IN THE MATTER OF	Resource Management Act 1991, Subpart 6 concerning Intensification Streamlined Planning Process
AND	
IN THE MATTER	of Plan Change 2, Proposed plan change to the Kāpiti Coast District Plan under The Resource Management Act 1991, Schedule 1 Subpart 6.

STATEMENT OF EVIDENCE OF

SEAN EDWARD RUSH

REGARDING THE PROPOSED CQMP

On behalf of
COASTAL RATEPAYERS UNITED Inc

March 2023

Introduction

1. My full name is Sean Edward Rush.

2. I qualified as a lawyer in 1992 and have spent most of my career advising clients in the petroleum industry.

3. I obtained a Masters Degree in Petroleum Law and Policy in 2012, with distinction, studying post-graduate geology in the process, and was the Todd Group's asset manager for the Maui pipeline which exposed me to soil movement analysis and technology.

4. In 2019 I went back to University full time to study climate science, which included the physical science, adaptation and mitigation strategies, and post-graduate legal training on the Resource Management Act 1991 which supplemented my working knowledge of planning rules gained whilst at the Todd Group.

5. I graduated with a Masters Degree in Climate Change Science and Policy from Victoria University of Wellington ("**VUW**"), with merit, in 2021 and was an Expert Reviewer for the IPCC, contributing to the recent Sixth Assessment Report (Working Group 1, The Physical Science Basis*)* ("**IPCC 2021**" or "**AR6**").

6. In 2019 I was elected to the Wellington City Council and was the Chair of its Infrastructure Committee, portfolio lead for Low Carbon Energy and its representative for several committees and trusts. Due to my climate studies, I familiarized myself with climate reports prepared by the likes of NIWA, GNS and the MfE regarding the Wellington region and regularly corresponded with experts regarding such reports. I took a particular interest in the sea-level literature and measurement techniques affecting the Wellington region.

7. I did not stand for re-election.

8. In preparation for this Statement of Evidence, I have read aspects of the following dealing with sea-level rise and vertical land movement:

    i. Kāpiti Coast Coastal Hazard Susceptibility and Vulnerability Assessment Volume 1: Methodology (**Jacobs 1**);

    ii. the *Kāpiti Coast Coastal Hazards Susceptibility and Vulnerability Assessment Volume 2: Results* report (**Jacobs 2**);

    iii. the Ministry for the Environment's July 2022 *Interim guidance on the use of new sea-level rise projection* (**MfE, 2022**);

    iv. the New Zealand Coastal Policy Statement 2010 (**NZCPS 2010**);

    v. the Coastal Erosion Hazard Assessment for the Kāpiti Coast: Review of the Science and Assessments Undertaken for the Proposed Kāpiti Coast District Plan 2012 (**Shand Review**);

    vi. the Kapiti Coast coastal hazard assessment, Dr Willem de Lange, Department of Earth and Ocean Science, the University of Waikato, (November 2013) ("**De Lange 2013"**);

Code of Conduct

9. I have read the Code of Conduct for expert witnesses in the Environment Court Practice Note 2023 and I have complied with it when preparing this evidence. Except when I state that I am relying on the advice of another person, this evidence is within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

10. I am not a member of CRU, I do own a coastal property in Otaki but have not submitted on PC2. My property is within the proposed CQMP although this was only communicated to me after I agreed to provide this evidence. I support the use of natural hazard mapping and adaptive management within hazard zones. However, for reasons I will outline in my evidence, I am of the view that the Jacobs 2 report does not provide a sound basis for the proposed CQMP.

Scope of Evidence

11. My evidence covers the following areas:

    i. A review of relative sea-level rise (**RSLR**) over the 20th century shows there has been no acceleration of RSLR across the 20th century. NIWA scientists previously confirmed that rising sea levels in New Zealand, as assessed by tide gauges, showed no statistically significant acceleration through to the early 21st century, although more recent literature suggests otherwise;

    ii. A review of Jacobs 1 leads to my view that the authors have not looked closely at some of the peer-reviewed literature, relied on some literature that has been superseded, and have under-estimated the uplift associated with the vertical land movement (**VLM**) component of relative sea- level rise (**RSLR**) and accordingly over-estimated the likely RSLR projections;

    iii. How the use of representative concentration pathway[1] 8.5 (RCP 8.5) (and its 83rd percentile derivative RCP 8.5H+) should not be used to predict coastal hazard lines, because it is now described as not a likely or plausible scenario by the latest IPCC report (AR6);

    iv. A critique of MfE 2022 is the interim coastal guidance that is underpinned by the "SeaRise"[2] project's satellite estimates of vertical land movement. In particular, how the SeaRise team's work has not passed the peer review process, was fast-tracked into policy anyway and has caused controversy amongst the geoscience community;

    v. A response to the Statement of Evidence of Derek John Todd.

[1] Representative concentration pathways are an estimate of the amount of emissions that would occur given certain assumptions around fossil fuel and other high emitting activities. The numeric value is the amount of warming in 'watts pe square metre, so RCP 8.5 denotes an expected increase in warming of 8.5 watts per square metre.

[2] The SeaRise project is led by Victoria University scientists with others from GNS and other NZ and international institutions. The project used satellite data between 2003-2011 to measure land uplift and subsidence around the NZ coastline. This work has been incorporated into MfE 2022 as the vertical land movement component of sea-level rise projections.

12. My main conclusions are that Jacobs 1:
    i. does not utilise the best available information on the likely effects of climate change (per NZCPS Policy 24) on the region or district;
    ii. omits reference to the latest science about important aspects of coastal planning relating to vertical land movement and tide gauge measurements;
    iii. is inconsistent with IPCC 2021; and
    iv. utilises conservative and in my view, unlikely scenarios that, when aggregated, have a compounding effect on the likelihood of their occurrence;

13. My evidence relates to the spatial extent of the "**Coastal Qualifying Matter Precinct"** proposed by the Council under Proposed Plan Change 2 (Intensification) (**PPC2**) to the Operative Kāpiti Coast District Plan 2021. The spatial extent of the "Coastal Qualifying Matter Precinct (**CQMP**) was informed by the methodology set out in Jacobs 1. As explained in my evidence this report did not incorporate the latest, best available information, including guidance on the likely effects of climate change, with the result that, in my opinion, Jacobs 2 overestimates the inland extent of coastal erosion and inundation over the planning time horizon of 100 years compared with what is required by the NZCPS Policy 24 when assessing coastal hazards under the RMA.

14. Consequently, in my view, Jacobs 2 does not provide a sound basis for determining the location and extent of likely coastal erosion in Kapiti and is therefore unsuitable as a basis for determining the proposed CQMP.

Relative Sea -Level Rise across the 20th century

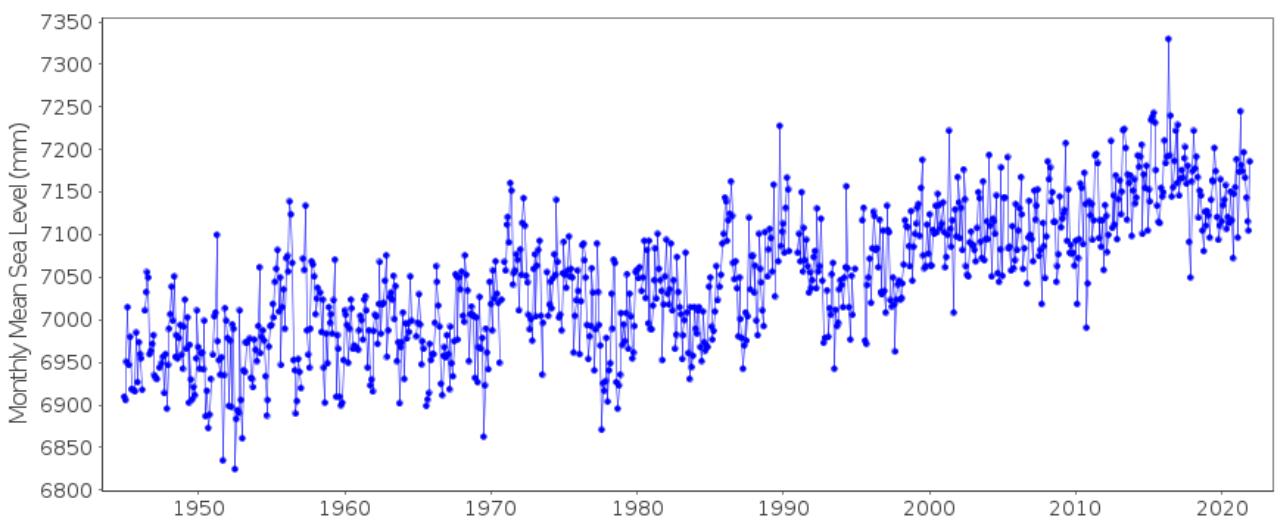
15. There are two ways of expressing sea-level rise ("**SLR**"):

(i) Absolute or eustatic[3] SLR is the rise in sea-level relative to the centre of the Earth and is essentially the actual rate of rise in ocean water level. It is measured by altimeters on board satellites, with orbits measured relative to the centre of the Earth, and

(ii) Relative sea-level rise (**RSLR**) is the local SLR, which includes both the absolute SLR plus changes (up or down) in land elevation for the relevant coastal area. RSLR is determined from tide gauge measurements, as the gauge is subject to both changes in ocean level as well as vertical land movement (**VLM**). It is RSLR that communities need to adapt to.[4]

16. Below is the tide gauge record from Queen's Wharf in Wellington since 1944. It will be observed that the sea level peaked in 2016, with the sharp drop likely due to the El Niño Southern Oscillation (**ENSO**) weather pattern and land uplift associated with the Kaikoura earthquake.

Figure 1: *Queen's Wharf (station 221) tide gauge from the Permanent Service for Mean Sea Level (2 March 2023)*



17. The oscillation of the sea-level trends can be attributed to the influences of local and regional meteorological effects (including storm surges), modes of climate variability (for example the El Niño-Southern Oscillation) and long-term trends (from both the ocean surface and land movements), including the impact of anthropogenic climate change (Church and White 2011)[5]

18. Undoubtedly sea-level is rising and an acceleration may be occurring, but (as set out in paragraph

[3] "Eustatic" sea-level changes relate to changes due to the volume of water, rather than land movement or oceanic currents.
[4] Bell et al 2018, page 7.
[5] Church, J.A., White, N.J. Sea-Level Rise from the Late 19th to the Early 21st Century. Surv Geophys 32, 585–602 (2011). https://doi.org/10.1007/s10712-011-9119

23 below) more time is needed to identify any accelerating trend that is outside the bounds of periodic, long-term, oscillations.

Satellite vs. Tide Gauges

19. Sea-level changes are predominantly measured by two systems, the satellites[6] and tide gauges but they measure different things and each has strengths and weaknesses.

20. For coastal planning purposes, it is the relative sea-level that is important and the go-to tool has traditionally been the tide gauge.

21. Satellite altimeters have measured sea level since 1992. They measure an average response over an area of ocean (the Global Mean Sea-level or **GMSL**), while tide gauges measure the sea level relative to the land at a specific location.

22. Any land within the satellite's footprint affects the reliability of the sea level estimate, with current systems unable to reliably measure sea level closer than 15-20 km from the coast (Centre National d'Études Spatiales (CNES), 2018[7]). In other words, satellites cannot measure relative sea-level with the same accuracy as a tide gauge but can give a less accurate measurement over a wider, spatial area.

23. Sea level varies in response to many factors over different time scales and in different regions. It is accepted international practice to determine rates of sea-level rise based on data series longer than 60 years to average out the effects of shorter duration oscillations (Chambers et al, 2012, Jevrejava et al 2008[8][9]). The satellite's 30-year data set is consequentially too short, hence the need for more time.

24. This caution was the key finding of Bâki et al 2020[10] whose concluding remark stated:

> "*Until the uncertainty of a recent GMSL [global mean sea level] acceleration is established in the context of "total evidence", i.e. in the light of systematic global sea level variations during the 20th century revealed by TG measurements together with the available SA [satellite altimeter] time series, any prediction of a GMSL rise ought to be made with extreme prudence.*"

25. This caution was echoed in MFE 2017 which noted that the 23-year satellite record showed a near 'doubling' from the prior record. But then went on to state: "*To ensure the separation of decadal-scale variability from the regional trends, and definitively assess long-term climate shift, a longer time series from the satellite altimetry is still required.*"[11]

Latest Science on the New Zealand Tide Gauges

26. An analysis of New Zealand's five long-term tide gauges was recently completed (Denys et al 2020).[12]; resulting in an overall VLM at the tide gauge benchmark of -0.62 ± 0.40 mm/y.

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[6] The satellites that measure global mean sea level (GMSL) should not be confused with the GPS satellites that are part of the Global Navigation Satellite System ("GNSS") that are important to the evaluation of land movement.

[7] CNES, 2018. Jason-3 Products Handbook. Centre national d'Études Spatiales (National Centre for Space Studies), Paris, France, Report SALP-MU-M-OP-166118-CN.

[8] Chambers DP, Merrifield MA, & Nerem RS, 2012. Is there a 60-year oscillation in global mean sea level? Geophysical Research Letters 39: L18607.

[9] Jevrejava et al 2008, "Recent global sea-level acceleration started over 200 years ago?" https://agupubs.onlinelibrary.wiley.com/doi/10.1029/2008GL033611

[10] İz, H. Bâki and Shum, C.K. "The certitude of a global sea level acceleration during the satellite altimeter era" Journal of Geodetic Science, vol. 10, no. 1, 2020, pp. 29-40. https://doi.org/10.1515/jogs-2020-0101

[11] MfE 2017 page 78.

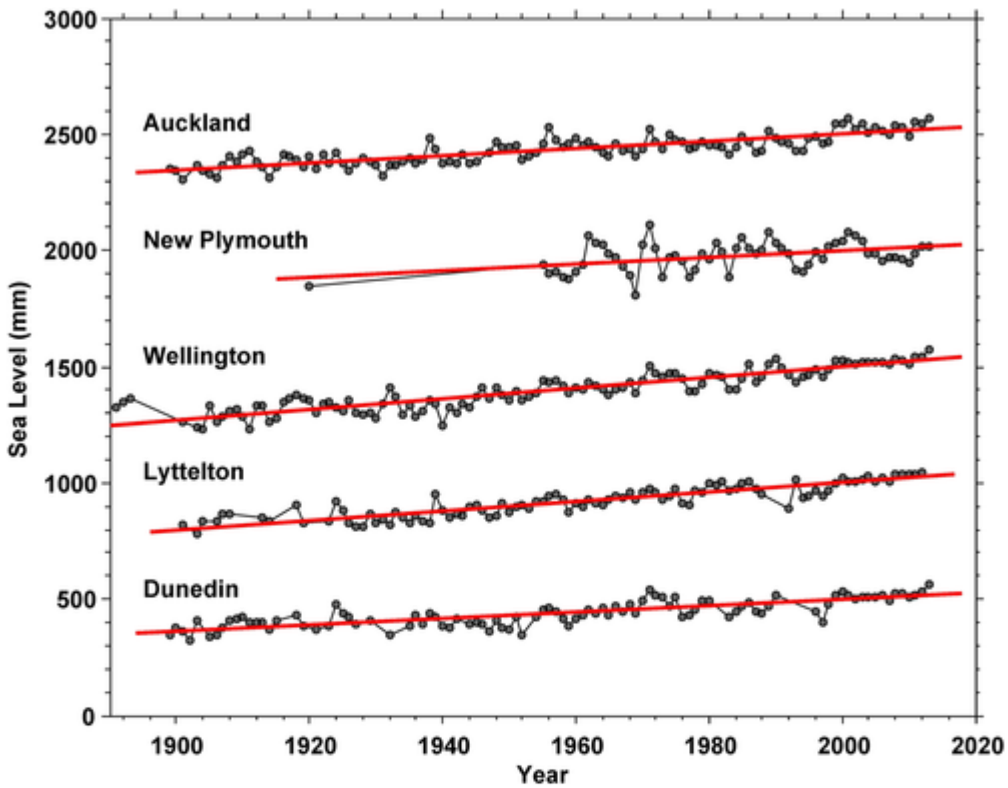
[12] Denys et al (2020) "*Sea Level Rise in New Zealand: The Effect of Vertical Land Motion on Century-Long Tide Gauge Records in a Tectonically*

27. Their results indicate an average rate of eustatic sea-level rise of 1.45 ± 0.36 mm.y-1, and they did not detect any acceleration in the rate over time, which agrees with an earlier assessment by Fadil et al (2013)[13] that found an average rate over 1900- 2011 of 1.46 ± 0.10 mm.y-1.

28. Denys et al (2020) did report that splitting the Auckland data at 1961 indicated a higher rate of sea-level rise for 1961-2013 but noted that internal variability (specifically Interdecadal Pacific Oscillation) could explain the apparent increase in trends.

29. Their analysis of RSL and VLM are plotted in figure 2 showing Wellington's sea-level rise, combined with subsidence, averaged +2.18 mm/year. Other long-term tide gauges show a similar trend.

Figure 2: *RSL trends with an arbitrary vertical offset applied to each sea-level record from Figure 2, Denys et al (2020)*



30. The lower rates of VLM that are implied by the tide gauges resulted in the following caution from the authors of Denys et al 2020:

> "*It also implies that unknown and unmodeled VLM is likely to occur at other global long record TG sites and is currently not being taken into account and therefore leading to bias GMSL [Global Mean Sea-Level] estimates. Thus, more work is needed to understand the physical processes responsible for lower rates of VLM-corrected sea level change in NZ when compared with GMSL.*"

31. Coastal planners have traditionally relied on tide gauges that have been reasonably consistent throughout the anthropogenic global warming period. An improvement would be to install such gauges along the Kapiti Coast shoreline.

Active Region."

[13] Fadil A, Denys P, Tenzer R, Grenfell HR, & Willis P, 2013. New Zealand 20th century sea level rise: Resolving the vertical motion using space geodetic and geological data. Journal of Geophysical Research: Oceans 118: 6076-6091

COMMENTS ON JACOB'S 1

32. I have reviewed the comments made in Jacob's 1 Section 3.3 *'Projections of Local Vertical Land Movements'* and found the authors had confused '*net'* subsidence with *'gross'* subsidence.

Section 3.3: Projections of [some] Vertical Land Movements [but not all]

33. I was struck by the considerable difference Jacobs 1 ascribes for VLM measured by Beaven and Litchfield (2012), Bell and Hannah (2012) and the more recent measurements stated by the authors Bell et al (2018). Jacob's 1 states that:

> "*the lower North Island had subsided at average rates of 1 – 3 mm/yr over the previous 10 years, with the average rate for the Wellington region being 1.8 mm/yr, with the Kapiti coast being closer to* ***1 mm/yr****. A more recent analysis by Bell et al (2018) notes that in general, the Wellington region is subsiding at rates of between 2-5 mm/yr over the last 20 years, with the Kāpiti Coast site averaging* ***5.15 mm/yr*** *and Paekākāriki site averaging* ***3.45 mm/yr****.*" (emphasis added)

The discrepancy between 1 mm/yr and 5.15 mm/yr for Kapiti and 3.45 for Paekākāriki seemed considerable and worthy of review as did the inference that the Kapiti site's VLM was averaged over 20 years. Bell et al 2018 reported on only the prior 10 years for the Kapiti site. Paekākāriki subsided by 3.45 mm/yr seemingly over the first and second 10-year periods of its record. Neither peer-reviewer appears to have investigated these discrepancies.

The mixing up of different data measurements across different timescales is confusing. The most important measurement for decision-makers was not highlighted. That both Kapiti and Paekakariki have been subject to net uplift of 21mm and 19 mm respectively across the last 10 years.

THE IMPORTANCE OF SLOW SLIP EVENTS TO SEA-LEVEL

34. The two values are measurements of different things. The former value (1 mm/yr) is the net movement after slow slip events and other uplifting movement has been factored in. The latter values are the "secular" subsiding trend, with the balancing uplift removed. Bell et al 2018 (Table 4.1), from where Jacobs 1 has sourced their data, clarifies how their measurements were compiled:

> "*tectonic components such as slow slip events, coseismic offsets, and post-seismic responses have been removed to isolate the underlying trend without tectonic events.*"

In other words, all uplifting events were removed leaving the subsiding trend. It is unclear what is the scientific justification for this other than to examine the subsiding trend for academic purposes. It has no practical utility.

35. Bell et al 2018 went on to include the uplifting trends to reflect the observational record and went on to conclude:

> "*The net effect is that the subsidence due to the subduction of the Pacific plate under the Australian plate and coseismic displacement to date was mostly cancelled out by the current day Kaikoura earthquake post-seismic deformation and the upwards ratcheting effect of the SSEs* [slow slip events]."

36. That is an important finding that has not been identified in Jacobs 1. Jacobs 1 does not address these uplifting effects even though they are well documented in the peer review (e.g. Wallace and Beaven 2010[14], Wallace 2020[15], Beaven and Litchfield 2012[16], King et al 2020[17]).

37. Due to their tectonic origins, these events have recurred and are certain to occur again. A detailed explanation of these uplifting movements resulting from the tectonic events is given in Bell et al (2012) who cites Denys et al. (2012)[18] which was an early draft of Denys' et al 2020:

> "*Denys et al. (2012) are of the view that it is the outcome of two related tectonic events. One is the coupling between the Pacific and Australian plates on the subduction interface that underlies Wellington (Wallace et al. 2004), and the other the outcome of slow slip events (SSEs) that have twice been observed in the region since 1997 (Wallace and Beaven, 2010).*"

38. In simple terms, the Australian plate upon which most of New Zealand lies, is being dragged down by the subducting Pacific plate, but periodically there is a ratcheting backup of the Australian plate as it decouples from the subducting Pacific plate. This ratcheting can manifest as an episodic earthquake or as a more subtle gradual uplift over longer periods, as slow slip events (SSEs). Bell et al 2012 note how these SSEs have almost certainly reduced the subsiding trend over the longer term. The tide gauges do not record subsidence at the higher values Jacobs 2 suggests should be adopted by policymakers. The authors caution:

> "*The fact that the cGPS trend estimates are derived from data collected between 2000-2009 i.e.., between the two SSEs is likely to result in regional ground motion that is quite different from the overall average for the 1891-2011 period of the tide gauge record.*"

39. These events have now been observed and documented four times (King et al 2020, Wallace 2020) and almost certainly occurred before the start of the GNSS record.

The Latest Science of Slow Slip Events

40. Slow slip events, and their effect on RSL, are explained in detail in Beaven and Litchfield 2012, "*Vertical land movement around the New Zealand coastline: implications for sea-level rise.*" Whilst this study informed the MfE's Coastal Guidance (MfE, 2017. section 5.3) no reference is made to SSEs in the guidance – an important omission which, given subsequent verification of the recurring nature of these events, should be corrected. Requests to MfE for clarification have gone unanswered.

41. Beaven and Litchfield's 2012 figure 8 illustrates the effect of SSEs and the importance of measuring the uplifting VLM over several SSE cycles:

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[14] Wallace and Beaven 2010 "Diverse slow slip behavior at the Hikurangi subduction margin, New Zealand" https://agupubs.onlinelibrary.wiley.com/doi/full/10.1029/2010JB007717

[15] Wallace Laura M., "Slow Slip Events in New Zealand" Annual Review of Earth and Planetary Sciences Vol. 48:175-203 (Volume publication date May 2020) First published as a Review in Advance on January 7, 2020 https://doi.org/10.1146/annurev-earth-071719-055104

[16] Beaven and Litchfield 2012 Vertical land movement around the New Zealand coastline: implications for sea-level rise. GNS 2012/29.

[17] King, D., Newnham, R., Gehrels, R Clark, K. (2020). Late Holocene sea-level changes and vertical land movements in New Zealand, New Zealand, Journal of Geology and Geophysics, DOI: 10.1080/00288306.2020.1761839.

[18] Note Denys et al 2012 was never published and was subsequently superseded by Denys et al 2020 who make the same point on page 14 of their study (pers comm P. Denys 7 March 2023).

Figure 3: *Figure 8 from Beaven and Litchfield 2012.*

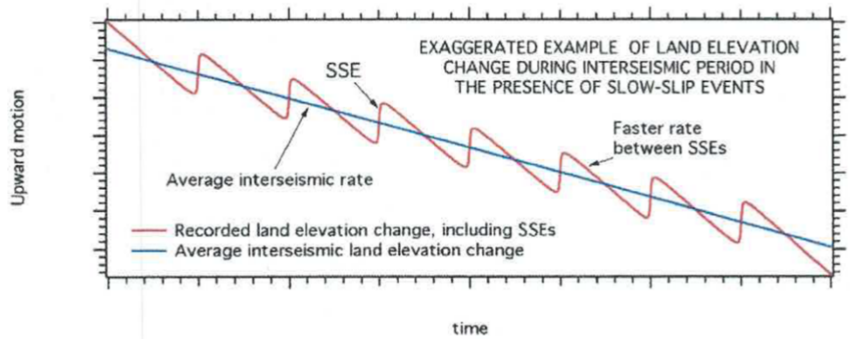


Figure 8 Slow-slip events (SSEs) have been recorded along the North Island east coast and at sites around the Wanganui Basin since the installation of cGPS units in the region. These are slow earthquake-like events that are observed to take place over days to weeks along the east coast, and over periods of a year or more along the Kapiti coast. They modulate the interseismic vertical motion, so that a measurement of land elevation change between two SSEs may be quite different from the rate averaged through many events (which is the rate of most interest for RSL predictions). In the idealised example above, the subsidence rate measured between two SSEs is substantially faster than the rate averaged through many SSEs.

42. Bell et al 2018 suggest SSEs provide 0-45 mm[19] uplift, with the biggest uplift on the Kapiti Coast. They state:

> "*The east coast of the North Island, Kāpiti Coast and top of the South Island are all affected by periodic slow slip events (SSE) that have, so far, uplifted the land over the period of GPS/GNSS measurements (approximately 20 years). The largest events occurred in 2003, 2008 and 2013.*
>
> *In this case, the Kapiti Coast 2013 SSE was active for approximately 12 months.*
>
> *Based on the long record of cGNSS sites (WGTN, WGTT, PAEK), these events appear to occur every 6–8 years and can last for up to one year. The SSE progressively become larger from the east coast to the west coast, which represents the transition from the Pacific to the Australian plates.*"

43. At the GNSS site, WGTT (at Te Papa) SSEs have caused 17 mm of uplift in the decade before the study. With the trend being for higher uplift further west away from the Hikurangi zone (Bell et al 2018, Jacob 1), then the uplifting trend on the Kapiti coast is likely to be higher. Table 4.2 in Bell et al 2018 shows this to be the case with the following uplift by SSEs for three sites over the prior 10-year period:

- PAEK (Paekākāriki): 54 mm
- KAPT (Kapiti): 72 mm
- LEVN (Levin): 44 mm

Bell et al 2018 concluded that: *"It is evident, for the 10-year period 2008–2018, that there is a pattern of net uplift on the Kāpiti Coast of ~20 mm, decreasing to the east where the net subsidence is ~30 mm."*

44. It is important to note that GNSS sites may not be on the coast and their measurements may not be an accurate proxy for what's happening at the shoreline. For example, the Paekākāriki site is on

[19] Bell et al 2018, page 26. Note at section 4.5 this is stated to be 6-8 years.

Paekākāriki Hill a dozen or more kms from the coast and elevated ~200 metres above it.

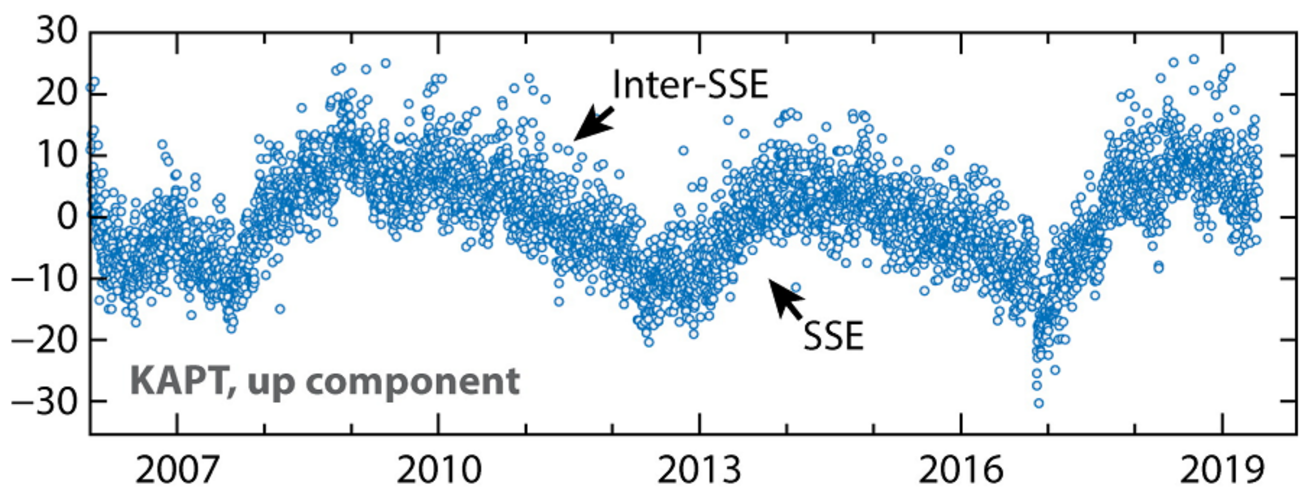
45. Whilst comparisons between GNSS sites can be useful, the rocks beneath each can be completely different and subject to different fault systems. They very much provide a local view of VLM.

46. The impact of SSEs on the Wellington area's rates of subsidence and its effect on the relative sea-level rise was explained carefully, with supporting literature, in King et al 2020. Similarly, Wallace 2020[20] reported that regarding the Kapiti Coast:

> "*past Kapiti SSEs have occurred in 2003, 2008, 2013, and late 2016–2018—the latter was triggered by the November 14, 2016, Mw 7.8 Kaikōura earthquake (Wallace et al. 2018), which appears to have brought the Kapiti SSE recurrence forward in time by a couple of years.*"

Figure 4 of Wallace 2020 shows the effect on the GNSS site at Kapiti.

Figure 4: Extracted *from Wallace 2020, figure 3, shows the uplifting effects of SSE's and the subsiding effects of subsidence during the 'inter-SSE' phase as measured at the Kapiti GNSS site.*



47. Despite Jacobs 1's publication in June 2021 (and the peer reviewers' comments from May 2021), the published work by Denys et al 2020, Wallace 2020 and King et al 2020 is not referenced or otherwise addressed. The most recent reference dealing with VLM is to Bell and Hannah 2018 who note how subsidence has been cancelled out.

48. Jacobs 1 is accordingly an incomplete analysis of the subject and leads to a biased assessment of the coastal hazards in terms of Policy 24 of the NZCPS 2010.

49. For example, Jacobs 1 concludes:

> "*While it is possible to estimate the secular subsidence (long-term) and estimate with less certainty the SSE rate; it is not possible to estimate the displacement of future earthquake events, and therefore is difficult to incorporate into long-term projections of RSLR.*"

50. The difficulty is that Jacobs 1 does not attempt to estimate the SSE rate even though they are predictable and have a significant impact on VLM and consequently, RSLR. In my view, this should be addressed before the RSLR projections can be used to predict the likely inland extent of coastal erosion and inundation over various time frames.

[20] Wallace, L. M. (2020). Slow slip events in New Zealand. Annual Review of Earth and Planetary Sciences, 48, 175-203.

51. Denys et al 2020[21] concluded that:

> "*Because there is clear nonlinearity in the VLM history at Wellington, and because this cannot be reliably documented prior to 1997, we can only determine the cumulative effect of the SSEs as indicative of the long-term trend.*"

In my opinion, this long-term uplifting trend needs to be identified and included in RSLR projections so that the *most likely* trend can be projected.

EARTHQUAKES

Jacobs 1 states in regards to the vertical land movement (VLM):

> "*The recent analysis from Bell et al (2018) concludes that it is difficult to provide a definitive long-term trend of VLM for any site in the Wellington region. This is largely due to the effects of, and ongoing influences on, crustal movement of the recent earthquake events since 2013, and that the complex deformation pattern in the region is likely to remain in the future. There is no reason to expect that the regional long-term trend of subsidence being driven by the Australian-Pacific Plate subduction is going to stop, and this is therefore included in the resulting RSLR projects in Section 3.4*"

52. As a clarification, the final sentence "*There is no reason to expect that the regional long-term trend of subsidence being driven by the Australian-Pacific Plate subduction is going to stop,* "is not from Bell et al 2018. Instead, Bell et al 2018 make clear that subsidence has been balanced by uplift.

53. The actual long-term trend is one of uplift. This is not controversial. Beaven and Litchfield 2012 cite studies examining the long-term VLM applying to New Zealand using 125,000-year markers. They all find the long-term trend is for New Zealand to be rising out of the sea.[22] Figure 3 from Beaven and Litchfield 2012 shows this trend with the Kapiti coast rising at 0.1 mm/yr.

54. Other studies[23] show that Wellington, and its surrounds, have an uplifting trend: up to 8 metres in Miramar over the last few thousand years and uplift from faults offshore along the Kapiti-Manawatu coast faults providing uplift (Nodder et al., 2007).[24] Bell and Hannah 2012 reported that there has been long-term tectonic uplift west of the Ohariu fault over the Holocene, citing a parallel study, Gibb, 2012.[25]

55. Numerous such studies, as recent as Ninis et al, in the January 2022 issue of the New Zealand Journal of Geology and Geophysics, have deduced net uplift over 200,000 years in the greater Wellington area.[26] It is unlikely that this trend would reverse, given the well-documented tectonic behaviour of this section of the plate boundary.

56. Jacobs 1's comment was presumably about the comparatively short-term data set provided by GNSS (10 – 20 years) that shows a subsiding trend during the 'inter-seismic' phase of the seismic

[21] Denys et al 2020, page 16.
[22] Pilans, 1986, 1990; Berryman and Hull, 2003; Berryman et al 2000; Litchfield, 2008.
[23] E.g. Pilans et al 1995 "*Interpreting coseismic deformation using Holocene coastal deposits, Wellington, New Zealand*" where Miramar and its surrounds was shown to have lifted by 8 metres over the last 6,500 years.
[24] Nodder, S.D., Lamarche, G., Proust, J--‐N., and Stirling, M., 2007. Characterizing earthquake recurrence parameters for offshore faults in the low--‐strain, compressional Kapiti--‐Manawatu Fault System, New Zealand. Journal of Geophysical Research: Solid Earth 112(B12): B12102.
[25] Gibb JG. 2012. Local relative Holocene sea-level changes for the Porirua Harbour area, greater Wellington region. Kerikeri: Coastal Management Consultancy Ltd. Report No.: C.R.2012/1.
[26] Ninis et al, 2022. "Pleistocene marine terraces of the Wellington south coast – their distribution across multiple active faults at the southern Hikurangi subduction margin, Aotearoa New Zealand". New Zealand Journal of Geology and Geophysics 65: 242-263.

cycle when the uplifting effects of SSE and co-seismic and post-seismic deformation have been removed. But that trend is frequently punctuated with uplifting episodic events (near and far away earthquakes, such as Seddon, Kaikoura, Christchurch, Napier 1931 and Wellington, 1855) or longer-term slow slip events which rachet the Kapiti coast back from the subducting Pacific plate.

57. The net result over the 'long-term' is uplift and this should properly feature in hazard assessments such as Jacobs 1 and 2.

58. In my opinion, the concluding remarks of Bell et al 2018 that recommend ongoing monitoring and review are worthy of consideration:

> *"the previous recommendation (Bell & Hannah, 2012) to update the analyses of RSLR and VLM a 5-yearly intervals is justified by the findings of this report and should continue at similar intervals with a more rigorous assessment undertaken every 10 years."*

59. MfE's 2017 Coastal Planning Guidance[27] (MfE 2017) cautioned against factoring in future occurrences of earthquake-generated uplift, <u>other than in those areas with a clear geological history of uplift</u>, citing Beaven and Litchfield 2012. The Kapiti Coast has a clear history of uplift which should be factored into coastal planning documents (and which should incorporate the revised National Seismic Hazard Model that was only released by GNS in late 2022).

60. Jacobs 1 has not followed MfE 2017 Guidance and considered the clear trend for uplift affecting the Kapiti Coast and consequently has produced a report on Kapiti Coast VLM that has focused on subsidence across a short period at the expense of the longer-term information that shows uplift over time. This has resulted in an exaggerated trend for sea-level rise going forward and overly conservative scenarios for coastal erosion and coastal inundation.

No Consideration of the Tide Gauges

61. Jacobs 1 relies on a sea-level rise model that has been artificially constructed by piecing together:

   i. the short-term ~10 - ~20-year GNSS VLM estimates (or SeaRise's even shorter 7-year InSar dataset); and

   ii. the global eustatic mean sea level measurements from the comparatively short-term satellite ~30-year data set,

   It ignores the seemingly consistent trends from the four/five long-term tide gauges that account for local effects of VLM, oceanic current changes and impacts of atmospheric weather patterns.

This approach is adding complication and uncertainty to an already complicated and uncertain task.

62. At a minimum, it would seem a missed opportunity not to use the tide gauge record to test the VLM findings from GNSS and InSar and the satellite altimetric data on sea level to ensure they correlate over the historic record. As Denys et al 2020 show, they have not done this.

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[27] MfE Coastal Hazards and Climate Change: Guidance for Local Government, 2017, page 86. https://environment.govt.nz/assets/Publications/Files/coastal-hazards-guide-final.pdf

RCP 8.5 – "Unlikely", "Implausible" under IPCC AR6

63. Jacobs 1 (table 3.2) provides projections using some of the IPCC emissions pathways.[28] The highest emission pathway is known as RCP 8.5 and Jacobs 1 makes projections using its median. There is also a non-IPCC pathway constructed by the MfE known as RCP 8.5H+ which is an even higher emission pathway (83rd percentile of the RCP 8.5 projection i.e. if RCP 8.5 occurs there is a 17% chance RCP 8.5H+ occurs).

64. MfE 2022, now uses shared socio-economic pathways (SSPs) introduced by the IPCC 2021 report. The MfE claim that these "span a wide range of plausible societal and climatic futures and replace the previous representative concentration pathways (RCPs) used in the 2017 guidance."[29]

65. MfE 2022 goes on to refer to SSP5-8.5 as "low confidence" out to 2300 and that it covers: "the upper range of plausible sea-level rise by incorporating an additional ice-sheet instability process."[30]

66. However, the IPCC 2021 report does not deem RCP 8.5's replacement, SSP5-8.5, as 'plausible' and nor does it consider sea-level rise due to ice-sheet instability plausible in the event of *likely* SSPs.

67. IPCC AR6 WG1 scientists have moved to clarify the status of the higher emissions scenarios (called 'SSP3-7.0' and 'SSP5-8.5'), making it clear that they are not likely:

> *"… However, the likelihood of high emission scenarios such as ... SSP5-8.5 is considered low in light of recent developments in the energy sector ..."* [IPCC AR6 WG1 Section 1.6.1.4]
>
> *"… SSP3-7.0 and SSP5-8.5 are explicit 'no-climate-policy' scenarios ... , assuming a carbon price of zero. These future 'baseline' scenarios are hence counterfactuals that include less climate policies compared to 'business-as-usual' scenarios – given that 'business-as-usual' scenarios could be understood to imply a continuation of existing climate policies...."* [IPCC AR6 WG1 Section 1.6.1.4]
>
> *"The high-end scenarios RCP8.5 or SSP5-8.5 have recently been argued to be implausible to unfold … . However, where relevant we show results for SSP5-8.5, for example to enable backwards compatibility with AR5, for comparison between emission-driven and concentration-driven simulations, and because there is greater data availability of daily output for SSP5-8.5."*
> [IPCC AR6 WG1 Section 4.2.2]

68. That RCP8.5 and SSP5-8.5 are no longer deemed plausible in IPCC (2021) is supported by recent literature including Hausfather and Peters (2020a[31]; 2020b[32]), Pielke and Ritchie (2021[33]), and

[28] The IPCC have determined that the rate of sea level rise is linked to human activities and associated emissions that act to warm the surface. The highest value is RCP 8.5 where the '8.5' in RCP 8.5 refers to 8.5 W/m2 with similar convention for the other RCPs.

[29] MfE 2022 page 10.

[30] MfE 2022, page 14.

[31] Hausfather Z, & Peters GP, 2020a. Emissions – the 'business as usual' story is misleading. Nature 577(7792): 618– 620.

[32] Hausfather Z, & Peters GP, 2020b. RCP8.5 is a problematic scenario for near-term emissions. Proceedings of the National Academy of Science 117(45): 27791-27792.

[33] Pielke Jr R, & Ritchie J, 2021. Distorting the view of our climate future: The misuse and abuse of climate pathways and scenarios. Energy Research and Social Science 72: 101890.

Burgess *et al* (2021[34]), none of which are referred to in Jacobs 1. It is also important to note that medium scenarios (RCP4.5, RCP6.0 (discontinued) and SSP2-4.5) are more plausible and consistent with current global policies and emissions. Figure 4 illustrates the "low-likelihood, high impact" storyline that describes SSP5-8.5.

Figure 5: *Figure 4 from IPCC AR6*

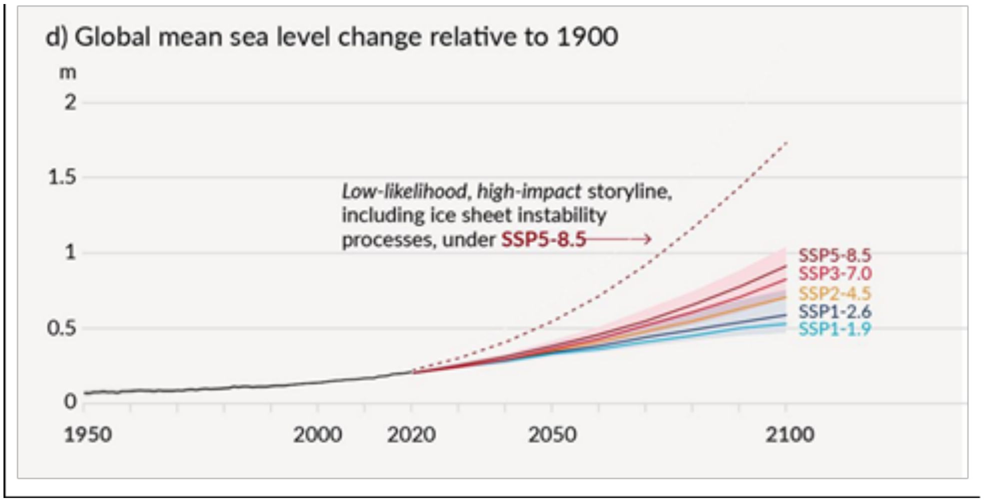

Figure 4: From IPCC AR6 WGI (SPM.8) projected eustatic sea level changes relative to AD 1900 for 5 scenarios (IPCC, 2021). The data for 1950-1992 are from tide gauges, satellite altimetry for 1992-2014, and CMIP6 models from 2014. Data are adjusted upwards to allow for 0.158 m sea level rise from 1900 to the 1995- 2014 baseline used for simulations.

69. Regarding policy, the IPCC concluded that "***High-end scenarios (like RCP8.5) can be very useful to explore high-end risks of climate change but are not typical 'business-as-usual' (BAU) projections and should therefore not be presented as such***."[35] (emphasis added)

70. MfE 2017 advised planners that for Category 'A' development, they should use the RCP 8.5H+ scenario. This has been walked back in the MfE's Interim Guidance (MfE 2022) on the use of new sea level rise projections assuming a Dynamic Adaptive Planning Process (DAPP)[36] strategy is available. It states:

> "*Use the five updated "medium confidence" scenarios out to 2150 to undertake risk and vulnerability assessments and stress-test proposals, strategies, project designs, policies, rules, statutory coastal hazard overlays, and emerging spatial plans.*"

71. MfE 2017 suggests the exact scenario chosen to apply to a district plan is at the discretion of the Council, based on what it considers (based on expert advice) to be the "*most likely*" scenario and how the DAPP strategy may operate in the event new information arises.

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https://www.sciencedirect.com/science/article/abs/pii/S2214629620304655

[34] Burgess MG, Ritchie J, Shapland J, & Pielke Jr R, 2021. IPSS baseline scenarios have over-projected emissions and economic growth. Environmental Research Letters 16: 014016. https://iopscience.iop.org/article/10.1088/1748-9326/abcdd2

[35] IPCC AR6 WGIII Chapter 3, FAQ 3.3, page 386.

[36] The Dynamic Adaptive Policy Pathways (DAPP) approach develops a series of actions over time (pathways). It is based on the idea of making decisions as conditions change, before severe damage occurs, and as existing policies and decisions prove no longer fit for purpose. Source: Auckland City Council.

72. Jacobs 1 does not reference a DAPP strategy as either in existence or as a recommendation for one to be developed. A DAPP strategy is likely to provide alternative options to the recommendations provided in Jacobs 2.

73. However, in any event, the requirements for any coastal hazard assessment are set out in Policy 24 of the NZ Coastal Policy Statement 2010, and that makes it clear that for any advice such as MfE 2017 to be taken into account in assessing hazards it must address the "likely effects" of climate change. Using high-end scenarios does not.

74. About ice-sheet instability, Jacobs 2 continues:

> "Dr R*ob Bell (pers com Nov 2021), has indicated that there is no plan to drop RCP8.5 (or SSP5-8.5 equivalent) scenarios from the updated New Zealand SLR projections to be released in mid-2022 as this scenario and RCP8.5H+ represents the runaway polar ice sheet instabilities, which are now accepted as having a tipping point somewhere approaching a 2° C rise in temperature since the pre-Industrial era. It is noted that for RCP8.5 sea level rise scenario, this temperature rise is predicted by IPCC AR6 (2021) to occur around 2050 under a mid-range SSP2-4.5 scenario.*"

75. Dr Bell's comments on *'runaway polar ice sheet instabilities'* are repeated in MFE 2022, which is consistent with Dr Bell's co-authorship of that document. MfE 2022 cite Schellnhuber et al 2016[37] in support of this claim.

76. A careful read of that paper, and figure 1 that addresses "Tipping elements", discloses that the biggest ice sheet, the East Antarctic ice sheet, is not included in the ~2°C tipping point and most of the Western Antarctic ice sheet survives well beyond the Paris range of 2°C. In this paper, a 'tipping point' does not mean 'irreversibility' so a different definition to that of the IPCC is used. Accordingly, caution should be exercised when considering its projections in the context of IPCC recommendations.

77. The paper is not cited by the IPCC in its AR6 2021. Instead, the IPCC notes that projections up to 2050 are similar irrespective of scenario.[38] Chapter 9 (Oceans and Cryosphere) regarding 2050 warming, RCP 8.5 and ice sheet instability, states:

> "*GMSL [global mean sea level] will rise by 2050 between 0.18 [0.15 to 0.23, likely range] m (SSP1-1.9) and 0.23 [0.20 to 0.29, likely range] m (SSP5-8.5), and by 2100 between 0.38 [0.28 to 0.55, likely range] m (SSP1-1.9) and 0.77 [0.63 to 1.01, likely range] m (SSP5-8.5). This GMSL rise is primarily caused by thermal expansion and mass loss from glaciers and ice sheets, with minor contributions from changes in land-water storage. These likely range projections do not include those ice-sheet-related processes that are characterized by deep uncertainty. {9.6.3}*"

Table 9.9 of AR6 (page 1302) references the SSP2-4.5 median scenario with a projection of 20 cm of global sea level rise by 2050 – there is no mention of "*runaway polar ice sheet instabilities*" or "*tipping points*."

78. The IPCC AR6 examined the potential for ice-sheet instability. The MfE (2022) (and Dr Bell) found "*the prospect of runaway polar-ice sheet instabilities and very long response time-lags (multi-decadal to centuries) in sea-level rise.* But the IPCC conclusions were equivocal due to the many uncertainties.

[37] Schellnhuber, H., Rahmstorf, S. & Winkelmann, R. Why the right climate target was agreed in Paris. Nature Climate Change 6, 649–653 (2016). https://doi.org/10.1038/nclimate3013 Why the right climate target was agreed in Paris | Nature Climate Change

[38] IPCC AR6, Section 9.6.3.3.

Its Summary for Policy Makers says:

> "*There is limited evidence for low-likelihood, high-impact outcomes (resulting from ice-sheet instability processes characterized by deep uncertainty and in some cases involving tipping points) that would strongly increase ice loss from the Antarctic Ice Sheet for centuries under high GHG emissions scenarios.*" [39]

The IPCC clarify (footnote 34) that "*Low-likelihood, high-impact outcomes are those whose probability of occurrence is low or not well known (as in the context of deep uncertainty) but whose potential impacts on society and ecosystems could be high.*"

And in the main text:

> "*The largest uncertainties in future sea level and cryosphere change are related to the Greenland and Antarctic ice sheets (Sections 9.4.1.3, 9.4.1.4, 9.4.2.5 and 9.4.2.6). While the ISMIP6 and LARMIP-2 protocols provide simulations permitting uncertainty estimation and probabilistic inferences, remaining deep uncertainty relates to ice-sheet processes and the atmospheric and oceanic conditions simulated by CMIP models in polar regions (Sections 9.4.2.3 and 9.4.2.4). ISMIP6 and LARMIP-2 have not been simulated beyond 2100, which greatly reduces the amount and variety of state-of-the-art projections available to make ice-sheet and sea level projections beyond 2150. After 2150, limited agreement causes us to* consider all projections as low confidence. Critically, the uncertainty in ice-sheet projections is the leading uncertainty in projections of future global sea level for the second half of this century and beyond (Section 9.6.3)."[40]

79. In short, there is low confidence and a high level of uncertainty surrounding the instability of the Antarctic ice sheet, and in the NZ context, these can be put aside because they rely upon the SSP5-8.5 scenario that is regarded as not likely/implausible. The IPCC does not dismiss the possibility that sea levels might be dramatically affected by Antarctic ice-sheet instability – of course, they can - but there is no suggestion of a ' runaway polar ice-sheet ' instability that has a tipping point somewhere around the 2°C increase in 2050. Accordingly, in my view, MfE has not used the best available data to support its guideline.

80. The world is likely to see more serious emissions mitigation efforts in the future, and so the likely future pathways will be below the current 'business-as-usual'. Thus, adaptation planning should in my view, consider SSP2-4.5 as the upper limit of what is *likely*. While higher scenarios are not impossible, they are very far from being likely, and in my opinion, should not be central to adaptation planning. In my view, based on IPCC AR6 WG1, the high end of the "likely effects" of climate change would be best represented by projections based on the SSP2-4.5 scenarios.

The Ministry for the Environment's July 2022 Interim guidance on the use of new sea-level rise projection (MfE 2022)

81. MfE 2022 was prompted by new data coming out of the "SeaRise" project team with whom I have corresponded in my capacity as a Wellington City Councillor with thousands of affected coastal constituents, since their findings were broadcast on national television on 1 May 2022. The Interim Guidance (MfE 2022) was fast-tracked into policy with minimal consultation or

[39] IPCC AR6 WG1 Summary for Policy Makers, B.5.2.

[40] IPCC AR6, Section 9.7, page

enquiry.

82. In summary:

(i) the results have not passed the peer review yet. It was submitted in July 2022 and is still in the peer review process.

(ii) It uses a short-term data set, between 2003 - 2011 (7 years) chosen for its 'inter-seismic' (and therefore subsiding) nature, and extrapolates the subsiding trend forward by decades and centuries to find enhanced but unrealistic RSLR. Like Jacobs 1, it ignores uplifting slow-slip-events and other uplifting trends that have caused Kapiti to rise out of the sea over the long term. There are acknowledged problems with the collection of the (descending) satellite data which means parts of the New Zealand coastline have been obscured from the line-of-sight radar.

(iii) As with MfE 2017, it continues to use the unlikely RCP8.5-based scenarios targeting areas "potentially affected" (MfE 2022 p. 13), basing this on a misreading of Policy 24 of NZCPS. Areas potentially affected are still assessed taking into account "the best information on the **likely** effects of climate change" (emphasis added). RCP8.5-based scenarios do not provide this.

(iv) Like GNSS, the InSar satellites measure VLM 'near' the coast but not at the coast. Instead, it takes a 5 km average of earth movement. Due to data collection issues, the team had to source data as far away as 40 km from the coast.

(v) CRU's 2013 adviser, Dr Willem De Lange (Waikato University) and former Christchurch City Council coastal planner, Dr Ian Wright and Tonkin+Taylor expert, Richard Reinen-Hamill[41], have all expressed concern with elements of the SeaRise model. Other leading scientists, including those from GNS and Canterbury University, have done so directly to me privately.

(vi) At the Geoscience Society's 2022 conference's 'poster' session Victoria University's Professor Tim Stern (a SeaRise project team member) and Professor Simon Lamb with Otago University's, Professor Paul Denys, presented their findings on the benefits of utilising tide gauges for coastal planning[42] noting that the short-term GNSS/InSar satellite data sets may have significant variances to long-term trends.

(vii) Documents disclosed under the Official Information Act show that:

a. The SeaRise results were destined to be published and implemented into policy irrespective of whether the findings had passed peer review and publication;

b. Dr Laura Wallace, New Zealand's foremost expert on slow slip events, described how experts in the geoscience community had reached out to her expressing concerns she had previously relayed and that the SeaRise model had "major holes" that would need to be addressed;[43]

[41] See https://www.tonkintaylor.co.nz/news/2022/5/nz-searise-through-an-alternative-lens/ last visited 21 February 2023

[42] See Stern et al 2022, "Do tide gauge records from New Zealand provide a reliable picture of relative sea level change over the past 100 years?" GSNZ 2022 Conference poster session 2b Abstracts available at https://az659834.vo.msecnd.net/eventsairseasiaprod/production-confer-public/7ce4a83973de4441a7e6e92be3f8ebce

[43] Email exchange Wallace – Naish/Levy September 2022 sourced via the OIA.

(viii) I have requested official information from Victoria University seeking the dissenting opinions of scientists involved in the peer review process but have been declined. A complaint has been made to the Ombudsman;

(ix) Recent exchanges[44] between myself and Professor Tim Naish, the SeaRise Project Lead, confirm that the team are taking many of the points I have made on board and they will be addressed in the published manuscript once it passes the peer review. There was no discussion about how MfE 2022 might be amended;

(x) Questions associated with this work and MfE 2022 have been raised by me with MfE but without substantive response.

(xi) The 'interim' guidance (MfE 2022) is due to be finalized in 2023 when many of the issues raised can be addressed. In the meanwhile, in my opinion, MfE 2022 is unsafe to use for policy making.

Response to the Evidence of Derek Todd

83. Many of the matters I would address in response to Mr Todd's Statement of Evidence ("SoE") have been addressed previously but I would make the following comments:

Purpose and Method – Paragraphs 8 - 27

84. The Purpose of the Jacobs 1 and 2 reports and the intended use of Assessment Results (paragraphs 8 – 12 of the SoE) seems to have been undermined by an overly cautious interpretation of the NZCPS (2010), MfE 2017 and guided by government planning documents prepared by NIWA (e.g. Bell et al (2018)) as 'client reports' for MfE and regional or city councils, rather than peer-reviewed publications that are published in respected international scientific journals.

85. We know that the ground beneath Kapiti is not subsiding at the rates described by the GNSS sites (or the SeaRise team). Tide gauges nearby show this and the science on SSEs from Wallace 2020 etc explains why. Further, 80% of the coastline is accreting and there is no evidence of that trend reversing. IPCC 2021 has said that the most intensive emission profile, RCP 8.5, is not 'plausible.'

86. I do not understand why Mr Todd is maintaining that RCP 8.5 should be modelled to determine the sea-level component for "Coastal Erosion Distance" (paragraph 22) with the result that the "very unlikely scenario" (the 'P10') is proposed to determine the CQMP (paragraph 25. b)) in contravention to the "most likely" approach required under the RMA?

87. I note that NZCPS (2010) Policy 24 has been partially reproduced in Mr Todd's SoE. It is missing the qualifying language designed to allow planners to adopt some common sense and broaden their analysis.

88. The missing words are the phrase in the first sentence of Policy 24:

[44] Email exchange Rush – Naish Feb/March 2023.

"*giving priority to the identification of areas at* *__high risk__* *of being affected*"

and the final sentence:

"*taking into account national guidance and the best available information on the* *__likely__* *effects of climate change on the region or district.*"

89. More recently the latest available information on VLM documents the ameliorating effects of slow slip events (SSEs) that are ongoing, recurring and likely to have prevailed before the GNSS sites were installed and across the long-term tide gauge record.

90. The SoE (paragraph 20) ignores two of three of the GNSS sites located on the Kapiti Coast that show significant uplift over the last 10 years. Rather it reports from three sites "along or close to" the Kapiti Coast i.e. "close to" are: Te Papa at Wellington and Wellington Airport which is at least two major fault systems away, with many other unknown faults in-between, and is entirely irrelevant to the Kapiti Coast. Whereas sea level is ubiquitous so I am surprised there was no consideration of the tide gauge data.

91. Furthermore, the one GNSS site described as "along" the Kapiti coast is located at Paekākāriki Hill, several kms from the coast and well above sea level which, given the millimetre precision we expect in this exercise, calls into question how the land beneath the coast at Paekākāriki beach is behaving compared to the bedrock beneath Paekākāriki Hill.

92. In my view, more consideration should have been given to the ameliorating effects of SSEs that have shown to have some predictability, the long-term uplifting trend in Kapiti, the accretion trend despite decades of anthropogenic global warming and what the New Zealand tide gauges say over the longer term.

93. In summary, in my opinion, Mr Todd's approach has been overly cautious:

   i. It did not involve the latest science relating to the likelihood of RCP 8.5,

   ii. It omitted reference to the leading New Zealand sea-level study (Denys et al 2020) that used tide gauges to evaluate sea level rise in New Zealand;

   iii. It omits the latest science (Wallace 2020) showing uplifting ground movement that slows the rate of sea-level rise along the Kapiti Coast.

Peer Review Process (paragraph 28)

94. As an initial concern, both reviews pre-date:

   (i) the release of IPCC AR6 and so neither had the benefit of assessing RCP 8.5 in the light of comments describing that scenario as 'implausible'; and

   (ii) MfE 2022,

and lose considerable utility as a consequence.

95. Both reviewers have confirmed Jacobs 1 is in line with various planning documents but, with due respect, neither has considered whether such planning documents, strictly (and conservatively) applied as they have in Jacobs 1, will achieve its stated purpose which is to: "*update previous coastal hazard assessments …along … the shoreline involving the identification of areas susceptible to current and future*

coastal erosion and inundation hazards…."[45]

96. Identification of unrealistic hazards based on unlikely scenarios is not within the stated purpose.

97. With respect, neither reviewer has considered matters outside the various planning documents that are important to achieving the stated purpose, such as:

(i) Do SSE's and other longer-term uplifting events mean the hazard assessment is overstated?

(ii) Whilst modelling RCP 8.5 and RCP 8.5H+ is appropriate, is its adoption to determine the CQMP as the most likely scenario consistent with the IPPC analysis and the description in Mr Todd's SoE that it is a 'very unlikely' scenario?

(iii) Do the projections for RSLR square with the trends observed from the tide gauge measurements?

98. Neither reviewer picked up the error of mixing up net subsidence with gross subsidence that Jacobs 1 referred to or that a long-term trend of subsidence prevails when it is well established that uplift has prevailed in the long term.

99. Neither thought that ameliorating effects of SSEs, or the steady rise of sea level observed by the regional tide gauges, nor the latest scientific publications by the likes of Denys et al 2020 and Wallace 2020, were omissions. And yet each is an important aspect of the 'latest' information on the likely effects of climate change on the region (per NZCPS Policy 24).

Overall, it seems the reviewers took the same approach as the authors of Jacobs 1.

Conclusions

100. In conclusion Jacobs 1:

(i) applies the various planning documents, conservatively, to achieve its purposes i.e. for present purposes, the inland extent of the coastal erosion line does not in my view represent what is likely during the planning horizon.

(ii) adopts RCP 8.5 and RCP 8.5H+ as its baseline for the spatial extent of the CQMP whereas such scenarios are regarded as no longer 'plausible'.

(iii) assumes a need to assume Antarctic ice sheet instability when that is not likely over planning horizons;

(iv) does not take account of more recent science about sea level and the known events of recurring land uplift on the Kapiti Coast that reduce the rate of sea-level rise and defer the projected sea-level rise and consequent coastal erosion and potential inundation;

(v) has used novel satellite data, with comparatively short-term measurements, that are not designed to measure either sea-level rise, or vertical land movement, at the shoreline;

[45] Section 1.1 Jacobs 1.

(vi) has ignored the tide gauge data in its forecast which is a tool designed to measure the sea-level rise and vertical land movement at the shoreline.

101. In my opinion, considerably more observational analysis, peer review and updates for the latest science are required before Kapiti Coast District Council (and this Panel) is in a position to propose hazard location lines such as those used to generate the CQMPs.