Before the Auckland Unitary Plan Independent Hearings Panel

IN THE MATTER OF	The Resource Management Act 1991 and the Local Government (Auckland Transitional Provisions) Act 2010
AND	
IN THE MATTER OF	Topics 016/017 – RUB and Topic 081 – Rezoning and Precincts (Geographical Areas)

SUPPLEMENTARY EVIDENCE OF JAMES DAHM
ON BEHALF OF KARAKA HARBOURSIDE ESTATE LIMITED
(SUBMITTER 3644; FS 2965)

RE PARAREKAU ISLAND

DATED 11 January 2016

INTRODUCTION AND SUMMARY

1. My full name is James Dahm. I am a Coastal Scientist and Director of Eco Nomos Ltd.

2. I have previously provided a statement of evidence on these topics on behalf of Karaka Harbourside Estate Ltd (KHEL) in relation to Pararekau Island addressing coastal erosion hazard. Details of my qualifications and relevant experience are outlined in that earlier evidence-in-chief (EIC) dated 16 November 2015.

3. I recorded in the EIC that I was undertaking further analysis to refine the anticipated coastal erosion rates for the Island. I have now completed that work and this supplementary evidence records the outcome of the analysis. The EIC argued that the coastal recession component of the existing coastal yard (and therefore the coastal yard as a whole) is overly conservative and can safely be reduced by 10 m around the entire coast of the island while still maintaining an appropriate level of precaution. The additional work that I have since carried out supports those conclusions.

SCOPE AND SUMMARY

4. This Supplementary Evidence is structured as follows:

    a) Brief outline of the present coastal hazard setback (i.e. operative coastal yard) – covered in more detail in my earlier EIC

    b) Review of existing erosion and erosion rates.

    c) Consideration of the potential effect of projected sea level rise on existing rates of erosion

    d) Implications for revision of the coastal yard

5. The conclusions of my Supplementary Evidence are that the operative yard can be reduced by 10 m around the entire shoreline while still ensuring a conservative and precautionary approach to coastal erosion hazard.

EXISTING OPERATIVE COASTAL YARD

6. As outlined in my EIC, the existing erosion hazard setback (i.e. the operative coastal yard) has 3 separate components:

   a) An allowance for erosion of the seaward toe of the bank – termed the Foreshore Regression Line (FRL). The FRL assumes long term erosion rates of 30 m per century for the more exposed and eroding north-western coastline and 20 m per century for the sheltered south-eastern shoreline.

   b) Allowance for potential collapse of the near vertical cliffs to a more stable slope – This allowance assumes a potential for these steep banks to collapse to 26° (i.e. a slope of 1V:2H - measured from the 100-year FRL)

   c) An additional safety buffer zone of 5 m – to allow for potential localised collapse to lesser slopes.

7. These 3 separate components are summed to give the total coastal yard which varies with bank height but is commonly 40-50 m wide, except for the sheltered areas of the south-east coast (i.e. east of the causeway) where it is typically 25-30 m wide.

8. This Supplementary Evidence primarily addresses the first of these 3 components – though I also provide very brief comment on the other two components.

EXISTING EROSION AND LONG TERM EROSION RATES

9. Existing erosion and erosion rates were analysed and reviewed using data from:

   a) Detailed field inspections conducted in May 2010 and October 2015

   b) Analysis of shoreline change using ortho-rectified vertical aerial photography from 1939 (SN 139 flown 29 December 1939), 1960 (SN 583 flown 20 August 1960) and 2011 (SN 50900D flown 8 March 2011) (Photos presented in **Appendix A**).

   c) Consideration of the potential effect of projected sea level rise of 1 m on erosion rates.

North-Western Shoreline

10. The north-western shoreline is the more exposed coast (particularly to the WNW and NW) and is subject to active erosion along the full length (see Figures 2 to 8 from my 2010 evidence).

11. Field inspection and aerial photography indicates that the process of erosional retreat typically involves:

    a) Wave erosion of the toe of the bank, leading to undermining and over-steepening of the bank

    b) Bank collapse depositing debris at the toe of the eroding cliffs; which debris can extend seaward of the shoreline and provide temporary protection against ongoing toe erosion.

    c) Wave erosion and removal of the deposited slump debris. The mud component is dispersed in suspension while the sand and coarser components accumulate as an intertidal beach at the base of the bank. This sand undergoes net eastwards longshore movement over time.

    d) Renewal of toe erosion once the eroded debris is removed and/or as the intertidal beach is reduced by net eastwards longshore removal.

12. Rates of erosion were assessed using the historic aerial photography dating from 1939, 1960 and 2011. To improve the accuracy of these measurements, emphasis was placed on using fixed points and features (e.g. fence-lines) common to successive aerial photographs and close to the shoreline. Where practicable, erosional retreat was also measured along the top edge of cliffs rather than the base as periodic collapse of slump debris complicates shoreline change measurements at the base of the cliffs.

13. Shoreline change over the period between 1939 and 2011 was variable along the shoreline, with maximum shoreline changes observed over the 71 year period typically up to 4-5 m (apart from very isolated areas). Lesser changes were observed in most areas but the higher rates have been assumed (for the sake of precaution) to apply as an average along the entire coastline. This is a precautionary assumption but it is likely that areas with lesser erosion in the 1939-2011 period will experience higher rates over time

– as they will become more exposed to erosion as the adjacent areas retreat. Cliff erosion shows considerable spatial and temporal variation and so lengthy periods need to be considered to get a true picture of average rates of retreat in both time and space. In cliff erosion hazard assessment for lengthy planning periods (such as 100 years), the critical factor is the average rate of erosion/recession over long periods of time and not limited areas of higher or lower erosion that may occur over short periods of time.

14. An example of high rates of erosion occurs towards the western end, where active cliffs up to 8-10 m high occur (shown in **Figure 1** – I have also arrowed the centre of the area in the 1939, 1960 and 2011 aerial photography in **Appendix A**). In this area, the 1939 aerial photograph shows grazed pasture extending to a fence-line variously located 1-5 m from the top edge of the cliffs and 6-12 m (most commonly 6-8 m) from the shoreline. By 1960, a dense line of pine trees had been established along the top edge of the cliff. These pines were already a moderate size (typically 10-14 m wide), indicating they were probably planted at least 10-12 years earlier (i.e. prior to 1950). The seaward edge of the pine trees typically extended out over the intertidal beach seaward of the shoreline, indicating the trees were planted relatively close to the top edge of the cliff; probably close to the fence-line evident in the 1939 photo. However, despite this, these pines were mostly still standing at the time of the field inspection in May 2010 - but by this time the trunks were commonly less than 1 m from the top edge of the cliff **(Figure 2)**. At least one tree had however been undermined and toppled down the bank (evident in a very clear 4 April 2009 aerial image on Google Earth – which also shows at least 2 other pine trees beginning to topple).

15. Overall, the top edge of the cliff in this area has retreated by up to 4-6 m between 1939 and the present (October 2015), indicating a time-averaged rate of cliff retreat of 0.05-0.08 m/yr (i.e. 5-8 m/century).

16. Similar (though typically slightly lesser) maximum rates of retreat were also observed in other areas along the north-western shoreline.

17. The time-averaged rates of retreat derived from the analysis of aerial photography are also broadly consistent with upper limit estimates suggested by geomorphic considerations. For example, the distance between the eastern end of Pararekau Island and the opposite Conifer Grove shoreline is in the order of 750-760 m. If it were assumed

that these 2 shorelines were only separated by a narrow tidal channel when current sea level was established (about 7500 years ago – Dahm and Munro, 2002; Clement, 2011) then the time-averaged rate of retreat of both shorelines would be in the order of 0.05 m/yr (i.e. 325-330 m/7500 yrs) or 5 m per century.

18. This is obviously a precautionary assumption and physical evidence suggests the original dimensions of Pararekau Island did not actually extend this far. For instance, shore platforms formed by historic cliff retreat are only visually evident up to 100 m offshore; suggesting time-averaged rates of cliff retreat of 1-1.5 m/century over the last 7500 years. However, shore platforms formed by cliff retreat may be more extensive (e.g. buried under intertidal flat sediments) than visually evident. For instance, the shallow intertidal flats seaward of the shoreline (an indication of the likely maximum extent of any buried shore platform formed from historic cliff retreat) are typically less than 300-350 m wide. If these flats are underlain by a shore platform formed by cliff retreat, this would indicate time averaged erosion rates of up to 0.04-0.045 m/yr (i.e. 4-4.5 m/century) over the last 7500 years; values very consistent with the aerial photograph analysis.

19. The upper end rates of erosion derived from this study are not as high as upper end rates suggested by some previous work. For instance, long term erosion rates of up to 30-40 m per century have been suggested for the Wattle Downs shoreline by some studies (see evidence of Dr Sinclair). I make the following comments in that regard:

    a) Geomorphic considerations indicate that such high average long term erosion at these rates is a physical impossibility. For instance, the total distance between the Wattle Downs shoreline and Pararekau Island is in the range of 1700-1800 m. Accordingly, even if these land masses had been much larger (e.g. only separated by a narrow tidal channel) when present sea level was initially reached (an unlikely assumption) the maximum time-averaged rates of erosion over the last 7500 years would still only have been in the order of 10-12 m per century (i.e. 850-900 m/7500 years). This is less than 25-30% of the high end erosion rates suggested by some previous work.

b) It is difficult to identify the reasons for the over-estimates in previous work but a common cause of such errors is the extrapolation of measured short-term rates of erosion over long periods of time or undue weight on data from a limited length of shoreline. The critical factor for erosion hazard assessment on cliffed coastlines is the <u>average rate of erosion over long periods of time</u> – as short term and spatially-limited rates are highly variable. Ideally, average rates should be based on at least 50-100 years of data. Errors can also arise through the use of unrectified imagery, difficulties with exact mapping of key features (e.g. top or toe of cliff) and many other causes.

20. In summary, measurements of shoreline change from historic imagery spanning 71 years indicate upper end average rates of shoreline erosion of 5-8m per century. Longer term geomorphic data suggests the average rate is probably in the order of 4-5 m per century. However, more detailed investigations would be required to confirm the indications from such data. Accordingly, to ensure precaution, the upper end rate from the aerial photography analysis (i.e. 8 m per century) is adopted in this review. It is probable that more detailed work would reduce this figure to 4-5 m per century or possibly even less.

South-Eastern Shoreline

21. This shoreline is extremely sheltered and subject to only minimal and very low wave energy.

22. Field inspection indicates no evidence of active erosion with the gently sloping shoreline commonly bordered by rushland **(Figure 3)**. Until recent clearance, dense mangroves also occurred directly seaward – typically 50-100 m wide in areas east of the causeway. These mangroves were not evident in 1939 but had begun to develop by the time of the 1960 aerial photography (see Appendix A); probably in response to anthropogenic changes in sedimentation and bed levels.

23. No measurable shoreline erosion was able to be reliably discerned from the aerial photography.

24. However, a low (typically less than 0.5 m high), steep scarp does occur at the toe of the sloping bank and therefore very slow rates of erosion may occur over time.

25. In the absence of other data, an upper limit estimate of long term erosion was developed using geomorphic considerations. The distance between this shoreline and the adjacent mainland typically varies from 340-440 m. Accordingly, assuming that the island was much larger (e.g. only separated from the adjacent mainland by a narrow channel) when present sea level was first reached about 7500 years ago, an upper limit time-averaged rate of erosion of 0.023-0.029 m/yr (i.e. 170-220 m/7500 yrs) is estimated. Or, in round figures, 2-3 metres per century. This is a very precautionary assumption. However, in the absence of other reliable quantitative data the higher figure of 3 m per century is adopted.

POTENTIAL EFFECT OF PROJECTED FUTURE SEA LEVEL RISE

26. The time-averaged rates of erosion derived above are for historic erosion which occurred at or about existing mean sea level (including some rise in mean sea level over the last 100-120 years – in the order of 0.14-0.16 m). However, in the future it is projected that mean sea level may rise quite considerably in response to anthropogenic climate change. Accordingly, it is important to include an allowance for the potential effect of such sea level rise on erosion rates.

27. The most recent IPCC projections indicate that the likely scale of mean sea level rise varies considerably with emissions scenarios. However, best present national guidance suggests allowing for up to 1 m sea level rise over the next century (MfE, 2008). This is also consistent with interim guidance from the PAUP Hearings Panel (Kirkpatrick, 2015).

28. The primary effect of a rise in mean sea level on cliff erosion will be to lift the focus of toe erosion a similar elevation up the face of the bank, but cliff erosion rates are not likely to be affected markedly (MfE, 2008 – see also **Figure 4).** Over long periods of time, a new shore platform will gradually develop with ongoing erosion at the higher sea level; with the shore platform formed during the period of rise likely to adopt a sloping form.

29. However, a precautionary approach is appropriate and hence this review assumes the rate of cliff retreat will double in response to 1 m sea level rise – yielding a time-averaged rate of 0.14 m/yr for the northwest coast and 0.06 m/yr for the sheltered southwest coast.

SUMMARY AND IMPLICATIONS FOR REVISION OF THE OPERATIVE COASTAL YARD

30. The results of the above review suggest that existing rates of long term erosion on the more exposed and actively eroding north-western shoreline are less than 8 m per century. Existing long term erosion rates on the sheltered south-eastern coast are negligible, less than 2-3 m per century.

31. A precautionary allowance for doubling of these rates in response to 1 m sea level rise would increase the time-averaged rate of erosion to 16 m per century for the north-western shoreline and 6 m per century for the south-eastern shoreline.

32. In the rebuttal evidence on behalf of Auckland Council, Chief Engineer Dr Sarah Sinclair suggests that a 1.25 Factor of Safety could also be applied – following the example of the regional assessment for Auckland Council by Tonkin and Taylor. I am not convinced of the need for this given the precautionary assumptions adopted in the review and strong geomorphic evidence that the adopted rates are conservative. Nonetheless, if this factor were applied it would increase rates on the north-western shoreline to 0.2 m/yr (20 m per century) and 0.075 m/yr (7.5 m per century) on the south-eastern shoreline.

33. These coastal erosion rates are still considerably less than the erosion rates assumed in the existing coastal yard; which assumed rates of 30 m per century for the north-western coastline and 20 m per century for the south-eastern shoreline.

34. Accordingly, it is my opinion that the erosion rates component of the coastal yard (i.e. the FRL) can safely be reduced by 10 m around the entire coast of the island while still including adequate precaution. For instance, with a 10 m reduction the revised erosion component assumes would be 20m on the north-west coast (about times the most typical upper end rates of historic long term erosion) and 10 m on the sheltered south-east coast (approximately 3-5 times the upper end rates of historic long term erosion).

35. This review has not considered the potential to review the other two elements of the coastal yard. However, it is clear from field inspections that the slope stability factor includes considerable precaution. For instance, the existing eroding cliffs on the north-western coast stand much more steeply than the 26° slope assumed in the setback. As per my EIC, I believe this is a reasonable precaution and should not be altered.

36. In regard to the 5 m buffer zone, I noted in my EIC that there may be some areas where this could be reduced or even eliminated (particularly low elevation areas with gentle slopes as discussed by Mr Lander in his Point 7b). However, as the geotechnical components are measured from the landward boundary of the erosion component (i.e. the FRL), I noted that no review of the buffer zone was practical until the detailed review of the FRL was completed. The need for this buffer could now be reviewed based on the revised FRL.

37. Dr Sinclair suggested in her rebuttal (her point 5.4) that any review of the buffer zone would be against best practice "*which typically includes a buffer, more commonly known as a 'factor of safety*'. However, with respect to Dr Sinclair, I note that the 5 m buffer zone was not actually included in the original setback as a "factor of safety" - as appears to be her understanding. Rather, the 5 m safety buffer zone was originally included specifically as an allowance for possible slope failure to slopes less than 26°. It is entirely consistent with best practice to review the need for this buffer, particularly in areas with gentle slopes as suggested by Mr Lander.

38. Each of the other 2 key parameters involved in the overall coastal yard setback (i.e. the FRL and slope instability) already includes considerable precaution and therefore no additional safety factor is required. Applying precaution to the determination of individual components is entirely consistent with best practice and, in my view, preferable to application of an arbitrary multiplier or safety buffer. The objective is to achieve a reasonable but precautionary hazard setback for a planning period of 100 years including 1 m of sea level rise.

Summary and Recommendations

39. The present coastal yard includes allowances for coastal regression, slope instability and a safety buffer zone. It was recognised at the time that the coastal regression component (and therefore the setback as a whole) was overly conservative. However, this was acceptable at the time given the relatively low density country-side use proposed.

40. A review of the erosion component (FRL) of the coastal yard has now been completed as outlined above. On the basis of this work, it is my opinion that the allowance for coastal

regression (and therefore the yard as a whole) can safely be reduced by 10 m around the entire island while still retaining a very conservative and precautionary approach.

41. Further reduction of the setback may also be possible in some areas with review of the need for the 5 m safety buffer setback by an appropriately experienced geotechnical specialist, particularly in areas with gentle slopes as suggested by Mr Lander.

Jim Dahm

8 January 2016

REFERENCES

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IPCC, 2013: Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Stocker, T.F. et al., (Eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA.

Kirkpatrick, D. 2015: Interim guidance text for Topic 022 Natural Hazards and Flooding, 5 May 2015. Issued by Hearings Panel for the Proposed Auckland Unitary Plan, 5p.

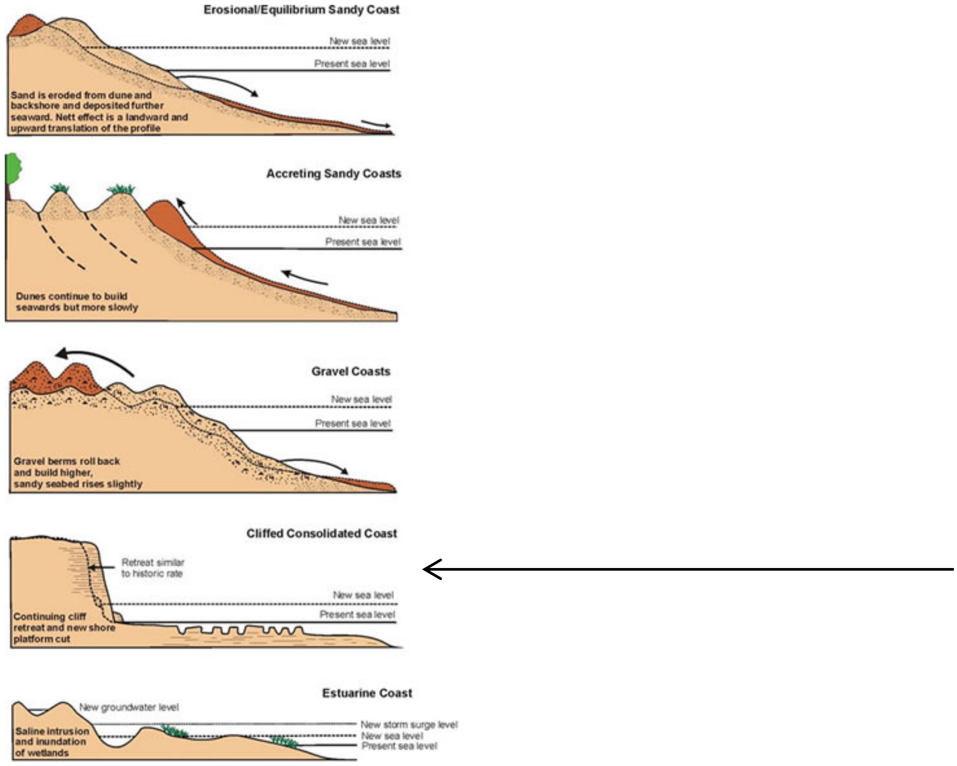
MfE, 2008: Coastal hazards and climate change. A guidance manual for local government in New Zealand. Second edition, July 2008. Report ME 892.

Figure 1: Views of steep eroding cliffs towards western end of the exposed north-western shoreline.

Figure 2: May 2010 view of area of northwest shoreline shown in Figure 1 – showing pine trees (planted prior to 1950) close to top edge of the cliff.

Figure 3: Views along sheltered south-eastern shoreline – viewed looking westward from eastern end.

Figure 3.3: Generalised impacts of sea-level rise on different types of coastal morphology



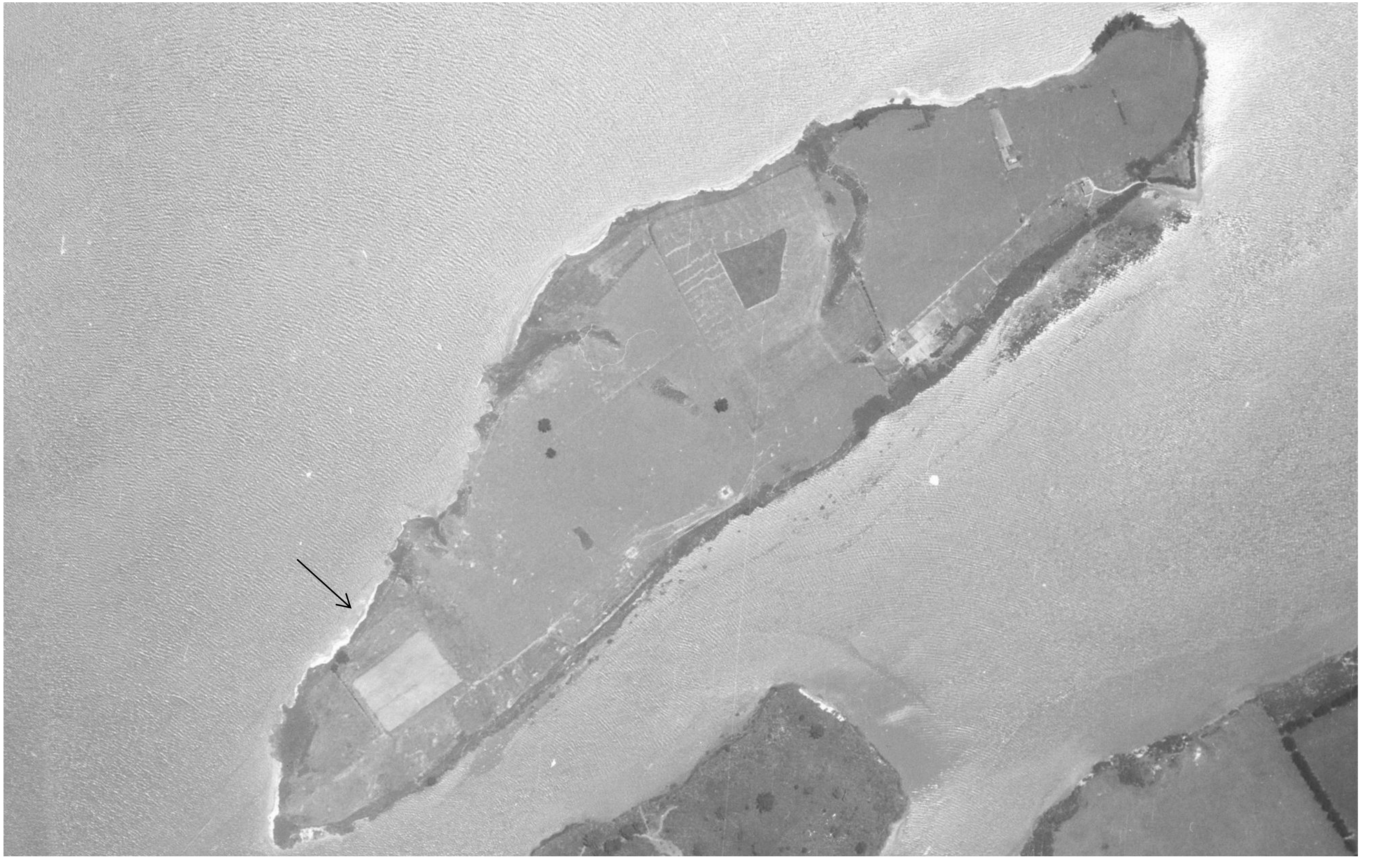
Text description of figure 3.3:

Five diagrams showing the general response of different types of coastal morphology to sea-level rise:

- Erosional/Equilibrium sandy coasts, where sand is eroded from the dune and backshore and is deposited further seaward. The net effect is a landward and upward movement of the shore profile.
- Accreting sandy coasts, where dunes continue to build seawards, but more slowly.
- Gravel coasts, where gravel berms are rolled back causing net movement landward and upward.
- Cliffed consolidated coast, where the cliff erodes slowly landward, at similar to historic rates and new shore platform develops, and
- Estuarine coast, where rising sea and storm-surge levels cause landward saline intrusion, inundation of wetlands, and raising of the groundwater level.

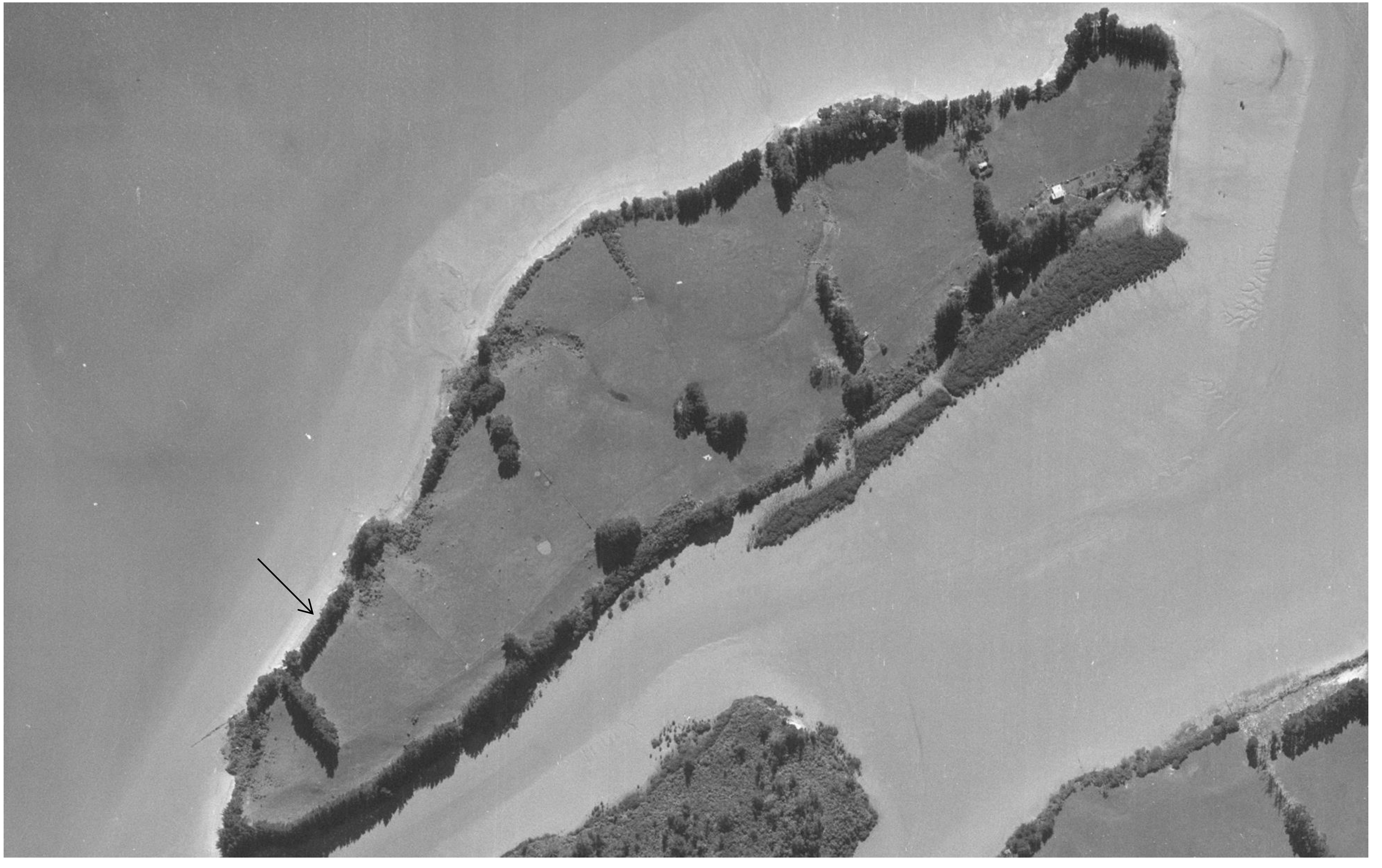
Figure 4: General response of different types of coastal morphology to sea level rise (Figure 3.3 from MfE, 2008). It can be seen that on cliffed coasts (arrowed) the general expectation is that the level of toe erosion would lift with sea level rise so that ongoing cliff retreat would form a new shore platform at a higher level. However, the rate of cliff retreat is likely to be similar to historic rates.

APPENDIX A: HISTORIC PHOTOGRAPHY



1939 Aerial Photography

DAA-008752-37-73-V2



1960 Aerial Photography

DAA-008752-37-73-V2

2011 Aerial Photography

DAA-008752-37-73-V2