Takutai Kāpiti Economic Analysis Methodology Memo

Date:	9 April 2024
Project name:	Takutai Kāpiti Coastal Hazard Adaptation
Project no:	IS355300
Attention:	Abbey Morris
Company:	Kāpiti Coast District Council
Prepared by:	Derek Todd, Damian Debski, Ian Wiseman, Gwebu Ngcebo
Document no:	IS355300-NP-MEM-0004
Copies to:	Jason Holland (KCDC) Stephen Daysh (Mitchell Daysh)

Level 2, Wynn Williams Building
47 Hereford Street
Christchurch Central 8013
PO Box 1147
Christchurch 8140
New Zealand

T +64 3 940 4900

1. Introduction

As part of the Takutai Kāpiti Coastal Hazard Adaptation project, Jacobs have been commissioned to undertake a high-level economics analysis of the top three short listed adaptation pathways in each Adaptation Management Unit. The sole purpose of this analysis is to allow a relative ranking of the economic metrics of the adaptation pathways to be undertaken. The economic metrics consider the costing of impact on the physical built environment values only (e.g. private properties and specific Council infrastructure) and do not include costing of impacts on cultural, ecological and landscape value. The results of the analysis will be used by CAP[1], in conjunction with the MCDA[2] previously undertaken by them, to confirm their recommended preferred pathways for each Management Unit. The purpose of this memo is to document the methodology and assumptions used in undertaking the economics analysis.

This economic analysis will involve developing the financial metrics for each pathway identified in the Decision-Making Framework report (Jacobs, 2022)[3], being "Cost + Loss" and "Value for Money" metrics, being the same metrics as were used in the Hawkes Bay coastal hazards adaptation project economic analysis (Infometrics, 2017)[4], under a Real Options Analysis (ROA) approach.

ROA is a costing method that can help evaluate policy pathways and quantify the investment risk associated with uncertain future outcomes. Under a full ROA, the assessment would consider a range of RSLR scenarios and a full range of possible pathways to assess whether it is better to invest now or to wait – and whether it is better to invest in options that offer greater flexibility in the future. Therefore, the ROA can assist in making economically efficient adaptation investment decisions both now and at future decision points by reducing the chance of over- or-under investment in adaptation actions. As such ROA is a complementary assessment tool to the MCDA of environment, social, cultural impacts and risk reduction benefits in defining preferred adaptation pathways under a DAPP[5] framework.

In this assessment, we are using the same principles of ROA as were applied in the Hawkes Bay economic assessment, with similar modifications of only using running the full analysis of "Losses" using the SSP5-

[1] CAP: Community Advisory Panel

[2] MCDA: Multi Criteria Decision-Making Analysis

[3] Jacobs (2022) Takutai Kāpiti : coastal hazards adaptation decision-making framework. Report for KCDC

[4] Infometrics (2017) Real Options Analysis of strategies to manage coastal hazard risks: Southern Units J-L. Report for Hawke's Bay Regional Council.

[5] DAPP: Dynamic Adaptive Policy Pathway

8.5[6] Relative Sea Level Rise (RSLR) scenario (although the SSP2-4.5[7] RSLR scenario is used in sensitivity testing of a selected number of pathways). This is appropriate for this high-level economic analysis focused on the relative rankings of the metrics applied, and does not prejudge any future Council decisions regarding use of SSP scenarios for district planning purposes. This analysis is applied to a limited number of possible pathways per Management Unit with fixed physical actions being applied at discrete time frames of short-term (0-30 years), medium-term (30-50 years), and long-term (50-100 years) for economic purposes. Land-use planning measures are not included as actions to reduce risk as are viewed as applying to all pathway options. While this approach does not deal with the uncertainty of when to move from one adaptation action to another (e.g. due to lower or higher rate of RSLR, or greater/less ability of the adaptation action to avoid the trigger level to move to another action, or change in community aspiration), it never-the-less provides an appropriate financial assessment of the relative costs and benefits of the pathway sequences for each Management Unit. These can be used by CAP in conjunction with the MCDA scoring to assist in defining their preferred adaptation pathways.

2. Economic Analysis Methodology

2.1 Metrics Applied

The ROA metrics, as set out by Infometrics (2017) included the following two specific metrics:

1. A **'Cost + Loss'** metric which is derived from two elements:

   'Cost': A total cost estimate covering both the implementation (e.g. design, consenting, construction) and operational/maintenance of all physical coastal hazard adaptation actions over the full 100-year time frame (discounted over time) of each pathway sequence.

   It is important to recognize that the cost estimates do not include any implication on how the actions may be funded. There is no implication that Kāpiti Coast District Council (KCDC) will fund actions where the benefits are solely to private land and assets. However, they are included in the assessment to provide a consistent approach to the costing estimates of all pathways across all Management Units and therefore to the relative financial benefits of the pathways.

   'Loss': A residual loss calculation reflecting there may still be coastal erosion or inundation damages even with the implementation of the adaptation actions due to uncertainty in the climate science, the probability of larger than design storm events, and the pathways not necessarily being designed to completely protect all properties and infrastructure. For erosion, this loss value is calculated from assumed percentage of the projected SSP5-8.5 RSLR erosion that could still occur with the adaptation actions in place. For flooding, this loss value is calculated from residual flooding from a 1% Annual Exceedance Probability (AEP) event under the SSP5-8.5 RSLR scenario.

2. A **Value for Money (VFM)** measure for each pathway. This compares the total cost estimate for each 100-year pathway sequence against the total MCDA score for each pathway to provide the cost of each MCDA point, hence a measurement of the "value for money" of the total pathway.

The economic analysis being undertaken in this assessment also provides two addition metrics:

- A **Damage Avoided Value,** being the difference between the losses from a "baseline" pathway (denoted as pathway 0 for each management unit) which has no additional future adaptation actions

[6] SSP5-8.5 RSLR scenario: The projected Relative Sea Level Rise under the IPCC (2021) A6 Climate change projections under a "medium confidence" fossil fuel intensive development scenario (SSP5-8.5) combined with projected district wide averaged Vertical Land Movement (VLM) rate of 1mm/yr.

[7] SSP2-4.5 RSLR scenario: A lower RSLR scenario under a 'middle-of-the- road' climate change projections from IPCC (2021) combined projected district wide averaged VLM rate of 1mm/yr.

or additional effort than the current management practices over the full 100-year time frame, and the top three ranked adaptation pathways for that Management Unit (denoted as pathways 1,2, & 3); and

- A **Benefit Cost Ratio (BCR),** which is a traditional cost benefit analysis (CBA) metric that provides a ratio between the total discounted benefits and total costs of a pathway.

The financial values assigned to the 'Costs' and 'Losses' for each pathway are high level indicative values based on the best information available at the time, and a number of assumptions that are outlined in Sections 4 and 5 of this memo. They are intended to allow a relative comparison of costs and losses between pathways rather than absolute financial values.

2.2 Pathways to be Analysed

The economic metrics are calculated for the top three ranked adaptation pathways as determined from the MCDA scoring for each Management Unit. Across the four Adaptation Areas there are 20 management units (11 erosion, 9 inundation), hence the metrics are required to be calculated across 60 individual adaptation pathways. The top three ranked adaptation pathways for each Management Unit are listed in Appendix A, along with details of each action required to calculate estimated costs of implementing the action (e.g. lengths of seawall, stopbank, areas of planting, number of flag-values etc.). For sensitive testing, the metrics are also calculated for 4 selected representative pathways (2 erosion and 2 inundation) with Losses calculated under the SSP2-4.5 RSLR scenario to test the impact of a lower RSLR on the economic metrics. Extrapolation of the difference from these to the SSP5-8.5 scenario will be applied to the other pathways.

In addition, the metrics are required to be calculated for each Management Unit under the "baseline" pathway under the SSP5-8.5 RSLR scenario over the100-year timeframe. This baseline pathway, which assumes no additional future adaptation actions or additional effort from the current management practices will be undertaken to reduce either coastal erosion or flooding over the 100-year period, is consistent with the scenario applied in the risk assessment for each Adaptation Area. The calculation of these baseline pathways metrics allows a comparison of the losses under the baseline and adaptation pathways. The difference in "loss" is the "**Damage Avoided Value",** which is the economic benefit of implementing the adaptation pathway. In total, 20 baseline pathways are required to be analysed (i.e. one per management unit) for the calculation of the damages avoided under the adaptation pathways.

The total number of pathways for which the metrics are required to be calculated is summarised in Table 1.

Table 1: Adaptation Pathways to be analysed.

Adaptation Area (AA)	# Management Units	#Adaptation Pathways per unit	Total # of pathways to be analysed
Northern (NAA)	8 (4 Erosion, 4 inundation)	3 + baseline	32
Central (CAA)	6 (3 Erosion, 3 inundation)	3 + baseline	24
Raumati (RAA)	3 (2 Erosion, 1 inundation)	3 + baseline	12
Paekākāriki (PAA)	3 (2 Erosion, 1 inundation)	3 + baseline	12
SSP2-4.5 sensitivity	4	1 + baseline	8
			Total 88 pathways

2.3 Methodology Overview

The economic analysis methodology involves the follows steps:

1. Calculation of average private property values[8] within each Management Unit by KCDC. Public property was excluded from the analysis to avoid bias of the average values due to lack of capital improvements on this land. The average property value is required for the calculation of erosion

[8] Average private property values are based on Ratable Values (RV) of all private properties in the Management Unit.

baseline and adaptation pathway 'Losses', and calculation of 'Costs' and 'Losses' for pathways that include actions involving retreat of private property.

2. Estimate the base implementation and annual operational/maintenance costs for all physical Adaptation Actions. These estimates were provided by KCDC supported by Jacobs. These base costs, and assumptions behind them, are presented in Appendix B.

3. Estimate the unit costs of repair and replacement to selected KCDC infrastructure that the risk assessments indicated could be damaged by either coastal erosion or inundation over the 100-year time frame. This infrastructure includes roads, pump stations, water bores, outfalls, bridges, culverts and pipes (note: no treatment plants are indicated as being at risk).

   Where available, the estimated unit repair and replacement costs were supplied by KCDC or Greater Wellington Regional Council (GWRC). Where this information was not available from these sources, unit repair/replacement costs were estimated by Jacobs based on experience from other projects. These unit costs are required for the calculation of the value of infrastructure losses in each Management Unit under each pathway. The estimated unit repair and replacement costs applied for each type of infrastructure and the source of the estimate are presented in Appendix C. Non KCDC infrastructure (e.g. power and gas supply) were also excluded due to this infrastructure not being within scope of this economic assessment.

4. Calculation of the private property and KCDC infrastructure 'Losses' with the baseline pathway under both SSP5-8.5 and SSP2-4.5 SLR scenarios for each Management Unit. The exposure of property and infrastructure was obtained from the spatial mapping undertaken by Jacobs for the risk assessments at each of the RSLR values applied in the risk assessments[9].

   a) For erosion Management Units, the Private Property Losses between each value of RSLR are calculated by:

      Average property value X *Additional number of properties exposed in that epoch*[10].

      For the economics analysis this value is converted to the Average Annual Loss (or damage) by dividing by the duration of the epoch. For example, for the short- and medium-term epoch, the resulting value of the private property losses in each are divided by the 20 years of the epoch (e.g. 2030-2050, and 2050-2070) to obtain the Average Annual Loss, while for the long-term epoch the value of the private property losses within the epoch are divided by the 60 years of the epoch (e.g. 2070-2130).

      Any property shown as exposed to the hazard is included in the property count, regardless of percentage of the property exposed or whether the dwelling is included in the exposed part of the property.

   b) For inundation Management Units, the Private Property Losses at the start and end of each epoch are calculated by:

      Annual Average flood damage value per property X *Number of properties exposed in a coastal storm event*

      For inundation management units, the private property losses at the start and end of each epoch are calculated using the NZ Buildings Outline dataset from LINZ Data service (filtered

[9] RSLR applied in the Risk assessments: 2020 (taken as present day) – 0m; 2050 – 0.2m (both SSP2-4.5 & SSP5-8.5); 2070 – 0.35m (SSP2-4.5) & 0.45m (SSP5-8.5); 2130 – 0.85m (SSP2-4.5) & 1.25m (SSP5-8.5)

[10] Excludes the properties exposed in the preceding epoch(s) to avoid double accounting of the losses.

to buildings on private property that were >40 m^2 to remove garages and sheds as best as practical). For each building, a maximum flood depth from the mapped 1% AEP coastal storm was determined, and estimated depths for the 2% AEP, 10% AEP and 50% AEP were interpolated from the dataset by subtracting the difference in storm tide levels between these events and the 1% AEP. Above floor flooding was calculated based on an assumed floor height of 0.225m based on the New Zealand Building Code's required minimum finished floor levels for a concrete slab above natural ground.

A simplified fragility curve from NIWA (2010)[11] was used to obtain a damage ratio (damage value as a function of property value), which was then multiplied by the average rateable value (RV) of the Management Unit to obtain the damage values in each AEP. Using the four AEP's, a simplified probability-damage curve was constructed to calculate the Average Annual Damage (AAD) for each building. The damages to each building were summed to obtain the total losses within the Management Unit. The total AAD were then interpolated between the discrete SLR scenario timeframes to obtain an AAD in each year for the present value calculation.

c) For all Management Units, KCDC infrastructure Losses at each increment of RSLR are calculated by:

Unit Cost of repair/replacement X *Number/length of Infrastructure exposed*

For erosion hazards, all infrastructure above and below ground (e.g. includes 3 waters pipes) is assumed to be lost if the footprint of the infrastructure is exposed to the hazard within the time epoch being considered. For flood hazards, infrastructure is restricted to above ground assets (e.g. does not include pipes). For roads, bridges and culverts, which are designed to convey flood water, the damage is taken to be zero on the basis that flood damage to such assets is usually due to erosion by very fast flowing water, beyond the design limits of the asset. In coastal inundation events the velocity of flood water is generally lower than for pluvial or fluvial flooding such that damage through erosion is considered less likely to occur. For stormwater and wastewater pump stations, flood damages are primarily to the electrical and control panels. Although these are generally located above ground level, individual designs are likely to vary. For the purposes of this assessment damage is therefore taken to be independent of water depth.

6. Calculation of the 'Total 'Cost Estimate' for the top three Pathways for each Management Unit. This calculation involves the following three sub-steps for each pathway:
   a) Jacobs estimate the lengths/areas/asset numbers of the Adaptation Actions (e.g. length of seawall or stopbank, area of dune planting) required to be implemented in each time epoch. The Adaptation Action lengths/areas/asset numbers for each Pathway are presented in Appendix A.
   b) Use the following equation and apply a 5% discount (see Section 3 for discussion) to calculate the Present Value (PV) of 'Cost' estimate of the Adaptation Action to be implied with each time epoch.

   Unit Implementation/operational/maintenance cost X *length/area of adaptation action*

   c) Sum the 'Cost' estimate across all three times epochs to obtain a PV 'Total Cost Estimate' for each pathway over the total 100-year time frame.

[11] NIWA (2010) RiskScape: Flood fragility methodology. Report prepared for NZ Climate Change Research Institute, Victoria University of Wellington.

7. Calculate the 'Residual Loss' value for the top three Pathways for each Management Unit. This calculation involves the following sub-steps:
    a) For Erosion Management Units, Jacobs estimate the effectiveness of the Adaptation Action at each time epoch as a percentage reduction in erosion distance from the baseline 'erosion pathway. The assumed erosion reduction percentages and the justifications for these are outlined in Section 4.2 below. Geographical Information Systems (GIS) is used to spatially map the resulting adaptation shorelines and to calculate the residual private property and KCDC infrastructure exposure within each epoch.
    b) For Inundation Management Units, Jacobs manually assess the residual flooded areas and/or number of properties susceptible to flooding following the implementation of the Adaptation Action at each epoch in each Management Unit. The assumptions applied to arrive at these manual assessments are outlined in Section 5.2 below. For 'accommodate' and 'retreat' interventions, the number of buildings flooded by more than 0.1 m above floor level (e.g. 0.325 m) were counted and flood damages were calculated as 'damages avoided' and subtracted from the baseline to obtain the value for remaining losses within the timeframe.
    c) Use the above exposure counts/areas to calculate the value of the residual private property and KCDC infrastructure Losses under each pathway as per point 5 above.
    d) Distribute the losses calculated across each epoch and apply the appropriate discount rate to calculate the PV 'Residual Loss' value for each pathway.

8. Calculate the 'Cost + Loss' metric for each pathway by summing 'Total Cost estimate' and 'Residual Loss' value.

9. Calculate the 'Value for Money' (VFM) metric for each pathway by dividing 'Total Cost estimate' by the MCDA score for that pathway.

10. For each pathway, calculate the 'Damage Avoided Value' (difference between the losses from the baseline pathway and the adaptation pathway), and the Benefit Cost Ratio (BCR) (ratio between the total discounted benefits and total discounted costs of the pathway).

11. Present the results in tables showing all the matrices calculated and the ranking of the 'Cost + Loss' and VFM, matrices for the three pathways in each Management Unit. There rankings will be compared to the MCDA for presentation to CAP.

12. Undertake a sensitivity analysis of the impact of higher and lower discount rates on the 'Cost + Loss' and VFM rankings of pathways. The discussion on the discount rates applied in this sensitivity analysis is presented in Section 3 below.

13. Undertake a sensitivity testing of applying higher and lower values to the 'Costs' and 'Losses'.

14. Undertake sensitivity testing of the metrics for the selected 4 pathways under the SSP2-4.5 RSLR scenario. Extrapolation of the difference from these to the SSP5-8.5 scenario will be applied to the other pathways.

3. Economic Analysis Assumptions

The following assumptions are made in the economic analysis:

- Economic analysis is undertaken over 100 years of operations after the initial adaptation is implemented. The Dollar value baseline is 2024.
- The start date for the implementation of the short-term adaptation actions is set to 2030. Losses at 2030 are assumed to be those calculated from the 2020 shoreline position (for erosion) and 1% AEP water levels (for inundation) as per the risk assessments for each Adaptation Area.

- The economic analysis is only covering direct losses of KCDC assets/infrastructure and private property.
- Implementation cost phasing is spread evenly for 2 years before and after the start date of implementing the adaptation action).
- Benefits of the adaptation pathways are the avoided losses. This is equal to the difference between the base case losses and the pathways' residual losses.
- Costs (implementation and operational/maintenance) included in the economic analysis are the incremental costs of the adaptation pathways. These can be explained as the difference between the adaptation pathway costs and the relevant base case costs. This allows for a 'like for like' comparison of the benefits of the adaptation pathways against the incremental costs that KCDC would have to invest to deliver the benefits.
- Annual maintenance costs are associated with all adaptation actions. Where maintenance costs were not available from KCDC, 5-10% of implementation costs were used.
- Average annual losses are calculated for each modelled year using the calculated losses and the AEP event level. Annual losses for non modelled years will be derived through interpolation.
- Core discount rate of 5% is applied on all future costs and losses to obtain present value figures. This is consistent with NZ government guidelines[12].
- Sensitivity tests to be undertaken on the following assumptions:
  - discount rates of 3% and 7% as lower and upper bounds.
  - +/-10% of capital costs of adaptation pathways
  - +/-10% infrastructure asset values

4. Erosion 'Cost' and 'Loss' Assumptions

4.2 Erosion 'Cost' Assumptions

There are a wide variety and combinations of Erosion Adaptation Actions within the pathways across all Management Units ranging from enhanced dune management (e.g. planting, fencing, pest control, access management), soft engineering (e.g. beach renourishment, dune reconstruction), seawalls, and progressive retreat of private properties and infrastructure. A number of assumptions are applied in estimating the implementation and operational/maintenance costs of implementing these Actions as set out in Appendix C, which include the following:

- The Costs are estimated from a unit base cost of implementing each Action applied equally across the district (e.g. no difference in base cost for Adaptation Action at different location).
- The Cost of status quo actions are per estimates on past costs and rates outlined in the KCDC Long Term Plan 2021-2041 (LTP) for 'Coastal Management'. Where necessary (e.g. dune management), these costs are averaged over the Management Units where these activities currently take place.
- The Cost of Emergency Management Community Awareness and Education Programs within the Enhanced Actions is based on 0.25 full-time equivalent employee (FTE) as supplied by KCDC.
- The implementation cost of most future Actions includes a 17.5% factor applied to supply and construction costs to cover: Design (5%), Construction Management (5%), Consenting (5%), and

[12] https://www.mbie.govt.nz/business-and-employment/economic-development/sustainable-and-resilient-economy-transformation/which-analytical-tools-are-suited-to-transformative-change/how-well-suited-is-cost-benefit-analysis-to-transformative-change/

Project Management (2.5%). Appendix B presents for which Actions these professional services costs are included and excluded.

- For the Management Units containing the Raumati and Paekākāriki seawalls, the cost of the proposed seawall replacements is not included in the short-term status quo Action costings, as the base data for action under the Adaptation Plan is taken to be 2030, by which time it is assumed that the seawalls have been replaced.

- The cost of set-back stepped sea walls in the Raumati and Paekākāriki Management Units are based on the unit costs provided by KCDC for more conventional vertical seawalls. It is acknowledged that costs may be cheaper for alternative stepped wall designs such as Ecoreef walls. However, due to this being new technology that has only been applied on a trial basis in a very limited number of sites, it is considered that full implementation and maintenance costs are not well established, hence the use of known seawall costs.

- Annual Maintenance costs are associated with all Adaptation Actions. If maintenance costs are not available from KCDC, a percentage of implementation cost of 5-10% has been used.

- All hard engineering structures (e.g. seawalls) include an annual maintenance cost provided by KCDC over their design life to cover minor damage during storm events.

- Beach nourishment Actions include a 5 yearly renourishment to maintain design sand volume over the total time of the epoch. This is included as a maintenance cost. Annual maintenance costs are also applied to cover ongoing foredune planting requirements to deal with the impacts minor storm events.

- Dune reconstruction Actions are assumed to be a one-off implementation activity, with annual maintenance costs associated with ongoing foredune planting to deal with the impacts minor storm events.

- The Costs of implementing managed retreat actions are calculated from a 2.5x multiplier to the average private property values based on the retreat costing approach employed for the Hawkes Bay Coastal Strategy (Tonkin & Taylor, 2022)[13]. This was calculated by comparing the calculated total cost of retreat in that report by the total cost in that report (land value and capital value) of those houses identified as requiring retreating. This indicated that retreat may cost approximately 2.5x the cost of the houses and land to be retreated. For the purpose of economic analysis, under the retreat Adaptation Action, a private property is assumed to retreat if the erosion hazard is mapped to reach the property boundary within the epoch.

In defining the lengths/area of Adaptation Action to be costed in each Management Unit as set out in Appendix A, the assumptions applied were:

- Hard engineering protection actions are limited to the length of the urban footprint within the relevant Management Units.

- Soft engineering actions are limited to the length of the urban footprint within the relevant Management Units, except for Management Unit 4A (Northern Rural Management Unit).

- Enhanced dune management actions are applied over the total length of the Management Unit.

4.3 Erosion 'Loss' Assumptions

For the estimation of Residual Erosion Losses, the base assumptions are:

[13] Tonkin & Taylor (2022) Hawke's Bay Coastal Strategy: Implementation approaches and indicative costs for planned retreat. Report prepared for Hawke's Bay Regional Council.

- The erosion probability used for mapping exposure under all pathways is P90 (e.g. only a 10% probability that erosion will exceed this location).

- The Losses for each epoch are calculated using the average erosion rate over the epoch across the entire Management Unit.

- For private property: If any part of a property is included in the erosion hazard exposure within an epoch, this results in the whole property value being included in the Losses for that epoch.

- For KCDC infrastructure: All infrastructure above and below ground included in the erosion hazard exposure within an epoch is assumed to be lost within that time epoch and require full replacement.

The Residual Erosion Losses of the Adaptation Pathways are dependent on the effectiveness of the Adaptation Actions to reduce the erosion distance from that projected to occur under the baseline pathway. The effectiveness of each Adaptation Action within the adaptation pathways is expressed as percentage reduction in the baseline erosion that is projected to occur within the epoch without the adaptation intervention. The assumed erosion reduction percentages and the justifications for these is set out in Table 2. Key assumptions applied to these percentages are:

- Enhanced dune management and soft engineering Adaptation Actions become less effective over time as the effects of RSLR on erosion increase such that these actions cannot keep up with increased offshore sediment losses.

- Seawalls, Enhanced seawalls, and Estuary Bank Protection are totally effective at stopping erosion within their design life (e.g. no erosion), which for implementation in the short and medium epochs is assumed to be 20 years (i.e. the duration of the epoch). Once this time frame is exceeded, the structures become totally ineffective and erosion rates return to those under the baseline pathway for the following epochs.

- In the Raumati and Paekākāriki units (9A, 10A, 11A and 12A), the losses include from erosion in a short-term storm (i.e. the structure has failed and erosion has occurred). This is consistent with the remapping of the hazard with interventions throughout the northern and central adaptation areas, where the short-term storm is still included within the present day and future erosion calculations.

- Set-back seawalls are assumed to be set-back 20 m from the shoreline at the start of the epoch in which they are implemented. This set-back distance allows for the construction of stepped (2H:1V[14] steps) or sloping (2H:1V) seawall structures without a toe foundation encroaching further seaward than the current seawall positions.

- Set-back seawalls with dune reconstructions: the set-back is 30 m to allow for a stable 3.5 m high dune (total elevation 5 m RL[15]) with a 8H:1V dune slope to be constructed over the seawall.
- For beach renourishment, sufficient volume is required to be placed on the foreshore at 5 yearly intervals to return the dune toe to the same position as the start of the epoch while retaining an average foreshore slope of 20H:1V.

Table 2: Approach to assessing losses from Erosion Adaptation Pathways

Adaptation Action	Assumption on effectiveness of Actions undertaken in each epoch (% reduction in erosion rate for that epoch from baseline pathway from undertaking the adaptation Action)	Notes

[14] 2H;1V - 2 m horizontal distance to 1 m vertical height, so for a stepped wall, each step has a 2m wide horizontal base followed a 1 m vertical rise.

[15] RL: Relative level. For Kapiti this is Wellington Vertical Datum 1953 (WVD53)

	Short Term	Medium Term	Long Term	
Enhanced Dune Management	50% reduction	30% reduction	10% reduction	Well vegetated, nourished and sloped dunes will reduce (but not prevent) storm erosion and given that storm effects make up a large percentage of the total short-term erosion, it is assumed that effectiveness would be around 50% for this epoch. However, the effectiveness will reduce over time as RSLR has a greater impact on the total projected erosion distances.
Beach Renourishment	70% reduction	50% reduction	30% reduction	Assumed within each epoch it is topped up every 5 years. In the Short term, assume that the nourishment reduces the storm erosion by 70% by having a larger buffer on the beach, and storm erosion is the dominant component of the total short-term erosion. By the time we get to the long-term, each renourishment would be less effective at retaining the design profile, so storm effects would be greater. The only way to make the nourishment more effective is more frequent placements involving greater volumes.
Dune Reconstruction	70% reduction	50% reduction	30% reduction	Assumed to be the same as beach renourishment; would provide protection in a different way by having a more stable dune buffer rather than adding sand volume into the active beachfront system that would be used to protection in storms.
Hard Engineering – Sea wall	Assume 100% reduction over the epoch	Assume 100% reduction over the epoch.	Assume 100% reduction over the epoch.	Assumes that seawalls are totally effective at reducing erosion over the epoch within which they are constructed on the basis that the design life of the wall is for the total epoch time period (e.g. 20 years for short & medium term, 50 years for long-term). However, should the pathway not include enhancement or replacement of the seawall in

				the next epoch, it is assumed that erosion rates will return to those assigned for the epoch without a wall in place.
Enhanced Seawall	Assume 100% reduction over the epoch.	Assume 100% reduction over the epoch.	Assume 100% reduction over the epoch.	Assumes that enhanced seawalls are totally effective at reducing erosion over the epoch within which they are enhanced on the basis that the enhancement will achieve the same design level of protection as a new seawall.
Setback sea wall	Not applicable as no setback seawalls in short-term epoch.	Losses associated with an assumed 20 m setback from shoreline position at the start of the epoch.	Losses associated with an assumed 20 m setback from shoreline position at the start of the epoch.	Based on the land elevations at Raumati and Paekākāriki, a 20 m setback is assumed to be sufficient to allow for the construction of a stepped seawall or sloped seawall
Setback sea wall with dune reconstruction	Not applicable as no setback seawalls in short-term epoch.	Losses associated with an assumed 30 m setback from shoreline position at the start of the epoch.	Losses associated with an assumed 30 m setback from shoreline position at the start of the epoch.	A 30 m set-back is required to allow for a stable dune 3.5 m high (total elevation 5 m RL) with a 8H:1V dune slope to be constructed over the seawall.
Estuary Bank Protection	Assume 100% reduction over the epoch	Assume 100% reduction over the epoch	Assume 100% reduction over the epoch	Assumes that bank protection seawalls are totally effective at reducing erosion over the epoch within which they are constructed on the basis that the design life of the wall is for the total epoch time period (e.g. 20 years for short & medium terms, 50 years for long-term). However, should the pathway not include enhancement or replacement of the seawall in the next epoch, it is assumed that erosion rates will return to those assigned for the proposed adaptation action for that epoch.
Retreat	Assume property is retreated when erosion hazard reaches property boundary	Assume property is retreated when erosion hazard reaches property boundary	Assume property is retreated when erosion hazard reaches	Property count of properties impacted by erosion at the time of pathway from previous epochs derived line.

			property boundary	

5. Inundation 'Cost' and 'Loss' Assumptions

5.1 Inundation 'Cost' Assumptions

There are a lesser number of Inundation Adaptation Actions compared to Erosion Adaptation Actions within the pathways across the Inundation Management Units. These differ to the Erosion Adaptation Actions except for progressive retreat for which the same approach to costing as in the Erosion Adaptation pathways has been adopted.

A number of assumptions are applied in estimating the implementation and maintenance costs of these Actions as set out in Appendix C, which include the following:

- The Costs are estimated from a unit base cost of implementing each Action applied equally across the district (e.g. no difference in base cost for Adaptation Action at different location).

- The Cost of status quo actions are as per estimates on past costs and rates outlined in the KCDC Proposed Long Term Plan 2024-2034 (LTP).

- The implementation cost of all future Adaptation Actions includes a 17.5% factor applied to supply and construction costs to cover: Design (5%), Construction Management (5%), Consenting (5%), and Project Management (2.5%). Inflation is not considered in these costs.

- All hard engineering structures (e.g. stopbanks) include an annual maintenance cost provided by KCDC over their design life to cover minor damage during storm events. This does not include periodic raising of the structures as it is assumed that they are initially constructed to a level able to withstand the design flood levels with RSLR within the epoch they were constructed or enhanced.

- Annual Maintenance costs are associated with all Adaptation Actions. If maintenance costs are not available from KCDC, a percentage of implementation cost of 5-10% has been used.

- Costs for Accommodate Adaptation Actions assume a 50/50 split of floor raising and flood proofing actions for buildings that are greater than 40 m^2 (i.e. assumed to be dwellings) and are flooded to depths greater than 0.325 m.

In defining the quantities of Adaptation Actions to be costed in each Management Unit as set out in Appendix A, the assumptions applied were:

- New hard engineering: this consists of new stopbanks – approximate alignments and their lengths defined to block direct overland flow paths from watercourses or the sea to properties containing buildings or to roads to maintain access.

- Enhanced existing infrastructure consists of the following actions:
    - providing flap valves to existing stormwater outfalls which are selected where potential pathways from watercourses or the sea to low lying properties containing buildings are identified.
    - Extending existing stopbanks or flood protection bunds - approximate alignments and their lengths defined to block direct overland flow paths from watercourses or the sea to properties containing buildings or to roads to maintain access.

- Enhancement of coastal wetlands: This option consists of an assumed 10 m strip of planting around existing wetlands (using significant or outstanding wetlands identified by GWRC) along wetlands adjacent to nearby development. In management units that do not have a wetland, and where applicable, riparian planting along streams is also considered using the same cost estimates as wetland planting. The 10m strip of wetland planting is considered a minimum width for an effective riparian buffer[16].

- Raising buildings or flood proofing to accommodate flooding: The number of properties is calculated by counting those properties where flood damages are estimated to exceed Damage State 1 ('DS1' - non-structural damage) of the NIWA Riskscape methodology for classifying flood damages to buildings (NIWA 2010[14]). This corresponds to a water depth of approximately 100 mm above floor level for timber frame buildings. In the absence of floor level information, a water depth (above ground level) of 325 mm has been used to select properties based on the NZS 3604:2011 minimum floor level requirement for concrete slab-on-ground floors for timber buildings of 225 mm (for floors adjacent to natural ground) and the DS1 depth limit of approximately 100 mm above floor level.

- For Retreating properties, the criterion for calculating the number of properties for retreat is the same as that for flood proofing – i.e., a water depth of 325 mm above ground level.

5.2 Inundation 'Loss' Assumptions

For the estimation of Residual Inundation Losses, the base assumptions are:

- Above floor flood depths are based on the assumption that floor heights are 0.225 m, as per the Building Code requirements as specified by KCDC. Above floor flooding is calculated as being water depths that are greater than 0.225 m.

- The inundation probability used for mapping exposure under all pathways is 1% AEP, with water depths interpolated for the 2% 10% and 50% AEP being estimated from the difference in average storm tide levels across two Kapiti sites (NIWA, 2011)[17].

- Average Annual Damages (AAD) are calculated using the NZ Buildings Outline dataset from LINZ Data service, which has been filtered to only include buildings on private property that were >40 m^2 to remove garages and sheds as best as practical. Losses are therefore reported as 'buildings' rather than properties. It is assumed that this filtering process reduced the number of buildings to each property to one, however if a property has two buildings >40 m^2 then the damage costs would be doubled for that property if they are both flooded.

- The calculation of AAD relies on a simplified fragility curve from the NIWA Riskscape report (NIWA 2010):

  Damage ratio = 0.41 x (depth of flooding above floor) $^{0.5}$

- The average RV for the Management Unit derived by KCDC is used to calculate the damages for each building.

- The AAD to buildings are not capped to the average RV. This creates the possibility of overestimation of the losses as the buildings are more likely to be written -off if damages exceed RV.

- For KCDC infrastructure: Only infrastructure above ground is included in the loss calculation.

---

[16] Auckland Council Streamside Planting Guide (https://www.aucklandcouncil.govt.nz/environment/plants-animals/plant-for-your-ecosystem/Documents/streamside-planting-guide.pdf)

[17] NIWA (2011) Joint probability of storm tide and waves on the open coast of Wellington. Report prepared for GWRC.

- Calculated damages to KCDC infrastructure are based on the unit costs in Appendix C. Rates for unit prices are downscaled to be representative of having a 1% chance of occurring within each year. To align with the AAD calculated for property, infrastructure repair rates were multiplied by 0.01 to give an annual average damage. The AADs for each year between assessed epochs is then interpolated, and the total damage is the sum of all the yearly damages, each being discounted. This assumes that there is no flood loss damage in events more frequent than 50% AEP.

The Residual Inundation Losses of the Adaptation Pathways are dependent on the effectiveness of the Adaptation Actions to reduce the exposure of buildings to inundation from that projected to occur under the baseline pathway. The effectiveness of each Adaptation Action within the pathway is determined by recounting the number of buildings exposed to inundation according to the areas protected from inundation by the Adaptation Actions as follows:

- Enhanced stormwater pipe outfalls (flap valves): the buildings susceptible to flooding by back flow in the stormwater drainage network served by the outfall are fully protected from flooding over the epoch. The buildings are excluded from the exposure count over the epoch period.

- Enhanced stopbanks and bunds or new stopbanks: the buildings served by the defence are fully protected from flooding over the epoch and are excluded from the exposure count over the epoch period.

- Enhancement of coastal wetlands: this option could be effective in reducing water velocities in higher frequency events than the 1 in 100 year coastal storm assessed in this process, but is unlikely to reduce losses to infrastructure or property in the significant storm event considered in this assessment. Therefore, any resulting losses to the built environment are considered negligible in calculating total loss. However, it is noted that there are other ecological, cultural, and social benefits to undertaking wetland/riparian enhancement that are not monetised through this assessment, and are only considered within the MCDA by the CAP.

- Raised or flood-proofed buildings: the selected buildings are assumed to be fully protected from flood damages over the epoch and are excluded from the exposure count over the epoch period.

- For the new and enhanced protection works and Accommodate Adaptation Actions the measures are assumed to only be effective in the epoch it is applied to, and completely ineffective in any future epochs in a pathway. Buildings are included in the exposure count in future epochs unless protected by other Actions (e.g., retreat). An example is that it is assumed that enhanced stopbanks could be outflanked by higher water levels (resulting from SLR) by the start of the next epoch thus allowing a pathway for inundation of a similar area.
- Retreat: the selected buildings are excluded from the exposure count for the epoch and any future epochs in the pathway.

- For accommodate (raising or floodproofing buildings) and retreat options, it is assumed that these options would only apply to buildings flooded with 10 cm above floor flooding (e.g. water depths of 0.325m). Therefore, the residual losses after these options are applied are buildings flooded up to 0.325 m.

Appendix A: The top three ranked adaptation pathways from MCDA for each Management Unit

Management Unit 1A – Otaki Beach Erosion

Management Unit	Pathway	MCDA Ranking	Short Term	Medium Term	Long Term
1A	Pathway 5	1	**Enhance** *Increase dune resilience by foreshore and backshore planting and education and emergency management.*	**Enhance** *Increase dune resilience by foreshore and backshore planting and education and emergency management.*	**Retreat** *Proactively moving people out of the way of the hazard.*
			Actions include: - 8.4 Ha of foredune planting, and 3.1 Ha of back dune planting. - Sand trap fencing along total 2800 m length of shoreline in management unit. - Plant and animal pest control - Planting maintenance - Community education and emergency management	**Actions include:** - Replanting of foredune (8.4 Ha). - Re-construction of sand trap fencing along total 2800 m length of management unit shoreline. - Plant and animal pest control - Planting maintenance - Community education and emergency management	**Actions include:** - For modelling purposes, retreat of properties exposed to erosion by 2130.
			Effectiveness: Reduces erosion rates by 50% for 20 years.	**Effectiveness**: Reduce erosion rates by 30% for 20 years.	**Effectiveness:** No impact of erosion rates, reduction in risk to private properties.
	Pathway 4	2	**Enhance** *Increase dune resilience by foreshore and backshore planting and education and emergency management.*	**Soft Engineering Protection (Renourishment)** *Importing sand and distributing it on the foreshore to supply more bulk to the beach profile.*	**Retreat** *Proactively moving people out of the way of the hazard.*

			Actions include: - 8.4 Ha of foredune planting, and 3.1 Ha of back dune planting. - Sand trap fencing along total 2800 m length of shoreline in management unit. - Plant and animal pest control - Planting maintenance - Community education and emergency management	**Actions include:** - Source and transport of 8,400 m^3 sediment to maintain the dune to at 2m RL along 2800 m of coastline. Foredune planting of a 10m strip on dune toe. - Machinery hire and labour costs to rework sediment into beach at rate of 40 m/day (e.g. 70 days) - Renourishment and replanting of 10 m strip of foredune plants (2.8 Ha) occurs every 5 years.	**Actions include:** - For modelling purposes, retreat of properties exposed to erosion by 2130.
			Effectiveness: Reduces erosion rates by 50% for 20 years.	**Effectiveness:** Reduce erosion rates by 50% for 20 years	**Effectiveness:** No impact of erosion rates, reduction in risk to private properties.
	Pathway 1	3	**Enhance** *Increase dune resilience by foreshore and backshore planting, and education and emergency management.*	**Enhance** *Increase dune resilience by foreshore and backshore planting, and education and emergency management.*	**Soft Engineering Protection (Renourishment)** *Importing sand and distributing it on the foreshore to supply more bulk to the beach profile.*

			Actions include: - 8.4 Ha of foredune planting, and 3.1 Ha of back dune planting. - Sand trap fencing along total 2800 m length of shoreline in management unit. - Plant and animal pest control - Planting maintenance - Community education and emergency management	**Actions include:** - Replanting of foredune (8.4 Ha). - Re-construction of sand trap fencing along total 2800 m length of management unit shoreline. - Plant and animal pest control - Planting maintenance - Community education and emergency management	**Actions include:** - Source and transport of 15,200 m^3 sediment to maintain the dune to at 2m RL along 2800 m of coastline. Foredune planting of a 10m strip on dune toe. - Machinery hire and labour costs to rework sediment into beach at rate of 40 m/day (e.g. 70 days) - Renourishment and replanting of 10 m strip of foredune plants (2.8 Ha) occurs every 5 years.
			Effectiveness: reduce erosion rates by 50% for 20 years	**Effectivenes**s: reduce erosion rates by 30% for 20 years	**Effectiveness:** reduce erosion rates by 30% for 60 years

Management Unit 1B – Otaki Inundation

<table>
<tr><th>Management Unit</th><th>Pathway</th><th>MCDA Ranking</th><th>Short Term</th><th>Medium Term</th><th>Long Term</th></tr>
<tr><td rowspan="3">1B</td><td rowspan="3">Pathway 3</td><td rowspan="3">1</td><td><u>Enhance</u>
Strengthen existing structures and infrastructure and enhance coastal wetlands.</td><td><u>Accommodate</u>
Pro-actively raise floors of homes which could be flooded</td><td><u>Retreat</u>
Proactively moving people out of the way of the hazard.</td></tr>
<tr><td>Actions include:
- Install flap valve on outfall at Karaka Street.
- Extend the stopbank 150 m around Atkinson Avenue/Marine Parade
- Maintain/clear existing floodgates at the Rangiuru Stream
- Wetland planting and ongoing maintenance around Waitohu Stream, Kapiti Lane, Rangiuru Road, and Mountainview Terrace around existing wetland areas.</td><td>Actions include:
- Raising of 50% of properties affected that have 0.325 m water depth on property.
- Flood-proofing of 50% of properties that have 0.325 m of water depth on property.</td><td>Actions include:
- For modelling purposes, retreat of properties exposed to 0.325 m water depth over this time period.</td></tr>
<tr><td>Effectiveness:
Reduction in properties flooded around Karaka Street. Some properties around Atkinson Avenue still could be flooded from low lying landward sources.</td><td>Effectiveness: Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.</td><td>Effectiveness: Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.</td></tr>
<tr><td></td><td></td><td>2</td><td><u>Enhance</u></td><td><u>Additional Hard Protection</u></td><td><u>Retreat</u></td></tr>
</table>

	Pathway 2		*Strengthen existing structures and infrastructure and enhance coastal wetlands.*	*Installation of floodgates, pump stations and stopbanks to prevent sea water entering the settlements*	*Proactively moving people out of the way of the hazard.*
			Actions include: - Install flap valve on outfall at Karaka Street. - Extend the stopbank 150 m around Atkinson Avenue/Marine Parade - Maintain/clear existing floodgates at the Rangiuru Stream - Wetland planting and ongoing maintenance around Waitohu Stream, Kapiti Lane, Rangiuru Road, and Mountainview Terrace around existing wetland areas. -	**Actions include:** - 1450 m stopbank along Rangiuru Stream. - 850 m stopbank along Rangiuru road - Installation of a flap valve on Moana Street outfall.	**Actions include:** - For modelling purposes, removes residual risk within timeframe for 1 in 100 year effected houses at 0.325m water depth.
			Effectiveness: Reduction in properties flooded around Karaka Street. Some properties around Atkinson Avenue still could be flooded from low lying landward sources.	**Effectiveness:** Risk to properties within the stop banked areas reduced along Rangiuru Road and Rangiuru Stream. Risks of flooding along Moana Street network reduced.	**Effectiveness:** Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.
	Pathway 1	3	**Enhance** *Strengthen existing structures and infrastructure and enhancing coastal wetlands.*	**Accommodate** *Pro-actively raise floors of homes which could be flooded*	**Additional Hard Protection** *Installation of floodgates, pump stations and stopbanks to prevent sea water entering the settlements*

			Actions include: - Install flap valve on outfall at Karaka Street. - Extend the stopbank 150 m around Atkinson Avenue/Marine Parade - Maintain/clear existing floodgates at the Rangiuru Stream - Wetland planting and ongoing maintenance around Waitohu Stream, Kapiti Lane, Rangiuru Road, and Mountainview Terrace around existing wetland areas.	**Actions include:** - Raising of 50% of properties affected that have 0.325 m water depth on property. - Flood-proofing of 50% of properties that have 0.325 m of water depth on property.	**Actions include:** - Stop banking around properties: - 2000 m stopbank along Rangiuru Stream. - 1200 m stopbank along Rangiuru road - 200 m at Waitohu Stream. - Installation of a flap valve at Moana Street outfall. - Installation of Pump station at Moana Street - New pump station at Karaka Street
			Effectiveness: Reduction in properties flooded around Karaka Street. Some properties around Atkinson Avenue still could be flooded from low lying landward sources.	**Effectiveness**: Removes residual risk within timeframe for 1 in 100 year effected houses at 0.325m water depth.	**Effectiveness:** Risk to properties within the stop banked areas reduced. Risks of flooding at Karaka Street and Moana Street reduced.

Management Unit 2A – Te Horo Beach Erosion

Management Unit	Pathway	MCDA Ranking	Short Term	Medium Term	Long Term
2A	Pathway 5	1	**<u>Enhance</u>** *Increase dune resilience by foreshore and backshore planting and education and emergency management.*	**<u>Enhance</u>** *Increase dune resilience by foreshore and backshore planting and education and emergency management.*	**<u>Retreat</u>** *Proactively moving people out of the way of the hazard.*
			Actions include: - 10.3 Ha of foredune planting; and 7.3 Ha of back dune planting. - Sand trap fencing along total 3600 m length of shoreline in management unit. - Plant and animal pest control - Planting maintenance - Community education and emergency management	**Actions include:** - Replanting of foredune (10.3 Ha). - Re-construction of sand trap fencing along total 3600 m length of management unit shoreline. - Plant and animal pest control - Planting maintenance - Community education and emergency management	**Actions include:** - For modelling purposes, retreat of properties still exposed to reduced erosion hazard by 2130.
			Effectiveness: Reduce erosion rates by 50% for 20 years	**Effectiveness:** Reduce erosion rates by 30% for 20 years	**Effectiveness:** No impact on erosion rates, reduction in risk to private properties.
	Pathway 4	2	**<u>Enhance</u>** *Increase dune resilience by foreshore and backshore planting and education and emergency management.*	**<u>Soft Engineering Protection (Renourishment)</u>** *Importing sand/gravel and distributing it on the foreshore to supply more bulk to the beach profile.*	**<u>Retreat</u>** *Proactively moving people out of the way of the hazard.*

			Actions include: - 10.3 Ha of foredune planting; and 7.3 Ha of back dune planting. - Sand trap fencing along total 3600 m length of shoreline in management unit. - Plant and animal pest control - Planting maintenance - Community education and emergency management	**Actions include:** - Source and transport of 2,100 m^3 sediment to maintain the dune to at 2m RL along 700 m of coastline. Foredune planting of a 10m strip on dune toe. - Machinery hire and labour costs to rework sediment into beach at rate of 40 m/day (e.g. 18 days) - Renourishment and replanting of 10 m strip of foredune plants (0.7 Ha) occurs every 5 years.	**Actions include:** - For modelling purposes, retreat of properties still exposed to reduced erosion hazard by 2130.
			Effectiveness: Reduces erosion rates by 50% for 20 years.	**Effectiveness:** reduce erosion rates by 50% for 20 years	**Effectiveness:** No impact of erosion rates, reduction in risk to private properties.
	Pathway 1	3	**Enhance** *Increase dune resilience by foreshore and backshore planting and education and emergency management.*	**Enhance** *Increase dune resilience by foreshore and backshore planting and education and emergency management.*	**Soft Engineering Protection (Renourishment)** *Importing sand and distributing it on the foreshore to supply more bulk to the beach profile.*

			Actions include: - 10.3 Ha of foredune planting; and 7.3 Ha of back dune planting. - Sand trap fencing along total 3600 m length of shoreline in management unit. - Plant and animal pest control - Planting maintenance - Community education and emergency management	**Actions include:** - Replanting of foredune (10.3 Ha). - Re-construction of sand trap fencing along total 3600 m length of management unit shoreline. - Plant and animal pest control - Planting maintenance - Community education and emergency management	**Actions include:** - Source and transport of 3,300 m^3 sediment to maintain the dune to at 2m RL along 700 m of coastline. Foredune planting of a 10m strip on dune toe. - Machinery hire and labour costs to rework sediment into beach at rate of 40 m/day (e.g. 18 days) - Renourishment and replanting of 10 m strip of foredune plants (0.7 Ha) occurs every 5 years.
			Effectiveness: Reduce erosion rates by 50% for 20 years	**Effectivenes**s: Reduce erosion rates by 30% for 20 years	**Effectiveness: R**educe erosion rates by 30% for 60 years

Management Unit 2B – Te Horo Inundation

<table>
<tr><th>Management Unit</th><th>Pathway</th><th>MCDA Ranking</th><th>Short Term</th><th>Medium Term</th><th>Long Term</th></tr>
<tr><td rowspan="4">2B</td><td rowspan="3">Pathway 3</td><td rowspan="3">1</td><td><u>Enhance</u>
Strengthen existing structures and infrastructure and enhance coastal wetlands.</td><td><u>Accommodate</u>
Pro-actively raise floors of homes which could be flooded</td><td><u>Retreat</u>
Proactively moving people out of the way of the hazard.</td></tr>
<tr><td>Actions include:
- Raise 50 m of road at end of Te Horo Beach Road
- Install a flap valve on drain into Mangaone Stream.
- Riparian management along Mangaone Stream.</td><td>Actions include:
- Raising of 50% of properties affected that have 0.325 m water depth on property.
- Flood-proofing of 50% of properties that have 0.325 m of water depth on property.</td><td>Actions include:
- For modelling purposes, retreat of properties exposed to 0.325 m water depth over this time period.</td></tr>
<tr><td>Effectiveness: Risk to properties directly around Mangaone stream mouth reduced.</td><td>Effectiveness: Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.</td><td>Effectiveness: Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.</td></tr>
<tr><td>Pathway 2</td><td>2</td><td><u>Enhance</u>
Strengthen existing structures and infrastructure and enhance coastal wetlands.</td><td><u>Additional Hard Protection</u>
Installation of floodgates, pump stations and stopbanks to prevent sea water entering the settlements</td><td><u>Retreat</u>
Proactively moving people out of the way of the hazard.</td></tr>
</table>

			Actions include: - Raise 50 m of road at end of Te Horo Beach Road - Install a flap valve on drain into Mangaone Stream. - Riparian management along Mangaone Stream.	**Actions include**: - Build 250 m of stop banking along Te Horo Beach Road from the raised road end to Sims Road.	**Actions include:** - For modelling purposes, retreat of properties exposed to 0.325 m water depth over this time period.
			Effectiveness: Risk to properties directly around Mangaone stream mouth reduced.	**Effectiveness:** Risk to properties directly around Mangaone stream mouth reduced.	**Effectiveness:** Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.
	Pathway 1	3	**Enhance** *Strengthen existing structures and infrastructure and enhancing coastal wetlands.*	**Accommodate** *Pro-actively raise floors of homes which could be flooded*	**Additional Hard Protection** *Installation of floodgates, pump stations and stopbanks to prevent sea water entering the settlements*
			Actions include: - Raise 50 m of road at end of Te Horo Beach Road - Install a flap valve on drain into Mangaone Stream. - Riparian management along Mangaone Stream.	**Actions include:** - Raising of 50% of properties affected that have 0.325 m water depth on property. - Flood-proofing of 50% of properties that have 0.325 m of water depth on property.	**Actions include:** - 700 m of stop banking from Sims Road east along Te Horo Beach Road around the front of most seaward properties.
			Effectiveness: Risk to properties directly around Mangaone stream mouth reduced.	**Effectiveness**: Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.	**Effectiveness:** Risk to properties directly around Mangaone stream mouth reduced.

Management Unit 3A – Peka Peka Erosion

<table>
<tr><th>Management Unit</th><th>Pathway</th><th>MCDA Ranking</th><th>Short Term</th><th>Medium Term</th><th>Long Term</th></tr>
<tr><td rowspan="4">3A</td><td rowspan="3">Pathway 5</td><td rowspan="3">1</td><td><u>Enhance</u>
Increase dune resilience by foreshore and backshore planting and education and emergency management.</td><td><u>Enhance</u>
Increase dune resilience by foreshore and backshore planting and education and emergency management.</td><td><u>Retreat</u>
Proactively moving people out of the way of the hazard.</td></tr>
<tr><td>Actions include:
- 9.2 Ha of foredune planting; and 6.4 ha of back dune planting.
- Sand trap fencing along total 2650 m length of shoreline in management unit.
- Plant and animal pest control
- Planting maintenance
- Community education and emergency management</td><td>Actions include:
- Replanting of foredune (9.2 Ha).
- Re-construction of sand trap fencing along total 2650 m length of management unit shoreline.
- Plant and animal pest control
- Planting maintenance
- Community education and emergency management</td><td>Actions include:
- For modelling purposes, retreat of properties still exposed to reduced erosion hazard by 2130.</td></tr>
<tr><td>Effectiveness: Reduces erosion rates by 50% for 20 years.</td><td>Effectiveness: Reduce erosion rates by 30% for 20 years.</td><td>Effectiveness: No impact of erosion rates, reduction in risk to private properties.</td></tr>
<tr><td>Pathway 4</td><td>2</td><td><u>Enhance</u>
Increase dune resilience by foreshore and backshore planting and education and emergency management.</td><td><u>Soft Engineering Protection (Renourishment)</u>
Importing sand and distributing it on the foreshore to supply more bulk to the beach profile.</td><td><u>Retreat</u>
Proactively moving people out of the way of the hazard.</td></tr>
</table>

			Actions include: - 9.2 Ha of foredune planting; and 6.4 ha of back dune planting. - Sand trap fencing along total 2650 m length of shoreline in management unit. - Plant and animal pest control - Planting maintenance - Community education and emergency management	**Actions include:** - Source and transport of 5,100 m^3 sediment to maintain the dune to at 2m RL along 1700 m of coastline. Foredune planting of a 10 m strip on dune toe. - Machinery hire and labour costs to rework sediment into beach at rate of 40 m/day (e.g. 43 days) - Renourishment and replanting of 10 m strip of foredune plants (1.7 Ha) occurs every 5 years.	**Actions include:** - For modelling purposes, retreat of properties still exposed to reduced erosion hazard by 2130.
			Effectiveness: Reduces erosion rates by 50% for 20 years.	**Effectiveness:** reduce erosion rates by 50% for 20 years	**Effectiveness:** No impact on erosion rates, reduction in risk to private properties.
	Pathway 1	3	**<u>Enhance</u>** *Increase dune resilience by foreshore and backshore planting and education and emergency management.*	**<u>Enhance</u>** *Increase dune resilience by foreshore and backshore planting and education and emergency management.*	**<u>Soft Engineering Protection (Renourishment)</u>** *Importing sand and distributing it on the foreshore to supply more bulk to the beach profile.*
			Actions include: - 9.2 Ha of foredune planting; and 6.4 ha of back dune planting. - Sand trap fencing along total 2650 m length of shoreline in management unit. - Plant and animal pest control	**Actions include:** - Replanting of foredune (9.2 Ha). - Re-construction of sand trap fencing along total 2650 m length of management unit shoreline. - Plant and animal pest control	**Actions include:** - Source and transport of 11,300 m^3 sediment to maintain the dune toe at 2 m RL along 1700 m of coastline. Foredune planting of a 10m strip on dune toe. - Machinery hire and labour costs to rework sediment into beach

			- Planting maintenance - Community education and emergency management	- Planting maintenance - Community education and emergency management	at rate of 40 m/day (e.g. 43 days) - Renourishment and replanting of 10 m strip of foredune plants (1.7 Ha) occurs every 5 years.
			Effectiveness: reduce erosion rates by 50% for 20 years	**Effectivenes**s: reduce erosion rates by 30% for 20 years	**Effectiveness:** reduce erosion rates by 30% for 60 years

Management Unit 3B – Peka Peka Inundation

Management Unit	Pathway	MCDA Ranking	Short Term	Medium Term	Long Term
3B	Pathway 3	1	**Enhance** *Strengthen existing structures and infrastructure and enhance coastal wetlands.*	**Accommodate** *Pro-actively raise floors of homes which could be flooded*	**Retreat** *Proactively moving people out of the way of the hazard.*
			Actions include: - Installation of flap valve for Marram Way outfall - Wetland enhancement around Te Harakeke Wetland.	**Actions include:** - Raising of 50% of properties affected that have 0.325 m water depth on property. - Flood-proofing of 50% of properties that have 0.325 m of water depth on property.	**Actions include:** - For modelling purposes, retreat of number of properties exposed to 0.325 m water depth over this time period.
			Effectiveness: Reduces flood risk to properties flooded around Marram Way	**Effectiveness**: Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.	**Effectiveness:** Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.
	Pathway 2	2	**Enhance** *Strengthen existing structures and infrastructure and enhance coastal wetlands.*	**Additional Hard Protection** *Installation of floodgates, pump stations and stopbanks to prevent sea water entering the settlements*	**Retreat** *Proactively moving people out of the way of the hazard.*

			3Actions include: - Installation of flap valve for Marram Way outfall - Wetland enhancement around Te Harakeke Wetland.	**Actions include:** - Install a flood gate on Peka Peka Road	**Actions include:** - For modelling purposes, retreat of number of properties exposed to 0.325 m water depth over this time period.
			Effectiveness: Reduces flood risk to properties flooded around Marram Way	**Effectiveness:** Reduces flood risk to properties south of Peka Peka Road.	**Effectiveness:** Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.
	Pathway 1	3	<u>**Enhance**</u> *Strengthen existing structures and infrastructure and enhancing coastal wetlands.*	<u>**Accommodate**</u> *Pro-actively raise floors of homes which could be flooded*	<u>**Additional Hard Protection**</u> *Installation of floodgates, pump stations and stopbanks to prevent sea water entering the settlements*
			Actions include: - Installation of flap valve for Marram Way outfall - Wetland enhancement around Te Harakeke Wetland.	**Actions include:** - Raising of 50% of properties affected that have 0.325 m water depth on property. - Flood-proofing of 50% of properties that have 0.325 m of water depth on property.	**Actions include:** - Construct 150 m stopbank along the stream from Raukawa Road - Expand Marram Way stormwater network 250 m to the north and 250 m to the south. - Install pump station around Marram Way.
			Effectiveness: Reduces flood risk to properties flooded around Marram Way	**Effectiveness**: Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.	**Effectiveness:** Reduces residual risk to properties around Marram Way and around Ruakawa Road.

Management Unit 4A – Northern Rural Erosion

Management Unit	Pathway	MCDA Ranking	Short Term	Medium Term	Long Term
4A	Pathway 1	1	**Status Quo** *No additional changes to current management of the erosion hazard*	**Enhance** *Increase dune resilience by foreshore and backshore planting and education and emergency management.*	**Enhance** *Increase dune resilience by foreshore and backshore planting and education and emergency management.*
			Actions include: - Averaged Capital and Operational Coastal Management Costs from Long Term Plan 2021-41	**Actions include:** - 19.3 Ha of foredune planting; and 12.8 ha of back dune planting. - Sand trap fencing along total 6600 m of shoreline in the management unit. - Plant and animal pest control - Planting maintenance - Community education and emergency management	**Actions include:** - Replanting of foredune (19.3 Ha). - Re-construction of sand trap fencing along total 6600 m length of management unit shoreline. - Plant and animal pest control - Planting maintenance - Community education and emergency management
			Effectiveness: Limited effectiveness	**Effectiveness:** Reduce erosion rates by 30% for 20 years	**Effectiveness:** Reduce erosion rates by 10% for 60 years
	Pathway 3	2	**Status Quo** *No additional changes to current management of the erosion hazard*	**Enhance** *Increase dune resilience by foreshore and backshore planting and education and emergency management.*	**Soft Engineering Protection** *Beach renourishment and beach scraping.*

			Actions include: - Averaged Capital and Operational Coastal Management Costs from Long Term Plan 2021-41	**Actions include:** - 19.3 Ha of foredune planting; and 12.8 ha of back dune planting. - Sand trap fencing along total 6600 m of shoreline in the management unit. - Plant and animal pest control - Planting maintenance - Community education and emergency management	**Actions include:** - Beach scraping over 1200m of coastline (south of Otaki River mouth) including machinery and labour to undertake scraping at rate of 40 m/day (e.g. 30 days) - Source and transport of 9,500 m^3 sediment to maintain the dune to at 2m RL along 5000 m of coastline. Foredune planting of a 10m strip on dune toe. - Machinery hire and labour costs to rework sediment into beach at rate of 40 m/day (e.g. 125 days) - Renourishment and replanting of 10 m strip of foredune plants (5 Ha) occurs every 5 years.
			Effectiveness: Limited effectiveness	**Effectiveness:** Reduce erosion rates by 30% for 20 years	**Effectiveness:** reduce erosion rates by 30% for 60 years
	Pathway 2	3	**Enhance** *Increase dune resilience by foreshore and backshore planting and education and emergency management.*	**Enhance** *Increase dune resilience by foreshore and backshore planting and education and emergency management.*	**Soft Engineering Protection** *Beach renourishment and beach scraping.*
			Actions include:	**Actions include:**	**Actions include:**

			- 19.3 Ha of foredune planting; and 12.8 ha of back dune planting. - Sand trap fencing along total 6600 m of shoreline in the management unit. - Plant and animal pest control - Planting maintenance - Community education and emergency management	- Replanting of foredune (19.3 Ha). - Re-construction of sand trap fencing along total 6600 m length of management unit shoreline. - Plant and animal pest control - Planting maintenance - Community education and emergency management	- Beach scraping over 1200m of coastline (south of Otaki River mouth) including machinery and labour to undertake scraping at rate of 40 m/day (e.g. 30 days) - Source and transport of 9,500 m^3 sediment to maintain the dune to at 2 m RL along 5000 m of coastline. Foredune planting of a 10m strip on dune toe. - Machinery hire and labour costs to rework sediment into beach at rate of 40 m/day (e.g. 125 days) - Renourishment and replanting of 10 m strip of foredune plants (5 Ha) occurs every 5 years.
			Effectiveness: reduce erosion rates by 50% for 20 years	**Effectiveness:** reduce erosion rates by 30% for 20 years	**Effectiveness:** reduce erosion rates by 30% for 60 years

Management Unit 4B – Northern Rural Inundation

Management Unit	Pathway	MCDA Ranking	Short Term	Medium Term	Long Term
4B	Pathway 1	1	**Status Quo** *No additional changes to current management of the inundation hazard*	**Enhance** *Strengthen existing stopbanks and structures and enhance coastal wetlands.*	**Accommodate** *Pro-actively raise floors of homes which could be flooded*
			Actions include: - Averaged Capital and Operational Coastal Management Costs from Long Term Plan 2021-41	**Actions include:** - Install floodgate at Tasman Road culvert (Otaki) - Flap valve on Tasman Road (Otaki) - Wetland enhancement around Peka Peka Road Swamp, Te Hapua Swamp Complex A.	**Actions include:** - Raising of 50% of properties affected that have 0.325 m water depth on property. - Flood-proofing of 50% of properties that have 0.325 m of water depth on property.
			Effectiveness: Limited effectiveness.	**Effectiveness:** Reduce flooding on the northern side of Tasman Road.	**Effectiveness**: Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.
	Pathway 2	2	**Accommodate** *Pro-actively raise floors of homes which could be flooded*	**Accommodate** *Pro-actively raise floors of homes which could be flooded*	**Retreat** *Proactively moving people out of the way of the hazard.*

			Actions include: - Raising of 50% of properties affected that have 0.325 m water depth on property. - Flood-proofing of 50% of properties that have 0.325 m of water depth on property.	**Actions include:** - Raising of 50% of properties affected that have 0.325 m water depth on property. - Flood-proofing of 50% of properties that have 0.325 m of water depth on property.	**Actions include:** - For modelling purposes, retreat of number of properties exposed to 0.325 m water depth over this time period.
			Effectiveness: Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.	**Effectiveness**: Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.	**Effectiveness:** Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.

Management Unit 5A – Waikanae Beach Erosion

Management Unit	Pathway	MCDA Ranking	Short Term	Medium Term	Long Term
5A	Pathway 1	1	**Enhance** *Increased dune resilience by foreshore and backshore planting, increased community education and emergency management.*	**Soft Engineering Protection (Dune reconstruction)** *Reconstructing the dune by distributing imported sand across the existing dune and reshaping to improve crest elevation and slope. The reshaped dune could be planted to optimise protection.*	**Soft Engineering Protection (Renourishment)** *Importing sand and distributing it on the foreshore to supply more bulk to the beach profile.*
			Actions include: - 11.1 Ha of foredune planting, and 5.1 Ha of back dune planting. - Sand trap fencing along total 3900 m length of shoreline in management unit. - Plant and animal pest control - Planting maintenance - Community education and emergency management	**Actions include:** - Machinery and labour to re-construct the dune along 3900 m length of shoreline, assuming a linear rate of 40 m/day (e.g. 98 days). - Replanting of foredune (11.1 Ha) and Back dune (5.2 Ha) - Plant and animal pest control - Planting maintenance	**Actions include:** - Sourcing sand supply of 11,900 m^3 sediment to maintain the dune to at 2m RL along 3900 m of coastline. Foredune planting of a 10m strip on dune toe. - Machinery hire and labour costs to rework sediment into beach at rate of 40 m/day (e.g. 98 days) - Renourishment and replanting of 10 m strip of foredune plants (3.9 Ha) occurs every 5 years.

			Effectiveness: Reduce erosion rates by 50% for 20 years	**Effectiveness:** Reduce erosion rates by 50% for 20 years	**Effectiveness:** Reduce erosion rates by 30% for 60 years
	Pathway 6	2	**Enhance & Soft Engineering (Dune reconstruction)** *Increased dune resilience by foreshore and backshore planting and dune reconstruction, increased community education and emergency management.*	**Retreat** *Proactively and progressively retreating properties as they become impacted by the hazard*	**Retreat** *Proactively and progressively retreating properties as they become impacted by the hazard*
			Actions include: - Machinery and labour to re-construct the dune along 3900 m length of shoreline, assuming a linear rate of 40 m/day (e.g. 98 days). - Replanting of foredune (11.1 Ha) and Back dune (5.2 Ha) - Plant and animal pest control - Planting maintenance - Community education and emergency management	**Actions include:** - For modelling purposes, retreat of properties exposed to erosion by 2070.	**Actions include:** - For modelling purposes, retreat of properties exposed to erosion by 2130.
			Effectiveness: Reduce erosion rates by 70% for 30 years	**Effectiveness:** No impact of erosion rates, reduction in risk to private properties.	**Effectiveness:** No impact of erosion rates, reduction in risk to private properties.

	Pathway 2	3	**<u>Enhance & Soft Engineering (Dune reconstruction)</u>** *Increased dune resilience by foreshore and backshore planting and dune reconstruction, increased community education and emergency management.*	**<u>Enhance & Soft Engineering Protection (Renourishment)</u>** *Increased dune resilience by foreshore and backshore planting and beach renourishment, increased community education and emergency management.*	**<u>Hard Engineering – Sea wall</u>** *Sea wall along the front of the settlement.*
			Actions include: - Machinery and labour to re-construct the dune along 3900 m length of shoreline, assuming a linear rate of 40 m/day (e.g. 98 days). - Replanting of foredune (11.1 Ha) and Back dune (5.2 Ha) - Plant and animal pest control - Planting maintenance - Community education and emergency management	**Actions include:** - Source and transport of 5,850 m^3 sediment to maintain the dune to at 2m RL along 3900 m of coastline. Foredune planting of a 10m strip on dune toe. - Machinery hire and labour costs to rework sediment into beach at rate of 40 m/day (e.g. 98 days) - Renourishment and replanting of 10 m strip of foredune plants (3.9 Ha) occurs every 5 years. - Community education and emergency management	**Actions include:** - 3900 m length of seawall - Maintenance of seawall
			Effectiveness: Reduce erosion rates by 70% for 20 years	**Effectiveness:** Reduce erosion rates by 50% for 20 years	**Effectiveness:** Reduce erosion rates by 100% for 60 years

Management Unit 5B - Waikanae Beach Inundation

Management Unit	Pathway	MCDA Ranking	Short Term	Medium Term	Long Term
5B	Pathway 3	2	**<u>Enhance</u>** *Enhance existing inundation protection, and coastal wetlands, and increase community education and emergency management*	**<u>Enhance</u>** *Enhance existing inundation protection, and coastal wetlands, and increase community education and emergency management*	**<u>Accommodate</u>** *Pro-actively raise floors of homes which could be flooded*
			Actions include: - Raise 50 m of embankment at Waimanu inlet. - Install a flap valve on outlet at Hona street into the Waimeha stream. - Install a flap valve at Lavinia Grove into Waimeha stream - Install a flap valve at Hemara Street outfall (or enhance P/S) - Wetland enhancement around Waimeha Lagoon and Te Harakeke Wetland. - Community education and emergency management	**Actions include:** - Install a flap valve at Titoki Road outfall - Extend 300m of embankment at Waimanu lagoon mouth - Wetland enhancement around Waimeha Lagoon and Te Harakeke Wetland. - Community education and emergency management	**Actions include:** - Raising of 50% of properties affected that have 0.325 m water depth on property. - Flood-proofing of 50% of properties that have 0.325 m of water depth on property.
			Effectiveness: - Reduce risk to properties around Waimanu lagoon.	**Effectiveness:** Reduce properties flooded around titoki road and properties around the edges of Waimanu lagoon.	**Effectiveness**: Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.

			- Reduce number of properties flooded around Hona Street and Lavinia Grove.		
	Pathway 4	3	**Enhance** *Enhance existing inundation protection, and coastal wetlands, and increase community education and emergency management*	**Accommodate** *Pro-actively raise floors of homes which could be flooded, flood proof homes and infrastructure*	**Retreat** *Proactively and progressively retreating properties as they become impacted by the hazard*
			Actions include: - Raise 50 m of embankment at Waimanu inlet. - Install a flap valve on outlet at Hona street into the Waimeha stream. - Install a flap valve at Lavinia Grove into Waimeha stream - Install a flap valve at Hemara Street outfall (or enhance P/S) - Wetland enhancement around Waimeha Lagoon and Te Harakeke Wetland. - Community education and emergency management	**Actions include:** - Raising of 50% of properties affected that have 0.325 m water depth on property. - Flood-proofing of 50% of properties that have 0.325 m of water depth on property.	**Actions include:** - For modelling purposes retreat buildings flooded with water depths >0.325 m within a 1 in 100-year flood.
			Effectiveness: Reduce risk to properties around Waimanu lagoon. Reduce risk to a number of properties flooded around Hona Street and Lavinia Grove.	**Effectiveness**: Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.	**Effectiveness:** Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.

	Pathway 5	1	**<u>Enhance</u>** *Enhance existing inundation protection, and coastal wetlands, and increase community education and emergency management*	**<u>Protect – Additional Hard Protection</u>** *Installation of floodgates, pump stations and stopbanks to prevent sea water entering the settlements*	**<u>Retreat</u>** *Proactively and progressively retreating properties as they become impacted by the hazard*
			Actions include: - Raise 50 m of embankment at Waimanu inlet. - Install a flap valve on outlet at Hona street into the Waimeha stream. - Install a flap valve at Lavinia Grove into Waimeha stream - Install a flap valve at Hemara Street outfall (or enhance P/S) - Wetland enhancement around Waimeha Lagoon and Te Harakeke Wetland. - Community education and emergency management	**Actions included:** - Construct 300 m of embankment at Waimanu Lagoon mouth. - 450 m stopbank from Huiawa Street to Te Moana Road along Waimeha Stream. - Install flap valve on Titoki Road outfall - Construct 250 m stopbank from Hodgkins Road to Titoki Road.	**Actions include:** - For modelling purposes, retreat of properties exposed to 0.325 m water depth over this time period.
			Effectiveness: - Reduce residual risk to properties around Waimanu Lagoon - Reduce properties flooded at Hona Street - Reduce properties flooded at Lavinia Grove.	**Effectiveness:** - Reduce residual risk to properties around Waimanu Lagoon - Reduce properties flooded around Huiawa Street. - Reduce properties flooded around Tikotu Road. - Reduce properties flooded on South west side of Titoki Road to Hodgkins Road along the stream.	**Effectiveness:** Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.

Management Unit 6A & 6B – Waikanae Estuary

Management Unit	Pathway	MCDA Ranking	Short Term	Medium Term	Long Term
6A & 6B	Pathway 5	1	**Enhance** *Wetland planting and management to increase resilience, increase community education and emergency management*	**Retreat** *Retreating recreational infrastructure to make way for wetland migration*	**Retreat** *Retreating recreational infrastructure to make way for wetland migration*
			Actions include: - 8.3 Ha of wetland planting (30 m strip of planting around the estuary edge) - Community education and emergency management	**Actions include:** - Retreat of 200 m of walking/cycle path at south-eastern edge of the estuary.	**Actions include:** - Retreat a further 150m of accessways/pathways to the estuary at northern and southern edges of the estuary.
			Effectiveness: Reduce erosion by 50%	**Effectiveness:** No impact on erosion rates.	**Effectiveness:** No impact on erosion rates.
	Pathway 3	2	**Enhance** *Wetland planting and management to increase resilience, increase community education and emergency management*	**Enhance** *Wetland planting and management to increase resilience, increase community education and emergency management*	**Protect – Bank protection** *Hard bank protection around the edge of the estuary to stabilise the edge.*

			Actions include: - 8.3 Ha of wetland planting (30 m strip of planting around the estuary edge) - Plant and animal pest control - Planting maintenance - Community education and emergency management	**Actions include:** - 4 Ha (approx. 15m additional strip around edge) of wetland planting - Plant and animal pest control - Planting maintenance - Community education and emergency management	**Actions include:** - 700 m length of installation of gabion baskets for bank protection to stabilise the bank.
			Effectiveness: Reduce erosion by 50%	**Effectiveness:** Reduce erosion by 30%	**Effectiveness:** Reduce erosion by 100%
	Pathway 1	3	**<u>Status Quo</u>** *Maintain existing management of infrastructure/wetlands, increase community education and emergency management*	**<u>Enhance</u>** *Wetland planting and management to increase resilience, increase community education and emergency management*	**<u>Enhance</u>** *Wetland planting and management to increase resilience, increase community education and emergency management*
			Actions include: - Averaged Capital and Operational Coastal Management Costs from 2021-41 Long Term Plan - Community education and emergency management	**Actions include:** - 8.1 Ha of wetland planting - Plant and animal pest control - Planting maintenance - Community education and emergency management	**Actions include:** - 4 Ha (approx. 15m additional strip around edge) of wetland planting - Plant and animal pest control - Planting maintenance - Community education and emergency management
			Effectiveness: Limited effectiveness	**Effectiveness:** Reduce erosion by 30%	**Effectiveness:** Reduce erosion by 10%

Management Unit 7B – Otaihanga Inundation

<table>
<tr><th>Management Unit</th><th>Pathway</th><th>MCDA Ranking</th><th>Short Term</th><th>Medium Term</th><th>Long Term</th></tr>
<tr><td rowspan="3">7B</td><td rowspan="3">Pathway 2</td><td rowspan="3">1</td><td><u>Enhance</u>
Enhance existing inundation protection, and wetlands, and increase community education and emergency management</td><td><u>Enhance</u>
Enhance existing inundation protection, and wetlands, and increase community education and emergency management</td><td><u>Accommodate</u>
Pro-actively raise floors of homes which could be flooded, flood proof homes and infrastructure</td></tr>
<tr><td>Actions include:
- Install a flap valve at Otaihanga Road
- Install a flap valve on outfall into Waikanae River at the Otaihanga Domain
- Install a flap valve on outfall at eastern end of adaptation area past Makora Road end into Waikanae River.
- Wetland Enhancement around Waikanae Estuary at Otaihanga Road, and riparian planting along Waikanae River near Otaihanga Domain.
- Community education and emergency management</td><td>Actions include:
- Install a flap valve at Otaihanga Road by Otaihanga Reserve
- Wetland Enhancement around Waikanae Estuary at Otaihanga Road, and Riparian Planting along Waikanae River near Otaihanga Domain
- Community education and emergency management</td><td>Actions include:
- Raising of 50% of properties affected that have 0.325 m water depth on property.
- Flood-proofing of 50% of properties that have 0.325 m of water depth on property.</td></tr>
<tr><td>Effectiveness: Reduce properties being flooded by backwater around Otaihanga Domain and on the eastern side of Otaihanga Road.</td><td>Effectiveness: Reduce properties being flooded around Otaihanga Reserve.</td><td>Effectiveness: Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.</td></tr>
</table>

	Pathway 4	2	**<u>Protect (Additional hard protection)</u>** *Installation of floodgates, pump stations and stopbanks to prevent sea water entering the settlements.*	**<u>Enhance</u>** *Enhance existing inundation protection, and wetlands, and increase community education and emergency management*	**<u>Retreat</u>** *Proactively moving people out of the way of the hazard.*
			Actions include: - Installation of 400 m of stopbanks at Makora Road - Flap valve on stormwater pipe at Makora road into drain - Install a flap valve at Otaihanga Road - Install a flap valve on stormwater outfall into Waikanae River at the Otaihanga Domain - Install a flap valve on outfall at eastern end of adaptation area past Makora Road end into Waikanae River.	**Actions include:** - Install flap valve at Otaihanga Road by Otaihanga Reserve - Wetland Enhancement around Waikanae Estuary at Otaihanga Road, and Riparian Planting along Waikanae River near Otaihanga Domain - Community education and emergency management	**Actions include:** - For modelling purposes, retreat of properties exposed to 0.325 m water depth over this time period.
			Effectiveness: - Reduce properties flooded by Makora Road/Ruru Road. - Reduce properties being flooded by backwater around Otaihanga Domain and eastern side of Otaihanga Road.	**Effectiveness**: Reduce flooded properties around Otaihanga Reserve	**Effectiveness:** Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.

	Pathway 5	3	**<u>Enhance</u>** *Enhance existing inundation protection, and wetlands, and increase community education and emergency management*	**<u>Protect (Additional hard protection)</u>** *Installation of floodgates, pump stations and stopbanks to prevent sea water entering the settlements*	**<u>Protect (Additional hard protection)</u>** *Installation of floodgates, pump stations and stopbanks to prevent sea water entering the settlements*
			Actions include: - Install a flap valve at Otaihanga Road. - Install a flap valve on outfall into Waikanae River at the Otaihanga Domain. - Install a flap valve on outfall at eastern end of adaptation area past Makora Road end into Waikanae River. - Wetland Enhancement around Waikanae Estuary at Otaihanga Road, and Riparian Planting along Waikanae River near Otaihanga Domain - Community education and emergency management	**Actions include:** - Installation of 450 m of stopbanks at Makora Road. - Install flap valve on stormwater pipe at Makora Road.	**Actions include:** - Installation of 400 m of stopbanks along Otaihanga Road. - Installation of 450m of stopbank along Makora Road. - Installation of 300m of stopbank along Makora Road by Toroa Road.
			Effectiveness: Reduce properties being flooded by backwater around Otaihanga Domain and eastern side of Otaihanga Road.	**Effectiveness:** Reduce number of properties flooded around Makora Road stopbank.	**Effectiveness:** Reduce number of properties flooded along Otaihanga Road, Makora Road and Toroa Road/Makora Road.

Management Unit 8A – Paraparaumu Beach Erosion

Management Unit	Pathway	MCDA Ranking	Short Term	Medium Term	Long Term
8A	Pathway 1	1	**Enhance** *Increased dune resilience by foreshore and backshore planting, increased community education and emergency management.*	**Soft Engineering Protection (Dune reconstruction)** *Reconstructing the dune by distributing important sand across the existing dune and reshaping to improve crest elevation and volume. The reshaped dune could be planted to optimise protection.*	**Soft Engineering Protection (Renourishment)** *Beach renourishment - Importing sand and distributing it on the foreshore to supply more bulk to the beach profile.*
			Actions include: - 9.3 Ha of foredune planting, and 4.2 Ha of back dune planting - Sand trap fencing along total 3650 m length of shoreline in management unit. - Plant and animal pest control - Planting maintenance - Community education and emergency management	**Actions include:** - Machinery and labour to re-construct the dune along 3650 m length of shoreline, assuming a linear rate of 40 m/day (e.g. 92 days). - Replanting of foredune (9.3 Ha) and back dune (4.2 Ha) - Plant and animal pest control - Planting maintenance	**Actions include:** - Sourcing sand supply of 6,750 m^3 sediment to maintain the dune to at 2m RL along 3650 m of coastline. Foredune planting of a 10m strip on dune toe. - Machinery hire and labour costs to rework sediment into beach at rate of 40 m/day (e.g. 92 days) - Renourishment and replanting of 10 m strip of foredune plants (3.6 Ha) occurs every 5 years.
			Effectiveness: Reduce erosion rates by 50% for 20 years	**Effectiveness:** Reduce erosion rates by 50% for 20 years	**Effectiveness:** Reduce erosion rates by 30% for 60 years

	Pathway 6	2	**<u>Enhance and Soft Engineering Protection (Dune reconstruction)</u>** *Increased dune resilience by foreshore and backshore planting and dune reconstruction, increased community education and emergency management.*	**<u>Retreat</u>** *Proactively and progressively retreating properties as they become impacted by the hazard*	**<u>Retreat</u>** *Proactively and progressively retreating properties as they become impacted by the hazard*
			Actions include: - Machinery and labour to re-construct the dune along 3650 m length of shoreline, assuming a linear rate of 40 m/day (e.g. 92 days). - Replanting of foredune (9.3 Ha) and back dune (4.2 Ha) - Plant and animal pest control - Planting maintenance - Community education and emergency management	**Actions include:** - For modelling purposes, retreat of properties exposed to erosion by 2070.	**Actions include:** - For modelling purposes, retreat of properties exposed to erosion by 2130.
			Effectiveness: reduce erosion rates by 70% for 30 years	**Effectiveness:** No impact of erosion rates, reduction in risk to private properties.	**Effectiveness:** No impact of erosion rates, reduction in risk to private properties.
	Pathway 2	3	**<u>Enhance and Soft Engineering Protection (Dune reconstruction)</u>** *Increased dune resilience by foreshore and backshore planting and dune reconstruction, increased community education and emergency management.*	**<u>Enhance and Soft Engineering Protection (Renourishment)</u>** *Increased dune resilience by foreshore and backshore planting and beach renourishment, increased community education and emergency management.*	**<u>Hard Engineering – Sea wall</u>** *Sea wall along the front of the settlement.*

			Actions include: - Machinery and labour to re-construct the dune along 3650 m length of shoreline, assuming a linear rate of 40 m/day (e.g. 92 days). - Replanting of foredune (9.3 Ha) and back dune (4.2 Ha) - Plant and animal pest control - Planting maintenance - Community education and emergency management	**Actions include:** - Sourcing sand supply of 3,300 m^3 sediment to maintain the dune to at 2m RL along 3650 m of coastline. Foredune planting of a 10m strip on dune toe. - Machinery hire and labour costs to rework sediment into beach at rate of 40 m/day (e.g. 92 days) - Renourishment and replanting of 10 m strip of foredune plants (3.6 Ha) occurs every 5 years. - Community education and emergency management	**Actions include:** - Construction of 3650 m length sea wall - Costs of maintaining seawall.
			Effectiveness: Reduce erosion rates by 70% for 20 years	**Effectiveness:** Reduce erosion rates by 50% for 20 years	**Effectiveness:** Shoreline does not move landward from where it was at the end of 2070.

Management Unit 8B – Paraparaumu Inundation

Management Unit	Pathway	MCDA Ranking	Short Term	Medium Term	Long Term
8B	Pathway 4	2	**<u>Enhance</u>** *Enhance existing inundation protection, and coastal wetlands, and increase community education and emergency management*	**<u>Accommodate</u>** *Pro-actively raise floors of homes which could be flooded, flood proof homes and infrastructure*	**<u>Retreat</u>** *Proactively and progressively retreating properties as they become impacted by the hazard*
			Actions include: - Install flap valve on stormwater pipes at Mazengarb Road; - Install three flap valves along Kapiti Road. - Riparian planting around Tikotu Stream. - Community education and emergency management	**Actions include:** - Raising of 50% of properties affected that have 0.325 m water depth on property. - Flood-proofing of 50% of properties that have 0.325 m of water depth on property.	**Actions include:** - For modelling purposes, retreat of properties exposed to 0.325 m water depth over this time period.
			Effectiveness: Reduces flooding of properties around Mazengarb and backflow up Tikotu Stream.	**Effectiveness**: Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.	**Effectiveness:** Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.
	Pathway 3	1	**<u>Enhance</u>** *Enhance existing inundation protection, and coastal wetlands, and increase community education and emergency management*	**<u>Enhance</u>** *Enhance existing inundation protection, and coastal wetlands, and increase community education and emergency management*	**<u>Accommodate</u>** *Pro-actively raise floors of homes which could be flooded, flood proof homes and infrastructure*

			Actions include: - Install flap valve on stormwater pipes at Mazengarb Road; - Install three flap valves along Kapiti Road. - Riparian planting around Tikotu Stream. - Community education and emergency management	**Actions include:** - Install flap valve along Marine Parade - Install flap valve at Seaview Road - Install three flap valves around Te Kupe Road and Olive Terrace - Install a flap valve at Nathan Avenue - Riparian planting around Tikotu Stream. - Community education and emergency management	**Actions include:** - Raising of 50% of properties affected that have 0.325 m water depth on property. - Flood-proofing of 50% of properties that have 0.325 m of water depth on property.
			Effectiveness: Reduces flooding of properties around Mazengarb and backflow up Tikotu Stream.	**Effectiveness:** Reduce flooding of private property around Marine Parade, Seaview Road, Te Kupe Road and Olive Terrace, and Nathan Avenue.	**Effectiveness**: Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.
	Pathway 5	3	<u>**Enhance**</u> *Enhance existing inundation protection, and coastal wetlands, and increase community education and emergency management*	<u>**Protect – Additional hard protection**</u> *Installation of floodgates, pump stations and stopbanks to prevent sea water entering the settlements*	<u>**Retreat**</u> *Proactively and progressively retreating properties as they become impacted by the hazard*
			Actions include: - Install flap valve on stormwater pipes at Mazengarb Road; - Install three flap valves along Kapiti Road. - Riparian planting around Tikotu Stream.	**Actions include:** - Install flap valve along Marine Parade - Install flap valve at Seaview Road - Install three flap valves around Te Kupe Road and Olive Terrace	**Actions include:** - For modelling purposes, retreat of properties exposed to 0.325 m water depth over this time period.

			- Community education and emergency management	- Install a flap valve at Nathan Avenue - Construct 150 m stop banking around Ocean Road.	
			Effectiveness: Reduces flooding of properties around Mazengarb and backflow up Tikotu Stream.	**Effectiveness:** Reduce flooding of private property around Marine Parade, Seaview Road, Te Kupe Road and Olive Terrace, Nathan Avenue, and Ocean Road.	**Effectiveness:** Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.

Management Unit 9A – Raumati (North of Wharemauku Stream) Erosion

<table>
<tr><th>Management Unit</th><th>Pathway</th><th>MCDA Ranking</th><th>Short Term</th><th>Medium Term</th><th>Long Term</th></tr>
<tr><td rowspan="2">9A</td><td rowspan="2">Pathway 4</td><td rowspan="2">1</td><td><u>Enhance</u>
Private owners increase the resilience of their structures by adding material to existing structures (e.g. sea walls) and increased community education and emergency management.</td><td><u>Re-establish the line with a setback seawall and dune reconstruction</u>
A hybrid approach of retreat and hard engineering that involves retreating the minimum number of properties possible and re-establishing the shoreline landward of the existing shoreline with a constructed sea wall. Dune reconstruction to be undertaken in front of the sea wall to provide additional resilience.</td><td><u>Soft Engineering Protection (Renourishment)</u>
Adding sediment to the beach system, either onshore or in the nearshore to maintain the dune re-construction undertaken in the medium term.</td></tr>
<tr><td>Actions include:
- Enhancement of existing shoreline structures along 1600 m of shoreline.
- Community education and emergency management</td><td>Actions include:
- Retreat of properties within 30m setback distance from 2050 shoreline position.
- Construction of a 1600 m length seawall
- Maintenance of seawall for 20 years.
- Sourcing of 51,200 m^3 of sand to construct 1600 m length of dune to cover constructed wall.
- 1.6 Ha of foredune planting on constructed dune.
- 20 years of plant and animal pest control</td><td>Actions include:
- Source and transport of 14,700 m^3 maintain the dune to at 2m RL along 1600 m of coastline. Foredune planting of a 10m strip on dune toe.
- Machinery hire and labour costs to rework sediment into beach at rate of 40 m/day (e.g. 40 days)
- Renourishment and replanting of 10 m strip of foredune plants (1.6 Ha) occurs every 5 years.</td></tr>
</table>

				- 5 years of planting maintenance	
			Effectiveness: Shoreline remains in current alignment place	**Effectiveness**: Setback seawall reestablished 30 m landward of current shoreline.	**Effectiveness:** No shoreline movement as setback seawall provides final line of defence.
	Pathway 2	2	**Enhance** *Private owners increase the resilience of their structures by adding material to existing structures (e.g. sea walls) and increased community education and emergency management.*	**Hard Engineering – Sea wall** *New coordinated sea wall along the front of properties along existing shoreline position.*	**Re-establish the line with protection structure** *A hybrid approach of retreat and hard engineering that involves retreating the minimum number of properties possible and re-establishing the shoreline landward of the existing shoreline with a new protection structure.*
			Actions include: - Enhancement of existing shoreline structures along 1600 m of shoreline. - Community education and emergency management	**Actions include:** - Construction of 1600 m length sea wall - Maintenance of seawall for 20 years	**Actions include:** - Retreat of properties within 20m setback distance from 2070 shoreline position - Construction of a 1600 m seawall - Maintenance of seawall for 60 years.
			Effectiveness: Shoreline remains in current alignment place	**Effectiveness:** Shoreline remains in current alignment.	**Effectiveness**: Setback seawall reestablished 20 m landward of current shoreline.

	Pathway 6	3	**<u>Hard Engineering – Sea wall</u>** *New coordinated sea wall along the front of properties along existing shoreline position.*	**<u>Re-establish the line with protection structure</u>** *A hybrid approach of retreat and hard engineering that involves retreating the minimum number of properties possible and re-establishing the shoreline landward of the existing shoreline with a new protection structure.*	**<u>Enhance seawall</u>** *Add material to the sea wall to increase resilience.*
			Actions include: - Construction of 1600 m length sea wall - Maintenance of seawall for 20 years	**Actions include:** - Retreat of properties within 20m setback distance from 2070 shoreline position - Construction of a 1600 m seawall - Maintenance of seawall for 20 years.	**Actions include:** - Cost of increasing elevation of 1600 m length seawall by 0.5 m - Maintenance of seawall for 60 years.
			Effectiveness: Shoreline remains in current alignment.	**Effectiveness**: Setback seawall reestablished 20 m landward of current shoreline.	**Effectiveness:** Shoreline remains in same alignment as 2070.

Management Unit 9B – Raumati Inundation

Management Unit	Pathway	MCDA Ranking	Short Term	Medium Term	Long Term
9B	Pathway 1	2	**<u>Status Quo & Enhance</u>** *Maintain existing management infrastructure, increase community education and emergency management*	**<u>Enhance</u>** *Enhance existing inundation protection, and increase community education and emergency management*	**<u>Addition Hard Protection</u>** *Installation of floodgates, pump stations and stopbanks to prevent sea water entering the settlements*
			Actions include: - Averaged Capital and Operational Coastal Management Costs from Long Term Plan 2021-41 - Community education and emergency management	**Actions include:** - Install a flap valve at outfall to sea north of Aotea Road - Install a flap valve on outfall at Groves Road - Install a flap valve at Raeburn Lane - Community education and emergency management	**Actions include:** - Installation of 600m of stop banking along the northern bank of the Wharemauku Stream. - Installation of 250m of stopbank by Moa Road along the Wharemauku stream. - Install a flap valve at Titoki Road - Install a flap valve at Weka Road outfall - Install two flap valves at Matatua Road - Install a flap valve at Alexander Road

			Effectiveness: Limited effectiveness	**Effectiveness:** Reduce flooding of properties around Aotea Road, Groves Road, and Raeburn Lane.	**Effectiveness:** reduces flooding along the banks of the Wharemauku Stream, Moa Road, Titoki Road, Weka Road, Matatua road, and Alexander Road.
	Pathway 3	3	**Status Quo & Enhance** *Maintain existing management infrastructure, increase community education and emergency management*	**Addition Hard Protection** *Installation of floodgates, pump stations and stopbanks to prevent sea water entering the settlements*	**Enhance** *Enhance existing inundation protection, and increase community education and emergency management*
			Actions include: - Averaged Capital and Operational Coastal Management Costs from Long Term Plan 2021-41 - Community education and emergency management	**Actions include:** - Install a flap valve at outfall to sea north of Aotea Road - Install a flap valve on outfall at Groves Road - Install a flap valve at Raeburn Lane	**Actions include:** - Install a flap valve at Titoki Road - Install a flap valve at Weka Road outfall - Install two flap valves at Matatua Road - Install a flap valve at Alexander Road - Community education and emergency management
			Effectiveness: Limited effectiveness	**Effectiveness:** reduce number of flooded properties at Aotea Road, Groves Road, and Raeburn Lane.	**Effectiveness:** reduces flooding around Titoki Road, Weka Road, Matatua road, and Alexander Road.
	Pathway 2	1	**Status Quo & Enhance** *Maintain existing management infrastructure, increase community education and emergency management*	**Enhance** *Enhance existing inundation protection, and increase community education and emergency management*	**Accommodate** *Pro-actively raise floors of homes which could be flooded, and/or flood proof homes and infrastructure*

			Actions include: - Averaged Capital and Operational Coastal Management Costs from 2021-41 Long Term Plan - Community education and emergency management	**Actions include:** - Install a flap valve at outfall to sea north of Aotea Road - Install a flap valve on outfall at Groves Road - Install a flap valve at Raeburn Lane - Community education and emergency management	**Actions include:** - Raising of 50% of properties affected that have 0.325 m water depth on property. - Flood-proofing of 50% of properties that have 0.325 m of water depth on property.
			Effectiveness: Limited effectiveness	**Effectiveness:** Reduce flooding of properties around Aotea Road, Groves Road, and Raeburn Lane.	**Effectiveness**: Removes residual risk for that timeframe for 1 in 100 year effected houses at 0.325m water depth.

Management Unit 10A – Raumati (South of Wharemauku Stream) Erosion

Management Unit	Pathway	MCDA Ranking	Short Term	Medium Term	Long Term
10A	Pathway 5	2	**Status Quo & Enhance** *Planned works in the LTP for like-for-like replacement of the Raumati sea wall, increased community education and emergency management.*	**Re-establish the line with a setback seawall and dune reconstruction** *A hybrid approach of retreat and hard engineering that involves retreating the minimum number of properties possible and re-establishing the shoreline landward of the existing shoreline with a constructed sea wall. Dune reconstruction to be undertaken in front of the seawall to provide additional protection.*	**Soft Engineering Protection (Renourishment)** *Adding sediment to the beach system, either onshore or in the nearshore to maintain the dune re-construction undertaken in the medium term.*
			Actions include: - Averaged Capital and Operational Coastal Management Costs from Long Term Plan 2021-41 - Community education and emergency management	**Actions include:** - Retreat of properties within 30m setback distance from 2050 shoreline position. - Construction of a 3000 m seawall - Maintenance of seawall for 20 years. - Sourcing of 96,000 m^3 of sand to construct 3000 m length of dune to cover constructed wall. - 3 Ha of foredune planting on constructed dune. - Plant and animal pest control - Planting maintenance	**Actions include:** - Source and transport of 27,500 m^3 maintain the dune to at 2m RL along 3000 m of coastline. Foredune planting of a 10m strip on dune toe. - Machinery hire and labour costs to rework sediment into beach at rate of 40 m/day (e.g. 75 days) - Renourishment and replanting of 10 m strip of foredune plants (3 Ha) occurs every 5 years.

			Effectiveness: Shoreline remains in current alignment place	**Effectiveness:** setback seawall reestablished 30m landward of current shoreline.	**Effectiveness:** No shoreline movement as setback seawall provides final line of defence.
	Pathway 2	1	**Status Quo & Enhance** *Planned works in the LTP for like-for-like replacement of the Raumati sea wall, increased community education and emergency management.*	**Enhance seawall** *Adding material to the sea wall to increase resilience and design life and increased community education and emergency management.*	**Re-establish the line with a setback seawall and dune reconstruction** *A hybrid approach of retreat and hard engineering that involves retreating the minimum number of properties possible and re-establishing the shoreline landward of the existing shoreline with a constructed sea wall. Dune reconstruction to be undertaken in front of the seawall to provide additional protection.*
			Actions include: - Averaged Capital and Operational Coastal Management Costs from 2021-41 Long Term Plan - Community education and emergency management	**Actions include:** - Increasing elevation of seawall by 0.5 m - Maintenance of seawall for 20 years - Community education and emergency management	**Actions include:** - Retreat of properties within 30m setback distance from 2070 shoreline position. - Construction of a 3000 m seawall - Maintenance of seawall for 60 years. - Sourcing of 96,000 m^3 of sand to construct 3000 m length of dune to cover constructed wall. - 3 Ha of foredune planting on constructed dune. - Plant and animal pest control - Planting maintenance

			Effectiveness: Shoreline remains in current alignment place	**Effectiveness:** Shoreline remains in current alignment	**Effectiveness:** setback seawall reestablished 30 m landward of 2070 position.
	Pathway 4	3	<u>**Status Quo & Enhance**</u> *Planned works in the LTP for like-for-like replacement of the Raumati sea wall, increased community education and emergency management.*	<u>**Re-establish the line with a setback seawall**</u> *A hybrid approach of retreat and hard engineering that involves retreating the minimum number of properties possible and re-establishing the shoreline landward of the existing shoreline with a constructed sea wall.*	<u>**Enhance seawall**</u> *Enhance and maintain the setback sea wall as the shoreline retreats back to that position so that the setback seawall can hold the line.*
			Actions include: - Averaged Capital and Operational Coastal Management Costs from 2021-41 Long Term Plan - Community education and emergency management	**Actions include:** - Retreat of properties within 20m setback distance from 2050 shoreline position - Construction of a 3000 m seawall. - Maintenance of seawall for 20 years.	**Actions include:** - Increasing elevation of seawall by 0.5 m. - Maintenance of seawall for 60 years.
			Effectiveness: Shoreline remains in current alignment place	**Effectiveness:** setback seawall reestablished 20m landward of current shoreline.	**Effectiveness:** Shoreline does not move inland from position in 2070.

Management Unit 11A – Paekākāriki Seawall Erosion

Management Unit	Pathway	MCDA Ranking	Short Term	Medium Term	Long Term
11A	Pathway 1	1=	**<u>Status Quo & Enhance</u>** *Planned works in the LTP for like-for-like replacement of the Paekākāriki sea wall,* *and increased community education and emergency management.*	**<u>Protect – Seawall</u>** *New coordinated sea wall along the same alignment as the Paekākāriki sea wall.*	**<u>Re-establish the line with protection structure</u>** *A hybrid approach of retreat and hard engineering that involves retreating the minimum number of properties possible and re-establishing the shoreline landward of the existing shoreline with a new protection structure.*
			Actions include: - Averaged Capital and Operational Coastal Management Costs from 2021-41 Long Term Plan - Community education and emergency management	**Actions include:** - Construction of 1600 m[18] length sea wall. - Maintenance of seawall for 20 years	**Actions include:** - Retreat of properties within 20m setback distance from 2070 shoreline position - Construction of a 1600 m length seawall - Maintenance of seawall for 60 years.
			Effectiveness: Shoreline remains in current alignment place	**Effectiveness:** Shoreline remains in current alignment place	**Effectiveness**: Setback seawall reestablished 20 m landward of current shoreline.

[18] Covers the total length of the management unit.

			Status Quo & Enhance *Planned works in the LTP for like-for-like replacement of the Paekākāriki sea wall,* *and increased community education and emergency management.*	**Re-establish the line with protection structure & Dune reconstruction** *A hybrid approach of retreat and hard engineering that involves retreating the minimum number of properties possible and re-establishing the shoreline landward of the existing shoreline with a protection structure. Dune reconstruction to be undertaken in front of the structure to provide additional protection.*	**Protect – Beach renourishment** *Adding sediment to the beach system, either onshore or in the nearshore to maintain the dune re-construction undertaken in the medium term*
	Pathway 4	3	**Actions include:** - Averaged Capital and Operational Coastal Management Costs from 2021-41 Long Term Plan - Community education and emergency management	**Actions include:** - Retreat of properties within 30m setback distance from 2050 shoreline position. - Construction of a 1600 m seawall - Maintenance of seawall for 20 years. - Sourcing of 51,200 m^3 of sand to construct 1600 m length of dune to cover constructed wall. - 1.6 Ha of foredune planting on constructed dune. - Plant and animal pest control - Planting maintenance	**Actions include:** - Source and transport of 14,700 m^3 maintain the dune to at 2m RL along 1600 m of coastline. - Foredune planting of a 10 m strip on dune toe (1.6 Ha). - Machinery hire and labour costs to rework sediment into beach at rate of 40 m/day (e.g. 40 days) - Renourishment and replanting of 10 m strip of foredune plants occurs every 5 years.
			Effectiveness: Shoreline remains in current alignment place	**Effectiveness**: Setback seawall reestablished 30 m landward of current shoreline.	**Effectiveness:** No shoreline movement as setback seawall provides final line of defence.

	Pathway 3	1=	**<u>Status Quo & Enhance</u>** *Planned works in the LTP for like-for-like replacement of the Paekākāriki sea wall,* *and increased community education and emergency management.*	**<u>Re-establish the line with protection structure</u>** *A hybrid approach of retreat and hard engineering that involves retreating the minimum number of properties possible and re-establishing the shoreline landward of the existing shoreline with a protection structure.*	**<u>Enhance protection structure</u>** *Add material to the protection structure to increase resilience and design life.*
			Actions include: - Averaged Capital and Operational Coastal Management Costs from 2021-41 Long Term Plan - Community education and emergency management	**Actions include:** - Retreat of properties within 20m setback distance from 2050 shoreline position - Construction of a 1600 m seawall - Maintenance of seawall for 20 years.	**Actions include:** - Increasing elevation of 1600 m length seawall by 0.5 m. - Maintenance of seawall for 60 years.
			Effectiveness: Shoreline remains in current alignment place	**Effectiveness**: Setback seawall reestablished 20 m landward of current shoreline.	**Effectiveness:** Shoreline remains in current alignment place.

Management Unit 11B – Paekākāriki Inundation

Management Unit	Pathway	MCDA Ranking	Short Term	Medium Term	Long Term
11B	Pathway 2	1	**<u>Status Quo and Enhance</u>** *Maintain existing management infrastructure, increase community education and emergency management.*	**<u>Enhance Package</u>** *Enhance existing inundation protection and increase community education and emergency management.*	**<u>Accommodate Package</u>** *Pro-actively raise floors of homes which could be flooded, and/or flood proof homes and infrastructure.*
			Actions include: - Averaged Capital and Operational Coastal Management Costs from 2021-41 Long Term Plan - Community education and emergency management	**Actions include:** - Flap valve on Tangahoe Street stormwater outfall - Community education and emergency management	**Actions include:** - Raising of 50% of properties affected that have 0.325 m water depth on property. - Flood-proofing of 50% of properties that have 0.325 m of water depth on property.
			Effectiveness: Limited effectiveness	**Effectiveness:** Reduced flooding at Tangohoe Street	**Effectiveness**: Removes residual risk within timeframe for properties flooded with water depths >0.325 m within a 1 in 100-year flood.
	Pathway 1	2	**<u>Status Quo and Enhance</u>** *Maintain existing management infrastructure, increase community education and emergency management.*	**<u>Enhance Package</u>** *Enhance existing inundation protection and increase community education and emergency management.*	**<u>Additional Hard Protection</u>** *Installation of earth bunds/stopbanks to prevent sea water entering the settlement.*

			Actions include: - Averaged Capital and Operational Coastal Management Costs from 2021-41 Long Term Plan - Community education and emergency management	**Actions include:** - Flap valve on Tangahoe Street stormwater outfall - Community education and emergency management	**Actions include:** - 200 m stop banking around Waikakariki Stream
			Effectiveness: Limited effectiveness	**Effectiveness:** Reduced flooding at Tangohoe Street	**Effectiveness:** Reduce flooding to properties around Waikakariki Stream area and Tangahoe Street
	Pathway 3	3	**Status Quo and Enhance** *Maintain existing management infrastructure, increase community education and emergency management.*	**Additional Hard Protection** *Installation of earth bunds/stopbanks to prevent sea water entering the settlement.*	**Enhance New Inundation Protection** *Enhance existing flood protection infrastructure*
			Actions include: - Averaged Capital and Operational Coastal Management Costs from 2021-41 Long Term Plan - Community education and emergency management	**Actions include:** - 200 m stop banking around Waikakariki Stream - Flap valve on Tangahoe Street stormwater outfall	**Actions include:** - Stopbank maintenance - Flap valves maintenance
			Effectiveness: Limited effectiveness	**Effectiveness:** Reduce flooding properties around Waikakariki Stream area and Tangohoe Street	**Effectiveness:** Reduce flooding of properties around Waikakariki Stream area and at Tangohoe Street

Management Unit 12A – Paekākāriki (South of seawall) Erosion

Management Unit	Pathway	MCDA Ranking	Short Term	Medium Term	Long Term
12A	Pathway 4	2	<u>**Enhance Package**</u> *Private owners increase the resilience of their structures by added material to existing structures and increase community education and emergency management.*	<u>**Re-establish the line with protection structure & Dune reconstruction**</u> *A hybrid approach of retreat and hard engineering that involves retreating the minimum number of properties possible and re-establishing the shoreline landward of the existing shoreline with a protection structure. Dune reconstruction to be undertaken in front of the seawall to provide additional protection.*	<u>**Protect – Beach renourishment**</u> *Adding sediment to the beach system, either onshore or in the nearshore to maintain the dune re-construction undertaken in the medium term.*
			Actions include: - Enhancement of 1300m of current shoreline structures along shoreline. - Community education and emergency management	**Actions include:** - Retreat of properties within 30m setback distance from 2050 shoreline position. - Construction of a 1600 m seawall along total length of management unit. - Maintenance of seawall for 20 years. - Sourcing of 51,200 m^3 of sand to construct 1600 m length of dune to cover constructed wall.	**Actions include:** - Source and transport of 14,700 m^3 maintain the dune to at 2m RL along 1600 m of coastline. Foredune planting of a 10 m strip on dune toe. - Machinery hire and labour costs to rework sediment into beach at rate of 40 m/day (e.g. 40 days) - Renourishment and replanting of 10 m strip of foredune plants (1.6 Ha) occurs every 5 years.

				- 1.6 Ha of foredune planting on constructed dune. - Plant and animal pest control - Planting maintenance	
			Effectiveness: Where there are structures, shoreline remains in the same position, where there are no structures, shoreline continues to erode.	**Effectiveness**: Setback seawall reestablished 30 m landward of current shoreline.	**Effectiveness:** No shoreline movement as setback seawall provides final line of defence
	Pathway 3	1	**Enhance Package** *Private owners increase the resilience of their structures by added material to existing structures and increase community education and emergency management.*	**Re-establish the line with protection structure** *A hybrid approach of retreat and hard engineering that involves retreating the minimum number of properties possible and re-establishing the shoreline landward of the existing shoreline with a protection structure.*	**Enhance Seawall** *Enhance and maintain the setback sea wall as the shoreline retreats back to that position.*
			Actions include: - Enhancement of 1300m of current shoreline structures along shoreline. - Community education and emergency management	**Actions include:** - Retreat of properties within 20m setback distance from 2050 shoreline position - Construction of a 1600 m seawall along total length of management unit. - Maintenance of seawall for 20 years.	**Actions include:** - Increasing elevation of 1600 m seawall by 0.5 m - Maintenance of seawall for 60 years

			Effectiveness: Where there are structures, shoreline remains in the same position, where there are no structures, shoreline continues to erode.	**Effectiveness**: Setback seawall reestablished 20 m landward of current shoreline.	**Effectiveness:** Shoreline remains in current alignment place.
	Pathway 2	3	**<u>Enhance Package</u>** *Private owners increase the resilience of their structures by added material to existing structures and increase community education and emergency management.*	**<u>Protect – Seawall</u>** *New coordinated sea wall along current seawall alignment in front of the properties.*	**<u>Re-establish the line with protection structure</u>** *A hybrid approach of retreat and hard engineering that involves retreating the minimum number of properties possible and re-establishing the shoreline landward of the existing shoreline with a protection structure.*
			Actions include: - Enhancement of 1300m of current shoreline structures along shoreline. - Community education and emergency management	**Actions include:** - Construction of a 1600 m seawall along total length of management unit. - Maintenance of seawall for 20 years.	**Actions include:** - Retreat of properties within 20m setback distance from 2070 shoreline position - Construction of a 1600 m seawall - Maintenance of seawall for 60 years.
			Effectiveness: Where there are structures, shoreline remains in the same position, where there are no structures, shoreline continues to erode.	**Effectiveness:** Shoreline remains in current alignment place.	**Effectiveness**: Setback seawall reestablished 20 m landward of current shoreline.

Appendix B: Base Implementation and Annual Operational/Maintenance Cost estimates for Adaptation Actions.

Erosion Adaptation Actions Cost Build-ups

Enhance (Planting, Emergency Management, Community Education)

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
Implementation Costs										
1	Foredune Planting	Ha	1		$202,141	$ -	$ -	KCDC	Jacobs	0.5 m spacing, includes fertiliser, labour, no guards. One off cost. Assume 30m strip for current shoreline landward
2	Backdune Planting	Ha	1		$48,306	$ -	$ -	KCDC	Jacobs	1.5 m spacing, includes fertiliser, labour and guards. One off cost. Assume 20m strip behind the 30m strip where possible (i.e. doesn't intersect with roads of houses)
3	Pest Control Hardware	each	1		$200	$ -	$ -	KCDC	KCDC	One off cost
4	Sandtrap Fencing	m	1		$10	$ -	$ -	KCDC	Jacobs	One off cost for 100m
5	Contractor provisional and general costs	%	1	30%		$ -	$ -			Assumed 30% on costs to include management, labour, H&S, onsite/offsite overheads, establishment/demolition site costs. Only applied to costs not provided by KCDC (assumed costs included in those provided).
Maintenance Costs										
6	Planting Maintenance	Ha/year	First 5 years		$600	$ -	$ -	KCDC	Jacobs	Only required for the first 5 years
7	Plant Pest control	Ha/year	Annual		$1,800	$ -	$ -	KCDC	Jacobs	Annual Cost, assume this is a new cost and not covered by anything else in Council
8	Pest Animal Control	Ha/year	Annual		$1,150	$ -	$ -	KCDC	Jacobs	Annual Cost, assume this is a new cost and not covered by anything else in Council
Emergency Management and Education										
9	0.25 FTE Manager Salary	0.25 FTE	Annual	1	$30,000	$ -	$ -	KCDC	KCDC	Annual Cost

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
Professional Services										
10	Design	%		5.0%		$ -	$ -			Assumed only applies to Implementation costs.
11	Construction Supervision	%		5.0%		$ -	$ -			Assumed only applies to Implementation costs.
12	Project Management	%		2.5%		$ -	$ -			Assumed only applies to Implementation costs.
13	Consenting	%		0.0%		$ -	$ -			Assume no consenting required
						Total Implementation Cost				$ -
						Total Operational and Maintenance Costs				$ -
						Total				$ -

Enhance (Existing Structures)

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
Implementation Costs										
1	Cost of sea wall enhancement	m	1		$3,750	$ -	$ -	KCDC	Jacobs	Assume costs is 25% of replacement costs if in the 1st epoch, and 40% of replacement costs if in the long-term epoch. This accounts for approach 0.5m rise of a 1.8m high structure in short term; then another 0.5 m raise in the long-term to deal with SLR.
2	Contractor provisional and general costs									Assumed provisional and general costs are included in the KCDC provided project costs for seawall replacement
Maintenance Costs										
3	Seawall Maintenance Costs	m/yr	Annual		$ 33	$ -	$ -	KCDC	Jacobs	Assumed ongoing maintenance costs same as for Raumati Seawall costs provided.
Professional Services										
4	Design	%		0%		$ -	$ -			Assumed professional services costs included within the total budget cost provided by KCDC.
5	Construction Supervision	%		0%		$ -	$ -			Assumed professional services costs included within the total budget cost provided by KCDC.
6	Project Management	%		0%		$ -	$ -			Assumed professional services costs included within the total budget cost provided by KCDC.
7	Consenting	%		0%		$ -	$ -			Assumed professional services costs included within the total budget cost provided by KCDC.
						Total Implementation Cost				$ -
						Total Operational and Maintenance Costs				$ -

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
						Total				$ -

Enhance (Estuary)

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
Implementation Costs										
1	Wetland Planting	Ha	1		$100,000	$ -	$ -	KCDC	Jacobs	Assume a 30 m strip of planting around estuary edge if in first epoch. If enhancing for a second period assume a 15 m strip of wetland planting.
2	Pest Control Hardware	each	1		$200	$ -	$ -	KCDC	KCDC	One off cost
3	Contractor provisional and general costs	%	1	30%		$ -	$ -			Assumed 30% on costs to include management, labour, H&S, onsite/offsite overheads, establishment/demolition site costs. Assumed these costs not already included in KCDC estimates.
Maintenance Costs										
4	Planting Maintenance	Ha/year	First 5 years		$600	$ -	$ -	KCDC	Jacobs	Only required for the first 5 years
5	Plant and Pest control	Ha/year	Annual		$1000	$ -	$ -	KCDC	Jacobs	Annual Cost, assume this is a new cost and not covered by anything else in Council
Emergency Management and Education										
6	0.25 FTE Manager Salary	0.25 FTE	Annual	1	$30,000	$ -	$ -	KCDC	KCDC	Annual Cost
Professional Services										
7	Design	%		5%		$ -	$ -			Assumed only applies to Implementation costs.
8	Construction Supervision	%		5%		$ -	$ -			Assumed only applies to Implementation costs.
9	Project Management	%		2.5%		$ -	$ -			Assumed only applies to Implementation costs.
10	Consenting		1		$2000	$ -	$ -	KCDC	KCDC	Assume minor consenting costs required.
						Total Implementation Cost				$ -

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
						Total Operational and Maintenance Costs				$ -
						Total				$ -

Retreat

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
1	Retreat	Property	1		$ -	$ -	$ -	T&T Hawkes Bay Managed Retreat Costings	Jacobs	Assumed 2.5x multiplier based on Hawkes Bay managed retreat costings. Assume properties that are exposed to erosion are retreated once exposed. Assume costs are all inclusive (e.g. engagement, relocation, remediation).
						Total Implementation Cost				$ -
						Total Operational and Maintenance Costs				$ -
						Total				$ -

Renourishment

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
Implementation Costs										
1	Sand (supply landed)	m^3	1		$60	$ -	$ -	KCDC	Jacobs	Assume $60 m^3 to import and place at beach, does not include distribution along shoreline. Volume required is to retain the dune toe (assumed 2 m RL) in the same position and dune slope the same as the start at of the epoch.
2	Placement/shaping material	day	1		$1,600	$ -	$ -	KCDC	Jacobs	Assume hire of 30T excavator for 8 hour/day ($200/hour) regardless of tidal effects. Assume this is the cost of moving around material along beach. Assume reworking of 40m linear per day (highly variable based on number of trucks available). Assume no labour included in excavator hire.
3	Labour cost	day	1		$1,400	$ -	$ -	Jacobs	Jacobs	Assume Foreman + labourer working 8 hours/day. (Foreman $850/day, labourer $550/day; total $1400 per day labour)
4	Foredune Planting	Ha	1		$202,141	$ -	$ -	KCDC	Jacobs Calculated Areas	0.5 m spacing, includes fertiliser, labour, no guards. One off cost. Assume 10 m strip and no maintenance within the 5 years, and will be replanted every 5 years with renourishment.
5	Contractor provisional and general costs	%	1	30%		$ -	$ -			Assumed 30% on costs to include management, labour, H&S, onsite/offsite overheads, establishment/demolition site costs. Only applied to costs not provided by KCDC (assumed costs included in those provided). Not applied to labour or foredune planting costs (which include labour).
Maintenance Costs										
6	Renourishment costs every 5 years	year	5 yearly			$ -	$ -	Implementation costs above	Jacobs	Assume it needs to be redone every 5 years
Professional Services										

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
7	Design	%		5.0%		$ -	$ -			Assumed only applies to implementation costs.
8	Construction Supervision	%		5.0%		$ -	$ -			Assumed applies to both implementation and maintenance costs.
9	Project Management	%		2.5%		$ -	$ -			Assumed applies to both implementation and maintenance costs.
10	Consenting	%		2.5%		$ -	$ -			Assumed only applies to implementation costs.
						Total Implementation Cost				$ -
						Total Operational and Maintenance Costs				$ -
						Total				$ -

Beach Scraping

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
Implementation Costs										
1	Excavator use and hire	day	1	50	$1,600	$ -	$ -	KCDC	Jacobs	Assume hire of 30T excavator for 8 hour/day ($200/hour) regardless of tidal effects. Assume this is the cost of moving around material along beach. Assume reworking of 40m linear per day (highly variable based on number of trucks available). Assume no labour included in excavator hire.
2	Labour cost	day	1	50	$1,400	$ -	$ -	Jacobs	Jacobs	Assume Foreman + Labourer working 8 hours/day. (Foreman $850/day, labourer $550/day; total $1400 per day labour)
3	Contractor provisional and general costs (incl management, labour, H&S, onsite/offsite overheads)	%	%	30%		$ -	$ -			Assumed 30% on costs to include management, labour, H&S, onsite/offsite overheads, establishment/demolition site costs. Only applied to costs not provided by KCDC (assumed costs included in those provided). Not applied to labour costs.
Maintenance Costs										
4	Re-scraping every 5 years	year	5 yearly		$ -	$ -	$ -			Assume re scraping required every 5 years
Professional Services										
5	Design	%		5.0%		$ -	$ -			Assumed only applies to implementation costs.
6	Construction Supervision	%		5.0%		$ -	$ -			Assumed applies to both implementation and maintenance costs.
7	Project Management	%		2.5%		$ -	$ -			Assumed applies to both implementation and maintenance costs.
8	Consenting	%		2.5%		$ -	$ -			Assumed only applies to implementation costs.

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
						Total Implementation Cost				$ -
						Total Operational and Maintenance Costs				$ -
						Total				$ -

Enhance and Dune Reconstruction Costs (NAA, CAA)

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
Implementation Costs										
1	Excavator use and hire	day	1		$1,600	$-	$ -	KCDC	Jacobs	Assume hire of 30T excavator for 8 hour/day ($200/hour) regardless of tidal effects. Assume this is the cost of moving around material along beach. Assume reworking of 40m linear per day (highly variable based on number of trucks available). Assume no labour included in excavator hire. Assume no additional material is required, and dune reconstruction utilises on site material.
2	Labour cost	day	1		$1,400	$ -	$ -	Jacobs	Jacobs	Assume 2 workers - Foreman + Labourer working 8 hours/day (Foreman $850/day, labourer $550/day; total $1400 per day labour)
3	Foredune Planting	Ha	1		$202,141.07	$ -	$ -	KCDC	Jacobs	0.5 m spacing, includes fertiliser, labour, no guards. One off cost. Assume 30m strip for current shoreline landward
4	Backdune Planting	Ha	1		$48,306.23	$ -	$ -	KCDC	Jacobs	1.5 m spacing, includes fertiliser, labour and guards. One off cost. Assume 20m strip behind the 30m strip where possible (i.e. doesn't intersect with roads of houses)
5	Pest Control Hardware	each	1		$200.00	$ -	$ -	KCDC	KCDC	One off cost
6	Sandtrap Fencing	m	1		$10.00	$ -	$ -	KCDC	Jacobs	One off cost
7	Contractor provisional and general costs	%	1	30%		$ -	$ -			Assumed 30% on costs to include management, labour, H&S, onsite/offsite overheads, establishment/demolition site costs. Only applied to costs not provided by KCDC (assumed costs included in those provided).
Maintenance Costs										
8	Planting Maintenance	Ha/year	First 5 years		$600.00	$ -	$ -	KCDC	Jacobs	Only required for the first 5 years
9	Plant Pest control	Ha/year	Annual		$1,800	$ -	$ -	KCDC	Jacobs	Annual Cost, assume this is a new cost and not covered by anything else in Council

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
10	Pest Animal Control	Ha/year	Annual		$1,150	$ -	$ -	KCDC	Jacobs	Annual Cost, assume this is a new cost and not covered by anything else in Council
Emergency Management and Education										
11	0.25 FTE Manager Salary	0.25 FTE	Annual	1	$30,000			KCDC	KCDC	Annual cost
Professional Services										
12	Design	%		5.0%		$ -	$ -			Assumed only applies to implementation costs
13	Construction Supervision	%		5.0%		$ -	$ -			Assumed only applies to implementation costs
14	Project Management	%		2.5%		$ -	$ -			Assumed only applies to implementation costs
15	Consenting	%		2.5%		$ -	$ -			Assumed only applies to implementation costs
						Total Implementation Cost				$ -
						Total Operational and Maintenance Costs				$ -
						Total				$ -

Seawall

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
Implementation Costs										
1	Cost of sea wall	m	1		$15,000.00	$ -	$ -	KCDC	Jacobs	Assume mid-range of $15k/m. $12k - $18k per linear metre LTP budgets: Paekākāriki $17m for 930m wall =$18k/m; Raumati $37m for 3000m wall = $12k/m 20 years design life.
Maintenance Costs										
2	Seawall Maintenance Costs	m	Annual		$ 33.00	$ -	$ -	KCDC	Jacobs	Assume $200,000 per year ($33/m). Does not include accessway maintenance.
Professional Services										
3	Design	%		0%		$ -	$ -			Assumed these costs are included within the total budget costs provided by KCDC
4	Construction Supervision	%		0%		$ -	$ -			Assumed these costs are included within the total budget costs provided by KCDC
5	Project Management	%		0%		$ -	$ -			Assumed these costs are included within the total budget costs provided by KCDC
6	Consenting	%		0%		$ -	$ -			Assumed these costs are included within the total budget costs provided by KCDC
						Total Implementation Cost				$ -
						Total Operational and Maintenance Costs				$ -
						Total				$ -

Re-establish the line with a setback hard protection structure

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
Retreat										
1	Retreat	Property	1		$ -	$ -	$ -	T&T Hawkes Bay Managed Retreat Costings	Jacobs	Assumed 2.5x multiplier based on Hawkes Bay managed retreat costings. Assume properties that are exposed to erosion are retreated once exposed. Assume costs are all inclusive (e.g. engagement, relocation, remediation).
Sea wall implementation										
2	Cost of sea wall	m	1		$15,000	$ -	$ -	KCDC	Jacobs	Assume mid-range of $15k/m. $12k - $18k per linear metre LTP budgets: Paekākāriki $17m for 930m wall =$18k/m; Raumati $37m for 3000m wall = $12k/m 20 years design life
Sea wall maintenance										
3	Seawall Maintenance Costs	m/yr	Annual		$ 16.50	$ -	$ -	KCDC	Jacobs	Assumed lower rate of maintenance as it is a new build seawall.
Professional Services										
4	Design	%		0%		$ -	$ -			Assumed these costs are already included in retreat and seawall budgets provided.
5	Construction Supervision	%		0%		$ -	$ -			Assumed these costs are already included in retreat and seawall budgets provided.
6	Project Management	%		0%		$ -	$ -			Assumed these costs are already included in retreat and seawall budgets provided.

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
7	Consenting	%		0%		$ -	$ -			Assumed these costs are already included in retreat and seawall budgets provided.
						Total Implementation Cost				$ -
						Total Operational and Maintenance Costs				$ -
						Total				$ -

Re-establish the line with a setback hard protection structure (seawall) and dune reconstruction

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
Retreat										
1	Retreat	Property	1		$ -	$ -	$ -	T&T Hawkes Bay Managed Retreat Costings	Jacobs	Assumed 2.5x multiplier based on Hawkes Bay managed retreat costings. Assume properties that are exposed to erosion are retreated once exposed. Assume costs are all inclusive (e.g. engagement, relocation, remediation).
Sea wall implementation										
2	Cost of sea wall	m	1		$15,000	$ -	$ -	KCDC	Jacobs	Assume mid-range of $15k/m. $12k - $18k per lineal metre LTP budgets: Paekākāriki $17m for 930m wall =$18k/m; Raumati $37m for 3000m wall = $12k/m 20 years design life
Sea wall Maintenance										
3	Seawall Maintenance Costs	m	Annual		$ 16.50	$ -	$ -	KCDC	Jacobs	Assumed lower rate of maintenance as it is a new build seawall.
Dune reconstruction										
4	Sand Supply	m^3	1		$60	$ -	$ -	KCDC	Jacobs	Assume $60 m^3 to import and place at beach, does not include distribution along shoreline. Assume volume required to reach elevation over stepped seawall is 32 m^3/m.
5	Placement/Shaping Material	day	1		$1,600	$-	$ -	KCDC	Jacobs	Assume hire of 30T excavator for 8 hour/day ($200/hour) regardless of tidal effects. Assume this is the cost of moving around material along beach.

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
										Assume reworking of 40m linear per day (highly variable based on number of trucks available). Assume no labour included in excavator hire.
6	Labour cost	day	1		$1,400	$ -	$ -	Jacobs	Jacobs	Assume 2 workers - Foreman + Labourer working 8 hours/day. (Foreman $850/day, labourer $550/day; total $1400 per day labour)
7	Foredune Planting	Ha	1		$202,141.07	$ -	$ -	KCDC	Jacobs	0.5 m spacing, includes fertiliser, labour, no guards. One off cost. Assume 10m strip on dune toe of new dune.
8	Pest Control Hardware	each	1		$200.00	$ -	$ -	KCDC	KCDC	One off cost
9	Sandtrap Fencing	m	1		$10.00	$ -	$ -	KCDC	Jacobs	One off cost
10	Contractor provisional and general costs	%	1	30%		$ -	$ -			Assumed 30% on costs to include management, labour, H&S, onsite/offsite overheads, establishment/demolition site costs. Only applied to costs not provided by KCDC (assumed costs included in those provided).
Maintenance Costs										
11	Planting Maintenance	Ha	First 5 years		$600.00	$ -	$ -	KCDC	Jacobs	Only required for the first 5 years
12	Plant Pest control	Ha	Annual		$1,800	$ -	$ -	KCDC	Jacobs	Annual Cost, assume this is a new cost and not covered by anything else in Council
13	Pest Animal Control	Ha	Annual		$1,150	$ -	$ -	KCDC	Jacobs	Annual Cost, assume this is a new cost and not covered by anything else in Council
Emergency Management and Education										
14	0.25 FTE Manager Salary	0.25 FTE	Annual	1	$30,000			KCDC	KCDC	Annual cost
Professional Services										

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
15	Design	%		5.0%		$ -	$ -			Assumed only applies to implantation costs of dune reconstructions, costs already included in the budget costs provided by KCDC for seawall, and assumed included in retreat multiplier.
16	Construction Supervision	%		5.0%		$ -	$ -			Assumed only applies to implantation costs of dune reconstructions, costs already included in the budget costs provided by KCDC for seawall, and assumed included in retreat multiplier.
17	Project Management	%		2.5%		$ -	$ -			Assumed only applies to implantation costs of dune reconstructions, costs already included in the budget costs provided by KCDC for seawall, and assumed included in retreat multiplier.
18	Consenting	%		2.5%		$ -	$ -			Assumed only applies to implantation costs of dune reconstructions, costs already included in the budget costs provided by KCDC for seawall, and assumed included in retreat multiplier.
						Total Implementation Cost				$ -
						Total Operational and Maintenance Costs				$ -
						Total				$ -

Inundation Pathway Adaptation Actions Cost Build-ups

Enhance (Existing structures and infrastructure)/Additional Hard Protection

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
Implementation Costs										
1	Road improvements	m	1		$10,850	$ -	$ -	KCDC	Jacobs	Assumed 7 m wide road.
2	Stopbank extension	m	1		$10,000	$ -	$ -	KCDC	Jacobs	Assume costs are regardless of elevation. Costs sourced from GW information.
4	Flap valves	Each	1		$30,000	$ -	$ -	Jacobs	Jacobs	Highly variable as dependent on the size and the current state of the outfall. Comment from KCDC: Renewal of 2 x 300mm diameter outfalls and 1 x 225 outfall (Aug 2023) - $79391.50.
5	Stormwater pipe upgrades	m	1		$950.00	$ -	$ -	KCDC	Jacobs	Varies depending on the pipe diameter and depth. $400 per linear metre [small diameter – 300mm – shallow] to 1,500 per linear metre [larger diameter – 600mm – shallow]. Mid-range of $950 taken.
6	Flood gate	Each	1		$150,000	$ -	$ -	Jacobs	Jacobs	Highly variable, dependent on the size of the floodgate and the modification/new structure required. Average estimate taken.
7	Stormwater Pump Station	Each	1		$1,505,000	$ -	$ -	KCDC	Jacobs	$1,505,000 for large pumpstation – 6m deep – [includes 3 pumps]. Doesn't include provisional and general costs, health & safety, TMP, design, dewatering and consenting. Variable and dependent on ground conditions/foundation design.
8	Wetland Planting	Ha	1		$100,000	$ -	$ -	KCDC	Jacobs	Assumed minimum planting of 10 m strip around existing wetland or stream based on Auckland Council Guidance for streamside planting. Costs are also applied for riparian zone planting along streams. Quantity of planting determined from linear length around existing wetland or stream which is adjacent to land or properties where there is a present or future flood hazard.
9	Pest Control Hardware	One off	1		$200	$ -	$ -	KCDC	KCDC	Assume one off cost.
10	Contractor provisional and general costs	%	1	30%		$ -	$ -			Assumed 30% on costs to include management, labour, H&S, onsite/offsite overheads,

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
										establishment/demolition site costs. Only applied to costs not provided by KCDC (assumed costs included in those provided).
Maintenance Costs										
11	Road maintenance	m	Annual		$2,450	$ -	$ -	KCDC	Jacobs	Assume 7m wide road.
12	Stopbank maintenance	m	Annual		$50	$ -	$ -	KCDC	Jacobs	Information from GW
13	Flap valve maintenance	%	Annual	5%		$ -	$ -	Jacobs	Jacobs	Assume % of build costs.
14	Floodgate maintenance	%	Annual	5%		$ -	$ -	Jacobs	Jacobs	Assume % of build costs
15	Stormwater Maintenance	%	Annual	10%		$ -	$ -	Jacobs	Jacobs	Assumed % of implementation cost for maintenance - higher maintenance because includes both mechanical and electrical maintenance (switchboards), and potential replacement of pumps.
16	Planting maintenance	Ha	Annual		$600	$ -	$ -	KCDC	Jacobs	Only required for the first 5 years
17	Plant and Pest Control	Ha	Annual		$1000	$-	$ -	KCDC	Jacobs	Annual Cost, assume this is a new cost and not covered by anything else in Council
Emergency Management and Education										
18	0.25 FTE Manager Salary	0.25 FTE	Annual	1	$30,000	$ -	$ -	KCDC	KCDC	Annual Cost
Professional Services										
19	Design	%		5.0%		$ -	$ -			Assumed only applies to implementation costs.
20	Construction Supervision	%		5.0%		$ -	$ -			Assumed only applies to implementation costs.
21	Project Management	%		2.5%		$ -	$ -			Assumed only applies to implementation costs.
22	Consenting	%		2.5%		$ -	$ -			Assumed only applies to implementation costs.

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
						Total Implementation Cost				$ -
						Total Operational and Maintenance Costs				$ -
						Total				$ -

Accommodate

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
1	Raising of floor levels	Property	1	Half of the total number of buildings that are flooded >0.325 m in defined scenario	0.5 x Average Cost of Improvements within Management unit	$ -	$ -	Jacobs	Jacobs	Assumed 0.5 x Average Cost Of Improvements for the management unit to raise floor levels of a house on average. Assume houses are raised if flood depth within building footprint is > 0.325 m. Assume costs include design, consenting and raising.
2	Flood proofing	Property	1	Half of the total number of buildings that are flooded >0.325 m in defined scenario	$50,000	$ -	$ -	Jacobs	Jacobs	Assumed $50,000 to flood proof a house Assume houses are raised if flood depth within building footprint is > 0.325 m Assume costs include design, consenting and raising.
						Total Implementation Cost				$ -
						Total Operational and Maintenance Costs				$ -
						Total				$ -

Retreat

Item	Component	Unit	Frequency	Quantity	Rate ($/Unit)	Amount	Total	Cost Source	Quantity Source	Assumptions
1	Retreat	Property	1		$ -	$ -	$ -	T&T Hawkes Bay Managed Retreat Costings	Jacobs	Assumed 2.5x multiplier based on Hawkes Bay managed retreat costings. Retreat of properties only where building footprint is flooded by >0.325 m (e.g. 10 cm above assumed floor heights).
						Total Implementation Cost				$ -
						Total Operational and Maintenance Costs				$ -
						Total				$ -

Appendix C: Estimated Unit Cost for Repair/Replacement of Council Infrastructure

Unit Costs for Repairs to Council Infrastructure to Calculate Flood Losses

Infrastructure	Unit	Rate/Unit Loss	Notes
Roads	m	$2,520	Information provided by KCDC: $360/m - Assumed 1m wide road damage + replace kerb. Assumed 7 m wide road, therefore $2,520 m per linear m for whole road repair. Assumes road sections exposed to water require repair following 1% AEP event.
Pumpstation (Wastewater or Stormwater)	Each	$188,125	Approximately 10-15% of implementation costs of a pump station are electrical. In a flood typically switchboards would need to be replaced, and for cables would need to test to prove they can be reused. Midpoint of 12.5% of initial build costs is taken as the repair costs for a wastewater pump station to represent the replacement of electrics if damaged in a flood.

Unit Costs for Replacement of Council Infrastructure to Calculate Erosion Losses

Infrastructure	Unit	Rate/Unit Loss	Notes
Roads	m	$10,850	KCDC provided estimate of $1550/m for road replacement costs. It is assumed this is m^2, and have therefore been increased to represent a 7 m wide road.
Pump Station (Wastewater or Stormwater)	Each	$1,505,000	KCDC provided estimate for a large pumpstation (6m deep - including 3 pumps). It is assumed this price is similar for both wastewater and stormwater pumpstations. However, it is noted that wastewater pumpstation could be slightly more expensive as may require different pumps. The price will be highly variable and dependent on ground conditions.
Three Waters Network Pipes	m	$950	Mid-range estimate taken from KCDC information provided: Cost varies depending on the pipe diameter and depth ($400 per linear metre for small diameter - 300mm –

			shallow; to $1,500 per linear metre for larger diameter - 600mm – shallow). Assumed pipes are same cost for stormwater, wastewater, and water supply pipes. It is assumed that as most open coast outfalls are not capped, they are included in the stormwater pipe loss estimates, and have not been assessed as an additional cost.