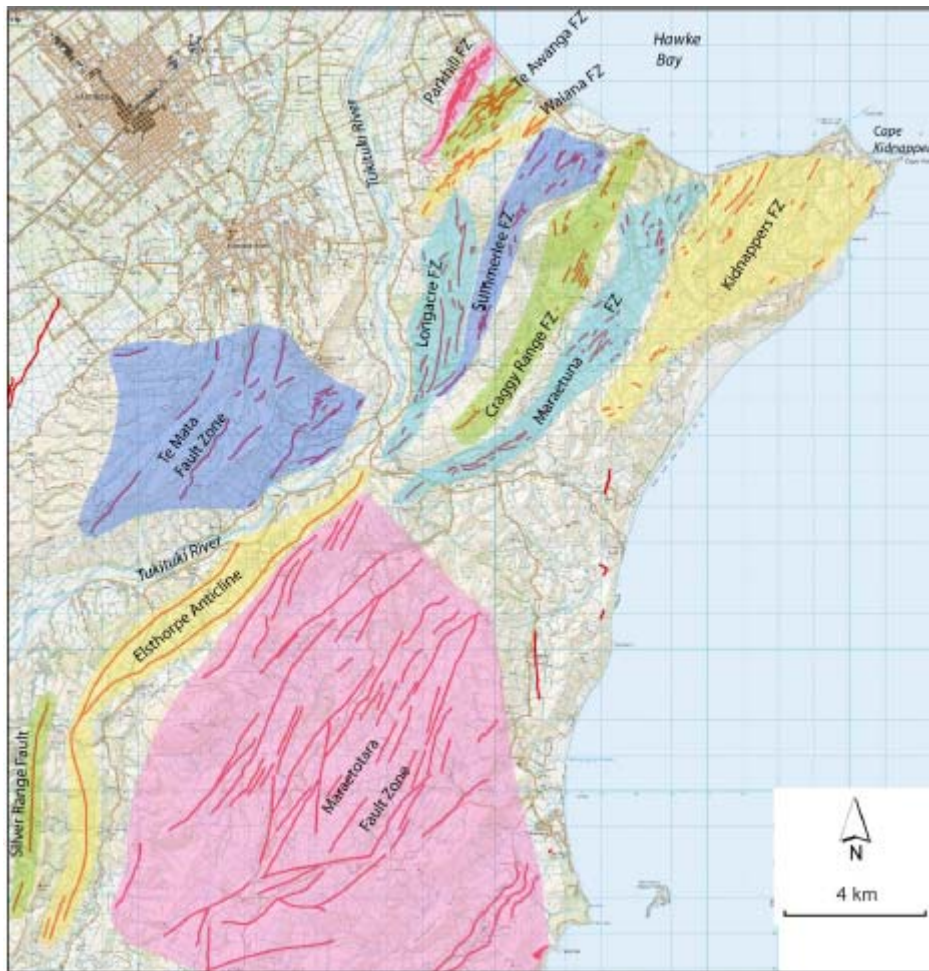


Figure 4: Active fault lines - Heretaunga Plains

The Hawke's Bay Hazards Portal, Jan. 2016

55. The Hawke's Bay Hazards portal⁵ contains a variety of information on a number of hazards, from human pandemic or animal epidemic to volcanic eruptions and floods, within the region. The portal contains information on hazards released pre and post 2010.
56. The information summarised from the portal below relates to natural hazard risks only.

Flood Risk Areas

57. Flooding is Hawke's Bay's most common natural hazard with a severe storm or flood happening every 10 years on average. Major storms affect wide areas and are usually accompanied by strong winds, heavy rain and rough seas. They can cause damage to property and infrastructure, affect crops and livestock, disrupt essential services and cause coastal inundation.

⁵ <http://www.hbemergency.govt.nz/hazards/portal>

58. There has been a significant amount of flood modelling carried out over many different parts of the region from Mahia to Porangahau. The council's hazard portal has been the repository for the spatial mapping of the hazards, along with references to the numerous council publications related to each modelled area. There is no single report for flood modelling across the Heretaunga Plains.
59. Figure 5 indicates floods with return periods of between 50 and 100 years⁶.

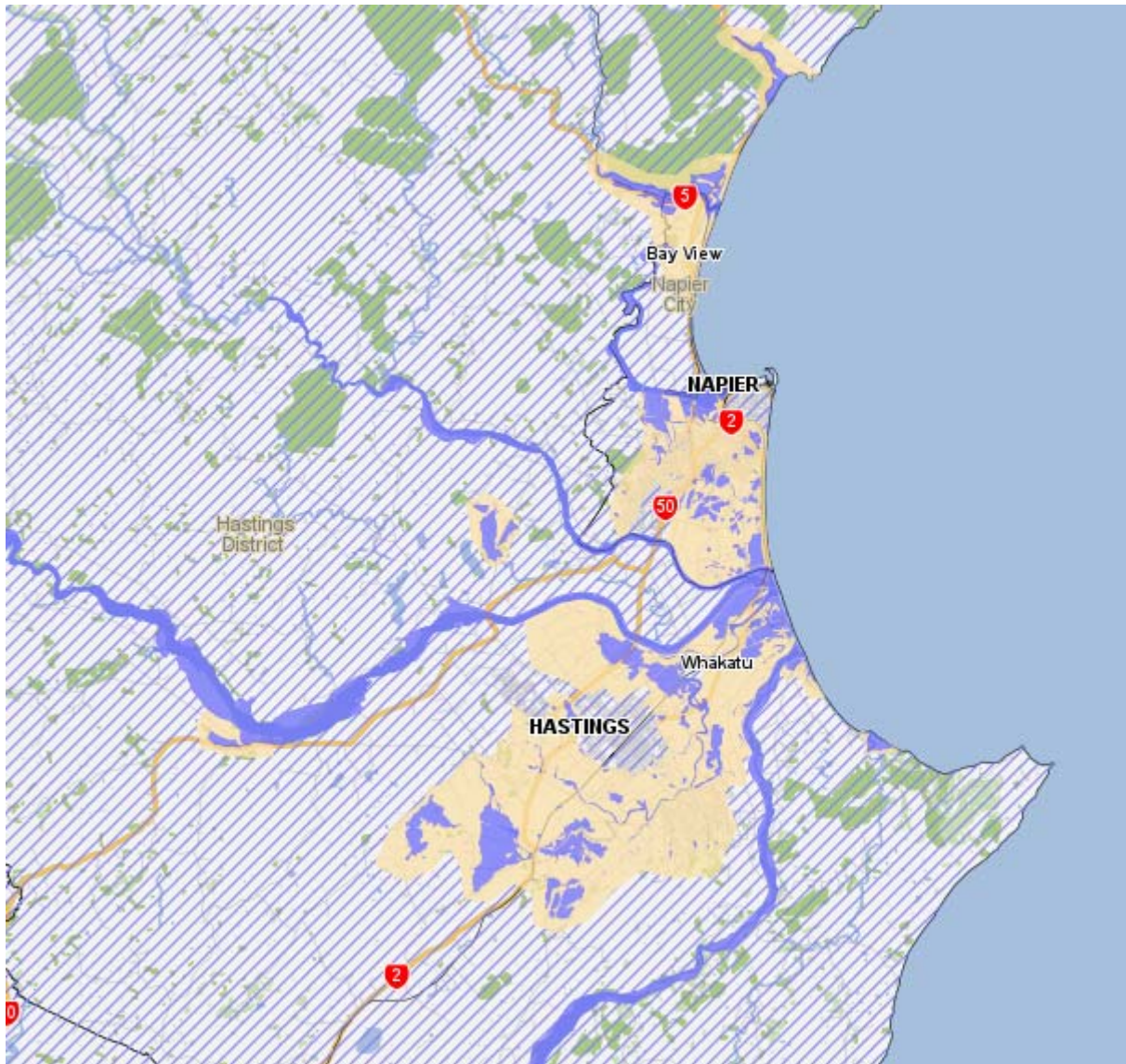


Figure 5: 50 and 100 year return period floods: Hawke's Bay

- ☒ ☒ Flood Risk Areas
- ☒ Flood Risk Areas
- ☒ Low Risk Areas
- ☒ Not In Study Area
- ☒ Stopbanks

⁶ Note: The blue shaded areas represent either a 50 or 100 year return period.

Faults Lines

60. There are numerous active faults in Hawke's Bay onshore and offshore. The Active Fault Map on the Hazards Portal shows generalised traces of active surface faults in the Hawke's Bay region. Active faults are those faults that have moved within the last 125,000 years.
61. No surface traces of active faults have been mapped in the Napier and Hastings city areas. This is not because they don't exist, but rather because historic floods and development have covered them over and scientists are unable to see them to map them. Scientists believe both cities have 'buried' or 'blind' fault sources including the large fault source that caused the Hawke's Bay earthquake of 1931.
62. The active faults located within the Heretaunga Plains are shown in Figure 6, below.

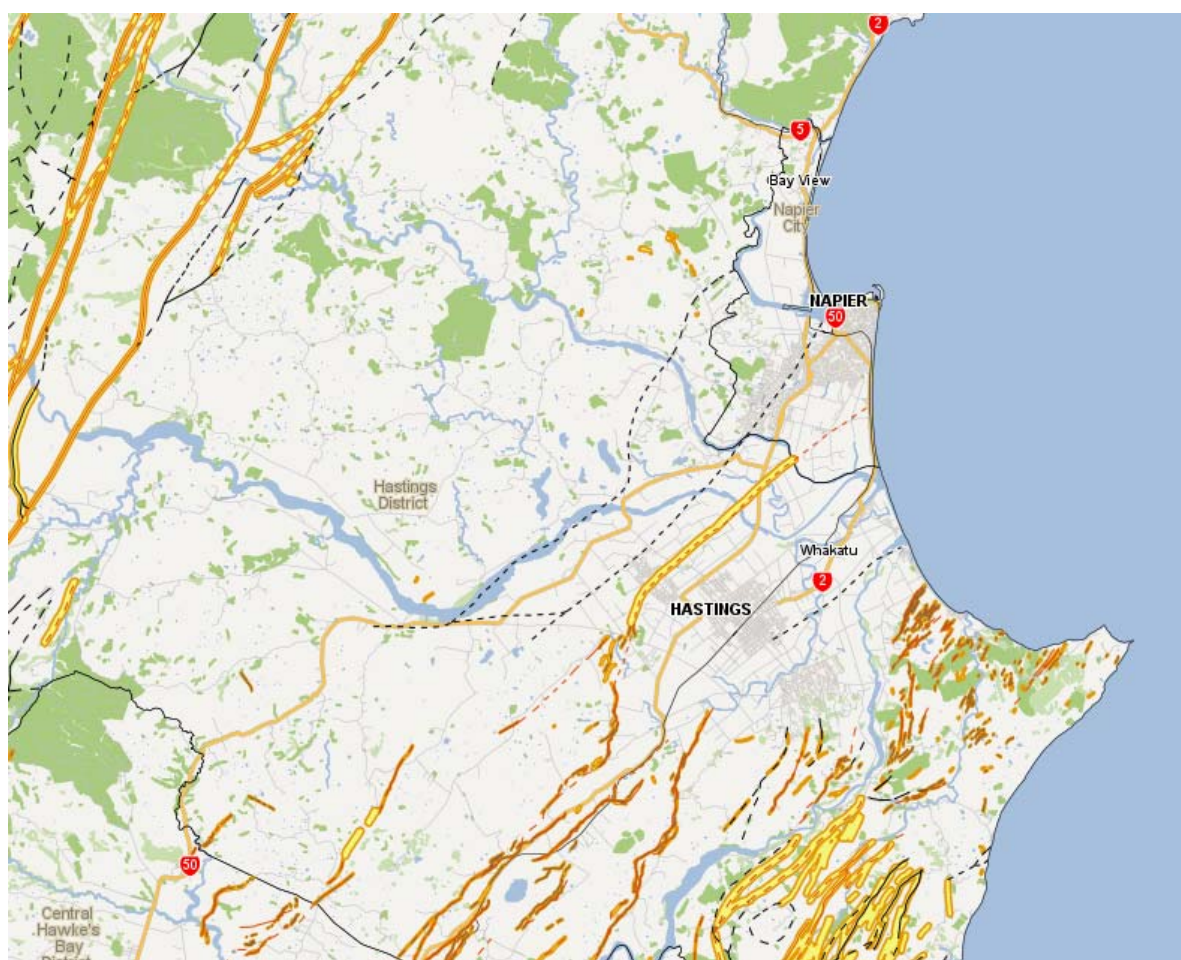


Figure 6 : Active surface faults - Hawke's Bay

<input checked="" type="checkbox"/> QMap Active Faults	<input checked="" type="checkbox"/> QMap Inactive Faults	<input checked="" type="checkbox"/> Hastings Fault Avoidance Zones 2015
<input checked="" type="checkbox"/> Accurate fault	<input checked="" type="checkbox"/> Hastings Faultlines 2015	<input checked="" type="checkbox"/> Napier Wairoa Faultlines 2010
<input checked="" type="checkbox"/> Approximate fault	<input checked="" type="checkbox"/> Accurate	<input checked="" type="checkbox"/> Approximate
<input checked="" type="checkbox"/> Concealed fault	<input checked="" type="checkbox"/> Approximate	<input checked="" type="checkbox"/> Inferred
<input checked="" type="checkbox"/> Inferred fault	<input checked="" type="checkbox"/> Inferred	

Liquefaction

63. Liquefaction occurs when waterlogged sediments are agitated by an earthquake. Buildings can sink and underground pipes may rise to the surface. Being so close to the coast and having a large amount of re-claimed land means the Heretaunga Plains has a number of areas with sediment of high liquefaction susceptibility and numerous earthquake sources capable of generating an earthquake large enough to cause liquefaction.
64. Figure 7 shows those areas in the Heretaunga Plains which are most likely to be subject to liquefaction.
65. It is noted that in July 2013, the Hawke's Bay Civil Defence Emergency Management (CDEM) Group commissioned a review of the liquefaction risks across the region to provide a clearer understanding of how liquefaction occurs and where it is likely to happen during a large-scale earthquake. This information is currently in a draft form and expected to be finalised by May 2016. This information is likely to be critical to informing future development locations and design standards for future buildings and infrastructure in the Heretaunga Plains sub region.

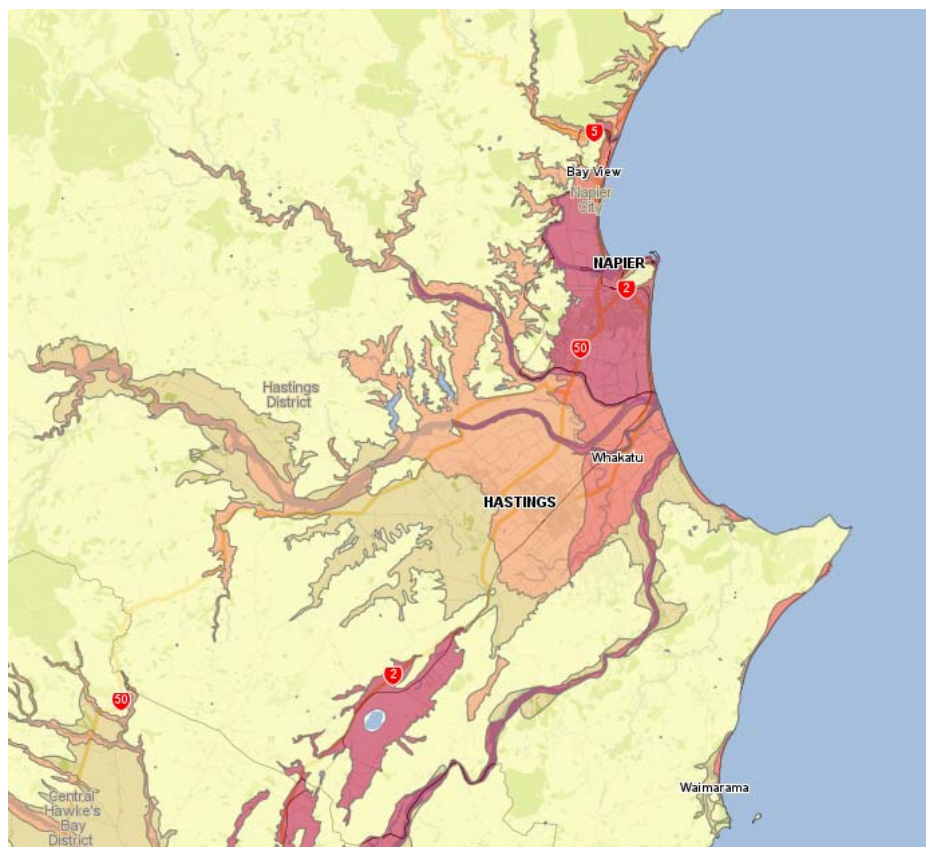


Figure 7: Liquefaction areas - Hawke's Bay



Tsunami Inundation Zones

66. GNS Science and the Hawke's Bay Regional Council have developed a series of tsunami hazard maps which show some of the worst case scenarios, up to a 2,500 year return period for Hawke's Bay for tsunami coming from both a very large local earthquake or from across the Pacific Ocean. The tsunami modeling work undertaken in 2011 by HBRC (discussed in paragraph 12) helped inform this work.
67. The Hazards portal details the possible inundation extents along the Hawke's Bay coast line, along with the Tsunami Evacuation Zones. This mapping shows two tsunami scenarios:
 - a) a distant tsunami – starting across the Pacific Ocean (e.g. South America) when there would be time for an official warning and evacuation;
 - b) a near source tsunami – starting near the coast (e.g. Hikurangi Trough 120 km east offshore) when there would be no time for an official warning.
68. In the case of a distant tsunami, a 5 metre wave was applied – being the highest credible wave height generated from a distant source. A 5 m wave height has a statistical probability of occurring approximately once every 500 years. For a near source tsunami, a 10 metre wave was applied (having a statistical probability of occurring approximately once in 2,500 years). The New Zealand Coastal Policy Statement is silent in terms of directing a suitable timeframe for assessing tsunami risk.
69. Figure 8 shows the inundation zones for a distant and near source tsunami, up to a 2,500 year return period.

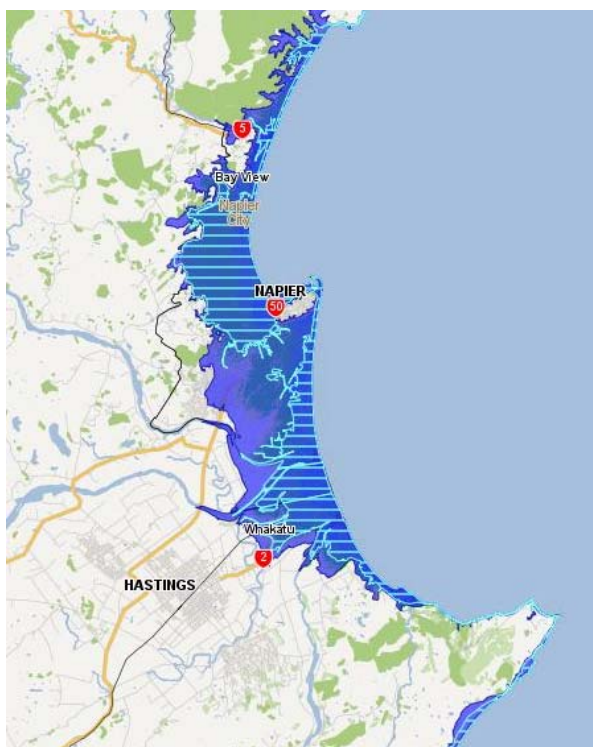


Figure 8: Tsunami Inundation Zones 500 and 2,500 year return period

- ☒ □ Tsunami Distant Source Inundation Extent
- ☒ ■ Tsunami Near Source Inundation Extent
- ☒ ▣ Tongo Clifton Tsunami NearSource MaxFlowDepth

Tsunami Evacuation Zones

70. The hazards portal contains official tsunami evacuation zone maps for the Hawke's Bay coastline. Figure 9 details the evacuation maps for the Heretaunga Plains.
71. The maps show evacuation boundaries based on a variety of hazard models which aim to include all possible flooding from all known tsunami sources, including 'worst case' rare scenarios for Hawke's Bay for tsunami coming from both a very large local earthquake or from across the Pacific Ocean.
72. The tsunami evacuation maps show red, orange and yellow zones, which need to be evacuated in different events, while all zones need to be evacuated in a major event i.e. after a long or strong quake, lasting more than a minute or one that makes it hard to stand.

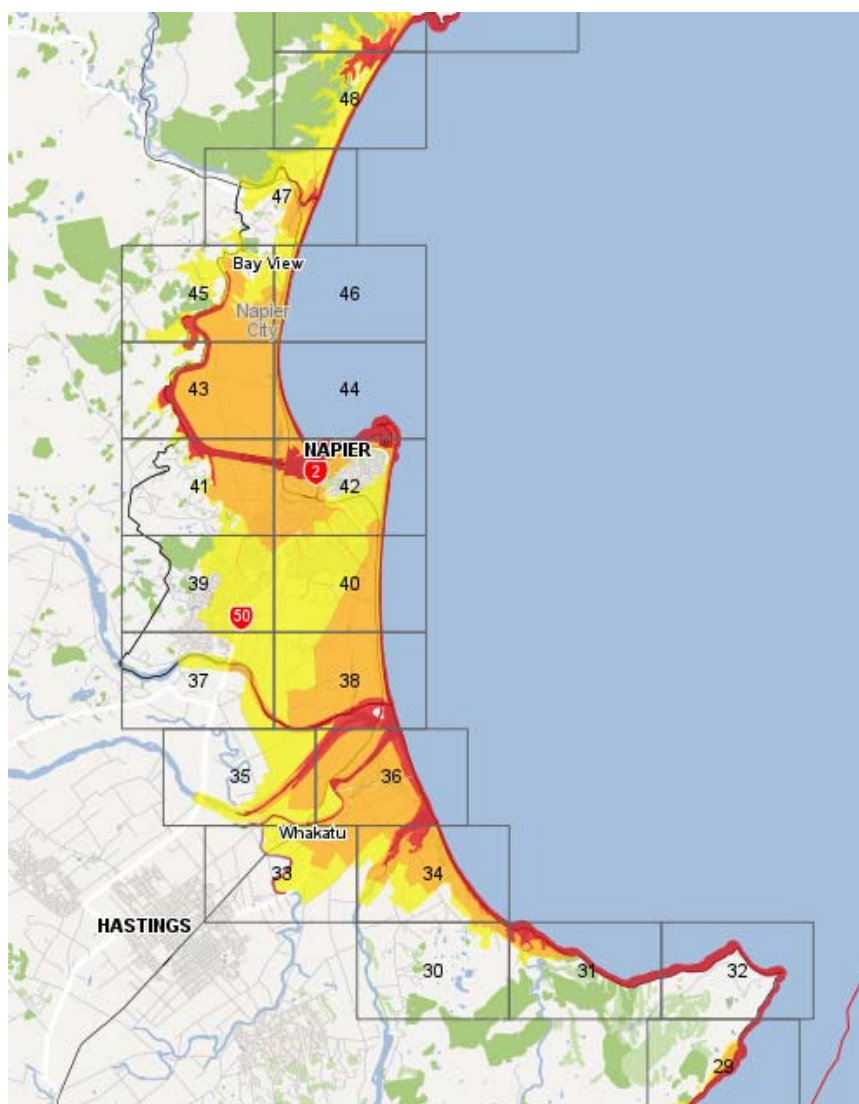


Figure 9: Tsunami Evacuation Zones

- Evacuation Zone Red
- Evacuation Zone Orange
- Evacuation Zone Yellow

Coastal Hazard Zones

73. Between 2003 and 2008 Tonkin and Taylor and the Hawke's Bay Regional Council developed a series of coastal hazard maps for inclusion within the Hawke's Bay Regional Coastal Environment Plan. These maps are contained on the Hazards Portal and identify areas at risk of coastal erosion and coastal flooding. Being pre 2010, these coastal hazard zones would have informed preparation of the original 2010 HPUDS so are not discussed further in this report.
74. Figure 10 shows coastal hazard zone 1. These areas are currently being reassessed as part of the Clifton to Tangoio Coastal Hazard Management Strategy (discussed in paragraph 75), with the new erosion and inundation extents expected to be finalised and publicly available in May 2016.

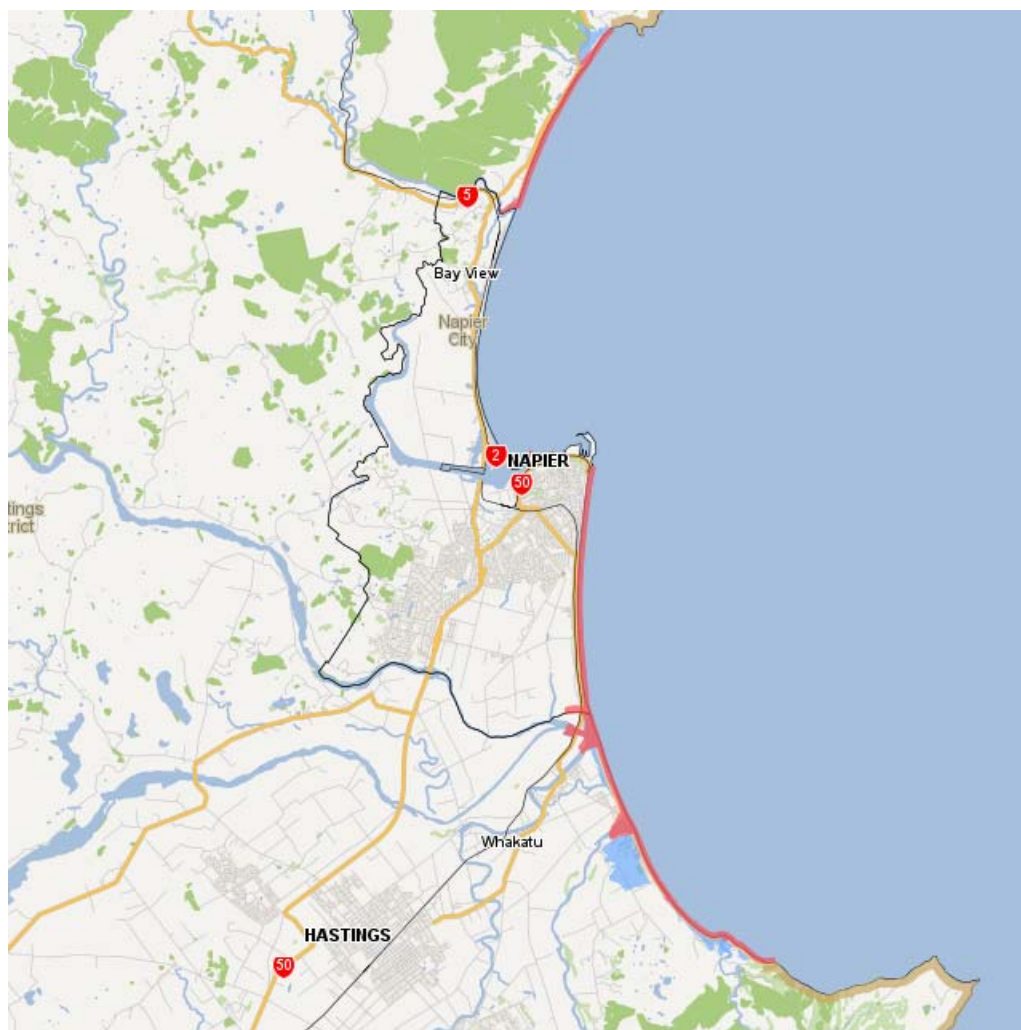


Figure 10: Coastal Hazard Zones - Heretaunga Plains

- ☒ Coastal Hazard Zone 1
- ☒ Coastal Hazard Zone 2
- ☒ Coastal Hazard Zone 3
- ☒ Transition Hazard Zones
- ☒ Cliff Shore Hazard Zone

Clifton to Tangoio Coastal Hazard Management Strategy

75. A long-term strategy for managing coastal hazards between Clifton and Tangoio is currently being jointly developed by Hawke's Bay Regional Council, Hastings District Council, Napier City Council and Iwi.
76. The strategy development process will focus on understanding the coastal hazards issues facing this part of the coastline and assessing the likelihood of occurrence and potential consequences of a variety of coastal hazards. This first phase will occur throughout 2015. The strategy will then go on to consider a range of options for managing or reducing those risks over the medium and long term
77. As part of the strategy process, Tonkin and Taylor have produced updated coastal hazard maps for this part of the coast line. These maps are still in draft form and due to some sensitivities around this information will likely be finalised in May.

CONCLUSION

78. This report provides a summary of the existing literature produced around natural hazards that have implications for urban growth. Its purpose is to enable a better understanding around what relevant national and local research has taken place on natural hazards, the key outcomes and the results of this research and ultimately whether it is relevant to the HPUDS review.
79. The literature review highlights the need for any future decision making around HPUDS to be mindful of the likelihood of an event occurring relative to the consequences particularly when considering future urban development in the Heretunga Plains sub region. It is important to note that each event has a risk profile, which means that no standard approach can be adopted to treat all risks.
80. There are two key reports due to be finalised in May 2016 which will provide updated information around liquefaction and coastal hazards. Because the reports are not yet finalised they are not currently available for analysis in this literature review.