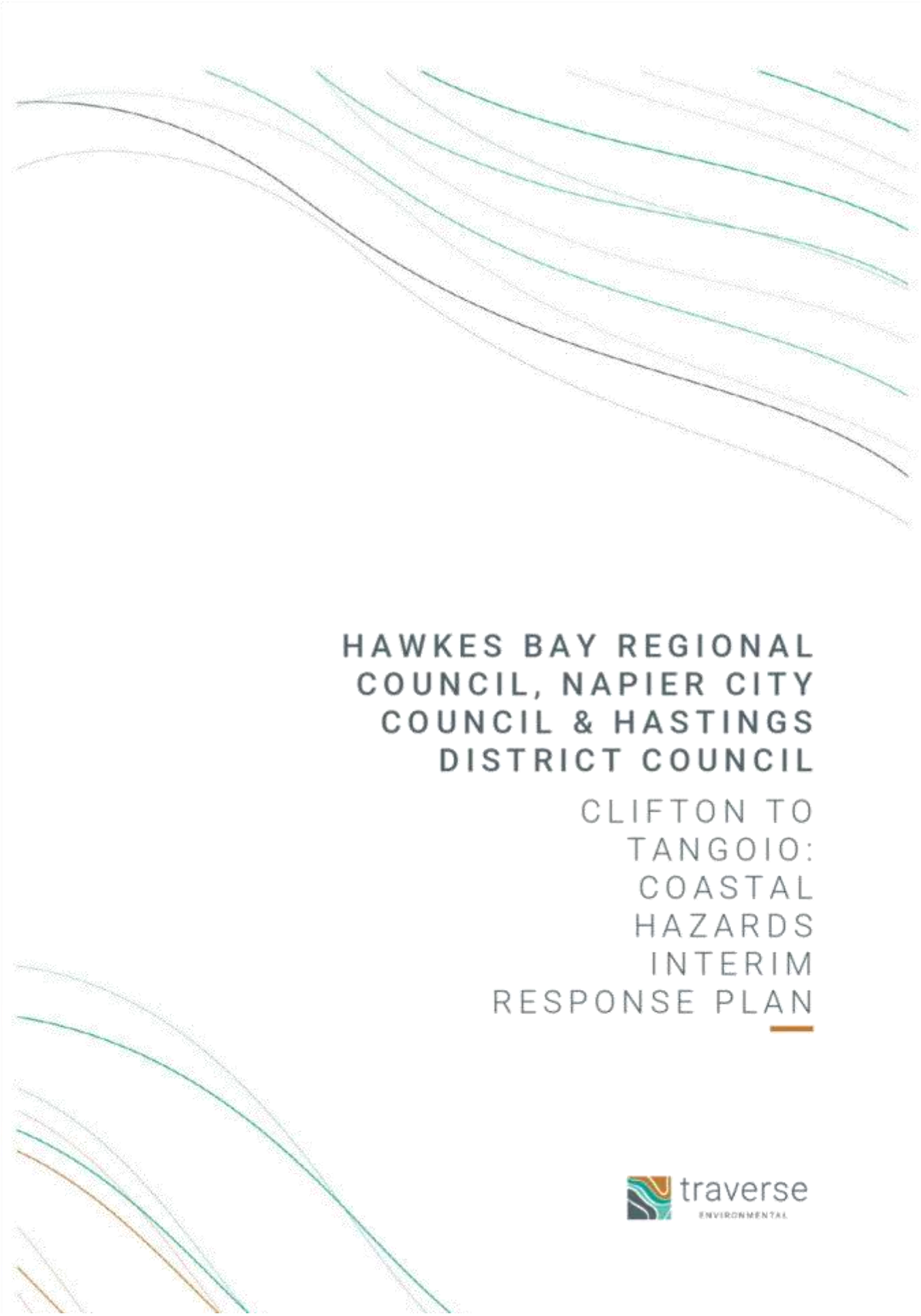
Meeting of the Clifton to Tangoio Coastal Hazards Strategy Joint Committee

Date: 11 August 2023

Time: 10.00am

Venue: Council Chamber
Hawke's Bay Regional Council
159 Dalton Street
NAPIER

Attachments Excluded From Agenda



HAWKES BAY REGIONAL COUNCIL, NAPIER CITY COUNCIL & HASTINGS DISTRICT COUNCIL

CLIFTON TO TANGOIO: COASTAL HAZARDS INTERIM RESPONSE PLAN

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Report Information

Report Status	Frist Draft
Author	Simon Bendall & Deborah Kissick
Review By	Technical Advisory Group, Clifton to Tangoio Coastal Hazards Strategy

1 Introduction

The Clifton to Tangoio Coastal Hazard Strategy ("the Strategy") is being developed to put in place a long-term adaptive plan for responding to the changing risks of coastal erosion and coastal inundation between Clifton and Tangoio.

While the Strategy is being finalised, the Hawkes Bay Regional Council ("HBRC"), Napier City Council ("NCC") and Hastings District Council ("HDC") ("the Councils") acknowledge that there are ongoing coastal hazard issues being faced by communities along the coast. Recent erosion events at Whirinaki, Bay View, Westshore, and Te Awanga highlight these concerns.

Coastal hazard issues are currently managed in a variety of ways with actions determined on a case-by-case basis by the relevant Territorial Authority (HDC or NCC) with HBRC providing environmental data and advice, while also acting in a regulatory capacity as needed. Recent examples of this arrangement include the Clifton, Cape View Corner and Whakarire Ave revetment projects.

A standing informal agreement between the Councils is that the Strategy development process should not prevent or hinder coastal hazard mitigation projects from taking place within the Strategy area, while ensuring that any interim actions are not inconsistent with the overall direction of the Strategy.

The Councils acknowledge however that the current case-by-case approach introduces some uncertainty for communities about what will happen in response to coastal hazard issues, who is responsible for action, and what action to expect, while the Strategy development process continues.

In response to this uncertainty, this Coastal Hazards Interim Response Plan ("Interim Response Plan") has been developed by the Councils.

2 Application

This Interim Response Plan applies:

- To the coastline between Clifton and Tangoio.
- To the actions the Councils may take to monitor and manage coastal erosion and coastal inundation risks.
- Until such time as coastal hazards issues are being managed under an adopted Clifton to Tangoio Coastal Hazards Strategy, at which time this Interim Response Plan shall be superseded.

3 Objectives

This Interim Response Plan seeks to achieve the following outcomes:

- To guide the actions of the Councils in monitoring and responding to emerging coastal hazard issues.
- To support the management of coastal hazard risks in a coordinated and efficient manner, and in a way that aligns with the overall direction and approach of the Strategy as it is developed.
- To provide greater clarity for the community on what actions Councils may undertake, and the limitations on such actions, to manage emerging coastal hazards issues.

4 Roles and Responsibilities

Existing arrangements between the Councils for the management of coastal hazard issues will continue under this Interim Response Plan. These are summarised in **Table 1**.

Table 1: Interim Arrangements for Council Roles for Coastal Hazard's Management – Clifton to Tangoio

Activity	Lead
Designing, seeking resource consent for and constructing new coastal hazard mitigation structures	Hastings District Council & Napier City Council (within respective district boundaries)
Undertaking emergency works in response to risks presented by coastal erosion under s.330 emergency provisions of the RMA *(noting legal test for use of s.330 must be met)*	Hastings District Council & Napier City Council (within respective district boundaries)
Re-shaping beach crests in response to coastal erosion	Hastings District Council & Napier City Council (within respective district boundaries and associated consents)
Gravel re-nourishment programme at Westshore Beach	Led by Hawkes Bay Regional Council, co-funded by Napier City Council & Hawke's Bay Regional Council
Monitoring and maintaining existing coastal hazard mitigation structures	Hastings District Council & Napier City Council (within respective district boundaries)
Monitoring coastal processes	Hawke's Bay Regional Council
Monitoring beach profiles and rates of shoreline movement and trends	Hawke's Bay Regional Council
Consent Authority functions in the Coastal Marine Area (i.e. the area below mean high water springs, extending 12 nautical miles off the coast)	Hawke's Bay Regional Council
Consent Authority functions in the Coastal Environment (as defined by the Regional Coastal Environment Plan)	Hawke's Bay Regional Council (primary) – may be additional District Plan regulatory requirements depending on nature and location of activity proposed
Natural hazard event emergency response	Hawke's Bay Civil Defence and Emergency Management (HB-CDEM)

It is noted that the Councils have signed a Memorandum of Transition (MoT) to confirm Council roles and responsibilities for the implementation of the Strategy. This MoT confirms in principle agreement that:

- HBRC will take charge of adapting to coastal hazards risks on the Clifton to Tangoio coast, including adopting and implementing the Clifton to Tangoio Coastal Hazards Strategy.
- HDC and NCC will transfer their assets relevant to mitigating and adapting to the impacts of coastal hazards affecting Napier City and the Hastings District to HBRC,
- An advisory committee formed by elected representatives of the Parties and Tangata Whenua will be established.

In order for this agreement to take effect, HBRC are required to complete a public consultation process under s.16 of the Local Government Act. This will occur as part of proposing and adopting a final Strategy. Until then, existing arrangements as outlined in Table 1 remain in place.

5 Monitoring for Coastal Change

To support decision making by the Councils in response to emerging coastal hazards issues, the following methods of data collection have been identified.

5.1 Council Monitoring

HBRC undertake a range of existing coastal monitoring initiatives, as follows:

Westshore Renourishment Project

- Annual survey to establish beach profiles and estimate quantities for renourishment.
- HBRC Project Delivery Team manages and supervises the annual physical renourishment works and reactive renourishment works.

Beach Profile Monitoring

- Annual survey to establish beach profiles within Strategy area. Processing and analysis of these results are combined and reported on in an annual report. The location of the profiles are noted in **Figure 1**.
- Surveying of one profile (HB11 at Marine Parade) is undertaken on a weekly basis over

Figure 1: HBRC beach profile survey locations

the summer period and monthly over winter period. This survey is on-shore only, and used to monitor trends in the beach profile above the waterline in between the annual survey.

Wave Buoy Monitoring

- Several wave buoys have been installed to collect wave data.

HBRC are investigating the installation of beach monitoring cameras (time lapsed photography) and/or the use of Cam-era (https://niwa.co.nz/our-services/online-services/cam-era) or other similar tools to provide additional monitoring data. It is noted that any further monitoring activity needs to be carefully planned to account for the capacity of Council (budget and staff time) to deliver.

Action 1:	HBRC to investigate the installation of fixed beach monitoring cameras at priority locations

5.2 Community-led Monitoring

Community-led monitoring and reporting provides a mechanism to capture the experiences of the people who are most familiar with the coast and emerging coastal hazard issues. Two new initiatives to support community-led monitoring are proposed under this Interim Response Plan, as discussed below. The initiatives are both low-cost and able to be funded within existing budgets for Strategy development.

5.2.1 Reporting of Observed Issues

Those that live in coastal communities and spend time at the coast observe coastal change, often on a daily basis.

The Councils will support community reporting of new and emerging coastal hazard issues by enabling community members to report issues by email (preferably with photos) to hbcoast@hbrc.govt.nz.

This email address is already in operation for the Strategy and is monitored by staff at HBRC.

When an email reporting a hazard issue is received, it will be logged in a database, and reviewed by an appropriate staff member who will be responsible for acknowledging receipt.

Community reporting of this nature can require significant staff resourcing, depending on the nature and number of reports being received. A successful reporting system will enable efficient reporting and useful data for the Councils. HBRC may develop procedures for the use of this email if the reporting system becomes inefficient.

The Joint Committee for the Strategy will receive a report at each meeting on any community reporting and any planned response.

Any emergency involving immediate risks to life or property should be reported to emergency services through the usual channels.

Action 2:	HBRC to promote community reporting of changing hazard issues to hbcoast@hbrc.govt.nz
Action 3:	HBRC to provide regular updates to Joint Committee on reports received by hbcoast@hbrc.govt.nz and actions taken in response

5.2.2 CoastSnap

CoastSnap is a citizen science project to capture changing coastlines through a mobile phone app (https://www.coastsnap.com/). CoastSnap is used globally, including in New Zealand in Nelson and Christchurch.

CoastSnap relies on repeat photos (using mobile devices) at the same location to track how the coast is changing over time.

The simplest way to achieve this repetition is to install purpose-built camera cradles at key points along the coast that allow members of the public to record the conditions at the coast at any given time.

Figure 2 shows an example CoastSnap station being installed at the Boulder Bank, Nelson by Nelson City Council.

Figure 2: CoastSnap station example: Nelson City Council

HBRC will:

1. Determine appropriate locations for CoastSnap stations.
2. Instal and maintain CoastSnap stations and interpretive signage.
3. Develop public communications to inform the community about the use of CoastSnap and encourage its use.
4. Review data collected through CoastSnap.

Action 4:	HBRC to install CoastSnap monitoring network (including instructional signage) within Strategy area
Action 5:	HBRC, NCC and HDC to jointly develop communications and engagement campaign on the use of CoastSnap

6 Responding to Emerging Issues

6.1 Confirming Response

If the monitoring activities described above identify a potential coastal hazard issue, HBRC and the relevant Territorial Authority will assess the situation and agree on the appropriate path forward.

As a first step, the Councils shall apply an agreed code to coastal hazard issues, in general accordance with Table 2.

Table 2: Coastal Hazards: Emerging Issue Codes

Code	Description	Council Action
Green	No or minor change in risk / exposure	None
Amber	Increased risk / exposure evident	Increased monitoring of problem area
Red	Risk / exposure high – mitigation measures required	Physical intervention to reduce risk undertaken under existing or newly acquired resource consent (subject to regulatory requirements).
Urgent Response	Risk / exposure high and urgent – rapid mitigation measures required	Urgent physical intervention to reduce risk undertaken under the emergency provisions of s.330 of the Resource Management Act 1991 (subject to meeting legal tests).

Action 6: HBRC to maintain and update (as new information is received) a register / log of known emerging hazard issues with assigned codes developed with the relevant Territorial Authority to confirm how each is being responded to.

6.2 Intervention Methods

If the Council's consider that physical intervention is required to respond to an identified coastal hazard issue, the following methods may be employed, subject to the limitations noted in section 6.3 below.

Method	Description
Beach shaping	Reshaping/contouring the beach into a more erosion resistant shape.
Beach scraping	Moving existing beach material, including material from below mean high water springs ("MHWS") up to the enhance the beach crest.
Small-scale renourishment (~1,000m³)	Importing material (gravel and/or sand) into the foreshore to offset erosion losses and increase beach size and crest height at hotspot locations
Large-scale renourishment (~15,000m³)	As above, but a greater volume required given scale of erosion losses
Rock Revetment / armouring	Placement of rocks / armoured units to hold coastline against erosion
Removal / relocation	Removal of asset / building from hazard affected area

6.3 Limitations

When an intervention method is employed, the following key limitations must be considered by the Councils.

6.3.1 Resource Consent Requirements

Methods involving the disturbance of the foreshore area (i.e. beach shaping or scraping), importing and placing material (i.e. renourishment) or armouring the coast will require resource consent under the Resource Management Act 1991 ("RMA").

This is required to ensure that these types of activities are carefully considered, and that the actual and potential effects of the activities are identified and managed.

Resource consents can be time consuming and costly however, often requiring expert assessments (e.g. assessment of effects on the coastal environment from the proposed activity) and consultation. The scale (time and cost) of the resource consent process is generally commensurate with the scale and complexity of the activity proposed, and the actual and potential environmental effects.

In a coastal hazard context, resource consent requirements can act as barrier to the rapid deployment of a physical intervention and may prevent action being taken in time.

There are two options the Council's can employ to enable urgent physical works within a resource consent framework:

1. Pre-emptive consenting, and
2. Emergency works.

The first option (pre-emptive consenting) involves securing resource consents for particular methods in defined locations before a coastal hazard issue eventuates.

This approach has already been taken by HDC, where a resource consent for beach scraping is in place at Te Awanga and Haumoana, allowing works to be undertaken as and when required to repair the beach crest (subject to the conditions of those consents).

This is an effective approach, as it allows rapid responses to be undertaken with appropriate controls in place (through conditions of resource consent).

There is likely significant benefit in expanding the existing consents at Te Awanga and Haumoana for beach scraping to cover all beaches in the Strategy area. There may also be benefit in assessing whether small scale nourishment could take place under a similar consenting regime.

The scale and complexity of the consenting process to achieve this requires investigation to determine the relative costs and benefits of this approach.

The use of the emergency provisions of s.330 of the RMA is the second option. This allows Councils[1] to undertake works to remove the cause of or to mitigate the adverse effect of an emergency, without the need to first obtain resource consent.

However, there are legal tests to meet in order to utilise s.330, including (among other requirements) that the event must be sudden, and likely to cause loss of life, injury, or serious damage to property. Resource consent must still be sought (retrospectively) for works undertaken under s.330, so the works still need to be 'consentable' in nature. This option should only be considered in genuinely urgent and emergency situations.

Action 7:	In collaboration with HBRC, HDC and NCC to investigate securing pre-emptive consents for beach shaping and/or scraping and/or small-scale renourishment where existing consents for these activities are not already in place

6.3.2 Allocation of Funding

Councils have limitations on spending and how funding can be allocated to projects. Funding decisions must consider impacts on all ratepayers (including future generations). Where additional funding is being considered in response to changing coastal hazards, Councils will consider the Strategy as part of following good decision-making processes. Depending on significance, additional public consultation may be required before funding is allocated.

6.3.3 Consistency with direction of Strategy

At the time of writing, the Strategy is being developed based on recommendations from Community Assessment Panels for long term adaptive pathways. The recommended pathways for Priority Units are presented below.

Priority Unit	Preferred Pathway	Short Term (0-20 yrs)	→	Medium Term (20 – 50 yrs)	→	Long Term (50 – 100 yrs)
Whirinaki (B)	Pathway 4	Status quo/ Renourishment	→	Renourishment + Control Structures	→	Sea wall
Bayview (C)	Pathway 3	Status Quo/ Renourishment	→	Renourishment + Control Structures	→	Renourishment + Control Structures

[1] The emergency works provisions are only available to authorised persons under the RMA which include Councils, network utility operators and lifeline operators (including electricity generators and distributors, airports, ports, road network providers).

Priority Unit	Preferred Pathway	Short Term (0-20 yrs)	→	Medium Term (20 – 50 yrs)	→	Long Term (50 – 100 yrs)
Westshore (D)	Pathway 3	Renourishment	→	Renourishment + Control Structures	→	Renourishment + Control Structures
Ahuriri (E1)	Pathway 6	Status quo	→	Sea wall	→	Sea wall
Pandora (E2)	Pathway 3	Status quo	→	Storm Surge Barrier	→	Storm Surge Barrier
East Clive (J)	Pathway 1	Status Quo	→	Renourishment + Control Structures	→	Retreat the Line / Managed Retreat
Haumoana (K1)	Pathway 2	Renourishment + Control Structures	→	Renourishment + Control Structures	→	Managed Retreat
Te Awanga (K2)	Pathway 3	Renourishment + Control Structures	→	Renourishment + Control Structures	→	Renourishment + Control Structures
Clifton (L)	Pathway 5	Status quo	→	Sea wall	→	Managed Retreat

An important concept is that each pathway is 'adaptive'; the timeframe of each action (short, medium and long) can be brought forward or delayed, depending on the actual effects of coastal hazards and climate change over time. If sea level rises more than expected or at a faster rate, actions can be implemented earlier in response; if less or slower, actions can be delayed. If necessary, the actions themselves can also be reviewed or changed.

The Strategy will also be reviewed a minimum of every 10 years, to ensure that the pathways remain fit for purpose as new information becomes available over time.

Any actions taken by the Councils under this Interim Response Plan should be broadly consistent with this direction, specifically any interim actions should:

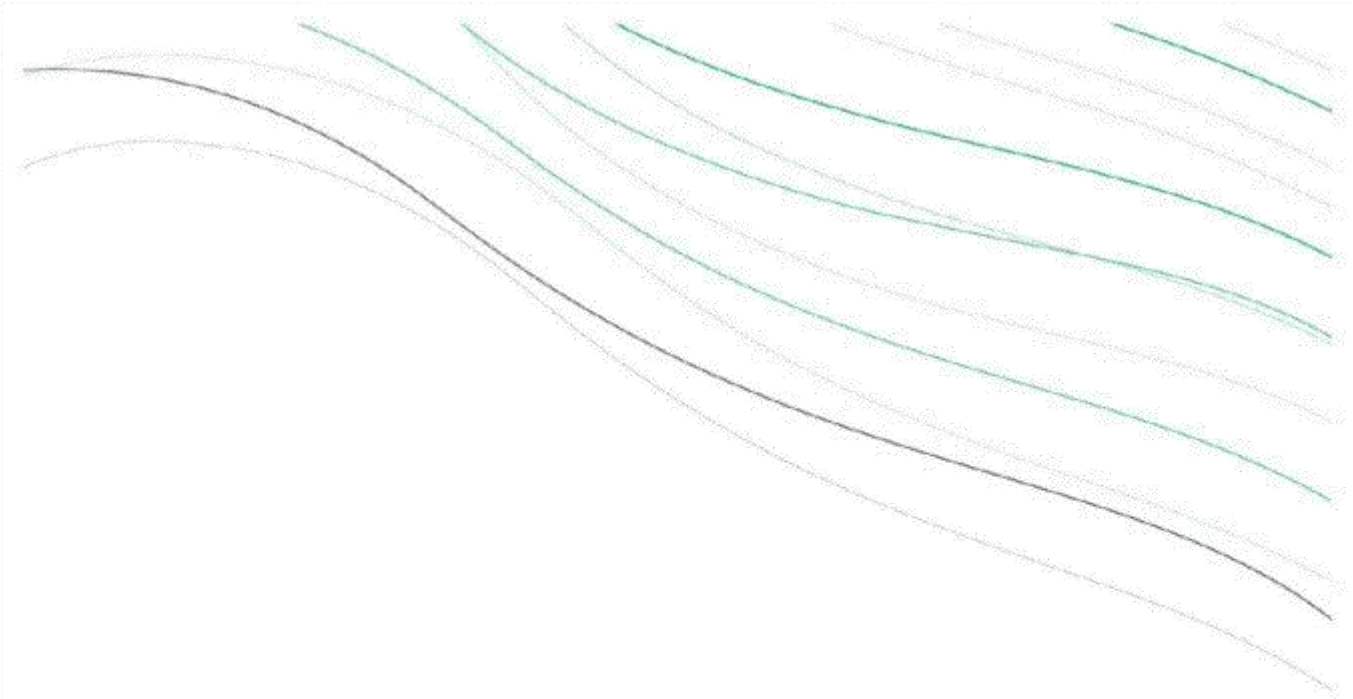
1. Complement (or at least not be contradictory to) implementation of the proposed pathways;
2. Support future adaptive action by avoiding 'locked in' outcomes; and
3. Be cognisant of the need to avoid maladaptation, which is when intentional adaptation actions are taken that result in explicitly negative consequences.

Action 8:	Where any Council determines to undertake a physical intervention under this Plan, a report is to be provided to the Joint Committee confirming how each of the limitations noted in this Plan have been taken into account.

7 Action Plan

Key actions have been recorded throughout this Interim Response Plan. The following captures these actions into a single Action Plan. Regular reporting to the Joint Committee on progress under the Action Plan will be provided.

Action	Lead	Description
1. Council Monitoring	HBRC	Investigate the installation of fixed beach monitoring cameras at priority locations.
2. Community-led Monitoring	HBRC	Promote community reporting of changing hazard issues to hbcoast@hbrc.govt.nz
3. Reporting on emerging issues	HBRC	Provide regular updates to Joint Committee on reports received by hbcoast@hbrc.govt.nz and actions taken in response.
4. CoastSnap – installation	HBRC	Install CoastSnap monitoring network (including instructional signage) within Strategy area.
5. CoastSnap – promotion	HBRC, HDC & NCC	Run communications and engagement campaign on the use of CoastSnap.
6. Coastal hazard issues register	HBRC	HBRC to maintain and update (as new information is received) a register / log of known emerging hazard issues with assigned codes developed with the relevant Territorial Authority to confirm how each is being responded to.
7. Pre-emptive resource consents	NCC & HDC	In collaboration with HBRC, investigate securing pre-emptive consents for beach shaping and/or scraping and/or small-scale renourishment where existing consents for these activities are not already in place.
8. Reporting on interventions	NCC or HDC (as necessary)	Where any Council determines to undertake a physical intervention under this Plan, a report is to be provided to the Joint Committee confirming how each of the limitations noted in this Plan have been taken into account.



CLIFTON TO TANGOIO COASTAL HAZARD STATEGY

ADAPTATION THRESHOLDS DEVELOPMENT REPORT

SUMMARY REPORT
13 DECEMBER 2022

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Report Information

Report Status	FINAL
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Review By	Simon Bendall

PART A

Adaptation Threshold Development Process

1 Introduction

The Northern and Southern Cell Assessment Panels (the Panels) for the Clifton to Tangoio Coastal Hazards Strategy (the Strategy) recommended a series of adaptative pathways to respond to coastal hazard risks.

These pathways, summarised in **Table 1**, have been determined by the Panels as being their preferred method for responding to coastal hazard risks for each unit, based on a range of assessment criteria and financial metrics.

In order for these adaptation pathways to be truly adaptive, signals, triggers and adaptation thresholds (STATs) need to be developed that enable changes in coastal areas to be monitored and decisions made before performance measures desired by the community are no longer being met or start to fail.

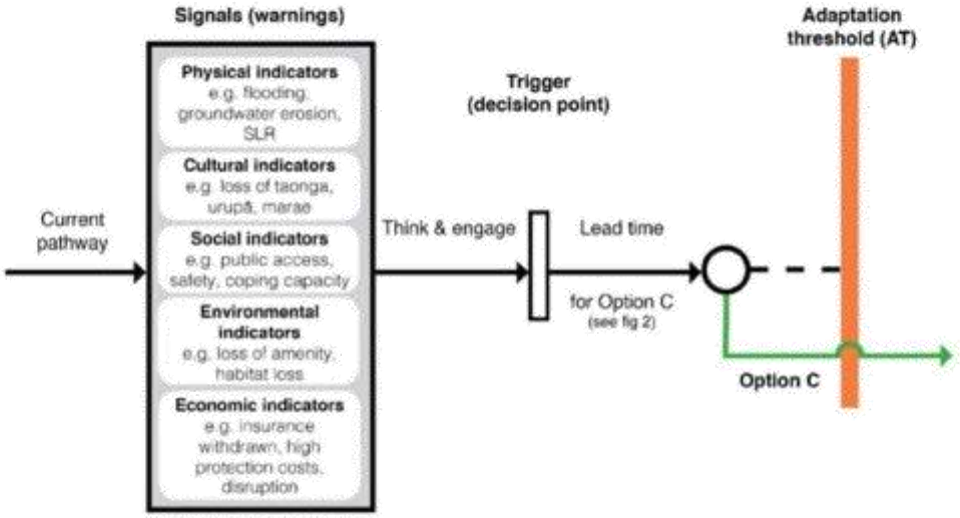
Table 1: Clifton to Tangoio Coastal Hazard's Strategy Recommend Adaptive Pathways: Revised 2021

Cell	Unit	Short term (0 - 20 years)	Medium term (20 - 50 years)	Long term (50 - 100 years)
Southern Cell	Clifton	Status quo	Sea wall	Managed Retreat
	Te Awanga	Renourishment + Groynes	Renourishment + Groynes	Renourishment + Groynes
	Haumoana	Renourishment + Groynes	Renourishment + Groynes	Managed Retreat
	Clive / East Clive	Status quo	Renourishment + Groynes	Retreat the Line / Managed Retreat
Northern Cell	Ahuriri	Status quo	Sea wall	Sea wall
	Pandora	Status quo	Storm surge barrier	Storm surge barrier
	Westshore	Renourishment	Renourishment + Control Structures	Renourishment + Control Structures
	Bay View	Status Quo / Renourishment	Renourishment + Control Structures	Renourishment + Control Structures
	Whirinaki	Status Quo / Renourishment	Renourishment + Control Structures	Sea wall

STATs are described below:

- **Signals** are an early warning of change that identifies when a trigger point or adaptation threshold may be approaching.
- **Triggers** are a decision point or points. They are designed to be set to allow sufficient time to take an action, before an adaptation threshold is reached.
- **Adaptation thresholds** describe a situation where performance measures are no longer being met or start to fail. Essentially, adaptation thresholds describe a situation that people/ communities don't want to see happen.

Figure 1 illustrates the role of signals, triggers and adaptation thresholds in an adaptive pathway.



Source: Lawrence, J., Bell, R., Blackett, P., Stephens, S., Collins, D., Cradock-Henry, N. & Hardcastle, M. (2020). *Supporting decision making through adaptive tools in a changing climate: Practice Guidance on signals and triggers*. Wellington: Deep South Challenge.

Figure 1 Diagram showing the role of signals, triggers and adaptation thresholds in an adaptive pathway

This report focusses on the process that was used to develop adaptation thresholds for the priority units identified in the Strategy.

1.1 Deep South National Science Challenge Guidance

In 2020, the Deep South National Science Challenge released a practice guidance document *"Supporting decision making through adaptive tools in a changing climate – practice guidance on signals and triggers"*. This guidance recommended a 5-Phase, 13-task process to defining thresholds, signals and triggers, monitoring and review (related to Steps 7 – 10 of the MfE guidance process) as illustrated on Figure 2 below.

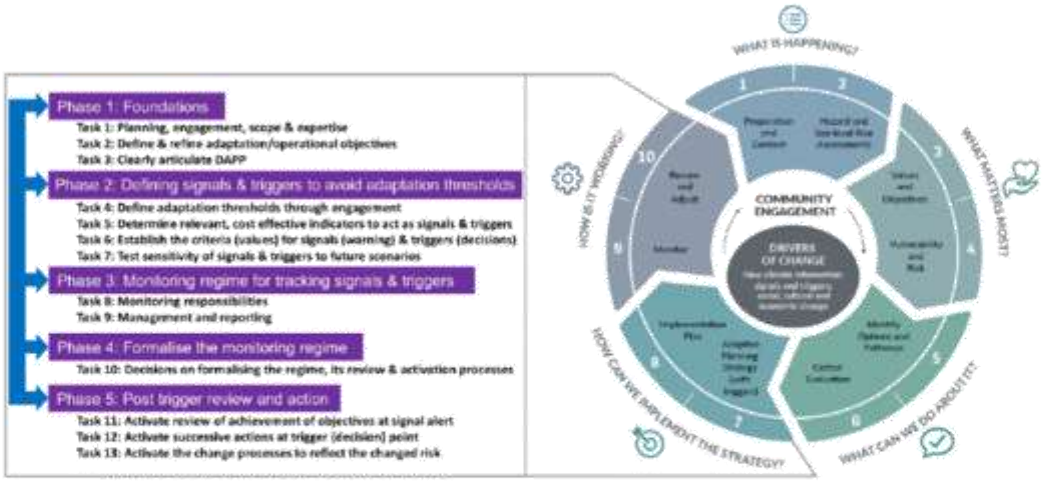


Figure 2 Thresholds, Signals and Triggers – the recommended process (Source: Deep South National Science Challenge)

The approach to developing adaptation thresholds for the Strategy was designed to align with this guidance.

2 Literature Review

In the first phase of work, a literature review was undertaken by Tom FitzGerald from Coastal Management Collective to provide guidance on current literature, recent practice and examples of the implementation of STATs.

The review provided a summary of current experience with adaptive planning approaches and STATs development.

It is noted that while some use of trigger points have been documented, at the time the literature review was undertaken there were no examples of STATs being developed and used in practice for natural hazards adaptation.

The literature review offers the following recommendations:

- Undertake a Gap analysis – it is important to understand work currently being undertaken by Councils that could be used to monitor, evaluate and report on signals, triggers and thresholds, including environmental, social, cultural, economic and governance areas.
- Community-driven – unsure that STATs are developed collaboratively to reflect a community's "lived values" of a place.
- Align with existing monitoring and evaluation activities including at a national, regional or area-specific scale.
- Monitoring, Evaluation, Reporting and Learning (MERL) plan – development of a robust, pragmatic and flexible MERL Plan is recommended to support adaptive planning decisions and track progress.

Appendix 1 contains the literature review in full.

3 Development process

The STATs development process was designed to first identify the adaptation thresholds, as illustrated in Figure 3.

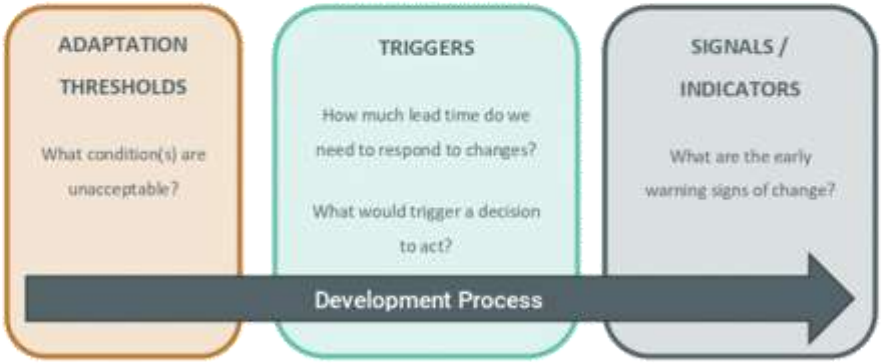


Figure 3 Development process of adaptation thresholds, triggers and signals

Adaptation thresholds take into account a range of factors that may be influenced as a result of coastal hazards including physical/built environment, social, cultural and economic factors.

In order to develop meaningful and effective adaptation thresholds that span the range of factors, the values of both the community and Councils (in their role as asset managers and emergency management) was considered essential.

This report only covers the adaptation threshold development process. Signals and triggers are currently in development, but necessarily follow the development of adaptation thresholds. Key considerations for signals and triggers include that they are practical and cost-effective to monitor and provide sufficient lead time on the relevant adaptation threshold such that actions can be implemented before the threshold is reached.

4 Workshop series

The threshold development process was primarily centred around a series of workshops held with the community and Council asset managers & CDEM team members.

Figure 4 shows the threshold development process and the roles each of the groups played. For clarity, "TAG" in the Figure 4 refers to the Technical Advisory Group established for the Strategy, which is formed by senior staff from each Partner Council and the Chair of the Joint Committee. "Panel" in Figure 4 refers to a working group of community members, primarily formed by former members of the Northern and Southern Cell Assessment Panels but including new members.

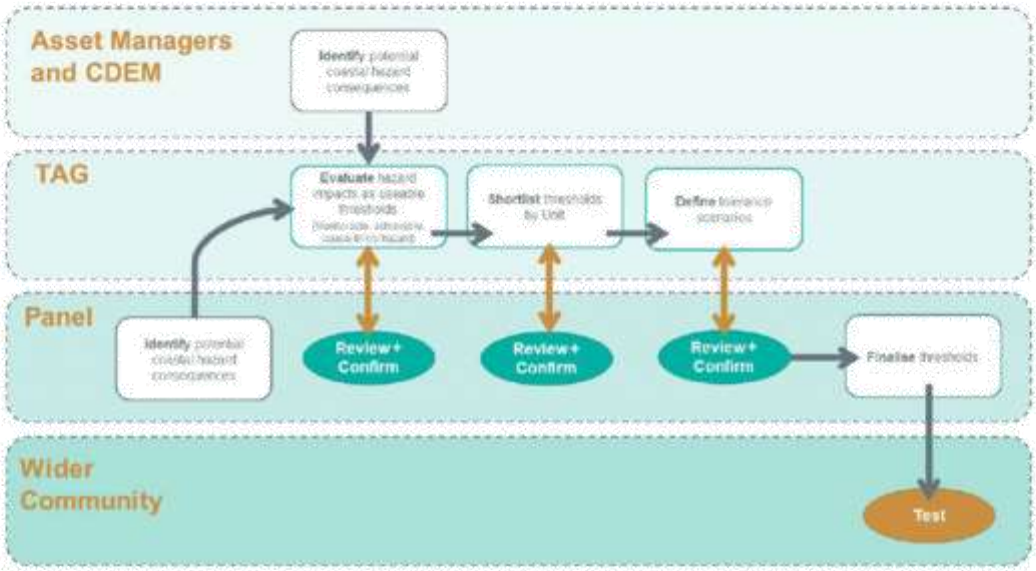


Figure 4 Workshop series

The following sections describe in more detail how proposed adaptation thresholds were developed through the workshop series.

4.1 Workshop #1: Consequences & elements at risk

For the first Panel workshop, our objectives were to communicate the role of adaptation thresholds and to get an initial understanding from community members of their experience, knowledge and concerns of the actual and potential consequences of coastal hazards.

To achieve this, we undertook a two-part exercise. We first sought to understand from the community, the consequences of coastal hazards occurring.

We then sought to understand the elements at risk of each of the identified consequences, and what these effects meant for individuals and their wider community. This part of the exercise encouraged participants to consider and identify a range of elements including physical, people (social and cultural) and economic factors.

A few weeks later, we ran an identical workshop with Council asset managers, engineers and CDEM team members to gain insights into Council perspectives on these issues. This workshop started from a clean page and was not shown the previous work by community members.

The information collected from both workshops was collated into a complete set and formed the basis for further workshops and discussions at TAG.

Figure 5 provides an example of the worksheet that was completed in these first workshops.

Coastal Hazard Consequence		Caused by		What would this mean for me & my community?			
Number	Description	Ind.	Grp.	Economic	Social	Cultural	Environmental
1.	Reduced stability of riverine deposits (particularly at mouth)	☒	☒	• Increased costs for funding maintenance (costs passed on to community beneficiary/ies)	• Boat ramps are decommissioned for recreational use • Compounding hazards if erosion not addressed (e.g. increasing P/T flooding risk) • Cycleways become disrupted/ impacted	• Access to traditional mahinga ka sites/ practices affected	• Compounding impacts on nearby natural processes (e.g. fish spawning, sedimentation of estuaries, narrowing river mouths etc
2.	Access to and along the coastline limited (vehicles and pedestrian), due to steepness of beach environments	☐	☒	• Recreational/ commercial activities affected/ cease	• Pedestrian safety increasingly vulnerable • Local boat launching sites affected/ un-usable • No vehicles on many beaches – safety?	• As above	• positive: no vehicles on beaches (esp. sensitive ecosystems) • Loss of natural ecosystems with nowhere to go/ re-create
3.	Impact on tourism activities, campsites / seasons camping, use of pathways	☐	☒	• Reduced commercial operators • Reduced 'choice' in location and market providers • Impact on HB reputation and marketing as active recreation destination/ experience	• Multiplier effect of reduced tourism • Reduced amenity/ wellbeing from limited recreational activities and coastal sense of place	• Loss of sense of place • Disrupted manual tradition over generations	• Inappropriate decommissioning of assets/ infrastructure/ built stuff

Figure 5 Worksheet example from Workshop 1

A full summary of Workshop 1 outcomes is provided as **Appendix 2**.

Workshop 1 outcomes were then used to define a set of proposed adaptation thresholds. This was done by assessing the consequences and elements at risk against two criteria to determine their usefulness and applicability as potential adaptation thresholds. The evaluation and selection criteria used were:

1. Coastal hazards are the cause of the threshold being breached; and
2. Data to assess the threshold is available or can readily be collected and interpreted

It became evident through this process that potential adaptation thresholds could be grouped into one of four categories, as presented in **Table 2**. This categorisation shows implications for how the adaptation thresholds can be monitored, and what sorts of signals and triggers would later be required to support them.

Table 2 Threshold types

Type of threshold	Description	Example
Pass/Fail	The effects of the threshold either are experienced, or they are not	*Coastal Erosion causes overwhelming or damage to/leakage from septic tank(s)*
Frequency	The effects of the threshold are time sensitive and consideration of a duration of the effect and/or the frequency of the effect is needed	*Coastal inundation causing loss of road access for the majority of the community.* *How long: At least 24 hours* *How often: More than once every 5 years.*
Subjective	Subjective thresholds are those that are influenced or determined by people's feelings or opinions.	*High levels of anxiety within the community regarding coastal hazard risks and impacts.*
Objective measure	Objectives thresholds are those that are those based on fact.	*Median house process for coastal properties decline in response to actual or perceived coastal hazard risks.*

Following this process, and with support from TAG, an assessment of the relevance of each potential adaptation threshold for each coastal unit was undertaken. This was based on spatial knowledge of the units and the assets within them and their risk exposure, including through using the coastal hazard portal. **Figure 6** shows an example how this information was captured, with the full results included in **Appendix 3**.

Figure 6 Potential adaptation thresholds identified from workshops

4.2 Workshop #2: Draft Thresholds for consideration

The potential adaptation thresholds were presented to the Panel at a second workshop for their consideration, comment and amendment.

At the workshop, we undertook a small groups exercise to test the relevance of the potential thresholds for a specific unit, based on the consequences information from the previous workshops. Each group reviewed and commented on the suggested tolerance measures for each threshold and rated the importance of each potential threshold for the specific unit they were working on. This part of the exercise was designed to support a shortlisting process for final proposed adaptation thresholds for each unit.

Feedback from the group was collated and later worked through with the TAG team to refine and shortlist final proposed adaptation thresholds for each unit.

4.3 Workshop #3 Thresholds by unit

At the final workshop, the Panel was presented with a refined set of potential thresholds.

Thresholds were divided into those that applied to all units, and those that only applied to a specific coastal unit.

The Panel first examined the proposed adaptation thresholds to apply to all units. They discussed whether each proposed threshold was suitable to apply across all coastal units and commented on the threshold's relevance and proposed threshold measures in terms of frequency and duration. **Figure 7** is a portion of the all-unit thresholds identified. The far right column of the table notes the rationale for any changes made as result of feedback in Workshop 3.

General Proposed Thresholds (apply to all Units)			
Threshold + Threshold Measure	Primary responsibility for monitoring and reporting to HBRC	Monitoring method/ data source	Rationale for changes made in response to feedback as a result of community workshop held 22 June 2022
Coastal inundation causing the loss of one or more essential services affecting the majority of the community. How long: At least 48 hours How often: More often than once every 5 years.	HBRC + Relevant TA	Observations during and following a coastal inundation event, including community feedback.	Majority of feedback suggested that in order for the impact to be substantial and therefore act as a threshold, not a trigger, duration should be extended to 48hrs from 24 hrs
Community-wide coastal inundation causing damage to multiple buildings/service. How long: Any duration How often: More often than once every 5 years.	HBRC	Observations during and following a coastal inundation event, including community feedback.	Some feedback proposed reducing this threshold to 3 years however retained as 5 to have parity with above threshold.
Any serious injuries and/or fatalities that occur as a result of a coastal erosion or coastal inundation event.	Civil Defence	CDEM observations during and following a coastal erosion or coastal inundation event, including community feedback.	Extensive debate on this threshold. All agreed that no fatalities are acceptable. Generally agreed that for injuries, threshold should be for serious injuries caused as a result of coastal hazards. Note, there are some standard definitions available
Civil Defence emergency is declared in response to coastal inundation or coastal erosion. How often: More often than once every 10 years.	Civil Defence	CDEM reporting during and following a coastal erosion or coastal inundation event, including community feedback.	Feedback suggested moving to 10 years from 5 to reflect that a Civil Defence Emergency is a major event that is not tolerable more frequently.

Figure 7 A portion of the whole of coast thresholds

The group then examined the unit specific thresholds. During this process, a number of potential thresholds were removed where they were identified as being better as a trigger due to the scale of the impacts or where there were clear management techniques to address the issue through other means, as shown in **Figure 8**.

Whirinaki Proposed Thresholds

Threshold + Threshold Measure	Primary responsibility for monitoring and reporting to HBRC	Monitoring method/ data source	Rationale for changes made in response to feedback as a result of community workshop held 22 June 2022
Coastal erosion at Whirinaki affecting Whirinaki Road and/or North Shore Road, causing loss of road access for the majority of the community.	HDC	Observed/ inspected/ reported by Council asset managers during/ following coastal erosion or coastal inundation events.	No changes suggested but change made to specifically reference Whirinaki and North Shore Roads as loss of access to either of these roads from coastal erosion would affect the majority of the community.
~~Coastal erosion at Whirinaki causing loss of road access that affects individual properties.~~	~~HDC~~	~~Observed/ inspected/ reported by Council asset managers during/ following coastal erosion or coastal inundation events.~~	Feedback suggests that this threshold would be better as a trigger given the individual scale of effects – we have applied this rationale to all individual scale thresholds in all units.
Buildings in Whirinaki are deemed uninhabitable as a result of coastal hazards (e.g. loss of septic tanks, building structural integrity etc).	CDEM/ HDC	Observed/ inspected/ reported by Council asset managers during/ following coastal erosion or coastal inundation events.	No changes suggested.
~~Kiwi access is disrupted as a result of coastal hazards.~~ ~~How long: more than 48 hours~~ ~~How often: More often than once annually~~	~~HDC~~	~~Reported by Kiwirail~~	Feedback suggested that this could be extended duration as there are alternative options that could be utilised in the event that rail is unavailable. Alternatively, some feedback suggested that this is better as a trigger as it is not exactly a community matter. Given the low impact for the wider community as a result of this infrastructure being affected i.e. not a commuter service, it was decided that this threshold was no longer needed.

Figure 8 Whirinaki example of unit-specific thresholds and the amendments as a result of community feedback.

Appendix 4 provides a summary of the final feedback from the panel.

This feedback was then used to compile a final set of proposed adaptation thresholds, which were later presented and adopted by TAG.

5 Final adaptation thresholds for the Clifton to Tangoio Coastal Hazards Strategy

Table 3 presents the final proposed adaptation thresholds for the Strategy. It is stressed that these thresholds have been developed in collaboration with community members and Council staff, but require much wider testing with the community as a whole to be legitimatised and confirmed. It is proposed that this will occur as part of consultation on the Clifton to Tangoio Coastal Hazards Strategy when it is publicly notified, which at time of writing is proposed to occur later in 2023.

Table 3: Final Proposed Adaptation Thresholds

	Threshold + Threshold Measure	Primary responsibility for monitoring and reporting to HBRC (Proposed)
All Units	*Coastal inundation causing the loss of one or more essential services affecting the majority of the community.* *How long: At least 48 hours* *How often: More often than once every 5 years.*	HBRC + Relevant TA
	Community-wide coastal inundation causing damage to multiple buildings/service. *How long: Any duration* *How often: More often than once every 5 years.*	HBRC
	Any serious injuries and/or fatalities that occur as a result of a coastal erosion or coastal inundation event.	Civil Defence
	Civil Defence emergency is declared in response to coastal inundation or coastal erosion. *How often: More often than once every 10 years.*	Civil Defence
	50% of an affected coastal community consider that a permanent loss of amenity has occurred as a result of coastal erosion or coastal inundation impacts	HBRC
	50% of the community report actual or perceived property purgatory effects i.e. actual or foreseeable damage to their properties from coastal erosion or coastal inundation and uncertainty about being able to recover their losses	HBRC
	50% of properties are unable to secure building insurance for losses from coastal hazards.	HBRC
	Access to and use of the beach, coastal reserves and/or recreational facilities is prevented as a result of coastal inundation. *How long: At least 7 days* *How often: More often than once every 5 years.*	Relevant TA

	Threshold + Threshold Measure	Primary responsibility for monitoring and reporting to HBRC (Proposed)
Whirinaki	*Coastal erosion in Whirinaki affecting Whirinaki Road and/or North Shore Road, causing loss of road access for the majority of the community.*	HDC
	Buildings in Whirinaki are deemed uninhabitable as a result of coastal hazards (e.g. loss of septic tanks, building structural integrity etc).	CDEM/ HDC
Bay View	*Coastal erosion in Bay View affecting Le Quesne Road, causing loss of road access for majority of the community.*	NCC
Westshore	*No unit specific thresholds – only Whole Coast Thresholds apply*	
Ahuriri	*No unit specific thresholds – only Whole Coast Thresholds apply*	
Pandora	*Coastal inundation in Pandora affecting Thames Street and Severn Street causing loss of road access for the majority of the community.* *How long: At least 48 hours* *How often: More often than once every 5 years.*	NCC
East Clive	*Buildings in East Clive are deemed uninhabitable as a result of coastal hazards (e.g. loss of septic tanks, building structural integrity etc).*	CDEM/ HDC
Haumoana	*Coastal inundation in Haumoana affecting Haumoana and/or Beach Road causing loss of road access for the majority of the community.* *How long: At least 48 hours* *How often: More often than once every 5 years.*	HDC
	Buildings in Haumoana are deemed uninhabitable as a result of coastal hazards (e.g. loss of septic tanks, building structural integrity etc).	CDEM/ HDC
Te Awanga	*Coastal inundation in Te Awanga affecting Clifton Road causing loss of road access for the majority of the community.* *How long: At least 48 hours* *How often: More often than once every 5 years.*	HDC
	Coastal erosion in Te Awanga affecting Clifton Road causing loss of road access affecting the majority of the community.	HDC
	Buildings in Te Awanga are deemed uninhabitable as a result of coastal hazards (e.g. loss of septic tanks, building structural integrity etc).	CDEM/ HDC

	Threshold + Threshold Measure	Primary responsibility for monitoring and reporting to HBRC (Proposed)
Clifton	*Coastal inundation in Clifton affecting Clifton Road causing loss of road access for the majority of the community.* *How long: At least 48 hours* *How often: More often than once every 5 years.*	HDC
	Coastal erosion in Clifton affecting Clifton Road causing loss of road access affecting the majority of the community.	HDC
	Buildings in Clifton are deemed uninhabitable as a result of coastal hazards (e.g. loss of septic tanks, building structural integrity etc).	CDEM/ HDC

6 Signals, Triggers & future monitoring

Work has now commenced on the development of appropriate signals and triggers. These will be designed to provide clear early warnings of change, with sufficient lead-time to enable robust decision making around next steps.

We consider it important to have good knowledge of likely next actions in order to accurately define signals and triggers. For example, if the likely next action in response to a trigger being reached is increased beach nourishment, little lead time (months) will be required in order to take that action to avoid an adaptation threshold being reached. A physical structure in the Coastal Marine Area and its associated consenting and construction process will require significantly more lead time (years). Managed or planned retreat is likely to require 10 years plus lead time. Consideration of lead-time has significant implications for how signals and triggers and defined and monitored for each part of the coast.

A subsequent but necessary step, once the signals and triggers have been identified, is the need to develop a pragmatic monitoring programme.

This programme will provide the mechanism for tracking identified adaptation thresholds, signals and triggers over time. In the development of the monitoring programme, existing monitoring already undertaken by Councils or others will be identified and its efficiency for monitoring signals, triggers and adaptation thresholds evaluated to identify any gaps where additional monitoring is required.

We recommend that a dedicated website or page is developed to provide "live" reporting of signals, triggers and adaptation thresholds once these are in place and being monitored. A simple traffic light system overlaid with an interactive map would be used to graphically show whether signals, triggers and adaptation thresholds are nominal (green), approaching (amber) or reached (red). This would provide a valuable node of communication for community members, Councils and asset owners/managers, and could provide an online forum for self-reporting of monitoring data by community members or others.

PART B

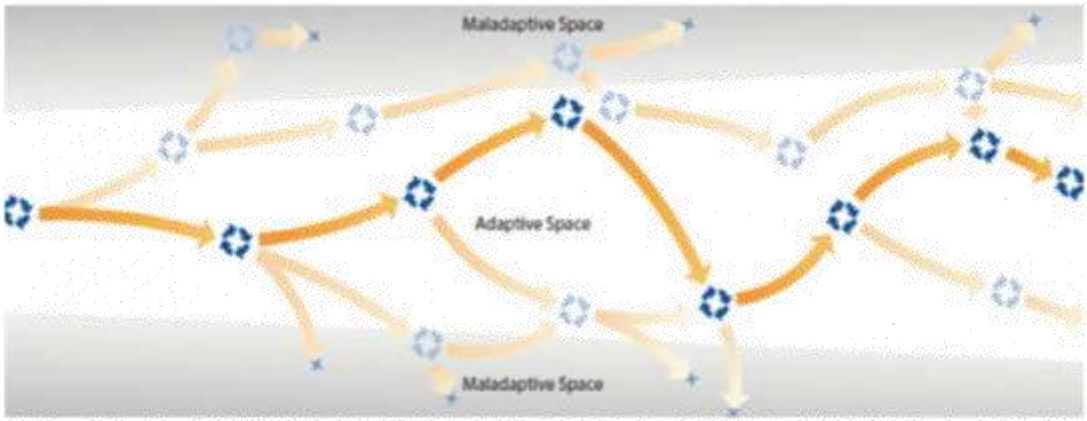
Appendices

Appendix 1

Literature Review

Clifton to Tangoio Coastal Hazards Strategy 2120

Supporting Adaptation using Signals, Triggers and Adaptation Thresholds (STATs): a brief review



Tom FitzGerald, Coastal Management Collective

May 2021

Cover image: a diagram showing conceptual adaptation pathways with intermittent decision points and alternative pathways seeking to stay in the adaptive space and avoid maladaptation. Source: [1]

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Table of Contents

1 Background

1.1 This document

This document reviews current literature, recent practice and examples of Signals, Triggers and Adaptation Thresholds (STATs) and provides a basis from which to inform their development as a key part of the next phase of the *Clifton to Tangoio Coastal Hazard Strategy 2120* (the Strategy).

The Strategy was developed as the pilot project of the MfE Guidance [2] but is not yet complete and requires the development of STATs to progress toward implementation whilst ensuring the Strategy is both dynamic and adaptive – as envisaged by the MfE Guidance.

1.2 The mandate for adaptive planning

In 2017, the Ministry for the Environment published new guidance setting out an approach to managing for coastal change that takes account of deep uncertainty and ongoing change. Steps in the MfE Guidance revolve around a core of ongoing community engagement and monitoring drivers for change. The 10 steps are founded upon a simple rubric captured by five deceptively simple key questions that form the backbone of a living adaptive planning strategy, they are:

1. *What is happening?*
2. *What matters most?*
3. *What can we do about it?*
4. *How can we do it?*
5. *How do we know it's working?*

Fundamentally, the MfE Guidance [2] places an emphasis on using *dynamic adaptive pathways planning* to deal with uncertainty.

According to the now emergent doctrine of Dynamic Adaptive Pathways Planning (DAPP) an *adaptive planning strategy* (see MfE, 2017) may be conceptualised as a series of actions over time that can proactively account for the uncertainty over future climate change and societal manifestations. Essentially, DAPP enables contingency actions to be

put in place proactively as conditions change. A pathways approach to adaptation planning is about keeping options open (so called 'low regrets' actions) and so avoiding path dependency and lock-in. Under the approach, rather than determining a final outcome or final decision at an early stage, decision-makers are able to build a strategy that will adjust to changing circumstances over time. The approach acknowledges that while not all decisions can be made now, they can be planned, prioritised and prepared for. It is a useful approach for dealing with uncertainty [3], and is the preferred approach set out in the MfE Guidance (2017) (see Figure 1 below).

Figure 1 The ten (10) steps and five (5) key questions that fundamentally underpin the mandated approach to coastal adaptation in New Zealand – Dynamic Adaptive Pathways Planning (DAPP) to support an adaptive planning strategy. Source: MfE, 2017.

Characteristics of a DAPP approach include:

- Each decision-point is triggered by some change in context (environmental, economic, cultural or social). In the design of the Adaptive Planning Strategy (see Step 7 above), the steps and the triggers must be identified.
- Each decision-point has a series of identified choices or adaptation responses associated with it.

5

- Once the decision-point is reached (or triggered), the adaptation responses for that step are 'tested' against plausible futures and the acceptable risk to the community, and a selection is made.
- The selection leads to the next section of the pathway, and in turn to the next decision-point.
- The adaptation responses that are not selected will, if appropriate, be available for selection at the next decision-point. The wide range of options considered, evaluated and left 'on the table' for the future gives decision makers flexibility and allows decisions to be responsive and iterative.

It is this kind of flexibility that is required to deal with an uncertain future. But underpinning our decision-making lies the foundations of monitoring, evaluation, reporting and learning (MERL) [4] and our ability to track adaptation progress.

1.3 Monitoring for change: the fundamental premise behind adaptive planning

However, the ultimate success of any adaptive planning strategy and implementation plan is critically dependent on the monitoring, evaluation and adjustments that are allowed for at the back end of this process *(How do we know it's working?)*. It enables us to learn from experience, and redesign better solutions iteratively. This is why monitoring for change (by way of signals and triggers) were placed at the very core of the MfE Guidance.

It's not an overstatement to suggest that appropriate monitoring and evaluation frameworks should be the bedrock underpinning any adaptive planning strategy. After all, if we haven't been able to define 'success' then there would be no reason to change course - any possible future would represent success and make the notion of adaptive planning redundant. Monitoring and evaluation are a critical component of understanding whether success as it has been defined, has been or is being achieved. Furthermore, as adaptive planning strategies seek to oversee and guide decision-making for the next 100+ years – being able to point to indicators that are suggesting onset of adverse conditions and then making decisions to avoid the worst of those adverse conditions becomes increasingly invaluable.

The DAPP approach focuses on keeping multiple pathways open into the future to deal with greater uncertainty over longer timeframes. It's all about flexibility. It's an iterative process requiring ongoing support from decision-makers and the community. Critical to this process is the underlying premise that adaptation actions (whether they be for example: policy decisions, structural solutions, or natural defences) can only ever have a finite life in the face of continual change (whether climate change or community change). In order to maintain the flexibility to change tack, or employ an alternative adaptation solution, monitoring and review of current actions for their efficacy is fundamental.

CoastAdapt (www.coastadapt.com.au) identifies three key elements of how regular monitoring and evaluation can help track adaptation progress, by:

1. Tracking the performance of activities during the development of an adaptative planning strategy (e.g. a survey about community engagement).
2. Tracking previously identified indicators pointing to approaching adaptation thresholds, signals and key decision points (or triggers).
3. Determining whether outputs and outcomes have been achieved.

In 2020, to provide additional support to the MfE Guidance (2017) and under the auspices of the Deep South National Science Challenge, Lawrence et al [5] published practice guidance on signals and triggers and proposed an approach to developing STATs to enable proactive decision-making (see Figure 2 below). The practice guidance sets out thirteen key tasks to be undertaken in developing STATs, as set out below:

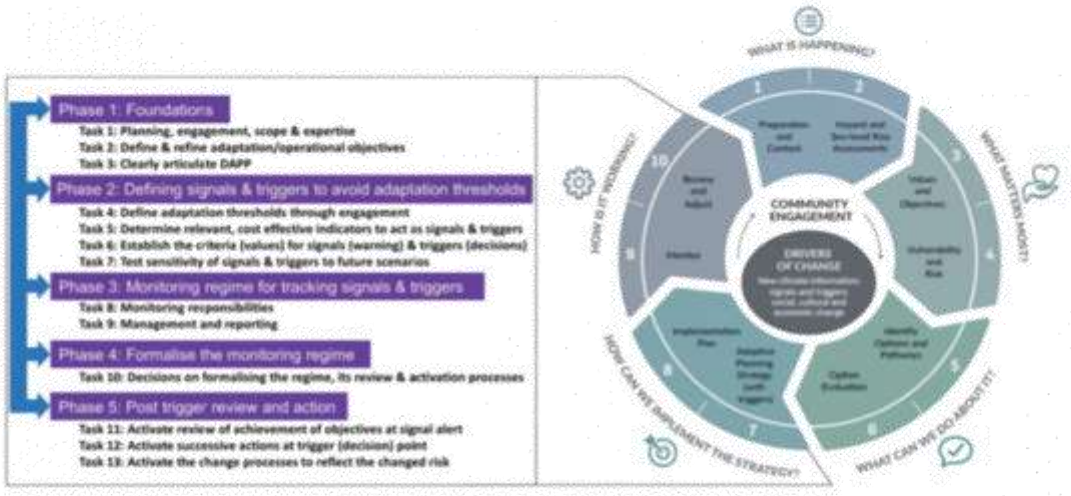

Figure 2 The proposed process for developing STATs as part of broader coastal adaptation process recommended by MfE (2017) – the 10-step decision cycle.

With that in mind, this review sets out the context and considerations for the development of STATs to support the implementation, monitoring and review of actions identified in the *Clifton to Tangoio Coastal Hazard Strategy 2120* and to help ensure its ongoing success as a truly adaptive planning strategy.

2 Signals, Triggers and Adaptation Thresholds (STATs)

Signals, triggers and adaptation thresholds (STATs) are first and foremost defined in the MfE Guidance, but for convenience they are summarised here:

- **Signals** – an early warning that identifies when a trigger point or adaptation threshold may be approaching[1].
- **Triggers** – the decision point(s), allowing sufficient time to take an action prior to an adaptation threshold being reached.
- **Indicators** - individual or combined metrics or qualitative values that can pick up changes or trends and be used to monitor for both signals and triggers. Indicators should be salient, credible and legitimate for decision-makers and the community (see Lawrence et al, 2020).
- **Adaptation Thresholds** – the conditions to be avoided by taking a new action i.e. what people do not want to happen.
- **Adaptation Pathway** - an approach designed to schedule adaptation decision-making: it identifies the decisions that need to be taken now and those that may be taken in future. The approach supports strategic, flexible and structured decision-making[2]. It allows decision-makers to plan for, prioritise and stagger investment in adaptation responses.

The below diagram (Figure 3) illustrates the relationships between the above described terms:

[1] In some cases it may be possible, or more practical, to combine signals and triggers into one point in time – see Section 3.2 of Lawrence et al, 2020. This may be due to the differences between the two being insignificant, or not significant enough e.g. the difference between 'minor' and 'moderate' or 'likely' and 'very likely' – this is particularly relevant for quantitative physical indicators like flooding and high sea level events.

[2] See CoastAdapt - https://coastadapt.com.au/pathways-approach

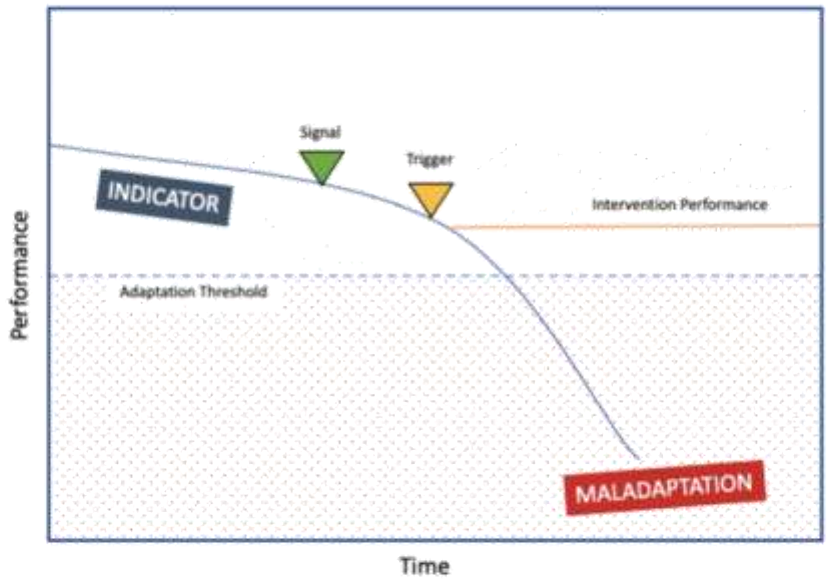

Figure 3 Conceptual diagram of the sequence and interaction between indicators, signals, triggers (decision point) and adaptation thresholds. Note that signals and triggers are identified at an earlier time than when the adaptation threshold is reached – this is to ensure sufficient lead time is built into the process to allow a new pathway (or intervention) to be planned and implemented. Note also that 'Performance' on the Y-axis could be described by reference to levels of risk, levels of service, metrics around community wellbeing etc. A dynamic adaptive pathways planning approach should guide decisions away from maladaptation, or negative outcomes.

The blue line in the diagram above represents an indicator of the status quo i.e. if nothing was done the indicator would trend down dipping below a known/unknown adaptation threshold (dashed line) and resulting in maladaptation. The yellow line represents an intervention (or adaptation response) designed to at least maintain performance for a specified period of time e.g. a seawall designed to withstand a 1 in 50 year event under a high sea level scenario.

Maladaptation in this diagram describes a space where interventions (or adaptation responses) result in an undesired state. This may also include lack of adaptation response.

Further detail, examples (Boxes 1-4) and commentary on STATs is provided in Sections 2.1 and 2.2 below.

2.1 Starting with Adaptation thresholds

The identification of adaptation thresholds (ATs) is a question fundamentally about risk tolerability. This is directly related to what people value, their objectives (including those set by policy or regulation) and how those values interact with the potential frequency and magnitude of coastal hazards. But really it is about asking the question: what you don't want to experience and why? [5] What is the breaking point?

According to Stephens et al [6], an *adaptation threshold* occurs *"...when the status quo is no longer effective in meeting objectives and a new action or pathway becomes necessary. Adaptation thresholds are associated with performance of the system of concern, for example storm-tide flooding becoming too frequent for a viable community to function or, when beach nourishment or a sea wall is no longer effective due to technical, economic, or social limitations."* CoastAdapt (2021) differentiates between two kinds of AT (1) a threshold of the system being managed, or tipping point, and (2) a threshold related to the adaptation responses being considered. For example, the second type of AT might be described by a point in time when a seawall is overtopped by rising seas.

As well as being defined by changing environmental conditions ATs can also be socially, culturally or economically defined and may be framed in terms of coping capacity, adaptive capacity, disruption to activities, or disconnection from special (highly valued) places (or other similar measures, see Figure 4). Community engagement is a central mechanism employed to unravel how an individual's or a group's values (framed as objectives) may be impacted by coastal hazards, and help determine acceptable, tolerable or otherwise intolerable levels of risk.

Community engagement does not have to be in person or undertaken through traditional mediums, it can also be done virtually. For example, novel US research has used social media (e.g. Twitter remarks) to help identify nuisance flooding thresholds. Researchers developed a 'remarkability metric' that implicitly considered risk consequences e.g. a flood that blocks an important roadway will generate more commentary than a similar event over less used, less populated land. Also of interest is that the remarkability of increasingly common events was noted to diminish over a period of 2-8 years as events become less and less surprising [7].

However a key difficulty with community engagement in longer-term planning has been in an individual's or community's inability to engage beyond the immediate planning horizon, or the temporal scale of the personal impact [8]. This has often resulted in a preference for hard coastal protection structures as an 'interim' or first step. Grace and Thompson [8] surmise about the short-sighted thinking in preferences for hard coastal protection structures and point to an inevitability about retreat as an ultimate endpoint:

> *"Engineered structures are designed to withstand a specified storm event, and have a design life after which they no longer offer viable protection. It is important for stakeholders to understand the temporary nature of protection*

measures. In the long term, the size and extent of engineering structures required to withstand sea level rise and more intense storm events will necessarily become larger, increasing their cost and impact. The logical conclusion is that the feasibility and cost of continuing protection will become untenable, and eventual retreat from the vulnerable land is therefore inevitable."

BOX 1: LAKES ENTRANCE, VICTORIA (AU)

One of the pioneering approaches to adaptation pathways in Australia was at Lakes Entrance on the East Coast of Victoria [9, 10]. The below diagram summarises the triggers (and implied ATs) identified and the possible steps to be taken. The triggers (derived through interviews, focus groups and surveys[3]) were identified as illustrating a marked departure from 'normal' experience with discernible social impacts for local business, employment, access, disadvantaged groups and the costs of living[4]. Importantly, they found that triggers of change that have social impacts are salient to local communities and help build consensus around adaptation decisions, essentially acting as collective expressions of risk tolerability and providing windows of opportunity to enact policy change (or change path). Descriptions of likelihood and physical environmental parameters can then be worked backward from there e.g. a once in 20 years flood event (1:20 yr flood) leads to flooding of the main road through the town.

[3] Further information on the methods used to derive triggers based on lived values is provided in Barnett et al (2014):
10. Barnett, J., et al., *A local coastal adaptation pathway.* Nature Climate Change, 2014. **4**(12): p. 1103-1108.

[4] For further work on 'lived values' undertaken by Sonia Graham at UNSW Sydney, see:
11. Graham, S., et al., *Local values for fairer adaptation to sea-level rise: A typology of residents and their lived values in Lakes Entrance, Australia.* Global Environmental Change, 2014. **29**(0): p. 41-52, 12. Graham, S., et al., *The social values at risk from sea-level rise.* Environmental Impact Assessment Review, 2013. **41**(0): p. 45-52, 13. Graham, S., et al., *Towards fair local outcomes in adaptation to sea-level rise.* Climatic Change, 2014. **130**(3): p. 411-424.

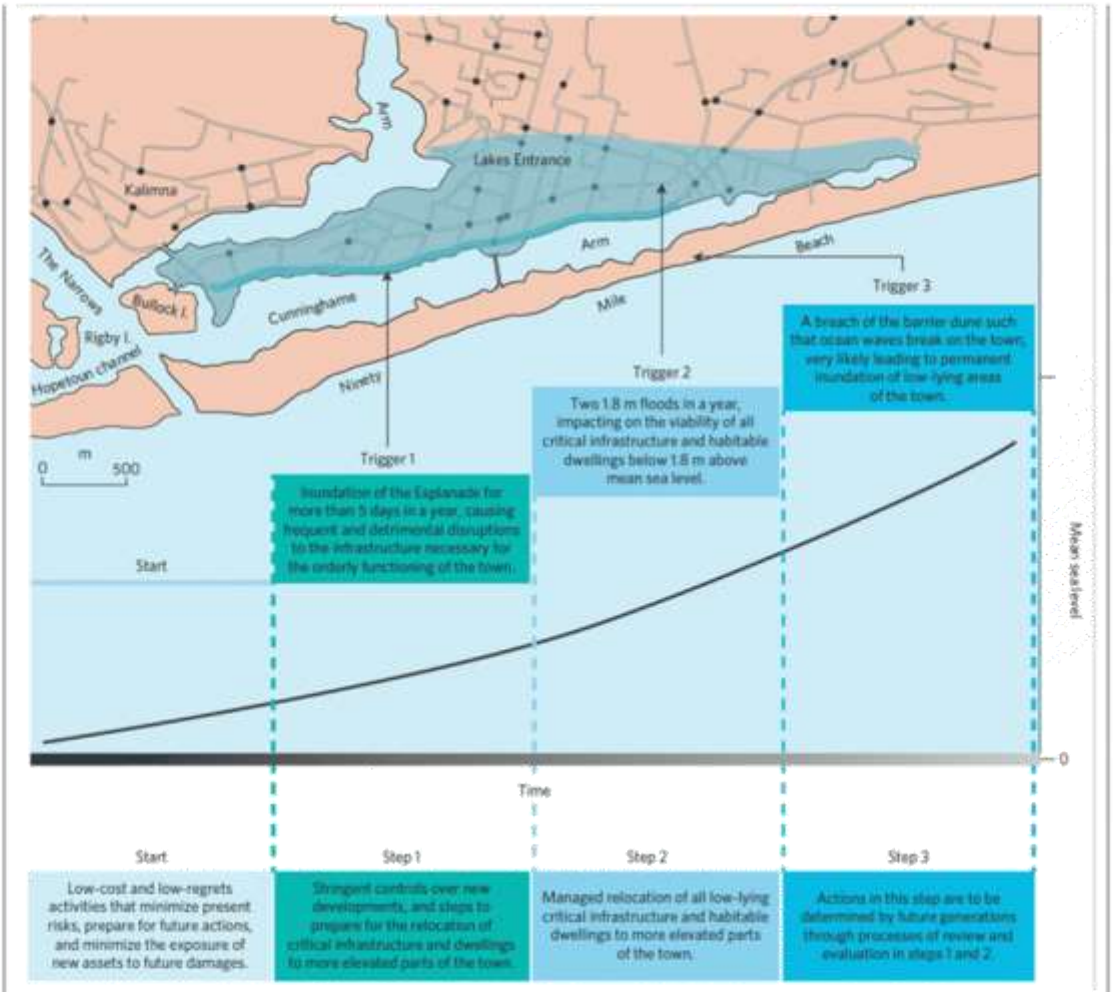

Figure 4 Summary of adaptation pathways approach adopted in Lakes Entrance, Victoria. Figure extracted from CoastAdapt website: https://coastadapt.com.au/pathways-approach original from Barnett et al (2014).

Adaptation thresholds, acceptable risk and limits to adaptation

Another way of contemplating an adaptation threshold is to frame the observation or decision in terms of risk tolerability. For human society, a risk is largely a social construct driven by natural hazards [14-16] determining STATs requires social and political judgments to be made regarding acceptable, tolerable and intolerable levels of risk in each circumstance. As each adaptation response involves some degree of residual risk[5]

[5] The risk that remains (and may continue to change unmanaged) after risk management measures and adaptation policies have been put in place (National Climate Change Risk Assessment: Method Report, 2020).

(i.e. the risk that remains after the adaptation response is in place), then this risk is either tolerated or accepted by the local community.

To provide a local example, in Westshore (Hawkes Bay) this might mean (for example) that every now and then a larger than anticipated storm will come along and overcome the protection afforded by the renourished beach in the short-term. This is because there is typically no 100% guarantee of success provided by any particular adaptation response. Therefore another way to frame the question for identifying the adaptation thresholds is to ask *"what level of risk would you consider to be intolerable?"*. These can be very personal, subjective and qualitative assessments that will differ person to person, place to place, and over time.

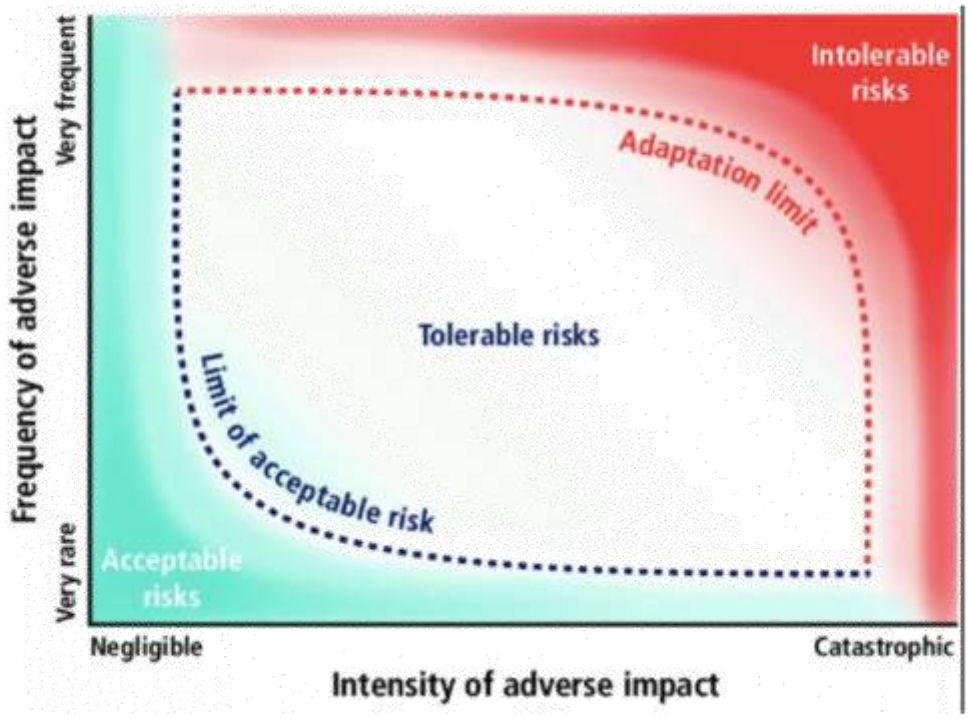

Figure 5 Conceptual model of the determinants of acceptable, tolerable, and intolerable risks and their implications for limits to adaptation [17-19]. In this conceptual diagram, adaptation efforts are seen as keeping risks to objectives within the tolerable risk space. The dotted lines indicate that individual or collective views on risk tolerance with respect to the frequency and intensity of climate-related risks are not fixed but may vary and change over time. In addition, the shape or angle of the lines and the relative area in each section of the diagram are illustrative and may themselves change as capacities and attitudes change.

Community perceptions of risk tolerability can be a very useful way of determining practical, useable ATs. However, there are also quantitative ways of determining when ATs have been reached that can complement and support community driven ATs. Technical, quantitative work could include identified levels of service, engineering design

or building standards and or consented performance standards, monitoring requirements or consent lapse/expiry dates.

Notably in Figure 5 above, the idea of 'limits to adaptation' are introduced. These can be defined as *"when adaptation efforts are unable to provide an acceptable level of security from risks to the existing objectives and values and prevent the loss of the key attributes, components or services of ecosystems"* [20]. There is large diversity in this literature and 'limits to adaptation' have also been described as "thresholds", "regime shifts", "tipping points", "dangerous climate change", "reasons for concern", "planetary boundaries" etc. They can also be described as being *hard* i.e. limits that will not change, or *soft* i.e. limits that can change depending on preferences and time.

BOX 2: PETONE, WELLINGTON (NZ)

Kool et al [21] applied the DAPP approach to stormwater and wastewater infrastrucrure in Petone, Wellington. The case study was chosen due to the criticality of infrastructure serving communities who may also be exposed to rising sea levels and changing coastal hazards, but also due to the fundamental problem of gravity-reliant systems (mostly) needing to rely on sufficient space to discharge at the ocean – space that will only be reducing as seas rise and begin to block discharge outlets.

For this study, ATs were identified by a combination of modelling and expert elicitiation, and limited to the identification of physical consequence parameters such as regular ponding or overflows (stomwater and wastewater) delineated by sea level rise (SLR) increments e.g. 0.3m, 0.5m, 0.8m above current (see Figure 6).

It is notable that ATs were defined without community input, instead using a proxy of "unacceptable" Level of Service as defined by projected asset/system failure conditions. Due to the complex system nature of the stormwater and wastewater network, Kool et al [21] identified that a number of different adaptation responses that would be required at different times (largely dependent on SLR projections and elevation) and for different geographical areas. Interstingly, rules and polcies in land use plans and stratetgies were also identified as potential signals for eventual retreat. It is also worth noting that the sensitivity of the systems was only investigated with regard to changing sea level conditions, and not changing land use patterns over the next 100 years – a much more

volatile set of scenarios, but something that is now possible to investigate using tools such as RiskScape.

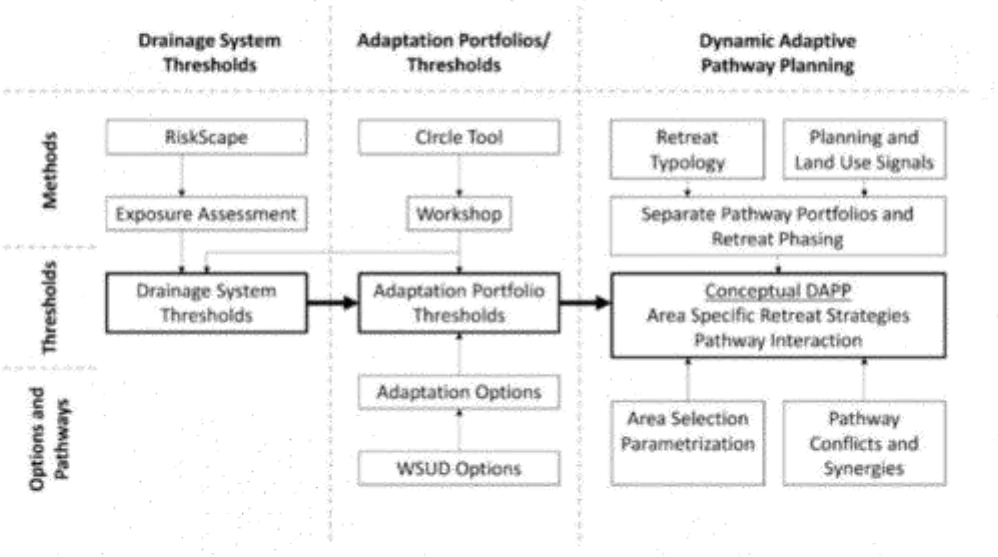

Figure 6 Method for applying a DAPP approach to stormwater and wastewater systems

Involving the community in investigating the adaptation threshold conditions (e.g. asking what is an unacceptable disruption to the function performed by stormwater and wastewater networks?) would have allowed a more nuanced and ground-truthed approach to decision-making that would likely engender greater support.

2.2 Monitoring using Indicators (Signals and Triggers)

Indicators are metrics or descriptors that are used to monitor change. In that sense, triggers and signals represent points in time somewhere along that continuum of change that are identified, described and selected by the relevant community. Therefore, in this report signals and triggers form a subset of indicators.

Stephens et al (2018) noted that identifying, evaluating and using indicators to develop STATs for climate adaptation is a relatively unexplored area in the scientific literature. Monitoring for signals and triggers is also more commonly used in other domains; such as ecological management, infrastructure planning [22] and transport policy, and water management [23]; and in other countries. It has also been used in coastal locations in Australia (see work in Lakes Entrance, Victoria [9, 10] and Cockburn, Western Australia

[8]), and is increasingly being applied in coastal guidelines for sea level rise across Australian jurisdictions [24].

TRIGGERS AND SIGNALS

In 2014, the use of triggers and adaptive pathways was an emerging field for coastal management and adaptation [23]. Designed to help deal with uncertainty and the identification of risk tolerability thresholds and key decision points (or triggers), they seek to recognise and account for dynamics in a changing environment and a changing socio-economic and cultural context, and therefore a changing risk profile [5].

Signals are intended to function as an 'early warning' notice that if things carry on as is, agreed community objectives and standards may be breached, signalling that planning, scoping and engagement should begin for the next set of possible pathways.

Ideally, well designed signals and triggers provide decision-makers advance notice allowing preventative actions to be undertaken thereby avoiding frequent damaging impacts that may be considered intolerable by the community. Critically, they help reduce uncertainty and make tangible the effects of climate change by using events rather than time horizons as decision points (CoastAdapt, 2021).

The idea of proactive decision-making is not new, but its practice could always be better. The author has observed and noted in numerous jurisdictions that decision-making is much more expedient in times of emergency, with big coastal storms often acting to create political impetus and triggering reactive decisions. It's this sort of reactive management that has blighted many parts of New Zealand's coastline for as long as humans have attempted to intervene in coastal processes. Wainui Beach is one such example.

BOX 3: WAINUI BEACH, GISBORNE (NZ)

The *Wainui Beach Erosion Management Strategy 2014* (WBEMS) identifies 'trigger points' to mark consideration or implementation of a change or continuation of management approach, in either the medium term (20-30 years) or the longer term (next 100 years).

Table 1 Identified triggers for each Management Area contained within the Wainui Bech Erosion Management Strategy 2014.

Management Area	Trigger
1 - Tuahine Point	Any future proposal for a dwelling or residential development on the seaward side of the ridgelines should trigger consideration of landslide hazard and appropriate action to mitigate this risk (e.g. consideration of change from pastoral to forested land uses).
2 - Tuahine Crescent	The trigger for considering alternative treatments such as relocation/removal is linked to expiry of resource consents for existing structures in this section (assumed 2042).
3 - Murphy Road South	In view of the fact that some houses are relatively close to the shoreline, consider appropriate action (e.g. reinstatement of the bluff face using a beach push-up or relocation/removal of the asset) if the top landward edge of any new erosion scarp extends to within 8m of a dwelling.
4 - Wainui Stream	Landward replacement of existing coastal protection structures if severe damage precludes ongoing maintenance and/or that adverse environmental effects (e.g. beach narrowing) become sufficiently serious. If the top landward edge of the erosion scarp lies within 8m of a dwelling after a major erosion event then appropriate action should be considered.
5 - Pare Street and Waipaoa Road	The 8m setback from the crest of the erosion scarp is required to trigger consideration of appropriate treatments will be required. The most appropriate action will generally be either reinstatement of the eroded dune using sand push-ups or landward relocation of the dwellings on the property.
6 - Hangaroa Stream	The 8m setback from the crest of the erosion scarp is required to trigger consideration of appropriate treatments will be required. The most appropriate action will generally be reinstatement of dune using push-ups or landward relocation of surf club
7 - Northern Wainui Beach	Reconfigure car parks if the seaward edge is threatened by future coastal erosion. Consider undertaking this work where the seaward edges of car parks are within 10m of the top landward edge of historic erosion scarps.
8 - Makorori Point	None

The triggers identified above all relate to the distance of an erosion scarp from an element identified as being at risk e.g. a car park, home etc. In the case of Management Areas 3-6 they appear to have been designed regarding Earthquake Commission (EQC) coverage limitations and to provide sufficient space to relocate a dwelling after a major erosion event.

The WBEMS was forward-thinking and sought to include triggers as a means of creating an adaptive management approach[1]. However, FitzGerald and Hume [25] concluded that their usefulness was hampered in a number of ways: the indicators and signals leading up to the triggers were not identified, tolerability thresholds were not specifically detailed, and potential actions at each trigger point were not set out and stress tested, effectively rendering the triggers redundant.

The lack of effort to track performance of coastal management or adaptation strategies is not unique to Wainui Beach. Many other jurisdictions have gone down the same path and invested heavily in the development of a Plan only to neglect its implementation – a kind of 'adaptive management lite' (Frohlich et al, 2019). There can be a multitude of reasons for this: a lack of funding or resourcing to advance specific actions, legal, political or policy barriers, reprioritisation of activities and budgets, changing roles and responsibilities of Council staff, lack of a 'champion' to advocate for the Strategy, changing community perspectives etc. There are significant opportunities in this space to improve tracking and reporting, but also to engage people, educate people and encourage local stewardship/kaitiakitanga through citizen science initiatives like CoastSnap (see www.coastsnap.com).

BOX 4: COCKBURN, WESTERN AUSTRALIA (AU)

Grace and Thompson [26] highlight a flexible adaptation pathway approach undertaken for the Cockburn Sound Coastal Alliance (CSCA) south of Perth. As with, NZ's MfE Guidance (2017) the approach identifies that using 'likelihood' measures associated with sea level rise will increasingly tend toward certainty, or inevitability. Thus using likelihood descriptors (like 1 in 100 yr flood) is not that helpful in conveying the real long-term risk.

They used a series of spatially explicit coastal setback lines (for erosion and inundation) derived from State Coastal Planning Policy that acted as proxies for levels of risk (see Figure 7 and Table 2 below). For erosion, setbacks are based on (1) current risk of storm erosion e.g. 1% AEP (2) historic shoreline movement trends (3) future sea level rise; for storm surge inundation a 0.2% AEP level is used. Those lines were then translated into risk contours on maps using different time periods and sea level rise scenarios i.e. erosion risk over 100 years would be identified as Y100, over 50 years as Y50 etc., and ultimately applying different planning rules.

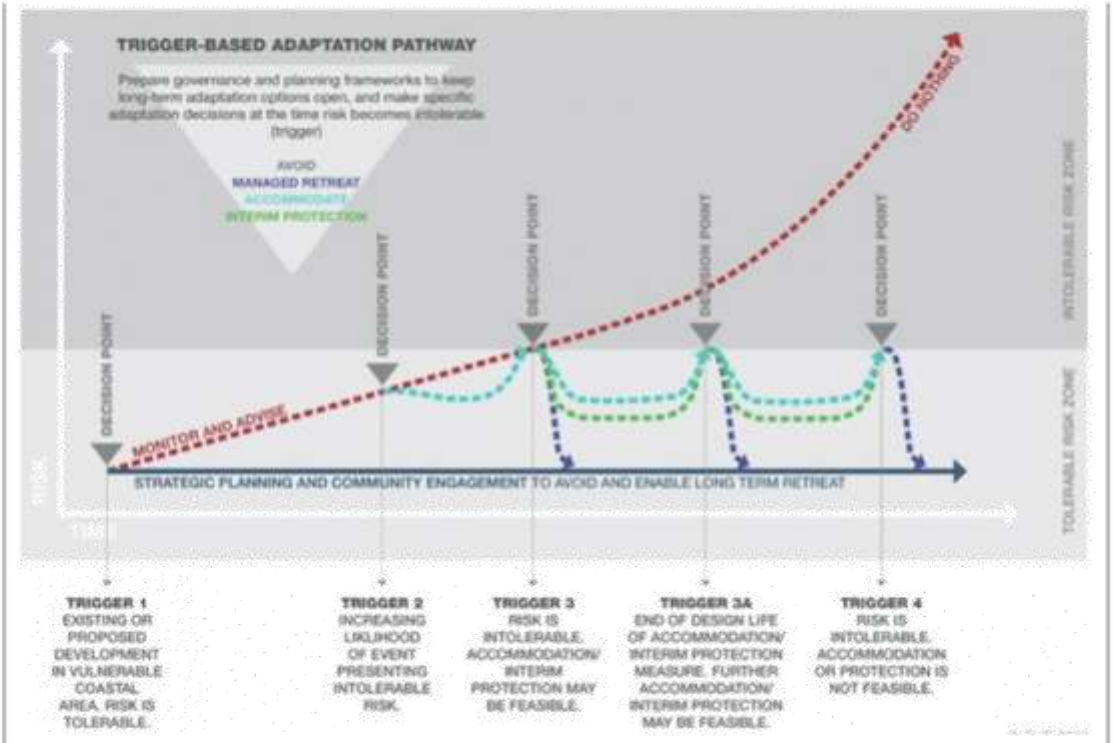

Figure 7 Example of a trigger based long-term adaptive pathway used for coastal planning in Cockburn Sound, Western Australia.

This approach represents incorporates adaptive planning explicitly into spatial and strategic planning – effectively with different coastal hazard zones acting as signals, triggers and adaptation thresholds for the use of different rules and assessment criteria. It relies on community engagement under the relevant planning system and operates on a presumption that the lines demarcating coastal hazard zones will change over time.

Table 2 Triggers, risk levels and actions identified in Cockburn Sound adaptive pathways approach.

TRIGGER	RISK LEVEL	LOCATION OF MOST SEAWARD ASSET/VALUE AT RISK	ACTION
1 – assets or values in coastal zone reach high risk level	Tolerable	Between Y100 and Y50	• Avoid through strategic planning measures • Ongoing monitoring
2 – assets or values in coastal zone will reach extreme risk level during planning period	Increasing likelihood of intolerable	Between Y50 and Y15	• Accommodate through asset or area specific measures. • Ongoing monitoring
3 – assets or values in coastal zone reach extreme risk level	Intolerable. Interim protection may be feasible	Seaward of Y15	• Evaluate whether interim Protection is justifiable on social, environmental, and economic grounds. • Where interim protection is justifiable, determine the nature of the works based on social, environmental and economic grounds. • Where interim protection is not justifiable, Retreat.
4 - assets or values in coastal zone continue at extreme risk level	Intolerable. Protection is not feasible.	Seaward of Y15	Actively plan for retreat in a coordinated manner

In New Zealand, summary examples of how triggers are used under the *Resource Management Act 1991* are also provided in Appendix 1 of Lawrence et al (2020). In summary, the mandate for monitoring of the environment, natural hazards and climate change which includes the *RMA*, *Local Government Act 2002* and *Civil Defence and Emergency Management Act 2002*. However, the newly amended *Climate Change Response Act 2002* has not been included and sets out the national level risk and adaptation monitoring and reporting requirements, including their application to local government:

5ZW Minister or Commission may request certain organisations to provide information on climate change adaptation

(1) The Minister or the Commission may, in writing, request that a reporting organisation provide all or any of the following information:

(a) a description of the organisation's governance in relation to the risks of, and opportunities arising from, climate change:

(b) a description of the actual and potential effects of the risks and opportunities on the organisation's business, strategy, and financial planning:

(c) a description of the processes that the organisation uses to identify, assess, and manage the risks:

(d) a description of the metrics and targets used to assess and manage the risks and opportunities, including, if relevant, time frames and progress:

(e) any matters specified in regulations.

Lawrence et al (2020) provide a useful list of potential triggers across different domains that could be explored in the Hawkes Bay context. These are provided in Figure 8 below:

Precursors	Hazards	Risk	Social/psychological	Financial/economic	Cultural	Environmental	Governance/ institutional
Average New Zealand 7-station air temperature reaches X degree C	Riverbank erodes to within X m of house(s), levee, or other infrastructure	Event causing >$XM damage (or insured losses)	Measure of concern/anxiety or wellbeing	Insurance withdrawn or no new build insurance for a section or a community	Taonga or sites (e.g., urupa) begin to be inundated or are regularly inundated	X% loss of wetlands/marshes/ bird numbers/riparian habitat	Regional or district plan controls for further development
Mean annual precipitation across the region or catchment reaches X mm/yr	When X flood events, exceeding 2% AEP or Y m3/s (historical), occur in a 10-year period.	Levels of service for a utility or infrastructure dip below a minimum agreed level (or for X times)	Health indicator arising from dampness, e.g., number of child hospital admissions for respiratory illnesses	Premium exceeds >$X	Disruption of cultural events (incl. tangi, hui, celebrations)		Reduction in LoS, e.g., flood control, wastewater, water supply
Peak storm intensities or durations reach X mm/ hr or mm/storm, both annually and during flood season	After X events flood an important road (or access road) preventing vehicle access (or worse)	Greater than X% of a defined area or town flooded or X times main access to a suburb closed for more than X hours		Bank mortgages difficult to secure	Access to mahinga kai limited or lost	Sediment supply for gravel extraction is depleted	Central control taken by national level government
Mean soil moisture levels during the flood season rise to X% of field capacity		Stopbanks damaged or breached X times	Aesthetic, e.g., river views – once protection works reach X m high	Small business, services and agriculture disrupted X times or for Y days/year		% loss of riverbank area for recreation	Room made for river
Mean annual hurricane intensity (Pacific Ocean; Southern Hemisphere) reaches X	The 20-year Mean Annual Flood reaches X m3/s	The next catastrophic flood (define risk/impact, extent)	Tolerance measure, e.g., sense of community is threatened; people start moving out or cannot move because cannot afford to (resale value too low)	Maintenance costs exceed $X pa for protection works			A managed retreat strategy begins
Mean precipitation over the flood season reaches X mm	Maximum flood extent reaches an agreed extent	A critical or significant facility is threatened, e.g., school, hall, fire station, rest home	Coping capacity measure	Council withdraws maintenance funding for access road when unsustainable at $X			Central government reading support withdrawn
Global air temperature reaches X degrees C	After X floods overtop flood protection or land use assets		Specific societal objective is no longer met	Median property valuations dip below $X			Central government adaptation law changes
Global CO2 concentration reaches X ppm	When sediment damage to water intakes exceed $X or becomes uneconomic to maintain		Resident population of an area drops below X	Sediment deposited from flood flows exceeds $X clean-up			

Figure 8 Selection of possible triggers for use in the NZ DAPP context. Source: Lawrence et al (2020).

While useful as a ready guide at the outset of any STAT development process, a scan of the table of coastal triggers identified above reveals a slant towards domains that are

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not well established, not explicit and not necessarily considered by many regional and/or district councils. For example, the *Hawkes Bay Science Strategy 2020-2025* explicitly identifies a lack of expertise and capacity in social science, economics, knowledge translation and science communication. Many of the triggers identified above would require bespoke Monitoring, Evaluation and Reporting plans to be drawn up, whether or not they were able to take advantage of existing data being collected.

An additional type of trigger not identified in the table above relates to how coastal adaptation can (or in most cases doesn't) link to emergency management. Involving emergency managers as key stakeholders in the development of appropriate STATs is critical. This would help make explicit the link between the 4 R's of emergency management (reduce Risk, Readiness, Response and Recovery) and longer-term adaptation actions. An example of an indicator of relevance to coastal hazards might be the number of activations of the Civil Defence Emergency Management coordination centre, or the number of warnings sent out over a particular time period.

Perhaps unsurprisingly, tracking adaptation progress is a relatively immature field globally [4]. However Monitoring, Evaluation and Reporting (MER) frameworks are not. Councils and agencies have a multitude of functions currently that require them to track progress, sometimes those functions are explicit (e.g. State of Environment reporting), other times they are explicit but not necessarily reported in a coordinated, strategic way for a purpose beyond compliance (e.g. consent reporting) or forward programming (e.g. asset levels of service). Using a 'lived values' approach with community panels will help draw out implicit measures of what needs to be avoided, what are the unacceptable or intolerable risks? Those discussions will help frame objectives, identify adaptation thresholds and generate metrics that can be tracked over time. This will facilitate ongoing learning and adaptation as the world we live in changes.

The *Clifton to Tangoio Coastal Hazards Management Strategy 2120* therefore provides an opportunity to develop an integrated, forward looking Monitoring, Evaluation, Reporting and Learning (MERL) framework that can be used to track adaptation progress against.

3 Adaptive pathways for the Hawkes Bay coast

3.1 Strategy Development

The *Clifton to Tangoio Coastal Hazard Strategy 2120* (the Strategy) represents a co-ordinated approach to identifying and responding to coastal hazards, risks and vulnerabilities taking account of the influence of climate change and sea level rise over at least the next 100 years. It was the first Strategy in New Zealand to try and 'operationalise' the MfE Guidance.

The Strategy has been developed through a Joint Committee formed by representatives from the Hawke's Bay Regional Council, the Napier City Council, and the Hastings District Council alongside representatives of the Maungaharuru-Tangitū Trust, Mana Ahuriri Trust and Heretaunga Tamatea Settlement Trust.

The Strategy covers the area between Clifton to Tangoio on the Hawke Bay coast (see Figure 9 below), looks out to a planning horizon of at least the next 100 years[6], assesses the risks posed by coastal erosion and coastal inundation, and adds climate change as a key driver for changing risk. The vision of the Strategy is *"that coastal communities, businesses and critical infrastructure from Tangoio to Clifton are resilient to the effects of coastal hazards"*.

[6] As required by the New Zealand Coastal Policy Statement 2010.

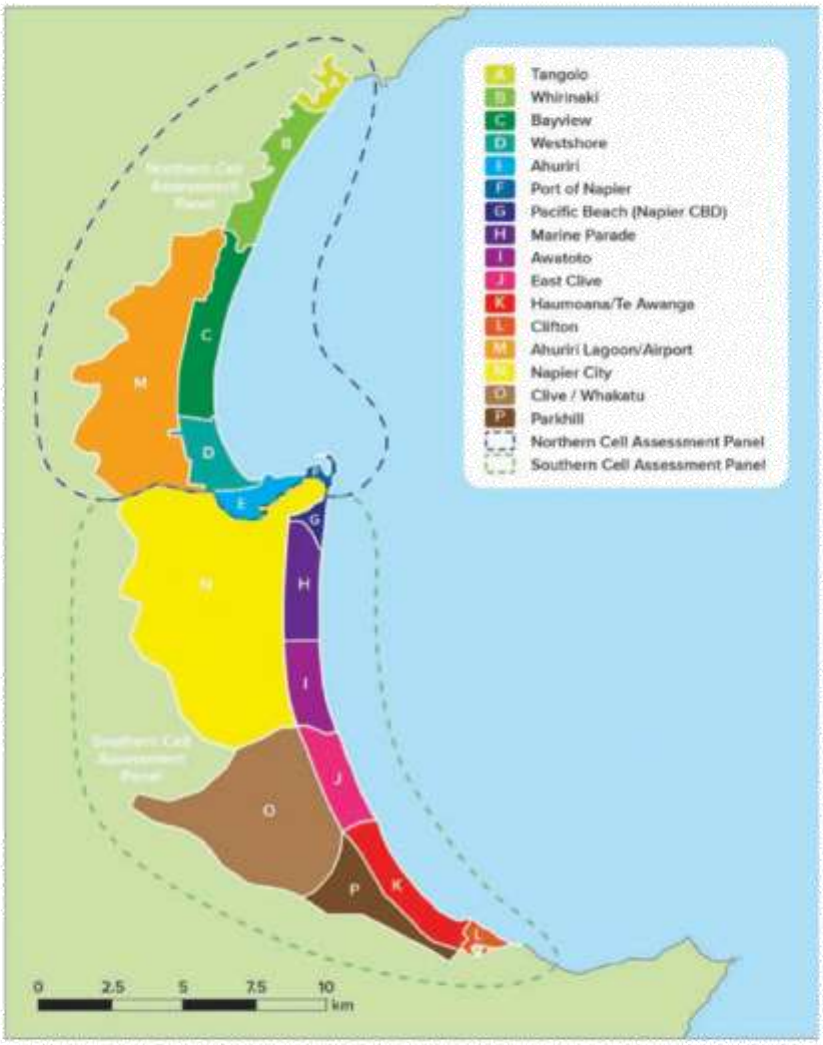

Figure 9 16 coastal units across two cells - Northern and Southern define the spatial extent of the Clifton to Tangoio Coastal Hazard Strategy 2120.

Initially 16 coastal units were identified across two cells (Northern and Southern – see Figure 9), however this was reduced to 9 priority units based on a vulnerability assessment undertaken in Workshop 4 [27]. Using a sequence of workshops with a Northern Assessment Panel and a Southern Assessment Panel, adaptive pathways were developed using nominal timeframes of short (0-20 years), medium (20-50 years) and long-term (50-100 years) [27] for each of the priority units. This represented a simplified process that did not yet answer the key question promoted in the DAPP approach of "under what conditions will the relevant adaptation response fail?". As discussed previously, adaptive pathways seek to identify how sensitive adaptation responses are

to a changing climate or socio-ecological system, rather than adopting nominal timeframes that may imply a guaranteed efficacy [28].

3.2 Approach taken to date and assumptions made

Throughout the Strategy development process a number of layers of decision-making were employed that implicitly or explicitly acted (through application of criteria) to filter and prioritise action – across and within units. For example, when undertaking the vulnerability assessment practitioners made expert judgements about the vulnerability of particular units – this resulted in identification of 9 priority units, with the default residual action for other units being to 'review in 10 years or earlier if trigger is reached'. This 10-year timeframe in effect acts as an early warning signal for units that have not been prioritised at this stage of Strategy development [7].

[7] Note that Port of Napier (F) was excluded as it is entirely privately owned land.

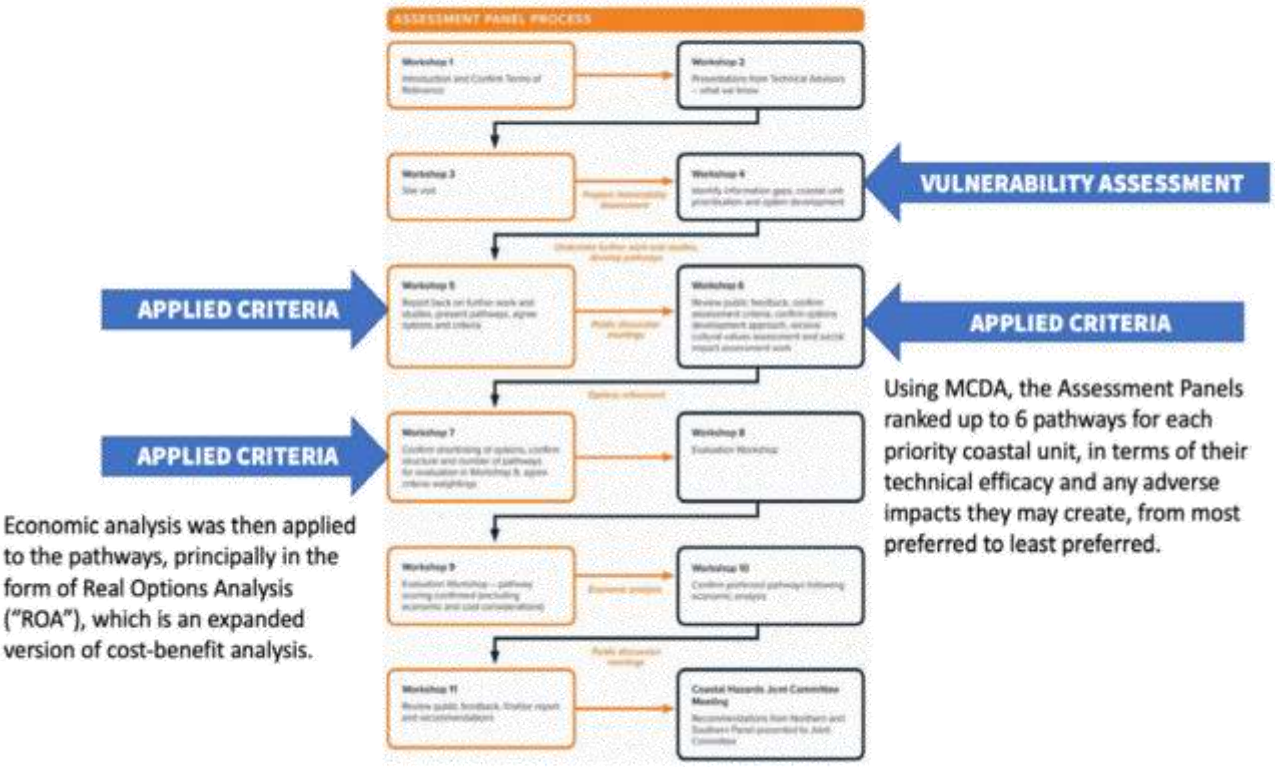

Figure 10 Sequence of 11 workshops undertaken by both the Northern and Southern Assessment Panels to derive the adaptive pathways for each of the 16 coastal units in the Clifton to Tangoio Coastal Hazards Strategy 2120. Blue arrows note activities that applied some form of decision-making criteria

The application of the Multi Criteria Decision Analysis and Real Options Assessment tools at Workshops 6 and 7 (see Figure 10 above) used social, cultural, environmental and economic reports to assess the performance of adaptation responses. This expert-led, technocentric approach in some ways acted as a kind of proxy for the 'lived values' approach as described by Barnett et al (2014) in the Lakes Entrance case study.

However, it may be also be useful to match community identified adaptation thresholds with explicitly defined community objectives set for each unit. At this stage this would include a specific consideration of the question *"What is it that we wish to avoid?"*. This would also include, for example, delineation and community agreement about the point in time at which the initial preferred adaptation response would need to be transitioned/swapped for the secondary adaptation response. These decisions would be based on the performance of the initial adaptation response, recognising that the fundamental premise of DAPP is that initial adaptation responses/decisions have a shelf life (see [29] and [5]).

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The following diagram summarises all preferred adaptive pathways for each priority unit in the Strategy:

Unit	Short-term (0-20 years)		Medium Term (20-50 years)		Long Term (50-100 years)
Northern Panel					
Ahuriri	Status quo	→	Sea wall	→	Sea wall
Pandora	Inundation Protection	→	Inundation Protection	→	Inundation Protection
Westshore	Renourishment	→	Renourishment + Control Structures	→	Renourishment + Control Structures
Bay View	Status Quo / Renourishment	→	Renourishment + Control Structures	→	Renourishment + Control Structures
Whirinaki	Status Quo / Renourishment	→	Renourishment + Control Structures	→	Sea wall
Southern Panel					
Clifton	Sea wall	→	Sea wall	→	Managed Retreat
Te Awanga	Renourishment + Groynes	→	Renourishment + Groynes	→	Renourishment + Groynes
Haumoana	Renourishment + Groynes	→	Renourishment + Groynes	→	Managed Retreat
Clive / East Clive	Status Quo	→	Renourishment + Groynes	→	Retreat the Line / Managed Retreat

Figure 11 All adopted pathways for each priority unit under the Clifton to Tangoio Coastal Hazard Strategy 2120.

Having gone through the sequence of workshops to develop the adaptation pathways above, community panels have identified a single pathway for each unit. Each of those pathways relies on a number of assumptions and implicit choices made throughout the development process.

EXAMPLE: Unit D - Westshore

How assumptions have been embedded in the process and outputs to date can be illustrated using Unit D – Westshore as an example (see Figure 12 below). The arrows identify the point in time at which a change of adaptation response was deemed necessary. But the key question to ask is, how *will we know when the short-term adaptation response (renourishment) is no longer meeting the objectives of the Unit (and therefore the community)?*

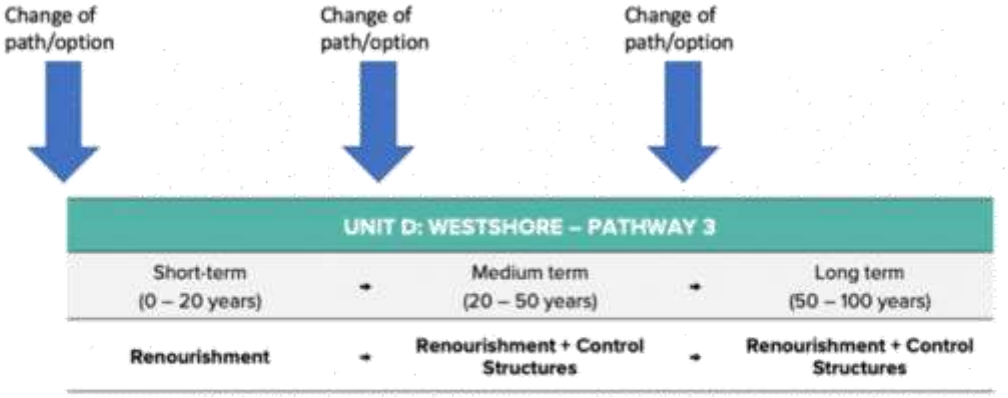

Figure 12 Map of area (LOWER) and preferred adaptive pathways (UPPER) developed for Unit D – Westshore in the Northern Assessment Panel area. The arrows show a point in time at which a change of pathway (or a different adaptation response) is necessary.

While not necessarily intended - the diagram as it stands implies that we already know that after 20 years we will need to swap from the preferred short-term adaptation response (nourishment) to the medium-term adaptation response (nourishment and control structures) to a satisfactory level. Built into this nominal change set to occur 20 years from now is the implicit assumption that nourishment will no longer be effective on its own to meet the objectives for Unit D – Westshore, and that the addition of control structures will be required to continue to meet the objectives of the area. Furthermore, there is also a position taken that the current (Year 0) nourishment activities on Westshore are inadequate (e.g. those already being undertaken and consented to) and need to be scaled up significantly[8] to see out the next 20 years [30].

Technical investigations for consentability for Westshore [30] confirm the requirement for immediate action noting that the current resource consent for nourishment of the beach contains insufficient allowance and inadequate guarantee to implement the short-term adaptation response. The consent also expires in 2027 so there is a already a need to get a replacement consent in train in order to transition from the status quo situation [30]. Other assumptions and conceptual standpoints are also made in that report about design aspects for the purposes of assessing consentability, such as the necessary width and height of the gravel barrier to meet an assumed objective. A key criterion is to ensure sufficient space between the ocean and property/assets is available to construct the barrier, noting that approximately 5m of space is required between the landward edge of the gravel barrier and the property boundary. This is more important in the northern part of this Unit where property boundaries and the road are closer to mean high water and the beach.

3.3 Previous workshops on STATs in the Hawkes Bay

Previous research on STATs has already been undertaken in Hawkes Bay as part of the *Clifton to Tangoio Coastal Hazard Strategy 2120* (the Strategy), by researchers acting as 'Critical Friends' to the process [5]. A series of three workshops was held with community

[8] From currently allowed 50,000m^3 per year to 850,000m^3 in the first year followed by 100,000m^3 per year thereafter.

members, technical staff and experts and others involved in the process. Participants were organised into groups of 4-5 people supported by a council officer and a researcher and large blank sheets and pre-prepared cards with examples of signals, triggers, and thresholds were provided. However it is unclear what the outputs of those workshops were, and if any records exist or are publicly available.

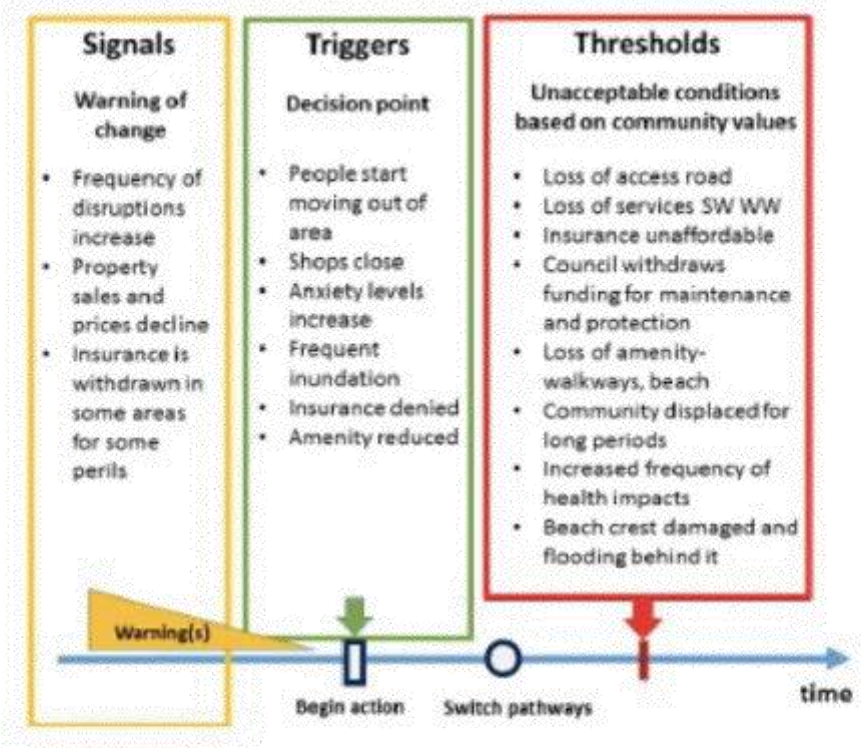

Figure 13 Example of workshop materials from previous Hawkes Bay workshops.

The workshop process began by asking participants the following questions:

1. What do you not want to experience and why?
2. What would trigger a decision to change pathway?
3. What would give you a warning that a trigger is approaching?

The above process enabled elicitation of community values that were key drivers of decision-making. In effect, asking people what sort of conditions or experience they wanted to avoid led to a fruitful discussion and refinement of objectives and risk tolerability (Lawrence et al, 2020). For example, outputs of the three workshops in the Hawkes Bay included an identification of road access as being an important consideration:

> *"In Hawke's Bay...road access was identified by the three groups as being a 'robust' signal across a number of scenarios. Reduced access – due to more frequent flooding or increased erosion – was a strong environmental signal that the effects of climate change were accelerating and impacting local communities; however, it was also a strong social and economic signal. Reduced road access might prevent people from getting to/from employment, for example. Regular disruption, in turn, was a warning of an impending threshold: complete loss of road access. By monitoring the signals, actions could be taken in advance (initiated at the pre-determined trigger) to limit further development and explore mitigation solutions. Furthermore, the signal was easily understood and directly relevant to local concerns because road access would also have effects on tourism and livelihoods."*
>
> - Lawrence et al, 2020 p.51

The results of these workshops should be used as a starting point for the next iteration of community engagement on STATs.

4 Conclusions and Recommendations

This review has highlighted the current state of experience of adaptive planning approaches and employment of STAT-based methods across a number of locations. It has also looked at the DAPP process undertaken to date in the Hawkes Bay and the implicit considerations therein. While not definitive, nor exhaustive, the review can be used to help inform the next stage of the process in the Hawkes Bay and found an adaptive planning strategy on useful, measurable metrics that will enable better decision-making. Tracking adaptation progress is an emerging field and so there exists opportunities for Strategy partners to innovate and lead.

Adaptive planning strategies like the *Hawkes Bay Coastal Hazard Strategy 2120* only represent a snapshot in time and must be iterative, and funded and resourced to be reviewed, evaluated, reported on and updated over time.

A number of recommendations have emerged from the literature reviewed and the author's own observations and experience.

4.1 Gap analysis: What STAT information exists already?

Councils should undertake an analysis of current monitoring, evaluation and reporting activities. This should not only be restricted to the environmental domain, but instead cover social, cultural, economic and governance domains. It should be noted that it is entirely possible that community panels may devise new metrics that are more suitable to act as STATs for their local coastal environment. These metrics may reflect the particular objectives of each area.

It is suggested that organisations party to the development of the Strategy undertake a review of relevant data sets, and identify existing information that may be relevant to the adaptation pathways chosen for each unit, and the Strategy in general. Data sets provided in Figure 8 may provide a useful starting point.

4.2 Community-driven STATs

A key recommendation from this literature review is to ensure that the deliberative process with community panels explicitly ties a community's 'lived values' [11-13] with

the technical work to identify and monitor STATs. Those lived values may be expressed in a number of different ways that the facilitators, recorders and decision-makers must pay close to attention to, including as objectives or negative outcomes to avoid. The results of the previous workshop should be used as a starting point for any future workshops.

4.3 Aligning with existing monitoring and evaluation activities

As referenced in Section 2 and outlined in the MfE Guidance [2] and Lawrence et al [5] monitoring, evaluation, reporting and review is supported by legislative mandate in New Zealand – through the *RMA 1991*, the *Local Government Act 2002*, the *Civil Defence and Emergency Management Act 2002* and at a national level under the *Environmental Reporting Act 2015*. These instruments provide useful context and guidance around designing indicators, undertaking reporting and how it can influence decision-making. As such, it should be noted that monitoring can be undertaken at multiple scales – nationally, regionally or in particular areas as directed by scientific strategies or consent requirements. Where possible monitoring, evaluation and reporting activities should be aligned.

4.4 Developing an integrated MERL Framework

A robust, pragmatic and flexible Monitoring, Evaluation, Reporting and Learning (MERL) plan should be developed to support the Strategy and track progress. This plan should be sufficiently resourced and embedded in day-to-day business.

Consideration should be given to developing a broad range of metrics that underpin climate change risk assessments and adaptation plans, and can be translated across other Council, agency or group planning mechanisms. Those metrics may be quantitative or qualitative, noting that indicators can be used to monitor for both signals and triggers. Where possible, they should be integrated with other Council and agency functions.

5 References

1. Wise, R.M., et al., *Reconceptualising adaptation to climate change as part of pathways of change and response.* Global Environmental Change, 2014. **28**: p. 325-336.
2. MfE, *Coastal Hazards and Climate Change: Guidance for Local Government*. 2017, Ministry for the Environment: Wellington, NZ.
3. CoastAdapt. 2021; Available from: www.coastadapt.com.au.
4. Olazabal, M. and M.R. De Gopegui, *Adaptation planning in large cities is unlikely to be effective.* Landscape and Urban Planning, 2021. **206**: p. 103974.
5. Lawrence, J., et al., *Supporting decision-making through adaptive tools in a changing climate: practice guidance on signals and triggers*. 2020, Deep South Challenge: Wellington, NZ.
6. Stephens, S., A. , R. Bell, G., and J. Lawrence, *Developing signals to trigger adaptation to sea-level rise.* Environmental Research Letters, 2018. **13**(10): p. 104004.
7. Moore, F.C. and N. Obradovich, *Using remarkability to define coastal flooding thresholds.* Nature Communications, 2020. **11**(1): p. 530.
8. Grace, B. and C. Thompson, *All roads lead to retreat: adapting to sea level rise using a trigger-based pathway.* Australian Planner, 2020: p. 1-9.
9. Barnett, J., et al., *Incorporating community values into climate change planning: a guide for government*. 2014, The University of Melbourne.
10. Barnett, J., et al., *A local coastal adaptation pathway.* Nature Climate Change, 2014. **4**(12): p. 1103-1108.
11. Graham, S., et al., *Local values for fairer adaptation to sea-level rise: A typology of residents and their lived values in Lakes Entrance, Australia.* Global Environmental Change, 2014. **29**(0): p. 41-52.
12. Graham, S., et al., *The social values at risk from sea-level rise.* Environmental Impact Assessment Review, 2013. **41**(0): p. 45-52.
13. Graham, S., et al., *Towards fair local outcomes in adaptation to sea-level rise.* Climatic Change, 2014. **130**(3): p. 411-424.
14. Birkmann, J., et al., *Framing vulnerability, risk and societal responses: the MOVE framework.* Natural Hazards, 2013. **67**(2): p. 193-211.
15. Douglas, M., *Risk acceptability according to the social sciences*. Vol. 11. 1985, New York: Russell Sage Foundation.
16. IPCC, *Summary for Policymakers. In: IPCC Special Report on the Ocean and Cryosphere in a Changing Climate.* 2019, [H.O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, M. Nicolai, A. Okem, J. Petzold, B. Rama, N. Weyer (eds.)]: In Press.
17. Dow, K., et al., *Limits to adaptation.* Nature Climate Change, 2013. **3**(4): p. 305-307.
18. Klinke, A. and O. Renn, *A New Approach to Risk Evaluation and Management: Risk-Based, Precaution-Based, and Discourse-Based Strategies.* Risk Analysis, 2002. **22**(6): p. 1071-1094.
19. Renn, O. and A. Klinke, *A Framework of Adaptive Risk Governance for Urban Planning.* Sustainability, 2013. **5**(5): p. 2036-2059.
20. Klein, R.J.T., et al., *Adaptation opportunities, constraints, and limits. In: Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, C.B. [Field, V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (eds.)]. Editor. 2014, IPCC: Cambridge, United Kingdom and New York, NY, USA.

21. Kool, R., et al., *Preparing for Sea-Level Rise through Adaptive Managed Retreat of a New Zealand Stormwater and Wastewater Network.* Infrastructures, 2020. **5**(11).
22. Ranger, N., T. Reeder, and J. Lowe, *Addressing 'deep' uncertainty over long-term climate in major infrastructure projects: four innovations of the Thames Estuary 2100 Project.* EURO Journal on Decision Processes, 2013. **1**(3-4): p. 233-262.
23. Haasnoot, M., et al., *Dynamic adaptive policy pathways: A method for crafting robust decisions for a deeply uncertain world.* Global Environmental Change, 2013. **23**(2): p. 485-498.
24. Norman, B. and N. Gurran, *Adapting to long term coastal climate risk through planning approaches and instruments.*, in *Coastal Adaptation Information Manual 5* 2018: Gold Coast.
25. FitzGerald, T. and T. Hume, *Phase 1 review of the Wainui Beach Erosion Management Strategy*. 2020, for Gisborne District Council.
26. Ramm, T.D., et al., *A review of methodologies applied in Australian practice to evaluate long-term coastal adaptation options.* Climate Risk Management, 2017. **17**: p. 35-51.
27. Bendall, S., *Report of the Northern and Southern Assessment Panels: Clifton to Tangoio Coastal Hazards Strategy 2120*. 2018.
28. Lawrence, J., R. Bell, and A. Stroombergen, *A Hybrid Process to Address Uncertainty and Changing Climate Risk in Coastal Areas Using Dynamic Adaptive Pathways Planning, Multi-Criteria Decision Analysis & Real Options Analysis: A New Zealand Application.* 2019. **11**(2): p. 406.
29. Marchau, V.A.W.J., *Decision Making under Deep Uncertainty*. 2019: Springer.
30. Daysh, M., *Consentability of short-term adaptation responses: Stage 4 Clifton to Tangoio Coastal Hazard Strategy 2120*. 2020, Hawkes Bay Regional Council.

Appendix 2

Workshop 1 Outcomes

Coastal Hazard Consequence		Elements at risk			
		Human (Society/ Culture)	Natural Environment	Economy	Built Environment
Road Access	Community	• Essential services e.g. Ambulance can't help, dialysis • Some residents can't visit or be visited • Food – can't get to Four Square • Widespread disruption	• People drive over land and damage natural environment • Debris scattered polluting environment	• Disrupted economic flow both inward and outward • Businesses suffer • Can't get to work	• Infrastructure disrupted • Pollution e.g. asbestos
	Asset Managers	• Connectivity and transport links impact on communities • Significant. cultural areas	• Kiwi creche at Westshore wildlife domain	• Tourism, access to business, transport, freight / commerce • Cost to rebuild • Insurability of Council-share of assets	• Cost to rebuild • Insurability of Council-share of assets • Unable to repair other services due to lack of access
Services disruption (power, telecommunications, water, sewage)	Community	• Isolation, psychology • Health and safety • Reliance on power for dialysis • Water essential/no tank • No gas supply • No recycling	• Sewage pollution • Poisonous debris	• Major economic impacts • Restoration costs	• Getting rid of damaged infrastructure • Can't get new materials to restore in
	Asset Managers	• Changes to day-to-day behaviours and lifestyles • WW failures impact on tikanga values and practices • Human health impacts on whanau/marae but also on cultural values of te Taiao more generally • Impacts on mahinga kai practices – eg. contaminated shellfish gathering	• Eg. WW failure impacting marine ecosystems if untreated coastal discharges • Coastal Birdlife affected by spillages/untreated waste • Reduced coastal water quality. • Water quality of estuarine environments impacted	• Cost of region to replace the capital investment elsewhere/or alternative • Communities still require services that key infrastructure provide if that infra is disrupted • Interim alternatives ongoing? Sustainability/viability of interim measures e.g. potable water supplies, portaloos etc.	• Not completed in workshop
Community psychology e.g. fear, anger	Community	• Community/human stress and consequences on health • Insecurity and emotional flow on • Risk to family adhesion (e.g. no work, no school) • Poor understanding leading to anger • Chronic illness – fear of lack of services and treatment • Crime risk increases	• Tip household waste • "Bad" decisions	• Dysfunctional community and need for counselling, support and associated costs	• Schools closed • Parks not accessible and health and safety risk • Flood leading to unhealthy home
Insurance excesses and premiums unaffordable Or no insurance possible	Community	• Stress/ mental health risk	• N/A	• Can't sell and move on • Forces rates up	• No maintenance etc

Coastal Hazard Consequence		Elements at risk			
		Human (Society/ Culture)	Natural Environment	Economy	Built Environment
	Asset Managers	• Not completed in workshop	• Not completed in workshop	• Not completed in workshop	• Not completed in workshop
Potential loss of life	Community	• Potential for: - Grief – individual/community - Anger – depends on understanding, blame - Fear – community and family • Increase risk taking, further compounding problems	• N/A	• Loss of bread winner • Funeral costs • Unrealistic expectations	• N/A
	Asset Managers	• Impact on households / whanau / communities	• Not completed in workshop	• Impact on households / families / businesses • Loss of expertise	• Not completed in workshop
Septic tank damage	Community	• Disease risk • Health and Safety	• Pollution	• Cost of clean up	• Cost of replacement
	Asset Managers	• Stress on the community is occurring at a large scale • Council to provide alternatives (port-a-loo etc) until a permanent solution found • Traditional practices – areas potentially contaminated and food gathering from natural environment	• Risks to the natural environmental from contamination	• Costs to individuals to provide another means of waste disposal – may mean reticulated network but may not – do you have any other options? • Costs to Council of providing alternative means of disposal	• Not completed in workshop
Groundwater changes/impacts	Community	• Lack of clean water	• Lack of irrigation water	• Loss of agricultural and horticultural production	• Cost to replace
Ecosystems – estuaries and wetlands	Community	• Aesthetics	• Biodiversity destruction	• N/A	• N/A

Coastal Hazard Consequence		Elements at risk			
		Human (Society/ Culture)	Natural Environment	Economy	Built Environment
	Asset Managers	• Not completed in workshop	• Not completed in workshop	• Not completed in workshop	• Not completed in workshop
Supply & Demand for land	Community	• Attraction to the coast would increase if some protection was in place	• N/A	• Raises economics fo the area • Community expands	• Leads to growth in the community
Overall financial impact of staying – community cohesion	Community	• Physical and mental health • Impact can vary from household to household • Education	• Loss of respect and care to the environment as the other factors come to the fore	• Breakdown of local economy • Increased cost for wider community to support that area	• Reduction in level and standard of services
Effects on Stormwater + Stormwater pumping	Community	• Health hazard	• Release of wastewater and contaminated water into the environment	• Cost to maintain • Cost to repair • Insurance premiums	• Damage to infrastructure • Water purity • Transport disruption
	Asset Managers	• Significant effects on properties that may be flooded by stormwater not being pumped away. • Insurance risks • Large areas likely to be susceptible to failure	• Backing up of stormwater with pumps out of action therefore risks of flooding	• Costs to Council – clean up and replacement of infrastructure, damage to property. • Insurance premiums likely to be affected. • Potential liability to Council from pump failure (1in 50 year rainfall event level of service planned for) – level of service changes as climate change increases risk of storm events	• Damage to stormwater outfalls
Impact on harbour entrance	Community	• Sport and recreation • Impacts on coastal, urban and rural	• Estuary and marine ecosystems	• Impact to fishing companies • Impact to harbour side businesses	• Potential damage to protection works
Frequency of inundation events	Community	• Confidence and displacement • Cost of staying • Loss of activity	• Saltwater ingress • Destruction of habitat and ecosystems	• All financial factors can be impacted	• Threat to buildings, roads, services etc

Coastal Hazard Consequence		Elements at risk			
		Human (Society/ Culture)	Natural Environment	Economy	Built Environment
Recreation access	Community	• Quality of life affects all communities	• Lack of recreational areas could have a positive impact on the natural environment	• Tourism and service industry	• Boat ramps?
	Asset Managers	• Changes to day-to-day behaviours and lifestyles • WW failures impact on tikanga values and practices • Human health impacts on whanau/marae but also on cultural values of te Taiao more generally • Impacts on mahinga kai practices – eg. contaminated shellfish gathering	• Eg. WW failure impacting marine ecosystems if untreated coastal discharges • Coastal Birdlife affected by spillages/untreated waste • Reduced coastal water quality. • Water quality of estuarine environments impacted	• Cost of region to replace the capital investment elsewhere/or alternative • Communities still require services that key infrastructure provide if that infra is disrupted • Interim alternatives ongoing? Sustainability/viability of interim measures e.g. potable water supplies, portaloos etc.	• Not completed in workshop
Isolation of communities (between or within)	Community	• Loss of community wellbeing, social cohesion and social welfare • Displacement	• Ghost town	• N/A	• Demolition • Lack of building
	Asset Managers	• Not completed in workshop	• Not completed in workshop	• Not completed in workshop	• Not completed in workshop
Raising of rates to cover events	Community	• Mental health issues due to lack of money	• Land use	• Lack of money for infrastructure, services etc	• Infrastructure and services • Transport – no maintenance or improvements
Saltwater intrusion into aquafers	Community	• Cultural – not being able to get water and food from traditional sources • Soil pH levels change	• Impact/damage/change ecosystems • Increased pests/insects	• Increased costs especially for fisheries, marine	• Different water processing plant requirements
	Asset Managers	• Unsuitable drinking water due to salt water intrusion and breakages in the network. • General risk to the community from losing access to drinking water	• Saline intrusion affecting plants and habitats (fauna and flora) • Impact on local water tables	• Bore – water becomes unsuitable for drinking and therefore need a new bore or connect to town water supply. • Council network effects – costs of ongoing repairs and health implications due to contamination – increases maintenance costs as well	• Council network effects – costs of ongoing repairs and health implications due to contamination – increases maintenance costs as well

Coastal Hazard Consequence		Elements at risk			
		Human (Society/ Culture)	Natural Environment	Economy	Built Environment
Amenity impacts	Community	• Lack of/loss of enjoyment of spaces	• Lack of green space	• Lack of tourism and tourism industries including wineries and tours • Loss of property values	• Waste management impacts
Loss of property value	Community	• Loss of life savings • Inability to repurchase • Having to move	• N/A	• Poorer • Less money in the community	• Services may degrade • Inability to fund improvements
Displacement of community	Community	• Cultural impacts • Families upended • Mental health	• N/A	• Less wealth • Shops unviable • Lack of tourists	• Decline in property • Less service industry
Frequency of physical danger	Community	• Potential loss of life • Mental health • Fear/insecurity	• N/A	• Lack of investment • Insurance • Lack of visitors	• Fear of building • Lack of investment • Degradation
Vulnerable plants	Community	• Diminished amenity and birdlife enjoyment • Visual impact	• Diminished greenspaces of coastal defence • Loss of biodiversity	• Replanting costs	• N/A
Reduced stability of riverine stopbanks (particularly at mouth)	Asset Managers	• Stopbanks are decommissioned for recreational uses • Compounding hazards if erosion not addressed (e.g. increasing FW flooding risk) • Cycleways become disrupted /re-routed • Access to traditional mahinga kai sites/practices affected	• Compounding impacts on nearby natural processes (eg. fish spawning, sedimentation of estuaries, meandering river mouths etc	• Increased costs for funding maintenance (costs passed on to community/beneficiary-pays)	• Not completed in workshop

Coastal Hazard Consequence		Elements at risk			
		Human (Society/ Culture)	Natural Environment	Economy	Built Environment
Access to and along the coastline limited (vehicles and pedestrian), due to steepness of beach escarpments	Asset Managers	• Pedestrian safety increasingly vulnerable • Local boat launching sites affected/un-usable • No vehicles on many beaches – a PLUS! • Access to traditional mahinga kai sites/practices affected	• Positive no vehicles on beaches (esp. sensitive ecosystems) • Loss of natural ecosystems with nowhere to go/re-create	• Recreational commercial activities affected/cease	• Not completed in workshop
Impact on tourism activities, campsites, freedom camping, use of pathways	Asset Managers	• Multiplier effect of reduced tourism • Reduced amenity/wellbeing from limited recreational activities and coastal sense of place • Loss of sense of place • Disrupted whanau tradition over generations	• Not completed in workshop	• Reduced commercial operators • Reduced 'choice' in location and market providers. • Impact on HB reputation and marketing as active recreation destination/experience	• Inappropriate de-commissioning of assets/infrastructure/built stuff
Loss of cropping and vineyard, productive agricultural land from inundation of sea water – economic impacts of this as well as the physical effects	Asset Managers	• Job losses • Seasonal productivity affected so different jobs at different times of year/growing cycle	• Runoff and contaminants from production land into FW and marine environments • Debris from land use into FW/coastal water • Land use change potential. e.g. cropping types affected therefore prompts wholesale land use change with other consequent impacts	• Impacts on commercial brands (individual business but also the collective region) • Potential loss of entire season/year of product • Soil characteristics altered for subsequent growing conditions • Livestock losses (e.g. loss of life or poorer health)	• Not completed in workshop
Public toilets stop operating / not accessible	Asset Managers	• Risk of using inappropriate sites • Risk of food contamination • Loss of park land – where can replacement land be found	• Potential waste generation in undesirable locations, including existing camping sites	• Tourism impacts – no facilities for visitors • Reconstruction of the facilities elsewhere – duplicated costs and where? • Need for land purchase for new park areas	• Loss of park land – where can replacement land be found • Effects on city design – suitable alternative locations for alternative
Port of Napier operations are impacted, more seas, storms – operations but may also impact facilities (general climate change impacts)	Asset Managers	• Employment at the Port at risk if there are long term impacts from events – will affect local cities/towns and regionally as well. • Exporters who rely on their products being transported via the port.	• Port Storage facilities – bitumen/fuel/hazardous substances – potential for environmental contamination • Ships damaged – potential for fuel contamination as well as cargo being lost	• Port out of action and cannot provide safe harbour for freight into and out of HB – significant impacts on horticultural, forestry, meat products being exported • Delays will increase costs and have impacts on businesses • Costs of repair at the Port itself • Access routes to the Port are also a source of vulnerability in suppling goods to the port	• Port and Ships damaged

Coastal Hazard Consequence		Elements at risk			
		Human (Society/ Culture)	Natural Environment	Economy	Built Environment
Loss of housing capacity e.g. uninsurable / uninhabitable (e.g. already short on supply)	Asset Managers	• Disconnect from the community • Loss of identity • First home buyer impacts • Loss of local social cohesion	• Additional waste to landfill	• Shortage of supply drives up market costs • Cost of managed retreat • Drives up new infrastructure costs e.g. reticulate to new areas/ abandon old areas	• Greenfields development requirements
Closed landfills (exposed) – Mill Road + others we don't know about	Asset Managers	• Blot on the landscape • Reputation • Enjoyment of areas + impacts on other infrastructure • Tourism and transport • Health impacts from using environment / contamination • Mahinga kai impacts • Cultural landscape • Mauri impacts	• Impact on waterbodies / pollution and on surrounding land	• Cost of clean up • Impacts on productive land • Cycle tour operators and other tourism operators	• Not completed in workshop
Awatoto industrial area impacts	Asset Managers	• Blot on the landscape • Reputation • Enjoyment of areas + impacts on other infrastructure • Tourism and transport • Health impacts from using environment / contamination • Mahinga kai impacts • Cultural landscape • Mauri impacts • Waitangi Regional Park impacts (cultural)	• Impact on waterbodies / pollution and on surrounding land • Waitangi Regional Park impacts (environmental)	• Cost of clean up • Impacts on productive land • Cycle tour operators and other tourism operators • Significant industrial area – jobs, productivity etc • Cost to retreat and established elsewhere	• Not completed in workshop
Hawkes Bay Airport – due to low lying nature, at risk of pump failure, access limitations as there are no airport alternatives	Asset Managers	• Connectivity and transport links impact on communities • Sig. cultural areas	• Kiwi creche at Westshore wildlife domain	• Tourism, transport links etc • Cycle trails effects • Landcorp farm • Cost to repair runways or relocate	• Not completed in workshop
Disruption to residential dwellings	Asset Managers	• Not completed in workshop	• Not completed in workshop	• Not completed in workshop	• Not completed in workshop
River mouth blockages increase (e.g. increased by SLR / high tides)	Asset Managers	• Not completed in workshop	• Not completed in workshop	• Not completed in workshop	• Not completed in workshop

Coastal Hazard Consequence		Elements at risk			
		Human (Society/ Culture)	Natural Environment	Economy	Built Environment
Loss of existing coastal protection works including natural defences such as dunes and gravel barriers and increased maintenance costs	Asset Managers	• Not completed in workshop	• Not completed in workshop	• Not completed in workshop	• Not completed in workshop
Rail impacts – Awatoto / Napier	Asset Managers	• Not completed in workshop	• Not completed in workshop	• Not completed in workshop	• Not completed in workshop
River level impacts – stopbanks / water supply etc	Asset Managers	• Not completed in workshop	• Not completed in workshop	• Not completed in workshop	• Not completed in workshop
Property purgatory affects community wellbeing and community cohesiveness.	Asset Managers	• Not completed in workshop	• Not completed in workshop	• Who pays the damaged clean-up costs? Individual vs other?	• Not completed in workshop

Appendix 3

Adaptation Threshold Development

Potential Physical/ Infrastructure Thresholds

Black text denotes consequences identified by the Community

Blue text denotes additional consequences identified by Council asset managers.

Coastal Hazard Consequence (Identified through community workshop series + Council asset manager workshops – July & November 2021)	Proposed Threshold (Developed with feedback from community workshop series - February 2022)	Likely source of data?	Threshold Evaluation and Selection			Relevant Unit									
			1. Coastal Hazards are the cause of the threshold being breached	2. Data to assess threshold is available or can readily be collected and interpreted	3. Selected as a threshold?	ALL UNITS	Ahuriri	Pandora	Westshore	Bay View	Whirinaki	Clifton	Te Awanga	Haumoana	East Clive
Potential Physical/ Infrastructure Thresholds															
Loss of Road Access (Community Scale)	*Coastal inundation in [NAME] causing loss of road access for the majority of the community.* *How long: At least 24 hours* *How often: More than once every 5 years.*	Observed/ inspected/ reported by asset manager	✓	✓	✓			✓				✓	✓	✓	✓
	Coastal erosion in [NAME] causing loss of road access affecting the majority of the community.	Observed/ inspected/ reported by asset manager	✓	✓	✓					✓	✓	✓	✓		
Loss of Road Access (Property Scale)	*Coastal inundation in [NAME] causing loss of road access that affects individual properties.* *How long: At least 24 hours* *How often: More than once every two years.*	Observed/ inspected/ reported by asset manager	✓	✓	✓		✓	✓	✓			✓	✓	✓	✓
	Coastal erosion in [NAME] causing loss of road access that affects individual properties.	Observed/ inspected/ reported by asset manager	✓	✓	✓		✓		✓	✓	✓	✓	✓	✓	
Services disruption (power, telecommunications, water, sewage)	*Coastal inundation in [NAME] causing the loss of one or more essential services affecting the majority of the community.* *How long: At least 24 hours* *How often: More than once every 5 years.*	Observed/ inspected/ reported by asset manager	✓	✓	✓	✓									

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Coastal Hazard Consequence (Identified through community workshop series + Council asset manager workshops – July & November 2021)	Proposed Threshold (Developed with feedback from community workshop series - February 2022)	Likely source of data?	Threshold Evaluation and Selection			Relevant Unit									
			1. Coastal Hazards are the cause of the threshold being breached	2. Data to assess threshold is available or can readily be collected and interpreted	3. Selected as a threshold?	ALL UNITS	Ahuriri	Pandora	Westshore	Bay View	Whirinaki	Clifton	Te Awanga	Haumoana	East Clive
	Coastal erosion in [NAME] causing the loss of one or more essential services affecting the majority of the community.	Observed/ inspected/ reported by asset manager	✓	✓	✓	✓									
Septic tank damage	*Buildings in [NAME] are deemed uninhabitable as a result of coastal hazards (e.g. loss of septic tanks, building structural integrity etc).*	Observed/ inspected/ reported by homeowner	✓	✓	✓						✓	✓	✓	✓	✓
Efficiency of Stormwater	*Loss of ability to effectively manage/discharge stormwater from urban areas.*	Observed/ inspected/ reported by asset manager	✓	✓	× Could be affected by blockage of pipes and/or increasing SLR. Interventions under the Strategy unlikely to address. Best addressed as an asset management function.		✓	✓	✓	✓			✓	✓	✓
Frequency of inundation events (Community Scale)	*Community-wide coastal inundation causing damage to multiple buildings/services in [NAME].* *How long: Any duration* *How often: More than once every 5 years.*	Observed/ inspected/ reported by Council/ building owners	✓	✓	✓	✓									
Reduced stability of riverine stopbanks (particularly at mouth)	*Stopbanks fail to meet design level of service as a result of coastal hazards.*	Observed/ inspected/ reported by asset manager	? Is it possible to establish causal link to coastal hazard from stopbank failure?	✓	× Is a flood control scheme/asset management issue not a coastal hazard issue								✓	✓	✓
Access to and along the coast is affected as a result of the steepness of beach escarpments	*Steep beach escarpments, created by erosion, prevent safe access to and along the coast.*	Observed/ inspected/ reported by asset manager	✓	✓	× More appropriate as a signal/trigger, management techniques can be implemented to re-establish access e.g beach scraping and this is a good signal for approaching impacts on infrastructure from erosion.				✓	✓	✓	✓	✓	✓	
Public toilets stop operating/are not accessible	*Public toilets in [NAME] are permanently inaccessible or not suitable for public use as a result of coastal hazards.*	Observed/ inspected/ reported by asset manager	✓	✓ *Based on asset managers assessment*	✓		✓		✓				✓	✓	
Rail impacts – Awatoto / Napier	*Rail access is disrupted as a result of coastal hazards.* *How long: more than 48 hours*	Observed/ inspected/ reported by Kiwirail	✓	✓	✓		✓	✓	✓	✓	✓				

Coastal Hazard Consequence (Identified through community workshop series + Council asset manager workshops – July & November 2021)	Proposed Threshold (Developed with feedback from community workshop series - February 2022)	Likely source of data?	Threshold Evaluation and Selection			Relevant Unit									
			1. Coastal Hazards are the cause of the threshold being breached	2. Data to assess threshold is available or can readily be collected and interpreted	3. Selected as a threshold?	ALL UNITS	Ahuriri	Pandora	Westshore	Bay View	Whirinaki	Clifton	Te Awanga	Haumoana	East Clive
	How often: More than once annually.														
Potential Social/Cultural Thresholds															
Community psychology	*30% or more of the [NAME] community indicate high levels of anxiety about coastal hazard risks and impacts.*	Community surveys by Councils	? Very subjective and personal/ individual measure. May or may not have causal link to hazard. Level of anxiety may or may not be reduced with actions in response to natural hazards.	? Data would be collected by a survey. Valid results would require a high percentage of the community responding to the survey. Results could be heavily influenced by recent weather events (good/bad) etc.	×	✓									
Frequency of physical danger	*Any injuries and/or fatalities that occur as a result of a coastal erosion or coastal inundation event.*	Reporting emergency services, CDEM, media, ACC, DHB NB Hazards in scope are slow onset and irregular in scale and frequency but impacts may not be slow onset.	✓	✓ Assume we can get reporting on this from media reporting, ACC/ DHB/ St John.	✓	✓									
	Civil Defence emergency is declared in response to coastal inundation or coastal erosion. *How often: More than once every 5 years.*	CDEM	✓	✓ CDEM	✓	✓									
Isolation between communities	*30% or more of the [NAME] community feel a sense of their community being isolated as the result of coastal erosion or coastal inundation impacts.*	Community surveys by Councils	? Very subjective and personal/ individual measure	? Data would be collected by a survey. Valid results would require a high percentage of the community responding to the survey. Results could be heavily influenced by recent weather events (good/bad) etc.	×	✓									
Isolation within a community	*30% or more of the [NAME] community feel a sense of isolation within their community as the result of coastal erosion or coastal inundation impacts*	Community surveys by Councils	? Very subjective and personal/individual measure.	? Data would be collected by a survey. Valid results would require a high percentage of the community responding to the survey. Results could be heavily influenced by recent weather events (good/bad) etc.	×	✓									

Coastal Hazard Consequence (Identified through community workshop series + Council asset manager workshops – July & November 2021)	Proposed Threshold (Developed with feedback from community workshop series - February 2022)	Likely source of data?	Threshold Evaluation and Selection			Relevant Unit									
			1. Coastal Hazards are the cause of the threshold being breached	2. Data to assess threshold is available or can readily be collected and interpreted	3. Selected as a threshold?	ALL UNITS	Ahuriri	Pandora	Westshore	Bay View	Whirinaki	Clifton	Te Awanga	Haumoana	East Clive
Amenity impacts	*30% of the [NAME] community consider that a significant loss of amenity has occurred as a result of coastal erosion or coastal inundation impacts*	Community surveys by Councils, Observed/ Inspected/ Report by asset managers	✓	✓ Could survey to obtain this information – would require skilled questioning and social science skills to complete this monitoring – this will be a subjective assessment for people/communities.	✓	✓									
Property purgatory affects community wellbeing and community cohesiveness	*The majority of the community in [NAME] report actual or perceived property purgatory effects i.e. actual or foreseeable damage to their properties from coastal erosion or coastal inundation and uncertainty about being able to recover their losses.*	Community surveys by Councils, Observed/ inspected/ reported by asset managers	✓	✓ Could survey to obtain this information	✓	✓									
River mouth blockages increase (increase by SLR/high tides)	*[NAME] River mouth clearance fails to maintain flood capacity as a result of coastal hazards.*	Observed/ inspected/ reported by asset manager	? More likely influenced by riverine systems? Strategy does not consider effects of river flooding nor groundwater effects. Note these need to be considered post-Strategy.	✓	× Expectation that these levels will be managed by the flood control scheme and the coastal hazard mitigations will not be effective in managing this consequence.						✓		✓	✓	✓
Loss of existing coastal protection works including natural defences such as dunes and gravel barriers and increased maintenance costs	*Loss of efficacy of existing coastal protection structures in [NAME].*	Observed/ inspected/ reported by asset manager	✓	✓	× Could be used as a trigger as are an indicator of changes occurring. Thresholds are more related to the effects of the change on buildings and infrastructure.			✓	✓	✓	✓		✓		
Frequency of inundation events (Property Scale)	*Localised inundation of buildings in [NAME].* *How long: Any duration* *How often: More than once every 2 years.*	Observed/ inspected/ reported by asset manager	✓	✓	× This is likely to be better suited as a trigger rather than a threshold as it could be used to monitor for repeated events to prompt a decision about whether action is needed.	✓									
Saltwater intrusion into aquifers	*[XX Name bore] becomes unsuitable for drinking water/ farming/horticultural use as a result of saltwater intrusion.*	Observed/ inspected/ reported by landowners/ homeowners, surveys and interviews	✓	✓	× This threshold would occur as a result of SLR and/or excessive aquifer use at the coast. Actions under the Strategy are not able to address this. This is a freshwater management function for the TA's/ Taumata Arowai entity and likely to	✓									

Coastal Hazard Consequence (Identified through community workshop series + Council asset manager workshops – July & November 2021)	Proposed Threshold (Developed with feedback from community workshop series - February 2022)	Likely source of data?	Threshold Evaluation and Selection			Relevant Unit									
			1. Coastal Hazards are the cause of the threshold being breached	2. Data to assess threshold is available or can readily be collected and interpreted	3. Selected as a threshold?	ALL UNITS	Ahuriri	Pandora	Westshore	Bay View	Whirinaki	Clifton	Te Awanga	Haumoana	East Clive
					result from a reduction in pressure in freshwater.										
Potential Economic Thresholds															
Insurance excesses and premiums unaffordable Or no insurance possible	*The majority of properties in [NAME] are unable to secure building insurance for losses from coastal hazards.*	Reported by Insurance Council/ Insurance Companies / property owners.	✓	✓ Best source for data would be directly from insurance companies however, it would likely become widely know through media /home owner reporting if broad scale insurance retreat was occurring.	✓	✓									
	10% or more of properties in [NAME] do not hold insurance due to owners deeming insurance premiums/excesses unaffordable.	Reported by Insurance Council/ Insurance Companies / property owners.	? Could be multiple factors contributing to unaffordable premiums	? Could survey property owners, however a very high percentage of properties in the community would need to respond for the data to be useful.	×	✓									
Loss of property value	*Median house price for coastal properties in [NAME], drops by 10% or more in 2 years.*	Reported by real estate sector.	× Difficult to link property price solely to coastal hazards	✓ Data available e.g. through online sources	× Intention of Strategy is not to maintain property values but to maintain community resilience	✓									
Raising of rates to cover events	*Council unwilling or unable to cover the cost of reinstating damaged services to properties impacted by coastal hazards in [NAME].*	Reported by Council(s)	✓	✓	× Consider this is more appropriate as a trigger for other consequences as a result of coastal hazards	✓									
Impact on tourism activities, campsites, freedom camping, use of recreational pathways.	*Council unwilling or unable to cover increasing costs from maintaining existing coastal defence structures/ renourishment programmes in [NAME].*	Reported by Council(s)	✓	✓	× Considered more appropriate as a trigger such as when financial limits are reached for renourishment programmes	✓									
Loss of cropping and vineyard, productive agricultural land from inundation of sea water – economic impacts of this as well as the physical effects	*XX ha or XX% of Plains Zone land becomes unsuitable for productive purposes as a result of coastal inundation.*	Observed/ inspected/ reported by landowners/ homeowners, surveys and interviews	✓	✓	× Geological feature that cannot be retreated and covers a significant area that would be difficult to actively protect.						✓		✓	✓	✓
Impacts on Hawkes Bay Airport – due to low lying nature, risk of pump	*Coastal inundation in [NAME] causing inaccessibility of Hawke's Bay Airport*	Reported by Hawke's Bay Airport	✓	✓	× Not currently a priority unit under the Strategy – no risk of erosion and										

Coastal Hazard Consequence (Identified through community workshop series + Council asset manager workshops – July & November 2021)	Proposed Threshold (Developed with feedback from community workshop series - February 2022)	Likely source of data?	Threshold Evaluation and Selection			Relevant Unit									
			1. Coastal Hazards are the cause of the threshold being breached	2. Data to assess threshold is available or can readily be collected and interpreted	3. Selected as a threshold?	ALL UNITS	Ahuriri	Pandora	Westshore	Bay View	Whirinaki	Clifton	Te Awanga	Haumoana	East Clive
failure (stormwater), access limitations as there are no airport alternatives	*facilities for the majority of the community.* *How long: At least 24 hours* *How often: More than once annually.*				current inundation modelling shows no impact for next 100 years. Increasing ground water level is likely the main issue here.										
Potential Environmental Thresholds															
Recreation access	*Access to and use of the beach, coastal reserves and/or recreational facilities is prevented as a result of coastal inundation.* *How long: At least 24 hours* *How often: More than once annually.*	Observed/ inspected/ reported by asset manager	✓	✓	✓	✓									
Ecosystems – estuaries and wetlands	*(Specified ecological feature) is significantly adversely affected by coastal erosion or coastal inundation in [NAME].*	Observed/ inspected/ reported by asset manager	? This will be highly dependent on the nature of the feature in question and would require specialist technical assessment.	? This will be highly dependent on the nature of the feature in question and would require specialist technical assessment.	? May require a unit-by-unit assessment to determine whether a threshold can be sensibly determined.		?	?	?	?	?	?	?	?	?

First pass assessment- thresholds recommended not to progress

The following thresholds were identified in the workshops but during the first pass assessment were proposed not to be progressed further for the reasons in the table below.

Coastal Hazard Consequence identified by Community/ Asset Managers	Reason not to progress threshold
Potential loss of life	Perception/ potential for loss of life
Supply & Demand for land	Difficult to monitor and link directly to coastal hazards
Overall financial impact of staying – community cohesion	Already covered by other identified thresholds
Groundwater changes/impacts	Already covered by other identified thresholds
Vulnerable plants	Already covered by other identified thresholds
Displacement of community	Already covered by other identified thresholds
Impact on harbour entrance	No direct link to erosion/inundation hazards
River level impacts stopbanks/water supply etc	Already covered by other identified thresholds
Port of Napier operations are impacted, more big seas, more storms	Strategy not proposing actions/solutions for the Port
Loss of housing capacity e.g. uninsurable/uninhabitable e.g. already short on supply	Limited spatial extent of strategy i.e. coastal areas at risk from natural hazards – not anticipated to have a significant effect on housing capacity at a district/regional scale
Awatoto Industrial Area Impacts	Awatoto unit not currently identified as a priority for developing a long-term pathway however, is proposed to be included at next strategy review
Closed landfills exposed (Mill Road and others we don't know about).	Expect other thresholds to be triggered before known sites are at risk. Monitoring only possible where we know about the contaminated sites.

Appendix 4

Panel feedback

Revised thresholds as a result of community feedback (from workshop 22 June 2022)

General Proposed Thresholds (apply to all Units)			
Threshold + Threshold Measure	Primary responsibility for monitoring and reporting to HBRC	Monitoring method/ data source	Rationale for changes made in response to feedback as a result of community workshop held 22 June 2022
Coastal inundation causing the loss of one or more essential services affecting the majority of the community. *How long: At least 48 hours* *How often: More often than once every 5 years.*	HBRC + Relevant TA	Observations during and following a coastal inundation event, including community feedback.	Majority of feedback suggested that in order for the impact to be substantial and therefore act as a threshold, not a trigger, duration should be extended to 48 hrs from 24 hrs
Community-wide coastal inundation causing damage to multiple buildings/service. *How long: Any duration* *How often: More often than once every 5 years.*	HBRC	Observations during and following a coastal inundation event, including community feedback.	Some feedback proposed reducing this threshold to 3 years however retained as 5 to have parity with above threshold.
Any serious injuries and/or fatalities that occur as a result of a coastal erosion or coastal inundation event.	Civil Defence	CDEM observations during and following a coastal erosion or coastal inundation event, including community feedback.	Extensive debate on this threshold. All agreed that no fatalities are acceptable. Generally agreed that for injuries, threshold should be for serious injuries caused as a result of coastal hazards. Note, there are some standard definitions available.
Civil Defence emergency is declared in response to coastal inundation or coastal erosion. *How often: More often than once every 10 years.*	Civil Defence	CDEM reporting during and following a coastal erosion or coastal inundation event, including community feedback.	Feedback suggested moving to 10 years from 5 to reflect that a Civil Defence Emergency is a major event that is not tolerable more frequently.
50% of an affected coastal community consider that a permanent loss of amenity has occurred as a result of coastal erosion or coastal inundation impacts	HBRC	Community regularly surveyed by Councils and Observed/ inspected/ reported by Council staff e.g. parks staff during/ following coastal erosion or coastal inundation events, including community feedback.	Feedback to make specific to an affected coastal community clear and to replace significant amenity impact with permanent impact to reduce subjectivity. Adopt approach from debate on threshold re: property purgatory where 50% threshold measure is used alongside a 30% trigger.

General Proposed Thresholds (apply to all Units)			
Threshold + Threshold Measure	Primary responsibility for monitoring and reporting to HBRC	Monitoring method/ data source	Rationale for changes made in response to feedback as a result of community workshop held 22 June 2022
50% of the community report actual or perceived property purgatory effects i.e. actual or foreseeable damage to their properties from coastal erosion or coastal inundation and uncertainty about being able to recover their losses	HBRC	Community regularly surveyed by Councils	Extensive debate on appropriate measure 30%/50%/80%/ majority. Propose 50% as this is a meaningful proportion of a given community as a threshold. Suggestion that this was more appropriate as a trigger – suggest utilising 30% as a trigger.
50% of properties are unable to secure building insurance for losses from coastal hazards.	HBRC	Council seeks regular reporting from Insurance Council/ Insurance Companies. Opportunity to also be informed by property owners through survey results.	Adopt approach from debate on threshold re: property purgatory where 50% threshold measure is used alongside a 30% trigger.
Access to and use of the beach, coastal reserves and/or recreational facilities is prevented as a result of coastal inundation. *How long: At least 7 days* *How often: More often than once every 5 years.*	Relevant TA	Observed/ inspected/ reported by Council staff e.g. parks staff during/ following coastal erosion or coastal inundation events, including community feedback.	Feedback suggested that access to reserves is important but not fundamental and there is a high degree of tolerance of interrupted use and enjoyment of reserves, suggesting longer duration events are tolerable. Therefore, change made from 24 hours to 7 days as suggested. Change also suggested to the frequency from an annual event to a 5-yearly event to reflect this.

Whirinaki Proposed Thresholds			
Threshold + Threshold Measure	Primary responsibility for monitoring and reporting to HBRC	Monitoring method/ data source	Rationale for changes made in response to feedback as a result of community workshop held 22 June 2022
Coastal erosion in Whirinaki affecting Whirinaki Road and/or North Shore Road, causing loss of road access for the majority of the community.	HDC	Observed/ inspected/ reported by Council asset managers during/ following coastal erosion or coastal inundation events.	No changes suggested but change made to specifically reference Whirinaki and North Shore Roads as loss of access to either of these roads from coastal erosion would affect the majority of the community.
Buildings in Whirinaki are deemed uninhabitable as a result of coastal hazards (e.g. loss of septic tanks, building structural integrity etc).	CDEM/ HDC	Observed/ inspected/ reported by Council asset managers during/ following coastal erosion or coastal inundation events.	No changes suggested

Bay View Proposed Thresholds			
Threshold + Threshold Measure	Primary responsibility for monitoring and reporting to HBRC	Monitoring method/ data source	Rationale for changes made in response to feedback as a result of community workshop held 22 June 2022
Coastal erosion in Bay View affecting Le Quesne Road, causing loss of road access for majority of the community.	NCC	Observed/ inspected/ reported by Council asset managers during/ following coastal erosion or coastal inundation events.	Suggestion to make to specifically reference Le Quesne Road as loss of access to this road from coastal erosion would affect the majority of the community.

Westshore Proposed Thresholds			
Threshold + Threshold Measure	Primary responsibility for monitoring and reporting to HBRC	Monitoring method/ data source	Rationale for changes made in response to feedback as a result of community workshop held 22 June 2022
No Unit Specific Thresholds were identified for Westshore – All Units Thresholds to apply			

Ahuriri Proposed Thresholds			
Threshold + Threshold Measure	Primary responsibility for monitoring and reporting to HBRC	Monitoring method/ data source	Rationale for changes made in response to feedback as a result of community workshop held 22 June 2022
No Unit Specific Thresholds were identified for Westshore – All Units Thresholds to apply			

Pandora Proposed Thresholds			
Threshold + Threshold Measure	**Primary responsibility for monitoring and reporting to HBRC**	**Monitoring method/ data source**	**Rationale for changes made in response to feedback as a result of community workshop held 22 June 2022**
Coastal inundation in Pandora affecting Thames Street and Severn Street causing loss of road access for the majority of the community. *How long: At least 48 hours* *How often: More often than once every 5 years.*	NCC	Observed/ inspected/ reported by Council asset managers during/ following coastal erosion or coastal inundation events.	No changes suggested however suggestion to change the duration from 24 to 48 hours made to be consistent with feedback on this threshold for other units. Also, suggestion to specifically reference Thames and Severn Streets as loss of access to both these roads from coastal inundation would affect the majority of the community.

East Clive Proposed Thresholds			
Threshold + Threshold Measure	**Primary responsibility for monitoring and reporting to HBRC**	**Monitoring method/ data source**	**Rationale for changes made in response to feedback as a result of community workshop held 22 June 2022**
Buildings in East Clive are deemed uninhabitable as a result of coastal hazards (e.g. loss of septic tanks, building structural integrity etc).	CDEM/ HDC	Observed/ inspected/ reported by Council asset managers during/ following coastal erosion or coastal inundation events.	No changes suggested

Haumoana Proposed Thresholds			
Threshold + Threshold Measure	**Primary responsibility for monitoring and reporting to HBRC**	**Monitoring method/ data source**	**Rationale for changes made in response to feedback as a result of community workshop held 22 June 2022**
Coastal inundation in Haumoana affecting Haumoana and/or Beach Road causing loss of road access for the majority of the community. *How long: At least 48 hours* *How often: More often than once every 5 years.*	HDC	Observed/ inspected/ reported by Council asset managers during/ following coastal erosion or coastal inundation events.	Feedback suggested that in order for the impact to be substantial and therefore act as a threshold, not a trigger, duration should be extended to 48 hrs from 24 hrs Also, suggestion to specifically reference Beach Road and Haumoana Road as coastal inundation of these either or both these roads from coastal inundation would affect the majority of the community.
Buildings in Haumoana are deemed uninhabitable as a result of coastal hazards (e.g. loss of septic tanks, building structural integrity etc).	CDEM/ HDC	Observed/ inspected/ reported by Council asset managers during/ following coastal erosion or coastal inundation events.	No changes suggested

Te Awanga Proposed Thresholds			
Threshold + Threshold Measure	**Primary responsibility for monitoring and reporting to HBRC**	**Monitoring method/ data source**	**Rationale for changes made in response to feedback as a result of community workshop held 22 June 2022**
Coastal inundation in Te Awanga affecting Clifton Road causing loss of road access for the majority of the community. *How long: At least 48 hours* *How often: More often than once every 5 years.*	HDC	Observed/ inspected/ reported by Council asset managers during/ following coastal erosion or coastal inundation events, including community feedback.	Feedback suggested that in order for the impact to be substantial and therefore act as a threshold, not a trigger, duration should be extended to 48 hrs from 24 hrs. Suggestion to specifically reference Clifton Road as coastal inundation of this road would affect the majority of the community.
Coastal erosion in Te Awanga affecting Clifton Road causing loss of road access affecting the majority of the community.	HDC	Observed/ inspected/ reported by Council asset managers during/ following coastal erosion or coastal inundation events.	Suggestion to specifically reference Clifton Road as coastal erosion of this road would likely cause community-wide loss of road access.
Buildings in Te Awanga are deemed uninhabitable as a result of coastal hazards (e.g. loss of septic tanks, building structural integrity etc).	CDEM/ HDC	Observed/ inspected/ reported by Council asset managers during/ following coastal erosion or coastal inundation events, including community feedback.	No changes suggested

Clifton Proposed Thresholds

Threshold + Threshold Measure	Primary responsibility for monitoring and reporting to HBRC	Monitoring method/ data source	Rationale for changes made in response to feedback as a result of community workshop held 22 June 2022
Coastal inundation in Clifton affecting Clifton Road causing loss of road access for the majority of the community. *How long: At least 48 hours* *How often: More often than once every 5 years.*	HDC	Observed/ inspected/ reported by Council asset managers during/ following coastal erosion or coastal inundation events.	Feedback suggested that in order for the impact to be substantial and therefore act as a threshold, not a trigger, duration should be extended to 48 hrs from 24 hrs. Suggestion to specifically reference Clifton Road as coastal inundation of this road would affect the majority of the community. Note: Coastal inundation of Clifton Road in Haumoana unit could have access implication for the Clifton unit. Threshold in Haumoana unit covers this.
Coastal erosion in Clifton affecting Clifton Road causing loss of road access affecting the majority of the community.	HDC	Observed/ inspected/ reported by Council asset managers during/ following coastal erosion or coastal inundation events.	Suggestion to specifically reference Clifton Road as coastal erosion of this road would likely cause community-wide loss of road access. Note: Coastal erosion of Clifton Road in Haumoana unit could have access implication for the on the Clifton unit. Threshold in Haumoana unit covers this.
Buildings in Clifton are deemed uninhabitable as a result of coastal hazards (e.g. loss of septic tanks, building structural integrity etc).	CDEM/ HDC	Observed/ inspected/ reported by Council asset managers during/ following coastal erosion or coastal inundation events.	No changes suggested

Real Options Analysis of Strategies to Manage Coastal Hazard Risks in Hawke's Bay – An Update

for Hawke's Bay Regional Council

August 2022

Infometrics

Economics put simply

Authorship

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1. Summary

In 2017 Infometrics produced two reports for the Hawke's Bay Regional Council (HBRC), Napier City Council (NCC) and Hastings District Council (HDC). These reports presented Real Options Analyses (ROA) of the costs and benefits of various strategies for adapting to coastal hazard risks caused by climate change.

New estimates of the short term costs (mostly covering the next 20 years or so) for a number of the original adaptation strategies plus some new ones have been produced by HBRC. Tonkin and Taylor have produced more comprehensive costs for managed retreat and also updated the values of assets at risk.

Apart from those relating to managed retreat, medium-long term costs have not been updated, so some work-around assumptions have been necessary to ensure analytical consistency.

One key difference from the previous analysis is that the costs of managed retreat are spread over a much longer period in recognition of the planning, preparation and community engagement that is required before actual relocation and construction of capital assets can commence. Although this is much more realistic than previous practice, it does complicate the decision making somewhat as it means that a decision about adopting managing retreat is more difficult to defer in its entirety. Some preparatory costs may be worth accepting so as not to preclude full managed retreat at a later date.

Within the time and budget envelope available it has not been possible to undertake extensive sensitivity analysis. However, in most cases the cost difference between the lowest cost adaptation strategy and the second lowest cost strategy is such that there should be a reasonable degree of robustness of the results to changes in assumptions about costs and residual loss. The key results are summarised in the following table.

Summary of Preferred Adaptation Actions

Area	Least cost adaptation strategy
Units B+C+D, Whirinaki, Bayview and Westshore	Beach renourishment followed by control structures such as groynes and breakwaters. Around 2065 managed retreat could be reconsidered.
Unit E2, Pandora	Status quo until around 2045, then storm surge barrier with a mobile flood barrier across Pandora Rd. Managed retreat could be considered in 2065.
Unit K, Haumoana and Te Awanga	Groynes and beach renourishment are preferred. Our previous report showed that partial retreat involving those properties closest to the sea is also very cost-effective. We do not have the data to update that option.
Unit L, Clifton	Completion of the seawall may be justified, but managed retreat is too expensive in relation to the value of existing assets that are still exposed or could become exposed.

All results are subject to a number of caveats:

- Those listed with regard to the estimated costs of adaptation in the HBRC report (pp131-136)[1] and the limitations listed by Tonkin & Taylor (notably p3).
- The assumptions we have made to update other aspects of the earlier analysis to ensure its consistency with the new work by HBRC and Tonkin & Taylor.
- As always, evaluation of adaptation strategies is based on current knowledge about the risks of damage from climate change and the costs of addressing that risk. At any time new knowledge or weather events could render decisions obsolete.
- All of the analysis relates to economic costs and benefits. Non-economic considerations such as the risk to cultural assets or ecological areas are not included. These sorts of aspects could be evaluated with multi-criteria analysis, as was undertaken in the 2017 analysis.
- As before, infrastructure assets such as roads, water, power and telecommunications cables are excluded from the analysis. Tonkin & Taylor identify the length of road and rail networks affected, but not their values.

Based on current knowledge about climate change risk, for most areas especially Whirinaki, Bayview and Westshore (Units B,C,D), managed retreat is too expensive to commence in the short term, in relation to the expected damage from climate change events. It should be deferred until around 2065 unless plans are made redundant by an extreme climate event or new information. Our analysis is at the unit level. The situation for particular properties within a unit may differ from what applies to the unit as whole.

Previous analysis for Haumoana and Te Awanga (Unit K) showed that for properties immediately adjacent to the sea that face a very high risk of damage, relocation or rebuilding assets of equivalent quality may well be the most economical solution. We have not been able to update that analysis here. Otherwise beach renourishment and control structures continue to be cost-effective strategies.

For Clifton (Unit L) the cost of managed retreat exceeds the expected value of residual loss. The case for finishing the seawall is not robust with respect to relatively small changes in costs and values of exposed assets. Further investigation is recommended.

Pandora (Unit E) is rather unique in that it contains little housing, but a large number of industrial and commercial structures. It seems that these structures are not particularly expensive to replace so managed retreat should be retained as a feasible adaptation option. However, as the risk of serious damage from climate change events is currently considered low for at least the next two decades, and because there are other effective adaptation options available, managed retreat does not require immediate attention.

Data limitations preclude a meaningful update of the earlier analysis for Ahuriri and East Clive. It seems likely that the previously favoured adaptation strategies remain valid, but we recommend more investigation of adaptation costs for these units.

Overall, although commencing managed retreat for most of the Clifton to Tangoio coast is currently too costly in relation to probable damage risk, as an adaptation option it should never be discarded. Beyond 2125, if not before, the risk profile could be quite different. In some cases managed retreat might be the only long term response.

[1] See footnote 2.

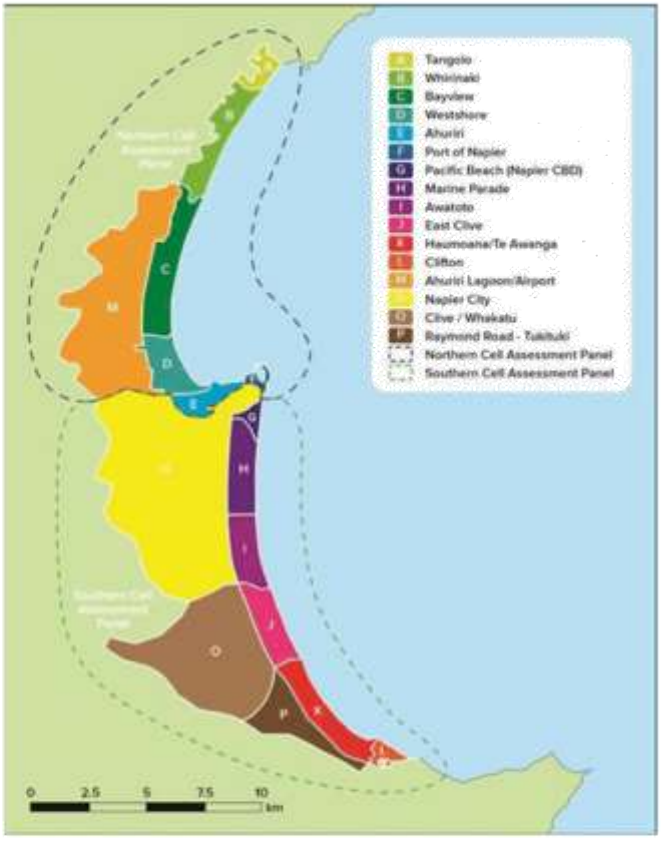
2. Data

New data has been provided by HBRC[2] for the short term costs of protection, and by Tonkin & Taylor[3], for managed retreat and the value of assets at risk for AEP=1% for inundation risk and the corresponding P5% for erosion risk.

For most northern units the hazard risk is erosion from more frequent and more severe storm surge, exacerbated by sea level rise. Pandora is unusual in that the main risk is inundation. The southern units are exposed to both erosion and inundation risk. Properties that are affected by both types of hazard (high wave events) are not double counted.

Figure 1 presents a map of the Clifton to Tangoio coast and shows the various geographical strategy 'units' that are used for the analysis.

Figure 1: Clifton to Tangoio



[2] HBRC (2021) Short-term concept design and costing - Clifton to Tangoio 2120 Coastal hazards strategy - Stage 4 - Design workstream Wave, shoreline evolution and gravel barrier response modelling - Groynes design and cost estimates. HBRC Report No. 5537. And
HBRC (2022) Short-term concept design and costing - Clifton to Tangoio 2120 coastal strategy - Design workstream, Flood defences Pandora Unit.

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

Short term costs

New data for short term costs (covering the first 20 years or so) has been made available for the following:

- A number of strategies for Units, B, C and D; Whirinaki, Bayview and Westshore combined.
- A number of strategies for Unit E2; Pandora, but applied after 2040.
- A number of strategies for Unit K; Haumoana and Te Awanga combined.
- The originally preferred strategy for Unit L, Clifton.

In the previous analysis, Units B, C and D were evaluated separately, and Unit K was split into Haumoana and Te Awanga.

Costs for Ahuriri, (Unit E1) and for East Clive (Unit J) have not been updated as no adaptation action is envisaged at those locations for at least the next 20 years.

The aggregation of costs across areas presents a problem. If we keep the aggregation in our updated analysis there is a risk of error from combining areas with somewhat different protection requirements, albeit that the reason for aggregation is that there is mutual dependency of strategies in adjacent locations. Alternatively, the data could be disaggregated using the earlier cost estimates, but that also risks introducing error.

Our judgement is that it is safer to use the aggregated data rather than attempting to split it. Consequently we look at four areas; Units B+C+D combined, Unit E2 (just Pandora), Unit K (Haumoana and Te Awanga combined), and Unit L.

Managed retreat

The new data for managed retreat (labelled planned retreat in the T&T report) is comprehensive, covering early planning and preparation costs, management fees, construction costs and clean-up costs. The original pathways did not include any early preparatory costs for managed retreat, nor clean-up costs. Recognising these costs is clearly an improvement on previous practice (see Olufson[4]).

Unfortunately, the costs are presented without a precise time dimension, being expressed as applying at any time over rather lengthy periods; the first 20 years, the next 30 years, and then the last 50 years to 2125 – the end point of the analysis. Although understandable, for analytical purposes and to keep matters reasonably simple it is assumed that:

- Preparatory costs over the first 20 years occur only in the last 10 of those years, from 2036 to 2045.
- Costs over years 20-50 are approximately uniform over the entire period, 2046 to 2075.
- Costs over years 50-100 are incurred only in the first 20 years, such that managed retreat and clean-up is complete by 2095, unless otherwise stated. Typically this period has the highest share of managed retreat costs.

[4] Olufson, S. (2019). Managed retreat components and costing in a coastal setting. Masters Thesis, Victoria University of Wellington, New Zealand. Retrieved from https://researcharchive.vuw.ac.nz/xmlui/bitstream/handle/10063/8359/thesis_access.pdf?sequence=1.

As our analysis is from a national economic perspective we do not include the sale and purchase of existing assets such as land as a cost component of managed retreat. Although these transactions represent a cost to the buyer (possibly a public entity) they are income to the seller (perhaps an offset against the cost of the receiving development), so the transaction is effectively a transfer. Apart from the associated administration costs such as conveyance of title, the resource costs of transfers are zero.

On the other hand, if land actually disappears – is lost to the sea or inundated – the economy loses a real asset, so that should be counted.

To prevent double counting, the capital value of existing assets is treated as the potential value of loss under climate change hazards, but this value is not also included as part of the cost of managed retreat. In other words, if a house with a market value of $x is inundated, it will cost $x to replace with like for like. Whichever way one looks at it, the resource cost is $x, not $2x.

For dwelling replacement costs T&T found it impractical to estimate costs on a like for like basis (essentially market value) for individual properties. Instead they used costs for a standard house with standard fixtures and fittings. Hence valuations of existing property, which are closer to market values, are more appropriate for our analysis than the costs of replacement with new structures. That is, new housing is assigned the capital value (where land is lost) of existing assets. To use a higher value would distort the analysis as the residual loss (or avoided loss) needs to be consistent across all adaptation options, including doing nothing. .

Asset values

Asset values relate to 2019-2020, which is consistent with the basis for the updated estimated costs of managed retreat and short term adaptation costs. As noted above, asset values enter the analysis on the loss side of the equation.

It is assumed that under managed retreat those assets most exposed to risk would be shifted first, such that the expected residual loss during the early phase of retreat is the same as if other adaptation options are pursued. In addition, to recognise that the value of assets at risk will decline substantially towards the end of the managed retreat process, residual losses are arbitrarily halved after 2075, given the above retreat profile.

We assume that eroded or inundated land is totally lost, so has no residual value. This may overstate losses somewhat if for instance submerged land has value as a wetland or has recreational uses.

We also assume that there is no increase in the real value of assets behind protective structures. The idea is that protection preserves asset values, not that it increases them. Constructing hard protection against climate change hazards may have the perverse effect of encouraging more development in areas made safer by protection, thereby strengthening the case for even more protection. Thus councils may need to restrict new building in such circumstances.

Medium-long term costs

Except for Pandora, there is no new information on medium-long term costs for any adaptation strategies apart from managed retreat (as above). Hence we retain the previous cost estimates although they do need to be adjusted for inflation. The updated short term costs are based on 2019/20 prices whereas as the original estimates were based on 2015

prices. We use a price index based on the Capital Goods Price Index produced by Stats NZ as this should be more appropriate that a general measure of inflation such as the Consumers Price Index. The index is the same for all units, though this could be reconsidered.

Climate change scenario

Values at risk of damage from inundation and erosion have not been updated to reflect either different climate change scenarios, nor different AEPs under the original damage functions from Tonkin & Taylor,[5] which were based largely on SRES Scenario A2.[6] We continue with those functions, but adjust the values pro rata to be consistent with the new AEP=1% and P5% values at risk.

Even in a scenario with no climate change and with no new protective measures, there is an escalation in the damage function over time, reflecting the cumulative effects of storm surge and erosion. The protection options remove that escalation, in most cases up to an approximate AEP=1% event under SRES Scenario A2, or equivalent erosion standard.

With the exception of retreat, no adaptation options reduce expected residual loss to zero as they are not designed for events that are more extreme than AEP=1% or P5% for erosion risk.

[5] Tonkin and Taylor (2016). *Hawke Bay Coastal Strategy, Coastal Risk Assessment*. Prepared for Hawke's Bay Regional Council.

[6] SRES is from the IPCC Special Report on Emission Scenarios. See https://www.ipcc.ch/site/assets/uploads/2018/03/sres-en.pdf. Scenario A2 is approximately two-thirds of the way between the newer RCP 6.0 and RCP 8.5 pathways, in terms of atmospheric CO_2 concentration. The RCP scenarios can be cross-tabulated against a number of Shared Socioeconomic Pathways (SSPs). RCPs are climate projections that do not directly correspond to specific social/economic pathways, while the SSPs portray alternative social/economic scenarios without reference to climate change. See https://www.carbonbrief.org/explainer-how-shared-socioeconomic-pathways-explore-future-climate-change/

3. Analysis

Real Options Analysis (ROA) is essentially an extended version of Cost Benefit Analysis (CBA) that includes estimating a value on the option to delay an action – an adaptation project for example. Note though, that the delay option is not a benefit that is added to a project's other benefits. Rather it amends the evaluation of the project's benefits by allowing for multiple decision points rather than a single decision point.

We note that numerous assumptions are required to compensate for the lack of updated data. We have endeavoured to make them as consistent with the original analysis as possible. Sensitivity analysis can be used to examine the robustness of results.

The total cost of an adaptation option comprises the investment and operating costs, plus the statistically expected residual loss – all discounted at 3% pa.

Unit K: Haumoana & Te Awanga

With the updated short terms costs for Unit K (now combining Haumoana and Te Awanga), there are a number of protection strategies that differ with regard to the amount of beach renourishment, the number of groynes, their location and length. The two alternatives recommended for funding assessment in the HBRC report are described as C2 and D2. Thus we look at these two options below, along with managed retreat.

Pathways C2 and D2 appear to provide very similar levels of protection, or at least sufficiently similar in built-up areas for any difference in expected residual losses to be within error margins. Pathway C2 has a lower initial cost, but higher ongoing costs, whereas D2 has a higher initial cost, but lower ongoing costs. Over 20 years their discounted costs are within ±10% of each other.

However, as shown in Figure 2, over 100 years C2 is cheaper, and is preferable to doing nothing for any probability of SRES A2 climate change over about 30%. See Table 1, where G denotes groynes and beach renourishment, and M denotes managed retreat.

Figure 2: Unit K Cut-off Probabilities

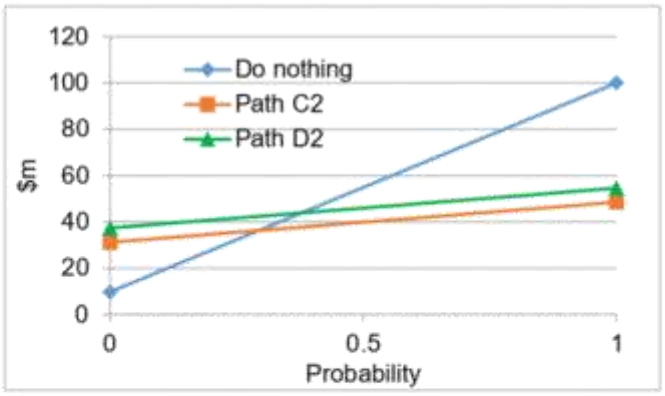


Table 1: Unit K Pathway Costs & Cut-off Probabilities

Pathway		Cut-off Probability	PV(cost) $m	PV(cost +loss) $m
Retreat	M+M+M	>100%	114.7	129.7
C2	G+G+G	29.5%	31.2	48.5
D2	G+G+G	37.8%	37.3	54.6

A cut-off probability as shown Table 1 is the probability at which the statistically expected value of loss from climate change hazards (for SRES A2 scenario) is the same as the cost of a particular adaptation strategy. For example, for Pathway C2, if the probability of damage from climate change (SRES A2) is less then about 30%, it is better to do nothing. This is illustrated in Figure 2.

Clearly a cut-off probability of over 100% is mathematically nonsensical, but it means that even if SRES A2 was 100% certain, managed retreat makes no economic sense at this stage. Investment in managed retreat is estimated to cost $377m undiscounted (and excluding land purchase transfers) or $109m discounted, assuming the time profile of costs described in Section 2. That is higher than the statistically expected residual loss of $100m if no adaptation is undertaken. Consequently, managed retreat under the assumed time profile is not currently economically efficient. Logically therefore it is also not efficient to consider it in parallel with either C2 or D2.

The upshot is that Pathways C2 or D2 are viable protection strategies until 2125, given current knowledge. Eventually, or sooner in the case of a major storm event or other trigger, that may not be true.

Partial retreat, which involves only those dwellings between the road and the sea – described as 'retreat the line' in the 2017 report – is a possibility. We have not been able to investigate this here, but our earlier analysis showed that immediate adoption of 'retreat the line' for both Haumoana and Te Awanga had the lowest expected total cost. However, other than some repositioning of the demarcation line it is not a flexible strategy. The next best choice in the earlier analysis was to construct control structures (groynes) to begin with, which allowed for the possibility of moving to 'retreat the line' at a later date, but that came with a cost premium of about $4m. Whether that premium still applies is not known.

Unit L: Clifton

For Unit L we have only one short term strategy, essentially beach renourishment with a rock revetment (sea wall), about three-quarters of which has already been built. The capital cost of the whole project is $3.47m with on-going operating costs of $0.154m per annum.[7] The capital cost exceeds the value of assets at risk under an AEP=1% scenario.

In the original analysis only two strategies (numbered 5 and 6) began in this manner, one persisting with a sea wall (which was the preferred strategy) and one moving to managed retreat around 2075. Here we include some managed retreat costs from the start, but with the largest share occurring over 2075-2095 as outlined above. Bringing costs forward would raise the discounted value. The pathways are illustrated in Figure 3.

The discounted expected costs and the cut-off probabilities relative to doing nothing are presented in Table 2.

[7] HBRC op cit

Table 2: Unit L Pathway Costs & Cut-off Probabilities

Pathway		Cut-off Probability	PV(cost) $m	PV(cost +loss) $m
5	S+M+M	>100%	5.4	5.8
6	S+S+S	>100%	4.6	5.0

Renourishment plus a seawall is denoted as S, while managed retreat is denoted M. Pathway 5 begins with S in the short term, but essentially involves an early commitment to managed retreat, which dominates the medium term and long term.

Pathway 6 has renourishment and a seawall for the entire period to 2125, but involves enhancement of the seawall around 2075.

As with Unit K probabilities of more than 100% make no sense. They mean that both pathways are too costly relative to the value of assets at risk. Pathway 5 assumes replacement of dwellings with like for like structures, recognising that the structures are not regular dwellings, but include caravans and similar set-ups. Even the values attributed to them seem expensive. Under T&T's costing existing dwellings are replaced with 'standard' dwellings, so the cost of managed retreat is higher still.

As illustrated in Figure 4, doing nothing is the least cost strategy.

Figure 3: Schematic of Unit L Pathways

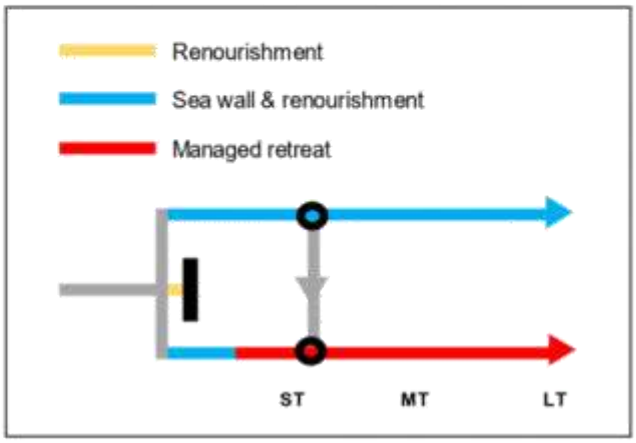
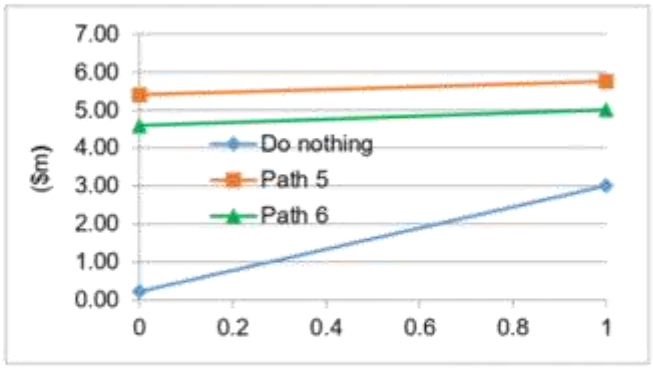


Figure 4: Unit L Cut-off Probabilities



However, a substantial section of the seawall has already been constructed (see cover page picture), primarily to ensure access to the boat ramp. This is an example of a non-economic value that has not been included in the foregoing analysis, but clearly provides some protection to other assets.

Parts of the camping grounds are still exposed, but the associated value of assets at risk is unclear as gaps in the seawall could still lead to damage to assets behind the wall. As a sensitivity test, if Pathway 6 is re-run with seawall costs reduced by approximately 46% (corresponding to the cost of what has already been built[8]), the cut-off probability for completing the seawall is lower, but still hovers around 100% depending on the value of the incremental residual loss – which is also lower than it would be without the partially completed wall. The logic here is that the part of the sea wall that has already been constructed is a sunk cost, so a lower probability of damage from climate change is required to justify completing it.

Thus depending on just how much additional damage would be prevented, finishing the seawall could be worthwhile if adverse climate change effects in the area are considered almost certain. However, we understand that the seawall will probably not be extended.

Lowering the discount rate from 3% to 1.5% does not make Pathways 5 and 6 cost-effective, but does strengthen the case for completing the seawall by lowering the cut-off probability to 75%-80%. Quite simply, the value of the assets at risk is very low and does not justify the cost of relocating them, but given the sunk cost of the seawall, the incremental cost of finishing it could be justified.

Some further refinement of costs and benefits around adaptation options for Until L seems worthwhile. Perhaps there are relocation options for the structures in and around the camping ground that are less expensive.

We stress that this is a purely economic analysis. Effects such as the social costs of dislocation and disruptions are out of scope.

Units B, C & D: Whirinaki, Bayview & Westshore

Three choices for Whirinaki, Bayview and Westshore combined are presented as Options A-C in the HBRC report.[9] Option B is very expensive as it would reinstate a sandy beach at Westshore (an example of a non-monetised benefit). We understand that it was not selected by the community panels. Of the other two options, Option C has more targeted protection than Option B. Option C has been recommended for funding assessment.

Table 3 shows the pathways along with managed retreat for the relevant properties. For Options/Pathways A-C the short term strategy is beach renourishment (R). In the previous report the least cost medium and long term strategies were control structures such as groynes and breakwaters (C). We assume that still applies, along with the costs estimated at the time, but adjusted for inflation.

Pathway C is the least cost option. Its risk-neutral probability between doing nothing and over-investing in protection is less than zero. Although as mathematically nonsensical as a probability above 100%, in this case it means that the case for Pathway C is so strong that

[8] HBRC op cit.
[9] HBRC (2021) op cit

it should be pursued even without the threat of increasing hazard risk from (SRES A2) climate change.

Table 3: Units B,C,D Pathway Costs & Cut-off Probabilities

Pathway		Cut-off Probability	PV(cost) $m	PV(cost +loss) $m
Retreat	M+M+M	84.4%	135.8	168.1
A	R+C+C	4.1%	30.2	72.5
B	R+C+C	23.1%	53.2	95.5
C	R+C+C	<0%	24.1	66.4
D	R+C+M	40.9%	75.9	115.1

Managed retreat is very costly, unsurprising given the value of the assets (mostly dwellings) at those locations. Even deferring its commencement until around 2065 (denoted as a new Pathway D) is still a costly option. However, this finding applies to Unit BCD as a whole, but the situation may be different for specific properties. Determining optimal pathways for that degree of disaggregation would require further analysis.

The implication of the results is that adopting R+C (in Pathway C) until around 2065, with a decision on the next step at that point, preserves flexibility and is the current least cost strategy. Given present knowledge the expectation is that groynes and breakwaters will continue beyond 2065, but circumstances at the time (or indeed before if some sort of trigger is reached) may warrant a change to managed retreat or to some other strategy.

Lowering the discount rate to 1.5% does not change the preference order of the options, but further strengthens the case for early action on beach renourishment. With regard to the cost of control structures, even quite large increases would be unlikely to swing the recommendation in favour of managed retreat. In any case if the cost of control structures does increase, the cost of managed retreat would probably rise in parallel.

Unit E2: Pandora

For Pandora the first 20 years is actually measured from about 2040 as it has previously been decided that no adaptation investment would occur within the next two decades, subject of course to the current state of knowledge about climate risk. The earlier analysis showed that stop banks are the least cost medium term and long term adaptation strategies. That does not preclude an eventual move to managed retreat.

Five options are described in HBRC[10], although two of those (2a and 2b) are extremely costly as they include upgrading the Napier Sailing Club (NSC). All options start with the status quo (Q) for the next two decades. Pathways 1a and 2a involve stop banks and walls of various types (S), with a mobile flood barrier (F) added in 1b and 2b instead of raising Pandora Rd. Pathway 3 has an inflatable storm surge barrier (I). See Table 4.

No operating costs were supplied for Pathway 3, so we assume $50,000 pa which is on a par with the other options. Further, it is assumed that with the exception of the NSC, all options provide much the same level of protection.

We have not added a higher residual loss under Pathways 1a and 1b to recognise that the NSC is outside the stop banks. Clearly though that expected loss would have to be around $13m for the total costs of Pathways 1a and 1b to exceed those of Pathways 2a and 2b.

[10] HBRC (2022) op cit.

That would make them more costly than retreat, so not efficient adaptation strategies. It may be possible to provide some sort of protection for the NSC for less than $13m in exchange for accepting a higher level of risk.

Table 4: Unit E2 Pathway Costs & Cut-off Probabilities

Pathway		Cut-off Probability	PV(cost) $m	PV(cost +loss) $m
Retreat	Q+M+M	94.6	15.7	17.5
1a	Q+S+S	88.8%	13.2	16.9
1b	Q+F+F	52.2%	8.7	12.4
2a	Q+S+S	>100%	26.1	29.8
2b	Q+F+F	>100%	21.6	25.3
3	Q+I+I	>100%	15.7	19.4
4	Q+F+M	96.1%	14.9	17.8

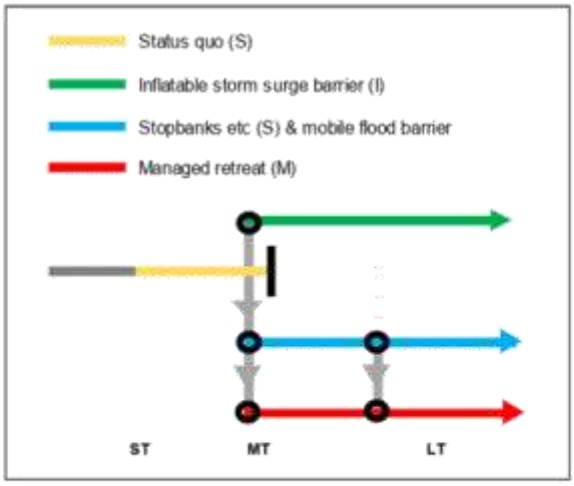
Pathway 1b has lowest expected total cost and merits adoption for any probability of SRES A2 climate change above 52% – essentially a 50/50 call. Managed retreat beginning in 2045 is too expensive, but is not the most expensive strategy.

What if the start of managed retreat was delayed by two decades, so beginning in 2065 and finishing in 2115, with Pathway 1b in action until 2065? Denote this as Pathway 4.

Figure 5 shows Pathways 1b, 3, and managed retreat, all of which start in the medium term around 2045. It also shows a transition from Pathway 1b to managed retreat occurring around 2065 as envisaged for Pathway 4. Other options, such as Pathway 3 could also transition to managed retreat, but would still be dearer than a modified Pathway 4.

Under Pathway 4 the total expected cost is actually marginally more than commencing managed retreat in 2045. Its discounted investment cost is less, but this is outweighed by higher expected damage cost. However, for a very small cost excess it does provide flexibility. That is, stopbanks and a mobile flood barrier (as in Pathway 1b) can be commenced in 2045, and then in 2065 a decision would be required (taking any new information into account) on whether to continue on that path or switch fully to managed retreat (or possibly do nothing).

Figure 5: Schematic of Selected Unit E2 Pathways



Given the differences in costs between the options, changes in construction costs (±30%) do not alter the preferred choice, but relative costs including those for managed retreat can be revisited closer to 2045.

Halving the discount rate to 1.5% does not change the pathway ranking, but by raising the cost of every option enhances the argument for Pathway 1b.

Unit E1: Ahuriri and Unit J: East Clive

The HBRC reports do not contain updated short term adaptation costs for the preferred pathways for Units E1 and J as for both areas the status quo measures continue for the next two decades. Hence we have no revised costs for any adaptation pathways for these units, except for managed retreat. Accordingly updating the previous ROA would be too speculative. We can, however, draw some inferences about preferred adaptation strategies.

Table 5 compares the previous and updated resource costs for managed retreat.

Table 5: Managed Retreat Costs for Units E1 and J

Unit	Previous*	Updated
E1, Ahuriri	42.5	118.4
J, East Clive	130.3	72.4

*Not inflated to 2019/20 prices.

For Ahuriri, given that managed retreat did not rank as a preferred option in the original analysis, it is unlikely that it would do so now, even allowing for likely cost escalation of other adaptation options. The previous conclusion was that a decision on managed retreat could be deferred until after 2065 (as with Pandora) so this strategy remains valid.

For East Clive the numbers are strange. T&T estimate the value of capital assets at risk in the long term (after about 2065) at only $17.5m, yet estimate the cost of managed retreat at $72.4m including the wastewater treatment plant, and $29.6m excluding the plant (both estimates excluding property transfers). Taken at face value these numbers imply that managed retreat should not be pursued as it costs considerably more than the assets are worth. That confirms the previous findings, albeit that the new numbers seem inconsistent.

We recommend more investigation of adaptation costs and asset values for Units E1 and J.