SUMMARY: JACOBS' RESPONSE TO CRU REVIEW AND NEXT STEPS

Introduction

The primary purpose of the Jacobs' work is stated to be to assess the nature and extent of coastal hazards now and in the future facing the Kāpiti Coast District considering various coastal processes including sea level rise.

It is intended for use in guiding community adaptation planning to address the hazards.

CRU notes that there is a distinction between hazard risk assessment (NZCPS Policy 24) and hazard risk management (NZCPS Policy 25 and 27), and different considerations apply.

The information provided by Jacobs is estimated areas potentially vulnerable to hazards, assuming a range of SLRs and dates. These combinations are chosen to reflect the wide range used in the literature[1]. CRU notes most of these SLR and date combinations would be regarded as not likely by IPCC (2021).

Strictly speaking, Jacobs gives no assessment or advice on if, when, and by how much the sea level component might arise[2], and any link back to the scenarios that might produce the selected combinations is put aside.

However, since timing and likelihood are central to assessing the impact of progressively unfolding events, CRU considers the Jacobs' assessment of vulnerability will have little to no value in a Policy 24 hazard risk assessment.

As we understand it Jacobs sees their assessments as fulfilling the role of being the first step to identifying trigger points in an adaptive planning process, i.e. part of a Policy 25 and 27 hazard management process. We return to the limitations CRU sees in their use in adaptive planning when we discuss Trigger Points below.

Therefore it is unclear how Jacobs perceives the usefulness (or relevance) of this output (i.e. a vulnerability assessment) in NZ/planning law/practice in each of these situations, and it would be useful to have Jacobs clarify its scope and describe how this might work.

However, it is useful first to clarify other issues before addressing this.

1. Conservative Approach

Jacobs acknowledges a degree of conservativeness, but states these are only small part of assessment, and, in many respects, there is no alternative data. Having said that there is acknowledgement that aspects of *Coastal Inlet Migration*, *The Bathtub model*, *Extreme Sea Level*,

[1] Jacobs have chosen RCP2.6 and RCP8.5H+ as the two primary scenarios to be used based on extremes derived from MfE (2017). It is not indicated whether this selection was made on their own advice or was specified by KCDC.

[2] Jacobs' however state "all of the predicted beach responses in the short to medium timeframes (i.e. 2050, 2070) will most likely occur at some time within a 100 year timeframe".

and *Groundwater levels* are not suitable for use in any hazard risk assessment. (See later for comments on related issues around the Bruun rule.)

Notwithstanding this acknowledgement, stating the results are conservative is not a sufficient response particularly in a report intended for use by a non-technical community panel, residents, and local government. As advised by the NZ Parliamentary Commissioner for the Environment (2015), the purpose of technical analyst is to elucidate the uncertainty rather than embed it[3].

The members of such a panel are not likely to understand what is meant by 'conservative' nor that a bias might have arisen from these choices. Even technical readers will have difficulty understanding how these assumptions propagate through into the variability in the final estimates[4]. Jacobs can, of course, give such guidance orally to the panel when presenting the findings, but in the interests of transparency and community confidence it would be far preferable to include it in the formal report.

CRU also note there is no apparent use of non-conservative methods or estimates which might have gone some way to test or offset the conservative bias, or even to give a sense of the magnitude of the bias.

2. Relationship between Global MSL and Local MSL

The first two bullet points in Jacobs' response (page 5) are the result of a misunderstanding. CRU simply observed that everything in their analysis starts with GMSLR, even if for their purposes Jacobs start with MfE projections that adjust GMSLR to the NZ region. Local (Kāpiti) RSLR is estimated from that.

The central question is whether Jacobs' assumption of a 1-3mm/yr for the Kāpiti Coast adjustment remains reasonable. We have now discussed with Denys and would repeat two points:

- As we previously noted *"The breakpoint analysis used in Bell et al. (2012) is not particularly sophisticated in the face of known regime changes whether natural (IPO, ENSO) or man-made (measurement techniques)."* e.g. Denys et al (2020) explicitly discusses the issue

[3] Excerpt from PCE (2015) "Preparing New Zealand for rising seas: Certainty and Uncertainty":

"Also needed is a clear distinction between the role of technical analysts who undertake coastal risk assessments and the role of the decision-makers who sit around council tables.

"Because current government policy on sea level rise emphasises the need to take a 'precautionary approach', technical analysts have been embedding 'precaution' into coastal risk assessments to varying degrees. This takes various forms such as assuming 'high end' amounts of sea level rise.

"But undertaking a coastal risk assessment is very different from designing a building or a bridge where redundancy and safety factors are intrinsic to the design. Technical assessments of coastal risk should be based on best estimates of all the parameters and assumptions that are fed into the modelling. Decision-makers should then take the modelling outputs including estimates of uncertainty, and then openly and transparently decide how cautious to be in delineating hazard zones"

[4] Carley et al (2014) "Coastal Erosion Hazard Assessment for the Kāpiti Coast: Review of the Science and Assessments Undertaken for the Proposed Kāpiti Coast District Plan 2012" notes "best estimates" rather than precautionary values be adopted, with margins of error or factors of safety kept separate from the estimates and added at the end if appropriate."

"However, the IPO index over the period 1990–2013 does show a substantial trend, which may affect the New Zealand sea levels and could result in the apparent increase in trends."

- The issue of the extent to which Slow Slip Events are predictable on the Kāpiti Coast, and the magnitude of adjustment. Bell et a. (2012) has Paekakariki SSE over 20 years (41mm) i.e. ~2mm/yr, and Kāpiti over 10 years 4.6mm/yr. This suggests a lower predictable vertical displacement of 1-1.5mm/yr

The effect of the first bullet point isn't quantified, and this and the latter point should be addressed.

3. Trigger Points

This has been addressed in the Introduction, and we reiterate that trigger points are relevant to hazard risk management not, hazard risk assessment under the RMA/NZCPS.

Even then it seems unlikely that the Report as it stands will be of much use in helping the community identify trigger points for any realistic adaptive approach, but CRU would like to have this further explained. Our concern is as follows:

In the second bullet point of Jacobs' response in the Trigger Points section, there is the comment "for assessment purposes, particularly for erosion impacts (due to be dependent [sic] on changes in rate of RSLR), a fixed date is required...".

We consider this to be exactly the wrong way around. Trigger points relating to SLR must be expressed in terms of the amount of SLR, (or the corresponding amount of erosion etc). What is uncertain is not that if a specified amount of SLR (say 50cm) might possibly occur in the next 100 years, but when it will occur. That defines the trigger for management action for the land impacted.

For the sort of planning exercise that the community is engaged in it is much more useful to express it in the form "SL will eventually be 50cm higher than at present; that point is expected to occur no sooner than 2055, and possibly as late as 2110, desirably with a probability distribution, and with consequences to be detailed later". Similar date ranges can be given for 1m SLR or other relevant levels.

Thus, not only is it incorrect that a fixed date is required for assessment, we contend that the fixed date is actively unhelpful for defining trigger points.

Further, CRU would add that the IPCC is now explicitly expressing a view on the likelihood and plausibility of the assumptions that go into their GSLR projections (see below). Therefore, the case for needing to cover the unlikely extremes (particularly on the high side where the risks lie) in developing trigger points no longer exists.

For this reason, CRU considers a probabilistic assessment based on SSP2-RCP4.5 and incorporating the IPCC modelling uncertainty is essential to support both hazard risk assessment (technical analysis in the words of the PCE) and adaptive planning (risk management undertaken by decision-makers, including property owners).

4. Use of RCP8.5+ and de facto Adoption of RCP 8.5 for Sea-Level Rise (SLR)

Jacobs defends their use of the extreme scenarios on four grounds:

1. MfE (2017) guidance is mandated by the NZCPS Policy 24, and it says no "most likely" scenario of climate futures can be determined. Further, no update has been issued to this guidance. It also suggests IPCC AR6 WG1 still shares this view, notwithstanding the statements to the contrary cited by CRU.
2. (a) The outcomes from RCP 8.5 or SSP5-8.5 could be derived from lower emissions models; (b) the IPCC states it has medium confidence in the processes producing SLR; (c) there is little difference between scenarios up to 2050; and (d) the extreme projections are consistent with those produced by a simple model fit to the satellite era measurements.
3. RCP8.5+ is legitimate for stress testing (MfE (2017).
4. In any event the RSLRs used by Jacobs cover all possibilities that could be generated by the IPCC scenarios. If CRU wanted RCP4.5 this could come out of the process.

In response CRU would note:

1. NZCPS Policy 24 does not exclusively mandate any specific sources[5]. MfE (2017) explicitly relies on IPCC (2014) and (as documented by CRU) IPCC (2019) and IPCC (2021) explicitly challenge some of the key assumptions made in MfE (2017). A Court will take this into account as modifying MfE (2017), just as Jacobs modifies MfE (2017) GSLR projections in light of IPCC (2019)[6]. A Court will do this independently of any update having been issued.

   On the Jacobs' suggestion that IPCC (2021) shares the view "*no likelihood is attached to the scenarios*" Jacobs relies upon a partial quote leaving out important qualifiers[7], i.e. "*In general, no likelihood is attached to the scenarios assessed in this Report … . However, the likelihood of high emission scenarios such as RCP8.5 or SSP5-8.5 is considered low …*" [emphasis added].;

2. (a) While GCMs forced with lower emission scenarios can produce SLRs at RCP8.5 levels, the IPCC assigns increasingly lower likelihoods to them. Using SSP2-RCP4.5 with the IPCC distributions would include these outcomes, assigning them an appropriate probability; (b) medium confidence in the process of projecting does not imply confidence in the likelihood of the assumptions; (c) the hazard assessment needs to be robust through to 2120, not just 2050[8]; and (d) having a projection fit to an extrapolation of a simple linear model of a complex system does not of itself make the projection any more likely.

[5] In particular MfE (2017) has no independent status in legislation in respect of its application here.
[6] PCE (2015) notes "The first step in such assessments is to use the most recent Intergovernmental Panel on Climate Change (IPCC) projections as the best guide available of future rates of sea level rise".
[7] Jacobs in their response also incorrectly attribute this view to CRU. CRU does not make this statement but does quote the IPCC (2021), including the qualifiers.
[8] In fact, Table 3.1 in Jacobs has RCP8.5H+ already 70% higher than RCP4.5 median by 2050.

3. The upper limits of SSP2-RCP4.5 (i.e., approx. RCP8.5 median) would be better as a stress test as at least the assumptions on which it is built would be "plausible" to use IPCC (2021)'s term.

4. As noted in the Introduction, covering all bases is of limited use if most are not likely.

5. Treatment of Vertical Ground-Level Movement

CRU's earlier comments were based on the understanding that each of the selected SLR/timeframes were to account for the uncertainty in local effects.

From Jacobs' response, it is now clear that these selections are only loosely related to their physical drivers. In light of this any particular choice is basically arbitrary as long as it is documented.

6. Treatment of Accretion When it Outpaces SLR.

Jacobs' response clarifies our concern, and we note that this means that most of the Kāpiti Coast properties north of the Paraparaumu Boating Club will show no vulnerability to coastal hazards.

7. Use of Bruun Rule and Lack of Validation

Jacobs acknowledge the limitations in the Bruun rule[9]. Jacobs defends its use in this context on the following bases:

1. It is widely used in NZ, and has been accepted by the Environment Court;
2. In terms of addressing the known limitations (a) adjustments were made for increasing backshore elevations where indicated; (b) time to reach equilibrium would be accommodated by adaptive planning; and (c) ongoing accretion and erosion are accommodated by projecting forward the historic shoreline movement, and this method is the same as methods that might remove the estimated RSLR changes from the historic record.
3. In any event without direct measurement of sediment changes Jacobs considers alternatives need better data than what is available and cannot see how the available record might be used in validating the projections.

CRU acknowledges that Bruun has been widely used, although the references cited are all around a decade old. Alternative methods have increasingly been explored since then.

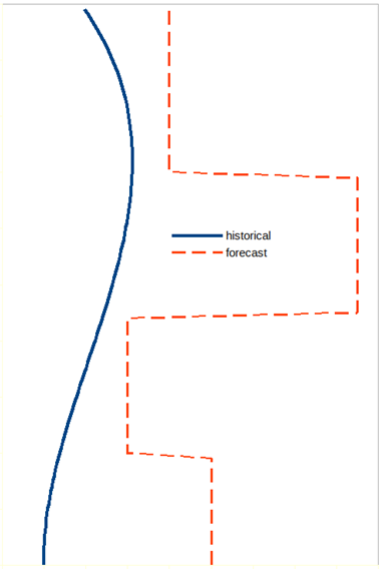
Further the two Environment Court judgements that CRU has located that reference the use of the Rule are dated before the NZCPS 2010:

[9] See e.g. Anderson et al "Doubling of coastal erosion under rising sea level by mid-century in Hawaii" (2015) that notes: "On its own, the Bruun model is virtually unusable in open-ocean coastal environments due to the theory's limiting assumptions of physical setting (constant longshore transport, no sediment sources or sinks)" and "Even with terms representing the sediment budget, the Bruun model remains controversial."

- Skinner v Tauranga District Council (A 163/2002)[10] in part turned on whether the beach was a closed system justifying the use of Bruun. In the event the Court determined it was, accepting the use of Bruun. Had it not been a closed system the Bruun rule was clearly at risk in the Court's mind.
- Fore World Developments Ltd v Napier City Council (W 029/2006)[11] addressed whether Bruun could be used on a gravel beach and determined its underlying assumption was reasonable for "our purposes". No evidence was given on open and closed systems.

CRU notes the steps taken by Jacobs to address backshore elevations; the recognition given to the need to reach equilibrium, and the steps taken to address the issues with Bruun that come with longshore transport.

In respect of the last, using a linear model to fit past shorelines at transects and projecting these forward as a surrogate for longshore transport assumes there is no interaction between it and beach profile. This is not likely, particularly for the more critical erosion case. Further, as CRU has noted, adjacent transects contain useful information on longshore transport, as does the historic SLR.



This schematic of the beach position in a section of coastline (landward to the right) illustrates the point: if the differences in forecast coastlines from one sector of beach to the next were as large as illustrated here, one could have very little confidence in the forecast. The differences between adjacent sectors contain important information about certain kinds of errors (not all) in the modelling.

The simple Jacobs approach ignores this information. Thus, if Jacobs' purpose was to model the historic longshore transport to support the use of Bruun for the projections, there are better approaches to use. These can be done with the information to hand.

What Jacobs has done (project forward the historic shoreline) could be seen as a rough approximation of longshore transport but confounded by historic SLR. This is not what CRU is suggesting.

CRU accepts that high quality probabilistic models of the shoreline need better information than is available[12,13]. But notwithstanding the potential model error using e.g., Bruun versus

[10] http://www.nzlii.org/cgi-bin/sinodisp/nz/cases/NZEnvC/2002/288.html?query=163/02
[11] http://www.nzlii.org/cgi-bin/sinodisp/nz/cases/NZEnvC/2006/120.html?query=029/06
[12] By the same token the lack of better information also means the Bruun approach is equally limited.
[13] The suggestion of getting some robust sediment budget experiments started was made to the KCDC a decade ago. This would be difficult to do, but without the data everyone is going to struggle with getting any coastline predictions correct, particularly in the critical eroding areas.

probabilistic can be large[14], and this behoves the use of whatever information is available to validate the results from the preferred approach.

CRU would therefore expect a hindcast using the Bruun model, and the use of more of the available historic information to produce a non-Bruun based projection by way of validation. The priority would be on the eroding shorelines.

8. Linear Model in Time for Historic Trends

Jacobs notes this is relatively easy but does not see the utility in so doing.

CRU has addressed reasons to do this under the previous section and would summarise as follows: Jacobs have used a method to translate the impact of SLR on to the shoreline relying on a method that has its limitations and is being applied outside its underlying assumptions. This is a source of major uncertainty in its results, some of which CRU has also referred to above.

Under these circumstances CRU would expect some attempt at empirical validation of the methods on the Kāpiti coast (e.g., hindcasting, testing results out of sample) and use of other independent methods to compare their results with. Neither has been attempted.

CRU notes Jacobs do add that the results of their projections will be broken down by contribution from each main driver, and this will assist evaluation.

9. Treatment of Options for Sea Walls

CRU broadly agree with the points Jacobs make in its response, but the issue here was the assignment of likelihoods to the options. This is not addressed.

In light of Jacobs' response CRU would suggest Scenario A be renamed the "do nothing" scenario; Scenario B, has no place in the real world and adds no information over Scenario A and C; and Scenario C be renamed "protect properties" and be amended to include rebuilding if this is practical. That then gives two realistic options to aid management decision making.

10. Uncertainty Distributions and Materiality.

Jacobs have stated these will be reported which is acknowledged.

Conclusion

By way of conclusion CRU would like to work through the issue raised in the Introduction: the need to clarify the exact intended scope of this work, and how it might be applied in practice.

[14] See e.g. Le Cozannet (2019) "Quantifying uncertainties of sandy shoreline change projections as sea level rises" that suggests where that information is available model uncertainty (Bruum vs. PCR) can account for "20 to 40% of the variance of shoreline projections by 2100 and beyond", adding: "This agrees well with previous studies showing that by 2100, the Bruun estimate lies in the range of 4–40% exceedance probability with respect to the corresponding approach based PCR estimates."