# Coastal hazards and land transport infrastructure guide

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WAKA KOTAHI NZ TRANSPORT AGENCY

Te Kāwanatanga o Aotearoa New Zealand Government

**More information**

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# Document information

## Purpose

This guidance seeks to improve the understanding of considerations for infrastructure in the coastal environment. The Guide is intended for consultants, contractors, project managers, stakeholders and the community who participate in the planning, design, construction and maintenance of land transport infrastructure. It should be considered in conjunction with the companion Coastal Hazards Assessment Guide.

## Availability

This document is held in electronic form by the Waka Kotahi Transport Services National Programme and Standards and on the Waka Kotahi internet (nzta.govt.nz)

## Guidance owner

Transport Services National Programme Group Waka Kotahi NZ Transport Agency. For guidance, clarification or technical assistance, please contact environment@nzta.govt.nz

## Acknowledgements

Waka Kotahi would like to thank Tonkin + Taylor for their expertise in producing the initial guidance document, as well as the internal and external reviewers for their time and feedback.

## Document history

| Version | Date | Authors | Description of changes |
|---|---|---|---|
| | | | |

# Contents

# 1. Introduction

Aotearoa New Zealand's coastline is a dynamic environment, acted on and constantly reshaped by waves, currents, tides, and tectonic and fluvial processes. Its position is not fixed, but changing, as these processes drive erosion, accumulation, and movement of sediment. New Zealand's climate is also changing, and this is likely to modify coastal processes continually into the future.

In contrast, land transport infrastructure (such as roads, rail, associated water infrastructure, port and maritime facilities) is relatively fixed in location due to traditional engineering techniques used, limited use of alternative systems, and the high costs of relocation if needed.

The aim of the guide is to set out how to consider and respond to the dynamic nature of the coastal environment across the business cases, implementation, and operational aspects of Waka Kotahi project life cycles. A part of this is asset condition monitoring, maintenance, and adaptation of structures to ensure they do not become increasingly vulnerable to degradation and failure.

It is to be read and used alongside other Waka Kotahi environmental and sustainability documents relating to the design, construction, and operation of state highway assets[1] and design guidance for highway structures.[2]

Appendix 1 provides checklists to support implementation of the guide. Appendices 2 and 3 provide details as to what should be included when preparing a coastal hazard assessment and functions as a screening tool to highlight risk and management options. Appendices 2 and 3 are primarily intended to be utilised by project managers and practitioners in the coastal hazards field, and project statutory planners responsible for gaining authorisations for coastal works.



## 1.1. Objectives of this guide

This key aims of this guide are to:

- provide nationally consistent systematic guidance for identifying, assessing, and managing coastal hazards effects;
- support adaptation to and mitigation of predicted climate change effects; and
- promote and implement a good/best-practice approach for future resilience of land transport infrastructure.

The guide is intended for use by Waka Kotahi project teams, supporting consultants and contractors. It also provides clarity for stakeholders on how Waka Kotahi has considered coastal issues in its design of coastal infrastructure. The approach can be adopted by other asset owners and operators of coastal land transport infrastructure and provides the opportunity to have integrated systems that work together.

## 1.2. Coastal processes

New Zealand is a relatively young and active landform, with over 15,000 km of coastline. This coastal environment ranges from the highly exposed, wave-dominated west and south coasts, to the moderately exposed north and east coasts, to sheltered sites in harbours and estuaries around the country.

The coast is a dynamic zone. It extends across the active coastal zone where waves are breaking and sediment is being transported, offshore where waves and tides begin, and inland where rivers carry sediment. Coastlines are in a constant state of erosion and accretion, as these actions move materials from one location to another. Figure 1 shows diagrammatically the active coastal zone and processes. Figure 2 illustrates a view of the complexity of coastal processes, landform type and

[1] See Waka Kotahi assessment and design guidance

[2] See NZTA (2016) Highway structures design guide and NZTA (2018) Bridge manual

impacts occurring on a natural coast and its interaction with aspects of land transport infrastructure (local roads and the state highway).

Coastal processes occur over a range of timescales. Storms and tsunami last from hours to days, and climate and sediment cycles occur over decades or longer. Coastal environments are complex and unpredictable, due to the links between these processes over time. These environments are also changing in response to climate change. Additionally, local tectonic movement (either ground uplift or dropping) can modify the processes by changing the sea level through uplift and subsidence.

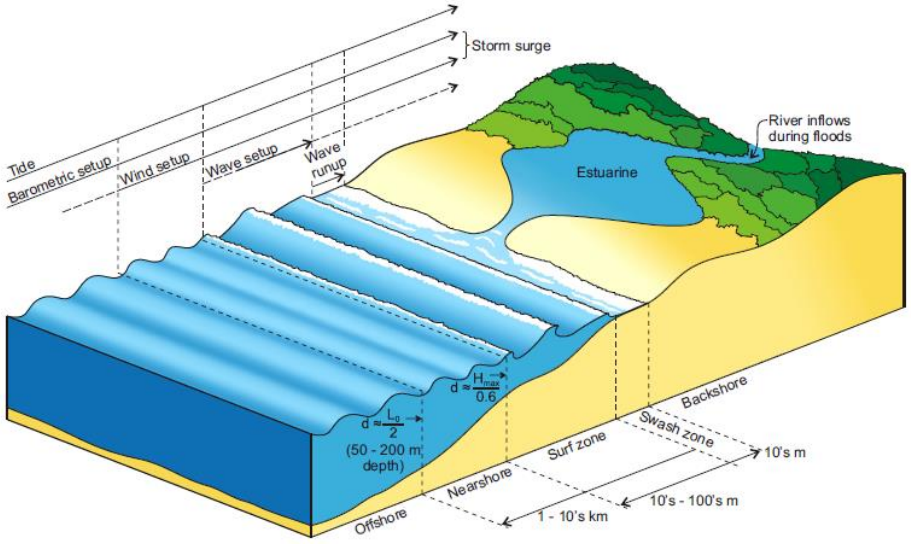


*Figure 1: The active coastal zone*

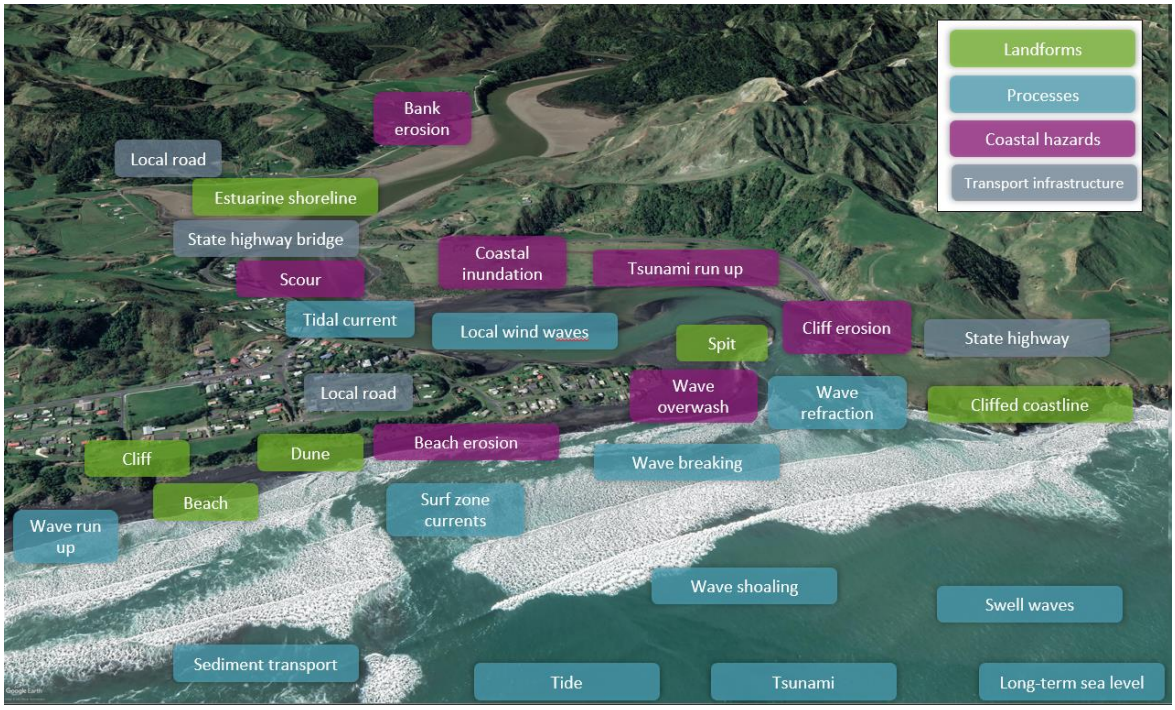


*Figure 2: Landforms, processes and hazards that may affect land transport infrastructure in the coastal environment (Satellite image: Maxar Technologies, 2020)*

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## 1.3. Values of the coastal environment

The coastal environment holds high natural and landscape values. Diverse habitats, including lakes, lagoons, tidal estuaries, saltmarshes and wetlands, support an abundance of vegetation and indigenous species, including migratory birds.

It also holds high social, cultural and economic value. Māori have been living in these environs for many generations, relying on it as a source of sustenance and for spiritual wellbeing, and this continues today. Most early European settlers also lived on the coastline, close to food sources, establishing industries such as whaling, and easily transporting natural resources such as timber. As such the coastal environment also holds cultural heritage values. Today, New Zealanders still live, work and play in the coastal environment, with much of the urban development situated on the coast and around harbours, estuaries, creeks and lowland rivers (MfE, 2017[3]).

Transport infrastructure is critical to supporting the social and economic fabric of these communities.

## 1.4. Coastal hazards

Where land transport infrastructure interacts with coastal processes, hazards arise and these adversely affect lives, livelihoods, property, transport links, or other aspects of society and the environment. These hazards will be exacerbated by climate change impacts such as higher sea levels and more extreme metrological conditions: increased temperature, rainfall, and storms.

Processes that may result in coastal hazards include:

- Erosion: sediment is lost through either storm-induced erosion or longer-term deficits.
- Cliff instability: cliffs become over-steepened by erosion at the base, and fail.
- Coastal inundation: water levels are elevated due to a combination of astronomical tide, storm surge caused by wind and low pressure, and potentially wave-breaking effects.
- Raised groundwater: the water table is raised near to the ground surface, causing surface flooding or instability.
- Wave overtopping or overwash: waves run up above the sea level and onto the land behind.
- Tsunami: long-period waves are caused by a displacement of the sea floor, generally generated by an earthquake.

Climate change is expected to modify many of the processes that drive these hazards, such as higher mean sea levels, more frequent and severe flooding and wave overtopping, and changes to local erosion and sedimentation.

## 1.5. Climate change

Waka Kotahi requires climate hazards to be assessed for all projects, and considered in planning and design.

This guidance document is broadly consistent with the guidance in the Ministry for the Environment (2017) document Coastal Hazards and climate change[3]. The MfE climate change projections provide a range of scenarios rather than a single predicted scenario. Four scenarios (referred to as representative concentration pathways / RCPs) are currently reflected in implementation of this Guide and the companion Coastal Hazards Assessment Guide. Waka Kotahi is currently working to update guidance on the use of these, and updated projections in relation to climate change assessment and sea level rise scenarios.

Developments in methodologies for predicting climate change are to be expected, the key principle to be applied however is that a range of outcomes should be considered.

[3] MfE (2017) Coastal Hazards and Climate Change: Guidance for Local Government. Report by the Ministry for the Environment.

## 1.6. What does this mean for land transport infrastructure?

### 1.6.1. Exposure

Sections of land transport infrastructure corridors in New Zealand have been identified as being potentially exposed to coastal hazard[4,5]. These areas will increase in extent over time with predicted climate change impacts. Important hazards that climate change may exacerbate include:

- Coastal inundation of low-lying land, particularly as sea levels are rising.
- Wave impacts at the shoreline, causing damage due to wave forces, high-flow velocities and scour. Higher sea levels and storms can allow larger waves to reach the sea's edge and/or move further inland.
- Erosion of the coastal edge, which could make higher landforms more unstable. Erosion and instability can damage infrastructure by removing the support of underlying land. Changes in sediment supply, along with higher sea levels and wave energy, could increase the rate or magnitude of erosion.
- Tsunami may affect larger areas (inundation, scour, debris) as a result of higher sea levels.

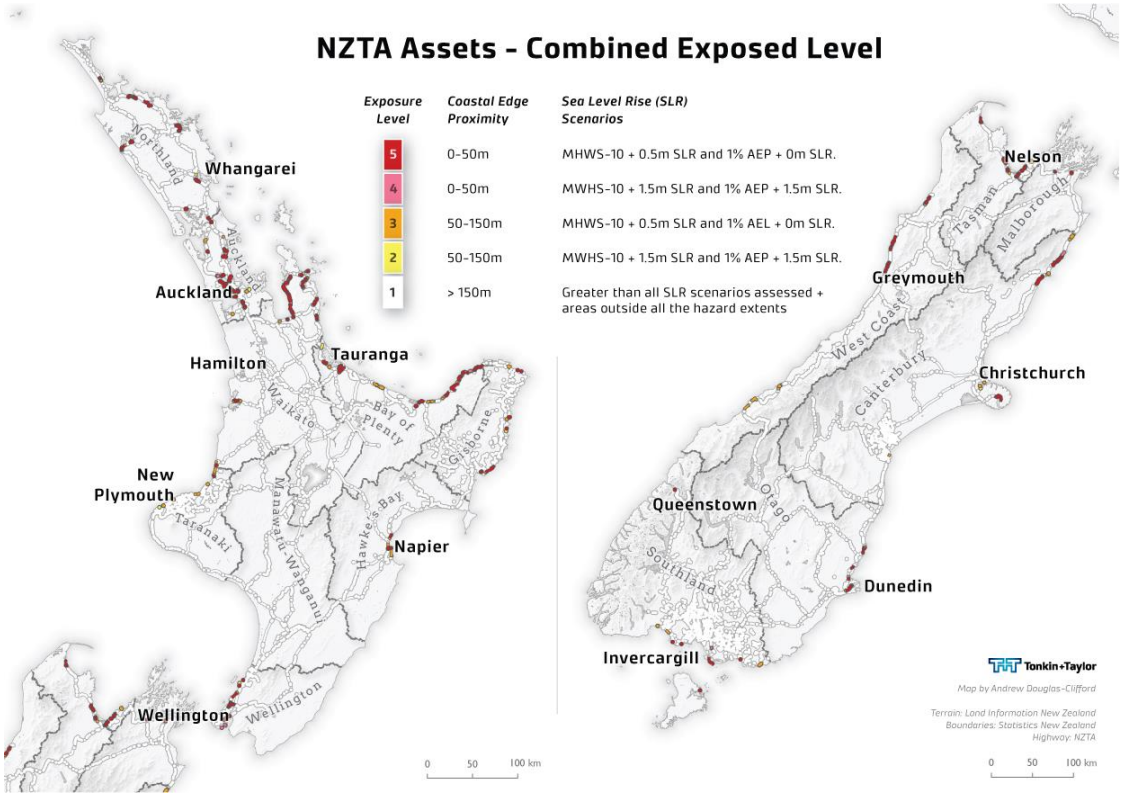



*Figure 3: Exposure level of Waka Kotahi assets to coastal processes (Tonkin + Taylor, 2020)*

[4] PCE (2014) Preparing New Zealand for Rising Seas: Certainty and Uncertainty. Parliamentary Commissioner for the Environment, 92p.

[5] Paulik, R., Stephens, S., Wadhwa, S., Bell, R., Popovich, B and Robinson, B. (2019) Coastal Flooding Exposure Under Future Sea-level Rise for New Zealand. Report prepared for The Deep South Challenge, 76p.

### 1.6.2. Consequences

The consequences of exposure will depend on the severity of the hazard event and the vulnerabilities of the impacted assets. Previous consequence assessments, while made at a high level, indicate between 2-4 per cent of State Highway infrastructure[6] and over $14 billion of local government infrastructure may be exposed to coastal hazards[7].

Significant parts of land transport infrastructure are recognised as a 'lifeline utility' within the Civil Defence Emergency Management Act 2002. Land transport infrastructure also provides access to remote communities with limited (or no) alternatives and include public transport facilities (eg. ferries).

The risks and consequences associated with exposure to identified hazards are a function of the transport network's exposure and sensitivity to them, and the network's capacity to respond effectively and return services levels to normal after the events. The combination of the network's sensitivity and capacity for response and recovery defines its vulnerability, or conversely, its resilience.

Figure 4 illustrates an example of exposure (erosion) and consequences for State Highway SH 12 (Opononi Beach). Figure 5 shows the response to exposure.

*Figure 4: SH 12 Opononi exposure and consequence (open sandy beach)*



[6] Tonkin + Taylor (2020) Coastal Exposure Assessment – Stage 2 Exposure Assessment for Coastal Hazards. Report prepared for the New Zealand Transport Agency, April 2020.

[7] Local Government New Zealand (2019) Exposed: Climate change and Infrastructure – Guidance for Councils

*Figure 5: SH12 Looking south towards Opononi erosion protection in place (after)*

# 2. Statutory and policy environment

## 2.1. Statutory context

Providers of land transport infrastructure are required to obtain statutory approvals for various activities and works on the coastal environment under the Resource Management Act 1991 (RMA) and this includes outcomes of the New Zealand Coastal Policy Statement 2010 (NZCPS), and local regional plan requirements.

There are other legislative obligations such as the Marine and Coastal Area (Takutai Moana) Act 2011, Ministry for Primary Industries, locality related (e.g. harbour) bylaws and treaty settlement legislation which are outside the scope of this guide.

Key considerations under the NZCPS include:

- Honour the principles of Te Tiriti o Waitangi, recognising the role of tangata whenua as kaitiaki and involving tangata whenua in management of the coastal environment.
- Identify important values in the coastal environment that may be affected by development. These include natural character and landscape values, public access (and specifically walking access), ecological, recreational, cultural, amenity. intrinsic, and economic values.
- Consider whether activities and structures have to be in the coastal marine area, or whether they can be located further away.
- Take a risk-based approach to identifying coastal hazards over the long term (at least 100 years), including expected effects of climate change.
- Consider natural defences and nature-based solutions against hazards, and alternatives to hard protection structures, while noting that such structures may sometimes be the only practical means to protect infrastructure of national or regional importance.

Resource management reform (underway 2023) will see the replacement of the Resource Management Act with three proposed Acts:

- The Natural and Built Environment Act (NBA), as the main replacement for the Resource Management Act (RMA), to protect and restore the environment while better enabling development;
- The Spatial Planning Act (SPA), requiring the development of long-term regional spatial strategies (RSS) to help coordinate and integrate decisions made under relevant legislation; and
- The Climate Adaptation Act (CAA), to address complex issues associated with managed retreat[8].

The NBA proposes a new national and sub-national policy framework referred to as the National Planning Framework (NPF) which will likely incorporate the NZCPS in the first instance. The NPF will set the outcomes for Regional Spatial Strategies and NBA Plans, these being promulgated subsequent to the NPF. Some amendments or updates may be made to bring the NZCPS into line with the proposed acts and their outcomes. Statutory planners working on coastal projects must be aware of statutory document changes and requirements and implement these as required within the projects.



[8] MFE Website: https://environment.govt.nz/what-government-is-doing/areas-of-work/rma/resource-management-system-reform/key-components-of-our-future-resource-management-system/#overview-of-the-new-legislation

## 2.2. Waka Kotahi policy framework

Waka Kotahi is required to observe national policy direction and has its own policy and objectives which, in relation to coastal hazards, are summarised and discussed below.

### 2.2.1. Government Policy Statement on Land Transport 2021 (GPS 2021) Statement of Ministerial expectations

The New Zealand Government Policy Statement on Land Transport (GPS 2021) includes a statement of Ministerial expectations[9] (section 3.7) which include:

- align investment decision making with the 2018 Resilience Framework[10]
- consider potential for climate change adaptation when approving projects for investment
- consider community wellbeing (including the wellbeing of regional communities) when approving projects for investment
- where relevant, ensure that project proposals have considered, and are designed in such a way to mitigate, significant threats to personal security.

The Waka Kotahi Resilience Framework requires it to:

- provide a strategic approach to resilience, and
- prioritise, guide and coordinate ongoing activity and strategic work programme to improve resilience.

### 2.2.2. Transport Outcomes Framework

Te Manatū Waka Ministry of Transport's Transport Outcomes Framework[11] is a non-statutory document, though it is given weight by being referenced in the GPS 2021 It identifies five transport outcomes which include *Resilience and security.* Key deliverable of *Resilience and security* is a transport system which:

- minimises and manages the risks from natural and human-made hazards
- anticipates and adapts to emerging threats, and
- recovers effectively from disruptive events.

### 2.2.3. Aotearoa New Zealand's First National Adaptation Plan

The New Zealand Government GPS 2021 requires Waka Kotahi to undertake relevant actions identified in the National Adaptation Plan (NAP). Waka Kotahi is a lead agency for delivery of parts of the NAP including achieving the following objectives:

- INF1: Reduce the vulnerability of assets exposed to climate change.
- INF2: Ensure all new infrastructure is fit for a changing climate.
- INF3: Use renewal programmes to improve adaptive capacity.

This guide will assist in meeting the following NAP actions:

- Action 3.8: Develop guidance for assessing risk and impact on physical assets and the services they provide
- Action 8.1: Develop and implement the Waka Kotahi Climate Change Adaptation Plan (complete: Tiro Rangi: our climate change adaptation plan 2022-24)

[9] GPS Section 3.7.

[10] NZ Transport Agency 2018 Resilience Framework https://nzta.govt.nz/assets/Highways-Information-Portal/Technical-disciplines/Resilience/Resilience-response-framework/transport-resilience-framework.pdf

[11] https://www.transport.govt.nz/area-of-interest/strategy-and-direction/transport-outcomes-framework/

- Action 4.7: Integrate adaptation into Waka Kotahi decision-making
- Action 8.7: Embed nature-based solutions as part of the response to reducing transport emissions and improving climate adaptation and biodiversity outcomes.

### 2.2.4. Tiro Rangi: Waka Kotahi climate change adaptation plan 2022-24

Tiro Rangi was released in December 2022 and is the Waka Kotahi plan for adapting the land transport system to the reality of a changing climate. It aligns with the government's national adaptation plan (NAP) and Te Manatū Waka Ministry of Transport Transport Outcomes Framework.

Tiro Rangi identifies five foundation themes:

1. Better understand and manage climate risks to Waka Kotahi
2. Ensure that our strategic system planning, and investment direction is enabling climate adaptation
3. Embed climate adaptation in our investment decision-making processes and delivery
4. Ensure that robust evidence underpins our work on climate adaptation
5. Embed te ao Māori worldview and build a partnership approach to climate adaptation for transport

Tiro Rangi proposes to begin the change for climate adaptation through planning, investment, design, delivery, operation and use the land transport system.

This guide, in conjunction with the companion Coastal Hazards Assessment Guide, will assist in delivering various Tiro Rangi actions (for example *2.2 Embed adaptation into strategic system and spatial planning, 3.3 Update standards and guidance* and *6.2 Build common understanding*).

### 2.2.5. Waka Kotahi One Network Framework (ONF)

The One Network Framework (ONF) is the Waka Kotahi national classification system for roads and streets. The ONF is a tool to help establish priority uses, performance measures and potential interventions for each road and street type. Project and local level uses include:

- Provide design guidance for the development of project options and solutions
- Provide a framework for project impact evaluation that can be aligned with wider network performance assessment
- Guide asset maintenance regimes
- This Guide will assist in delivery of infrastructure within the ONF.

### 2.2.6. Te Ara Kotahi, Waka Kotahi Māori Strategy and Hononga ki te iwi, Māori Engagement framework

Te Ara Kotahi, is the Waka Kotahi Māori Strategy which provides strategic direction on how to work with and respond to Māori as the Crown's Treaty partner. The strategy incorporates ngā uara / values mātāpono / principles for working together, as well as recognising, respecting and upholding the principles of Te Tiriti o Waitangi.

Usually for large projects engagement will be undertaken for a range of environmental aspects well before works start, in accordance with the Hononga ki te iwi framework. Early and regular engagement during a project will ensure that any issues can be communicated and addressed quickly.

Māori perspectives on activities in the coastal environment should always be considered. Waka Kotahi has some excellent resources that may assist when seeking to engage with Māori for a project, detailed below. The Te Mātangi Māori partnerships team should be contacted in the first instance if there are any queries on Māori engagement for a project.

### 2.2.7. Waka Kotahi Environment and Social Responsibility Policy 2022

This overarching policy states Waka Kotahi is committed to adapting the land transport system to the impacts of climate change in ways that respect the environment, biodiversity and community prosperity

To implement this policy Waka Kotahi will:

- Care for the natural and built environment
- Provide a land transport system that offers people, goods and services access that:
- increases the resilience of transport networks and the lifelines they provide.
- Steward all elements of the transport system within landscape and catchment contexts, to protect and enhance the natural environment, including retaining existing and introducing new nature-based solutions, protecting and enhancing biodiversity and supporting the adaptive capacity of the environment to respond to climate change.

### 2.2.8. Waka Kotahi Z19 Taumata Taiao – Environmental and Sustainability Standard

Taumata Taiao sets out the process and requirements that give effect to Waka Kotahi environmental and sustainability policies, other strategic objectives, outcomes and legal requirements during the development and management of the land transport system. It applies throughout the lifecycle of all Waka Kotahi infrastructure delivery.

# 3. Integrating project life cycle with coastal hazard assessment

## 3.1. Approach

Waka Kotahi has a whole of life cycle approach to (Figure 6) project development and decision making across business case considerations, asset design, statutory authorisation, and implementation (asset construction and management.[12]

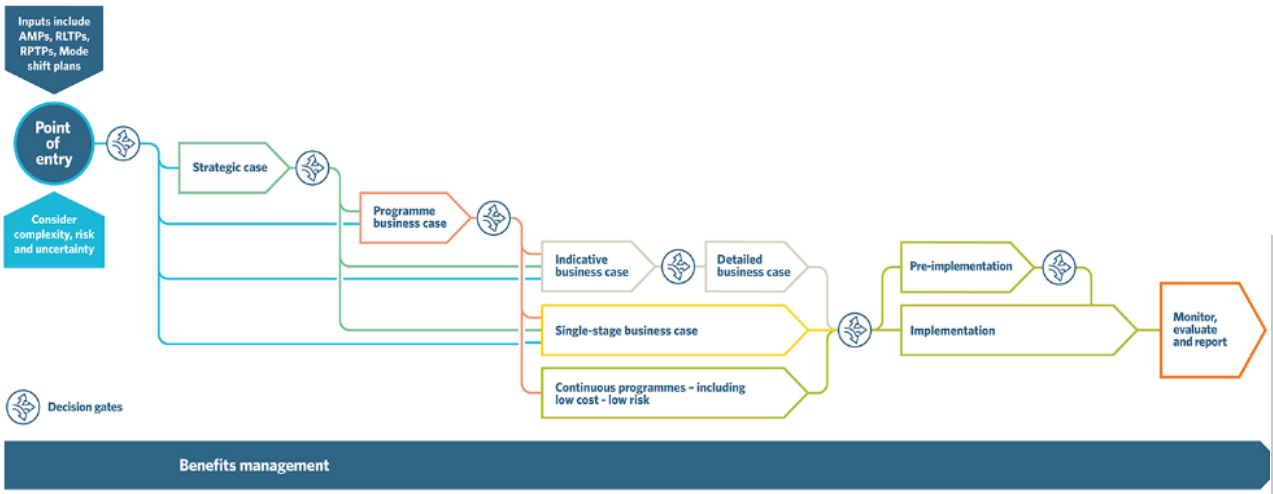



*Figure 6: Waka Kotahi business case process*

The process and considerations through the project life cycle when developing, maintaining or adapting infrastructure in the coastal environment are defined within Taumata Taiao, and utilises an Environmental Screen[13] which is required to be completed at the initiation of projects. The screen informs the project of the key issues for consideration across a range of factors to aid developing a strategic approach to address asset design, and required statutory authorisation processes.

To assist in ensuring effective, efficient, and consistent consideration of issues in respect to coastal aspects of projects this guide uses the following phase framework (and steps) to define levels of assessment and design detail appropriate for the Waka Kotahi project life cycle:

- Strategic Business Case and Program Business Case (step 1)
- Indicative Business Case, Detailed Business Case and Single Stage Business Case (step 2)
- Pre-implementation (preliminary design and consenting) (step 3 and 4)
- Implementation (detailed design and construction) (step 5 and 6)
- Long-term management (step 7 and 8).

Emergency response to asset failure or degradation is also addressed by indicating what steps are needed to be followed in those situations.

The following technical issues to be considered and assessed across these steps are:

- Coastal processes and hazard identification (Blue)
- Coastal engineering design (Green)

[12] Available at https://www.nzta.govt.nz/planning-and-investment/learning-and-resources/business-case-approach-guidance/business-case-phases

[13] Available at https://www.nzta.govt.nz/roads-and-rail/highways-information-portal/technical-disciplines/environment-and-sustainability-in-our-operations/z19-taumata-taiao/environmental-screen/

- Coastal effects assessment (Yellow)

Combining the information from these assessments will provide a clear level of detail and direction for the project teams to proceed with at the specific phase, and support the next phase. Table 4.1 collates the phases of project, along with the level of assessment to be considered. A colour coding is provided to assist (Blue, Green, Yellow).

The section following provides details of the levels of assessment expected at the various project phases and steps. Checklists for these assessments are also provided in Appendix 1. Appendices 2 and 3 provide more detailed guidance for the content and structure of assessment for each project life cycle stage.

**Table 3-1: Type and level of assessment through the coastal project life cycle**

| **Phase in project life cycle** | | **Coastal processes and hazard identification** | **Coastal engineering design** | **Coastal effects assessment** |
|---|---|---|---|---|
| Strategic Business Case and Programme Business Case | Level of assessment | A1 Initial exposure screening | B1 Option screening | C1 Effects screening |
| Indicative Business Case, Detailed Business Case and Single Stage Business Case | | A2 Preliminary exposure assessment | B2 Feasibility design | C2 Preliminary effects assessment |
| Pre-implementation (preliminary design and consenting) | | A3 Detailed process and hazard assessment | B3 Preliminary design | C3 Detailed effects assessment |
| Implementation (detailed design and construction) | | A4 Process and hazard verification | B4 Detailed design | C4 Effects compliance |
| Long-term management | | A5 Process monitoring | B5 Remediate or adapt | C5 Monitoring effects |

## 3.2. Business case

The business case process has a range of steps starting from the higher-level Strategic Business Case (SBC), Programme Business Case (PBC) and moving the Detailed (DBC) or Single Stage Business case (SSBC) (as the last and most detailed business case stage).

The business case process develops options far enough to determine a project's feasibility. It should establish the likely benefits, costs and risks, and gain enough information to assign a budget and resources. This phase consists of two steps – the indicative business case, and the detailed business case.

**Table 3-2: Step 1: Strategic Business Case and Program Business Case**

| | | |
|---|---|---|
| **Description** | The SBC and PBC business cases provide decision makers with early indication of the preferred option.<br>In the coastal environment, this involves establishing whether the project will be exposed to coastal hazards, in the present and over the long term (ie, 100-year timeframe). This is typically a high-level assessment using readily available information, to determine any constraints or opportunities that would affect the feasibility of the project. It will also assist distinguishing between options.<br>In addition, consider the general approach to managing hazards eg, avoid, accommodate, protect. Identify potential effects on the environment, using the Z/19 Taumata Taiao – Environmental and Sustainability Standard and Environmental Screen. | |
| **Type and level of assessment** | Coastal processes and hazards | A1 – Initial exposure screening |
| | Coastal engineering design | B1 – Option screening |
| | Coastal effects | C1 – Effects screening |
| **Outcome** | • Problem identified. Appreciation of coastal hazard exposure.<br>• Potential long-term management approaches identified; including recognition of the situations where there is substantial uncertainty and adaptive strategies may be needed.<br>• Values and matters of importance defined. | |

**Table 3-3: Step 2: Indicative Business Case, Detailed business case and Single Stage Business Case**

| | | |
|---|---|---|
| **Description** | The purpose of the IBC, DBC and SSBC detailed business case is to refine and confirm the preferred option through more detailed analysis of the costs, risks and benefits. At the end of this step, a funding application is developed to proceed to implementation (or pre-implementation if required).<br>If the project is required to be in the coastal environment, and the hazards cannot be avoided, investigation and design must enable a confident selection of a preferred option or shortlist.<br>Establish a basis to assess functional requirements, design life and other requirements or constraints. Options should include the 'do-nothing' case as the baseline. Identify adaptation options for the long-term resilience of assets.<br>Assess the effect / risks, for example: technical viability – constructability (access, service clashes); maintenance and operations; safety in design; environmental effects; tangata whenua views and impacts on cultural heritage; social impacts – stakeholders, community; comparative whole of life cost; consenting risks/opportunities; benefits and biodiversity co-benefits.<br>Consider varying or optimising the design and adaptation to meet the service life, as coastal hazards change over time. Also consider whole of life cost, safety in design, constructability, and social and environmental effects.<br>Value engineering may be a method to address this outcome. | |
| **Type and level of assessment** | Coastal process and hazards | A2 – Preliminary exposure assessment |
| | Coastal engineering design | B2 – Feasibility design |
| | Coastal effects | C2 – Preliminary effects assessment |
| **Outcome** | • Understanding of the current and a variety of future scenarios for coastal hazards over a 100-year timeframe.<br>• Agreed design basis and preferred option, with indicative resourcing.<br>• Appreciation of the likely effects the preferred option will have under different climate change outcomes. | |

## 3.3. Pre-implementation

This phase covers the preliminary design and consenting the recommended option. Progressing the designs usually requires further investigation or surveys.

**Table 3-4: Step 3 and 4: Preliminary design and statutory approval**

| | | |
|---|---|---|
| **Description** | Develop the preferred option to the point where you can apply for statutory approval, if required (or other regulatory requirements, eg, an authority to modify under the Heritage New Zealand Pouhere Taonga Act 2014, Wildlife Act requirements?). This typically requires further site investigations (eg, geotechnical) and survey (topography / bathymetry), as well as more detailed engineering design.<br>Prepare and lodge a statutory approval application, if required. A coastal effects assessment shows that you have considered the effects on the environment for all stages of the project. It addresses any cumulative effects and identifies any mitigation or management to minimise these.<br>For more information, see NZTA (2017[14]). | |
| **Type and level of assessment** | Coastal process and hazards | A3 – Detailed process and hazard assessment |
| | Coastal engineering design | B3 – Preliminary design |
| | Coastal effects | C3 – Detailed effects assessment |
| **Outcome** | • Site-specific understanding of the coastal processes and likely hazards now and in the future.<br>• Preliminary design including long-term or adaptive management, and guidance on operation and maintenance.<br>• Level of effect assessed and quantified, and mitigation measures in place.<br>• Statutory approval(s) granted. | |

## 3.4. Implementation

This phase covers finalising the preliminary engineering design, building the work, and meeting requirements for consent, other authorisations and procurement.

**Table 3-5: Step 5 and 6: Detailed design and construction**

| | | |
|---|---|---|
| **Description** | Finalise the design with construction drawings and specifications. Prepare a schedule of quantities to support engineers' estimates. Specifying material is particularly important for the coastal/marine environment, so take extra care.<br>Prepare contract documentation. The detailed design will address any consent conditions specific to the coastal environment (e.g. particular construction methods, works at low tide), and support safe construction through safety in design measures.<br>After contract award, construction can begin. The contractor builds the asset to design tolerance and specification. Any mitigation measures noted in the consent process must be applied during construction. | |
| | Coastal process and hazards | A4 – Process and hazard verification |
| | Coastal engineering design | B4 – Detailed design |

[14] NZTA (2017) Coastal effects assessment guidelines for transportation infrastructure

| | | |
|---|---|---|
| **Type and level of assessment** | Coastal effects | C4 – Effects compliance |
| **Outcome** | • Detailed design ready for construction.<br>• Compliance management plans.<br>• Asset built.<br>• Maintenance and operations plans.<br>• Funding identified. | |

## 3.5. Long-term management

This phase covers monitoring, maintenance and operation of the asset to support continued performance through its service life, and adaptation to future events such as rising sea levels. Figure 7 and Figure 8 show examples of long term management responses.

**Table 3-6: Step 7 and 8: Monitor, maintain, and adapt**

| | | |
|---|---|---|
| **Description** | Undertake monitoring to ascertain maintenance and periodic repair requirements to assist with improving the life of coastal structures/protection measures. A monitoring and maintenance regime allows for continued, acceptable performance, prioritising repairs to reduce or avoid cumulative damage or failure.<br>Over time, a structure may need to be adapted for greater resilience, or to respond to changing environmental conditions. This may include adapting existing structures or applying pre-determined design options.<br>As assets near the end of their life, or are damaged, consideration should be given to repair, replacement, decommissioning or adaptation. Each has varying costs and wider opportunities (e.g. use of nature-based solutions, improvements to biodiversity) and functional outcomes for the asset and coastal environment should be considered. If the preliminary design did not include adaptive measures, this may involve returning to the business case to refine the design philosophy, screen, assess and select before working on the new solution. | |
| **Type and level of assessment** | Coastal process and hazards | A5 – Process monitoring |
| | Coastal engineering design | B5 – Remediate or adapt |
| | Coastal effects | C5 – Monitoring effects |
| **Outcome** | • Asset monitoring and maintenance regime to retain function and level of service.<br>• Adaptive management plan in place/developed, to extend service life or meet new demands. | |

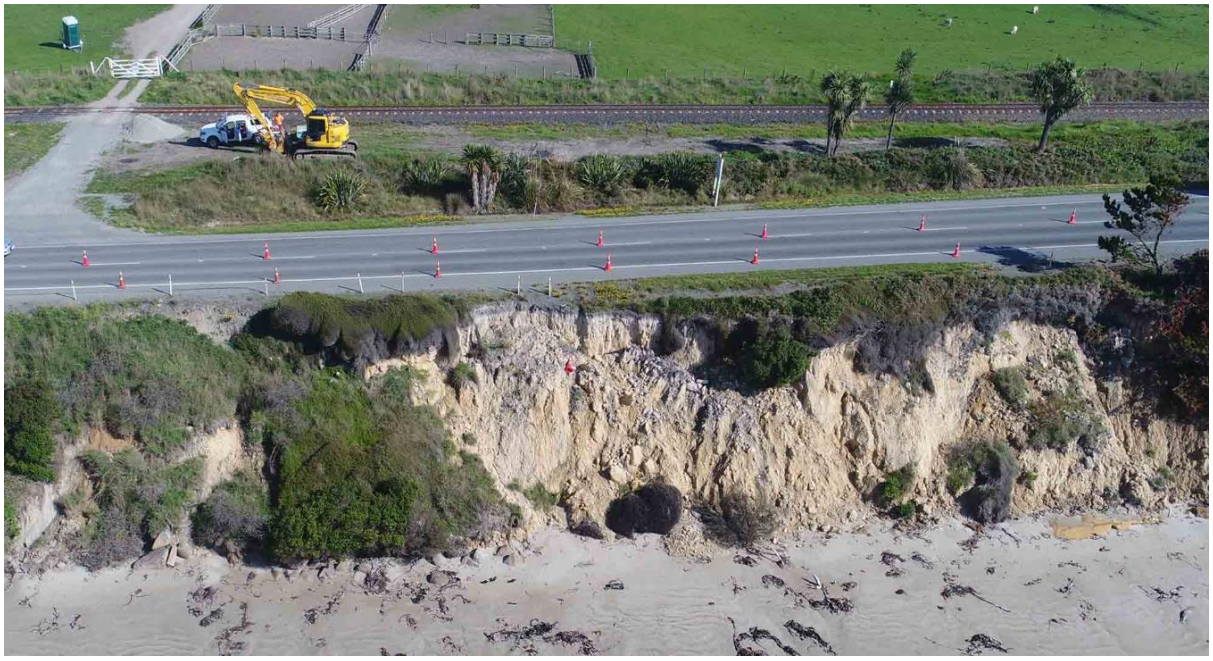


*Figure 7: Cliff erosion State Highway 1 (Katiki Beach North Otago)*

*Figure 8: Rock armouring of cliff base and extension as reef into sea to break wave energy State Highway 1 (Katiki Beach North Otago)*

# 4. Emergency response

## 4.1. Emergency works

Some circumstances will necessitate an immediate/urgent or emergency response to quickly re-establish access or utility lifelines.

The Resource Management Act[15] has specific and limited circumstances which are considered an 'emergency' and commensurate consent requirements. These situations generally result from catastrophic events (e.g. storms) which are unforeseen or not able to be planned for.

From an RMA perspective, emergency works do not include emergencies which are generally foreseeable (for example, resulting from lack of maintenance).

The approach to these works will depend on the circumstances but generally fall within two categories:

a. Emergency – works necessitated by a significant event (e.g. storm, earthquake). Works under the Civil Defence Emergency Management Act 2002 would be likely to fall within the RMA definition of emergency works.
b. Urgent – these are works which become urgent but generally do not stem from an event or unforeseen action (e.g. un-noticed degradation results in an urgent repair being required). These may (or may not) fall within the RMA emergency works scope and may need to go through the regular statutory (consenting) process.

Before commencing emergency or urgent works, consideration should be given to the following matters:

- Statutory approval requirements (either prior to after the works);
- Longevity of works (temporary or permanent);
- Effects of the works (are the temporary or permanent);
- Alternative designs which achieve co-benefits (eg, erosion protection which still retains public access) ;

Completion of the Emergency Works Checklist in Appendix 1 will guide the level of coastal assessment needed. The Environment Screen should also be completed as it will identify if a land transport option could have environmental and sustainability opportunities and sensitivities.

In all circumstances, advice from planning and legal teams should be sought prior to relying on RMA emergency works and other statutory requirements.

Figure 9 and Figure 10 provide examples of emergency works and responses.



[15] Sections 330, 330A, 330B and 331.

*Figure 9: State Highway 25 (Firth of Thames Coromandel) coastal damage*

*Figure 10: State Highway 25 (Firth of Thames Coromandel) sea wall repairs*

# Appendix 1: Checklists

## Checklist: New Transport Infrastructure on the Coast

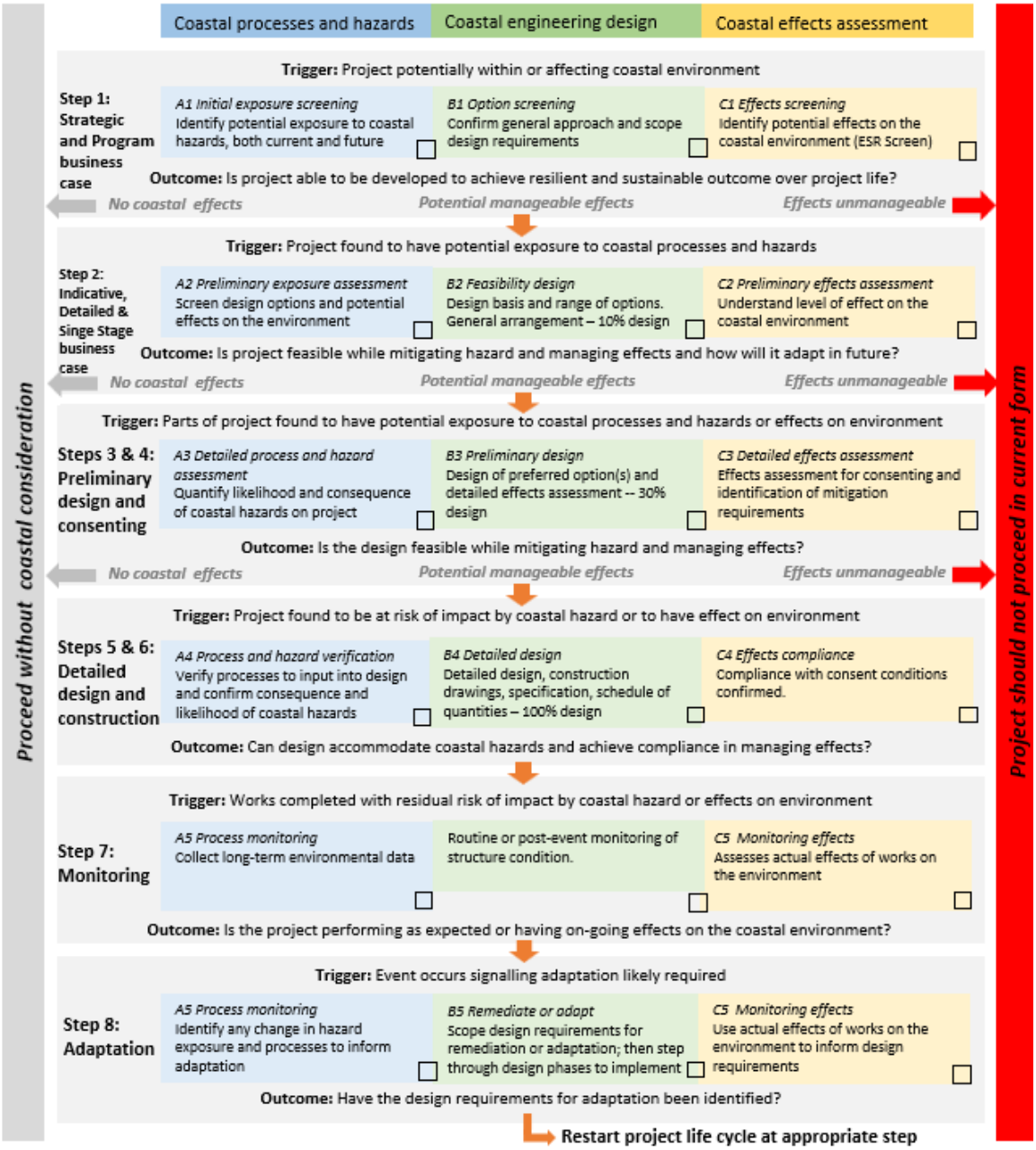
For a new asset required to be at the coast the project will be initiated at the Strategic and Program Business Case stage.

**Step 1-2: Business cases** - problem is defined and hazards identified and quantified over time. All management approaches considered (avoid, accommodate, protect). Integrated and robust options assessment and effects assessments undertaken. Long term, adaptive, management plan developed including signals and triggers for adaptation.

**Step 3 & 4 - Pre-implementation**: site specific assessments to inform design and detailed effects assessments. Consent application lodged (if required).

**Step 5& 6 - Implementation:** design finalised, and solution implemented with effects monitored.

**Step 7 & 8 - Long term management:** regular monitoring, maintenance and operation of the asset to support continued performance through its service life, and adaptation to future events such as rising sea levels



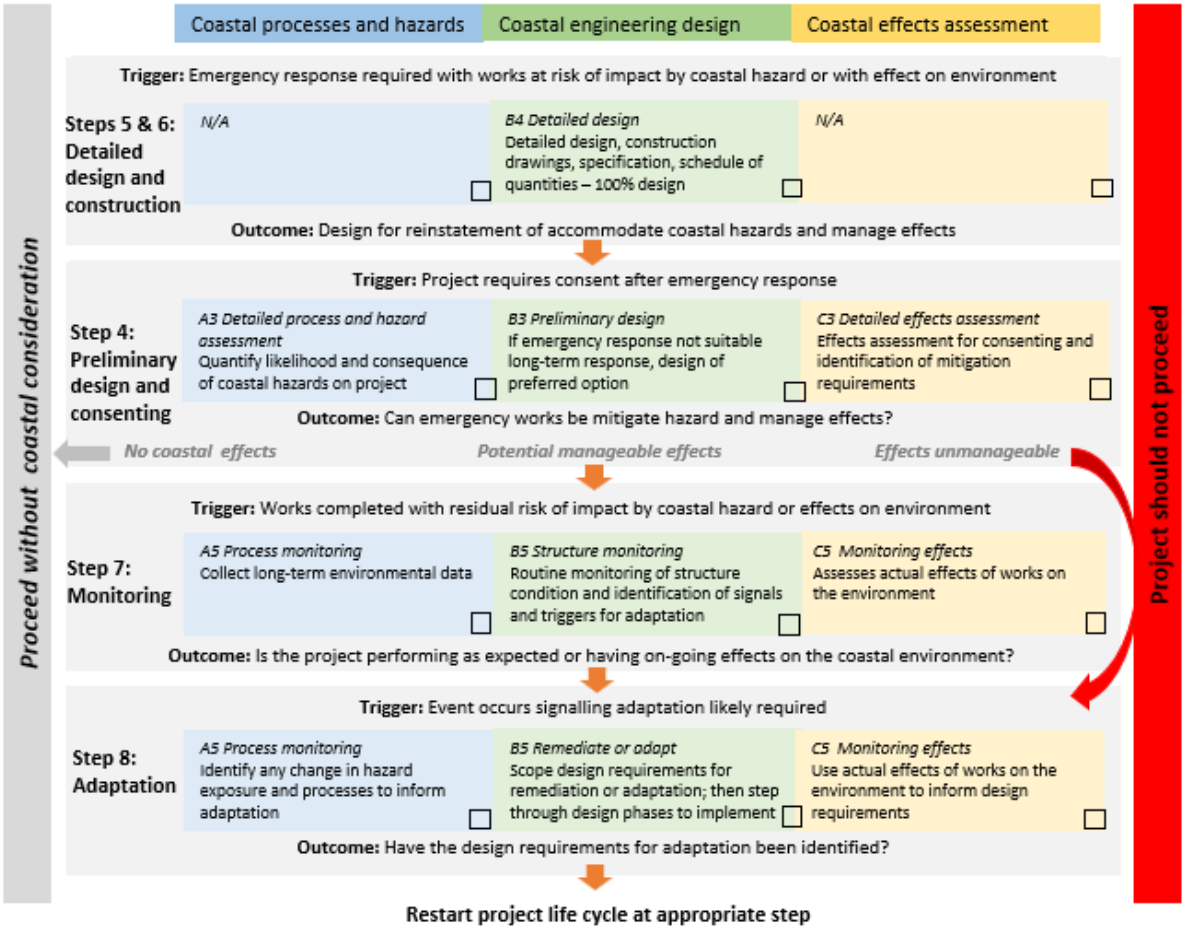
# Checklist: Emergency Response

Emergency works are undertaken when immediate action is necessary to rectify a problem that, if left longer, would result in either worse outcomes for the environment or the likelihood of death or injury, or serious damage to property.

For an existing asset, the project will be initiated at Implementation phase **(Step 5 - Detailed Design & Step 6 - Construction).** If the asset is required to remain at the coast then the emergency response may need to be consented or an appropriate long term solution developed. This may require taking a step back in the project cycle to authorise the emergency works prior to moving back into the project cycle at an appropriate step.

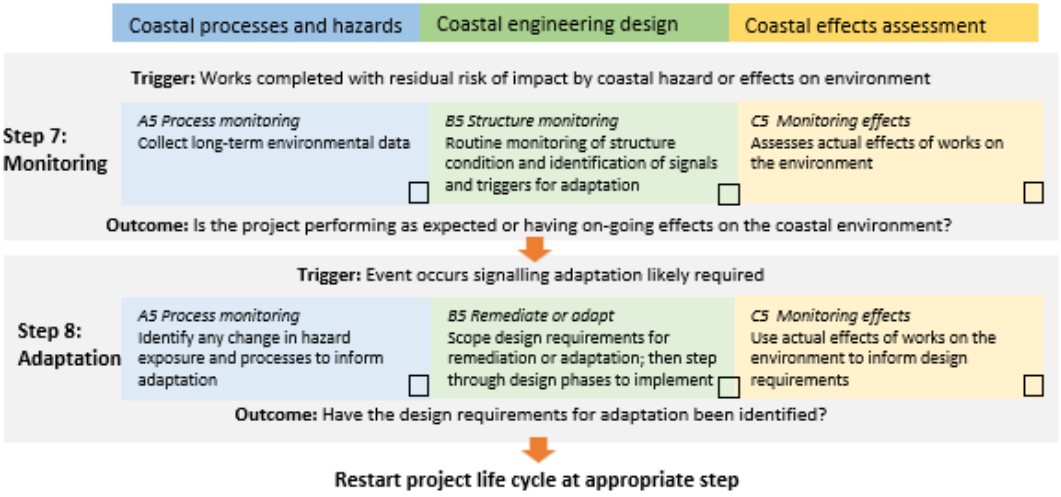
**Step 4 - Consenting:** Section 330 of the RMA enables specific persons or bodies to undertake emergency works prior to gaining necessary resource consents, under specific circumstances.

**Step 7 - Monitoring & Step 8 - Adaptation:** The need for emergency works may indicate that the long-term management of an asset may need to be re-evaluated. Increased maintenance and repairs may be required to avoid future emergency works or it may be more appropriate to consider replacement or adaptive measures.



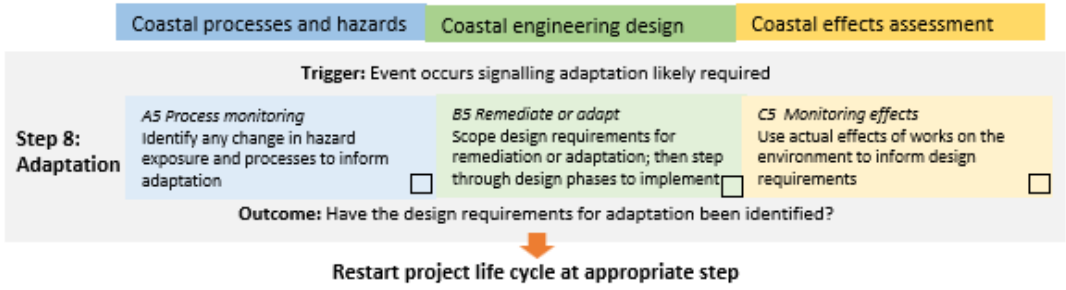
# Checklist: Monitoring and maintenance

For an existing asset at the coast, Long Term Management includes:
**Step 7: Monitoring –** Without routine maintenance and periodic repairs, the service life of coastal structures/protection measures can be significantly reduced. A monitoring and maintenance regime allows for continued, acceptable performance, prioritising repairs to reduce or avoid cumulative damage or failure.
**Step 8: Adaptation –** Over time, a structure may need to be adapted for greater resilience, or to respond to changing environmental conditions. This may include adapting existing structures or applying pre-determined design options. The project life cycle may be restarted at business case or pre-implementation phase depending on adaptation options.




# Checklist: Adapt existing infrastructure

For an existing asset adapting to future climate change effects, the project will be initiated at the Long Term Management phase **(Step 8: Adaptation).**
As assets near the end of their life, or are damaged, you must decide whether to repair, replace or adapt. Each has varying costs. However, this is not just a financial decision. You should revisit the functional requirement for the asset to be at the coast. If the preliminary design did not include adaptive measures, this may involve returning to the business case to refine the design philosophy, screen, assess and select before working on the new solution.



# Appendix 2: Hazard assessment guidance

This appendix provides guidance on what to assess, what to design and how to consider coastal effects. It identifies three ‘parts’ of an assessment:

a. **Coastal processes and hazard identification;**
b. **Coastal engineering design; and**
c. **Coastal effects assessment.**

These three parts each have differing levels of assessment depending on the project life cycle stage. This inter-relationship is reflected in Table 2-1 which sets out the level of assessment required for each ‘part’ at each project phase. This assessment should be integrated with and support Z/19 Taumata Taiao Environmental and Sustainability Standard and Screen.

Appendix 3 has an outline structure for a coastal hazard assessment which addresses the three ‘parts’ of the assessment is to be utilised as a guideline.

Coordination with other specialist outputs which may impact any of the three parts eg. ecology, archaeology, public access (urban and landscape), is also recommended to identify additional constraints.

## Table A2-1: Type and level of assessment through the project life cycle

| Phase in project life cycle | | Coastal processes and hazard identification (Refer Table 2-2) | Coastal engineering design (Refer Table 2-3) | Coastal effects assessment (Refer Table 2-3) |
|---|---|---|---|---|
| Strategic Business Case and Program Business Case | Level of assessment | A1 Initial exposure screening | B1 Option screening | C1 Effects screening |
| Indicative Business Case, Detailed Business Case and Single Stage Business Case | | A2 Preliminary exposure assessment | B2 Feasibility design | C2 Preliminary effects assessment |
| Pre-implementation | | A3 Detailed process and hazard assessment | B3 Preliminary design | C3 Detailed effects assessment |
| Implementation | | A4 Process and hazard verification | B4 Detailed design | C4 Effects compliance |
| Long-term management | | A5 Process monitoring | B5 Remediate or adapt | C5 Monitoring effects |

Tables A2-2, A2-3 and A2-4 go on to provide additional detail for each 'part' of the assessment.

The assessment detailed in Tables A2-2, A2-3 and A2-4 is influenced by the risk associated with a project, as well as the stage of development. For example, desktop analysis may be enough to decide on solutions where there is limited exposure to coastal hazards.

However, projects with higher risks or complexity will require much greater analysis to determine the best solutions. Likewise, in the early stages of a project high-level information will guide management approaches (eg, avoid, accommodate, adapt), but as the project progresses, more detail will be required to choose the preferable option.

When preparing a coastal assessment, an interdisciplinary approach should be taken. For example, consideration of potential ecological benefits (or losses) should be addressed and, where in an urban environment, consideration of the urban context in which the works are proposed should be made.

This is general guidance only, and should be used in conjunction with site-specific assessment by suitably qualified and experienced practitioners.

Tables A2-2, A2-3 and A2-4 present considerations and inputs for an assessment and links those to the project life cycle stage. Lighter shades indicate a higher level (less detailed) assessment. Darker shades represent more in-depth analysis that is site-specific and based on collected data. For smaller or lower-risk projects, non-specialists may do the initial exposure screening (A1) and (B1) or process monitoring (A5). Consult subject matter experts for larger or high-risk projects, and for more detailed analysis.

## Table A2-2: Coastal processes and hazard identification

| Level of assessment | | Description | Trigger | Input data | Analysis | Output |
|---|---|---|---|---|---|---|
| **A 1** | **Initial exposure screening** | High-level screen to identify proximity to the coast and potential exposure to hazards of the options | Project potentially in or affecting coastal environment, eg, areas identified by regional hazard assessments, or <10m NZVD or within 500m of the coast | Existing information – high-level, eg, regional hazard assessment | Desktop assessment | Include at Strategic Business Case and Program Business Case stage<br><br>Identify potential project exposure, both current and future of the options<br><br>Feeds into Environmental screen |
| **A 2** | **Preliminary exposure assessment** | Preliminary screening for design options and potential effects on the environment. Where possible, plan works to avoid hazards and effects entirely | Project found to have potential exposure to coastal processes and hazards | Existing information – site-specific, eg, local hazard assessment | Empirical assessment (likely including site visit) | Include at Indicative Business Case, Detailed Business Case and Single Stage Business Case stage.<br><br>Identify exposure of different parts of the project to specific coastal processes and hazards |
| **A 3** | **Detailed process and hazard assessment** | Where hazards or effects cannot be avoided, further detailed analysis is required to understand the risk | Project found to be exposed to specific processes and hazards | Site-specific field data (short-term), eg, bathymetry, topography, waves and water levels | Modelling to examine hydrodynamic or morphological processes. Note The type of model to be used should be determined by the level of risk/uncertainty and team. | Include at Pre-implementation stage.<br><br>Quantify likelihood and consequence of coastal hazards on project |

| | | | | | | |
|---|---|---|---|---|---|---|
| **A 4** | **Process and hazard verification** | Residual medium to high-risk scenarios or complex processes that warrant verification through advanced analysis techniques to support design | Project found to be at medium to high risk of impact by coastal processes or hazards | Site-specific field data (medium to long-term) | Analysis of field data and validated numerical and/or physical modelling to resolve complex processes. Level and type of modelling to reflect project risk and uncertainty. Project team to determine. | Include at Implementation stage.<br><br>Verify processes to input into design and confirm consequence and likelihood of coastal hazards |
| **A 5** | **Process monitoring** | Requirements for monitoring will depend on the type of hazard and degree of exposure expected | Works found to be at medium to high risk of impact by coastal processes or hazards | Ongoing field data | Analysis of field data and comparison with A4 predictions | Include at Long-term management stage.<br><br>Collect long-term environmental data.<br>Identify any change in hazard exposure, inform remediation or adaptation. |

## Table A2-0: Coastal engineering design

| Design phase | | Description | Trigger | Input data | Analysis | Outputs |
|---|---|---|---|---|---|---|
| **B1** | **Option screening** | Considers the general approaches to managing hazards, eg, avoid, accommodate, protect | Project is potentially in or affecting coastal environment | A1 Initial exposure screening | Desktop assessment of options and responses to hazards over at least 100 years | Include at Strategic Business Case and Program Business Case stage.<br><br>Confirm general approach and scope design requirements, if the hazard cannot be avoided |
| **B2** | **Feasibility design** | Establishes a design basis. Considers a range of mitigation options, where the hazard cannot be avoided over the long term | Works are likely to be in the coastal environment | A2 Preliminary exposure assessment | Identify design basis screening for a shortlist of viable options.<br><br>Empirical modelling to inform option development. | Include at Indicative Business Case, Detailed Business Case and Single Stage Business Case stage.<br><br>Design basis and range of options. General arrangement – 10% design to prove option viability, cost certainty ±100% |
| **B3** | **Preliminary design** | Develops one or more preferred options to build resilience over the planning timeframe | Selected options are in the coastal environment | A3 Detailed process and hazard assessment | Empirical and or numerical modelling to inform consent design. Type of modelling must reflect the level of risk or uncertainty. Project team discussion to determine. | Include at Pre-implementation stage<br><br>Design of preferred options(s). Detailed effect assessment to inform resource consent – 30% design suitable for schedule of quantities, cost certainty ±50% |

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|---|---|---|---|---|---|---|
| **B4** | **Detailed design** | The level of design suitable for construction | Consented works option is in the coastal environment | A4 Process and hazard verification | Validated numerical and/or physical modelling to inform detailed design<br>Value engineering (as appropriate) | Include at Implementation stage.<br>Construction drawings<br>Specification<br>Schedule of quantities<br>100% design, cost certainty ±20% |
| **B5** | **Remediate or adapt** | A programme of monitoring environmental and structure condition to inform remediation and future adaptation ('whole of life' considerations) | Constructed works are in the coastal environment | A5 Process monitoring | Condition assessment/monitoring informing remediation<br>Site-verified empirical modelling and development of adaptation works | Include at Long-term management stage.<br>Routine or post-event monitoring of structure condition.<br>Scope design requirements for remediation or adaptation; step through design phases to implement |

## Table A2-4: Coastal effects

| Level of assessment | | Description | Trigger | Input data | Analysis | Outputs |
|---|---|---|---|---|---|---|
| **C1** | **Effects screening** | Identifies potential effects on the environment | Project is potentially in or affecting coastal environment | A1 – Initial exposure screening<br>B1 – Option screening | Desktop | Include at Strategic Business Case and Program Business Case stage.<br><br>Follow? Z/19 Taumata Taiao – Environmental and Sustainability Standard, and complete environmental screen? |
| **C2** | **Preliminary effects assessment** | Preliminary assessment of effects based on the proposed option(s) and available information | Project found to have potential effect on coastal processes | A2 – Preliminary exposure assessment<br>B2 – Feasibility design | Initial quantification of effects/risks | Include at Indicative Business Case, Detailed Business Case and Single Stage Business Case stage.<br><br>Understand level of effect on the coastal environment. Identify opportunities to avoid, remedy, mitigate or offset adverse effects and update the Environmental screen |
| **C3** | **Detailed effects assessment** | Assesses the selected option as more information becomes available | Parts of the project found to have effect on coastal processes | A3 – Detailed process and hazard assessment<br>B3 – Preliminary design | Detailed quantification of effects/risks, and options to avoid, remedy, mitigate | Include at Pre-implementation stage<br><br>Inform effects assessment for consenting, and identification of mitigation requirements |

| | | | | | | |
|---|---|---|---|---|---|---|
| **C4** | **Effects compliance** | Sets out the Methods and conditions for managing effects | Works found to have medium to high-level effect on coastal processes | A4 – Process and hazard verification<br>B4 – Detailed design | Compliance management | Include at Implementation stage.<br>Coastal management plan/or environmental management plan?<br>Confirm compliance with consent conditions |
| **C5** | **Monitoring effects** | Monitoring the environment to assess actual versus predicted effects | Works found to have medium to high-level effect on coastal processes | A5 – Process Monitoring<br>B5 – Remediate or adapt | Detailed quantification of effects/risks and options to mitigate | Include at Long-term management stage.<br>Assess actual effects on environment.<br>Use this information to support design requirements for remediation or adaptation. |

# Appendix 3: Coastal assessment report structure guideline

This section is structured with reference to the same three 'parts' of the coastal assessment as reflected in Tables A2-1, A2-2, A2-3 and A2-4. The guideline should be adopted to the level of detail which matches the risk and project.

## Table A3-1: Coastal processes and hazard identification

| Section | Sub-section | Overview[1] |
|---|---|---|
| **1 Describing the physical setting** | 1.1 Site overview | Geographical location and site description. Current use, amenity value and any other human geography of importance. Include role of infrastructure in wider transport network, servicing communities and existing level of service. Reference other specialist inputs (eg. ecology, archaeology, contaminated land etc) to identify other key features that may influence assessment or design. |
| | 1.2 Landforms | Topography and bathymetry near the site. |
| | 1.3 Geology and sediments | In situ rock and mobile sediment characteristics. |
| | 1.4 Land elevation changes | Recent or historic eustatic, tectonic, seismic changes, or subsidence. |
| | 1.5 Structures and services | Existing built environment and access (including non-vehicular access). |
| **2 Understanding coastal processes** | 2.1 Wave climate | Distribution of wave height, period and direction averaged over a timeframe for the site. |
| | 2.2 Water levels | Astronomical tide, storm surge, medium-term fluctuation, long-term changes and wave effects through wave set-up and run-up. |
| | 2.3 Currents | Wave, river or tidally induced. |
| | 2.4 Sediment transport | Mechanisms for the movement of sediment. |
| | 2.5 Coastal geomorphology | Historical changes including erosion, accretion and landform change. |
| **3 Effects of climate change** | 3.1 Sea-level rise | Observed and predicted changes in water levels over time as a result of climate change. The National Adaption Plan[16] requires an assessment of at least two climate change scenarios. |
| | 3.2 Meteorological conditions | Observed and predicted increase in the severity of storms over time as a result of climate change. |
| | 3.3 Frequency of events | Observed and predicted increase in frequency of storms as a result of climate change. |
| **4 Exposure to coastal hazards** | 4.1 Coastal erosion | Assessment and prediction of areas susceptible to erosion. |
| | 4.2 Coastal inundation | Assessment and prediction of areas inundated by the sea. |
| | 4.3 Elevated groundwater | Assessment and prediction of changes to groundwater. |

[16] https://environment.govt.nz/assets/publications/climate-change/MFE-AoG-20664-GF-National-Adaptation-Plan-2022-WEB.pdf pages 68 and 69.

| | | |
|---|---|---|
| | 4.4 Wave overtopping | Assessment and prediction of incoming waves overtopping structures. |
| | 4.5 Tsunami | Assessment and prediction of exposure to tsunami. |
| **5 Level of impact of coastal hazards** | 5.1 Likelihood | The probability or frequency of an event occurring. Include consideration of combinations of frequency and severity (and changes over time) of various hazards over time. |
| | 5.2 Consequence | The outcome of an effect occurring. |
| | 5.3 Evaluation of level of impact | Through consideration of likelihood and consequence, evaluation of the level of impact for any given hazard. |

## Table A3-2: Coastal engineering design

| Section | Sub-section | Overview[1] |
|---|---|---|
| **1 Design basis** | 1.1 General | Expected level of service, tolerance to outages and repairs, serviceability and permanence. |
| | 1.2 | Potential design impacts or opportunities for biodiversity; refer to companion assessments including ecological assessment, landscape or urban assessments. |
| | 1.3 Design life | The structure's specified working life. An appropriate selection depends on a range of factors. For significant structures, the effectiveness of different design lives should be undertaken where there is considerable uncertainty of future scenario projections. |
| **2 Assessing environmental design conditions** | 2.1 Water levels | The range of established design water levels at a site, including tide and storm surge, and allowing for medium and long-term sea level changes. |
| | 2.2 Waves | The transformation of waves from offshore to nearshore and their interaction with structures, to inform design. |
| | 2.3 Currents | The speed and direction of flows. |
| | 2.4 Sediment/ geology/ground conditions | The size, shape and movement of mobile sediments. Analysis of the underlying geology to inform foundation design. |
| | 2.5 Climate change allowance | Changes in sea level, storm surge magnitude, wave height or sediment supply. The National Adaption Plan[17] requires an assessment of at least two climate change scenarios. |
| **3 Identifying options** | 3.1 General approaches | The three general approaches are: avoiding the hazard by not developing, or moving assets away from the coast; accommodating the hazard by reducing the likelihood or consequence; protecting against the hazard with hard or soft defences. |
| | 3.2 Developing options | The identification of suitable mitigation options that meet the design basis. |

[17] https://environment.govt.nz/assets/publications/climate-change/MFE-AoG-20664-GF-National-Adaptation-Plan-2022-WEB.pdf pages 68 and 69.

| | | |
|---|---|---|
| **4 Assessing options** | 4.1 Criteria development | Includes social and cultural, environmental, technical and economic factors. |
| | 4.2 Decision-making | The tools or methods for evaluating the preferred option, eg, Multi-Criteria Design Analysis (MCDA). |
| **5 Whole of life considerations** | 5.1 Monitoring | Ongoing inspections to inform maintenance requirements. |
| | 5.2 Maintenance | Either maintaining a level of performance or reducing the rate of degrade. |
| | 5.3 Indicators and trigger points | Early identification to implement an adaptation, eg, the number of flooding or overtopping events. |
| | 5.4 Adaptation/ removal | Modifying a structure to better accommodate changed environmental conditions, or to move to another approach. If an asset is no longer required it can be removed. |

## Table A3-3: Coastal effects assessment

| Section | Sub-section | Overview[1] |
|---|---|---|
| **1 Coastal setting** | 1.1 Baseline | The current state of the coast as informed by the coastal process and hazard assessment. |
| | 1.2 Proposed works | Requirement for the work and details of the structural form, footprint, geometry and materials. |
| **2 Types of effects** | 2.1 Coastal processes affected | Engineering works can interrupt, change, amplify or reduce coastal processes – investigate occupation, water levels, waves, currents, sediment processes and shoreline change. Developments in methodologies for predicting climate change are to be expected, the key principle to be applied however is that a range of outcomes should be considered. |
| | 2.2 Interdependence | Consider interdependent processes such as biodiversity and land and seascapes and other intrinsic values (eg water quality, public access). |
| | 2.3 Spatial extent of effects | Understanding the near and far field effects is important in identifying the level of effect. |
| | 2.4 Duration of effects | Consider construction, long-term and cumulative effects. |
| **3 Assessing effects** | 3.1 How to test | Tools to assess the effects may include comparison to similar works, empirical guidance, numerical or physical modelling. |
| | 3.2 Likelihood | The frequency or probability of the effect occurring. |
| | 3.3 Consequence | The impact the effect will have on coastal processes. |
| | 3.4 Evaluation of level of effect | Evaluate the level of effect by considering the likelihood and consequence. |
| **4 Effects management** | 4.1 Avoid, remedy, mitigate, offset | Strategies for managing effects. |
| | 4.2 Monitoring | Provides information on the effects. Can include trigger point information, leading to adaptation. |

| | | |
|---|---|---|
| | 4.3 Adaptive management | Responding to adverse effects by remedying them before they become irreversible. |

# Appendix 4: Key resources

The following resources support assessments of coastal effects.

***Coastal Hazards and Climate Change: Guidance for Local Government***

A step-by-step approach to assessing, planning and managing the increasing risks facing coastal communities. It has an updated synthesis of information, and tools and techniques. It sets out expected climate change effects in New Zealand, particularly from sea-level rise, and considerations and limitations of assessing coastal hazards. (MfE, 2017)

***Preparing New Zealand for Rising Seas***

Identifies low-lying areas around major coastal centres that may be exposed to elevated sea levels (between 0.5 and 1.5m above high tide). Although the potential additional storm surge varies around New Zealand, these levels would usually represent 0.5 to 1m of sea-level rise above storm tide levels. (PCE, 2014)

***Review of Tsunami Hazard in New Zealand***

Examines all likely sources of tsunami that could affect New Zealand (Power, 2013). An accompanying report (Power, 2014) presents hazard curves for the New Zealand coast in 20km sections.

**Research documents such as *Climate Changes, Impacts and Implications for New Zealand to 2100 Synthesis Report: RA5*[18]**

This is an example of application of SSPs to a New Zealand. RA5 describes development of national-scale socio-economic scenarios for New Zealand, nested within SSPs, to inform national and local scale studies of climate change impacts and implications. Developments in methodologies for predicting climate change are to be expected, the key principle to be applied however is that a range of outcomes should be considered.

***Defining Coastal Hazard Zones for Setback Lines***

A guide to good practice for assessing coastal hazards, including erosion and inundation. (Ramsey et al, 2013)

***Coastal Exposure Assessment***

This first-pass national assessment identifies Waka Kotahi and KiwiRail assets that may be exposed to the effects of sea-level rise, based on level and proximity to the coastal edge. This information may be used for initial assessment of assets exposed to coastal hazard. (Tonkin + Taylor, 2020)

**Local government GIS viewers**

Many district and regional councils have assessed the extent of local coastal erosion or inundation, and occasionally tsunami and elevated groundwater levels. This information is often available in online GIS viewers. They indicate the extent of hazards under a range of likelihoods, and scenarios for sea-level rise.

**Z/19 Taumata Taiao – Environmental and Sustainability Standard**

Taumata Taiao guides project teams through the process and requirements that give effect to Waka Kotahi environmental and sustainability policies, other strategic objectives, outcomes and legal requirements during the development and management of the land transport system.

[18] https://niwa.co.nz/sites/niwa.co.nz/files/RA5-Synthesis-report.pdf

***Coastal hazards and climate change: guidance for local government***

This guide supports councils to manage and adapt to the increased coastal hazard risks posed by climate change and sea-level rise. (MfE, 2017)

These documents should be used together with Waka Kotahi guidance on effects assessments and engagement, such as:

- Public Engagement Guidelines
- Landscape Guidelines
- Ecological Impact Assessment Guide
- Te Ara Kotahi – our Māori Strategy