Coastal hazards guide for land transport infrastructure

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NZ TRANSPORT AGENCY
WAKA KOTAHI

Te Kāwanatanga o Aotearoa
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More information

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If you have further queries, call our contact centre on 0800 699 000 or write to us:

NZ Transport Agency Waka Kotahi
Private Bag 6995
Wellington 6141

This document is available on NZ Transport Agency's website at www.nzta.govt.nz

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.

Availability

This document is held in electronic form by NZ Transport Agency Waka Kotahi (NZTA) Transport Services and on the NZTA website (nzta.govt.nz)

Guidance owner

Transport Services, NZTA. For guidance, clarification or technical assistance, please contact environment@nzta.govt.nz

Acknowledgements

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Amendments and review strategy

The guidance will be reviewed on a three-yearly basis by the Environment and Sustainability team Significant legislative or technical updates will be incorporated as soon as practicable.

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.

This guide sets out how to consider and respond to the dynamic nature of the coastal environment across the asset lifecycle. This includes asset condition monitoring, maintenance and adaptation of structures to ensure they do not become increasingly vulnerable to degradation and failure.

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 used by project managers and practitioners in the coastal hazards field, and also project statutory planners responsible for gaining authorisations for coastal works.

Appendix 4 lists key resources to support the assessments set out in this guide. Appendix 5 is a glossary of technical terms and abbreviations found in this guide.

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 affecting land transport infrastructure
- support adaptation to and mitigation of the effects of climate change, and
- promote and implement a best-practice approach for future resilience of land transport infrastructure.

The guide is intended for use by project teams, supporting consultants and contractors. It also provides clarity for stakeholders on what coastal issues should be considered in the 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 Approach to identifying, assessing, and managing coastal hazards

This guide sets out an approach aligned with the NZ Transport Agency Waka Kotahi (NZTA) business case process and overall asset management lifecycle.

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

- coastal processes and hazard identification
- coastal engineering design
- coastal effects assessment.

These assessments augment the environmental screen process required to be undertaken at the start of NZTA projects.

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 and in 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, local 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 and allow for adjustment 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. Ensure new developments are located away from areas prone to coastal hazards.
- 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.

2.2 NZTA policy framework

NZTA is required to observe national policy direction, and has its own policy and objectives in relation to coastal hazards and developing and operating transport infrastructure in the costal environment. Key policy and guidance documents are listed below, and further documents can be found on nzta.govt.nz.

- Government National Adaptation Plan
- NZTA Tiro Rangi: Our Climate Change Adaptation Plan 2022–24
- NZTA Resilience Framework 2018
- NZTA Climate Change Policy for Land Transport Infrastructure Activities
- NZTA Z19 Taumata Taiao – Environmental and Sustainability Standard

3 Coastal environment

3.1 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 indigenous plants and animals, including migratory birds and fish species.

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 many 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.

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

3.2 Coastal processes

New Zealand is a relatively young and active landform, with over 15,000km 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 the active coastal zone and processes.

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 relative sea level through uplift and subsidence. Biological activity also effects some aspects of coastal processes in particular shallow and sheltered areas, along with adjacent landforms.

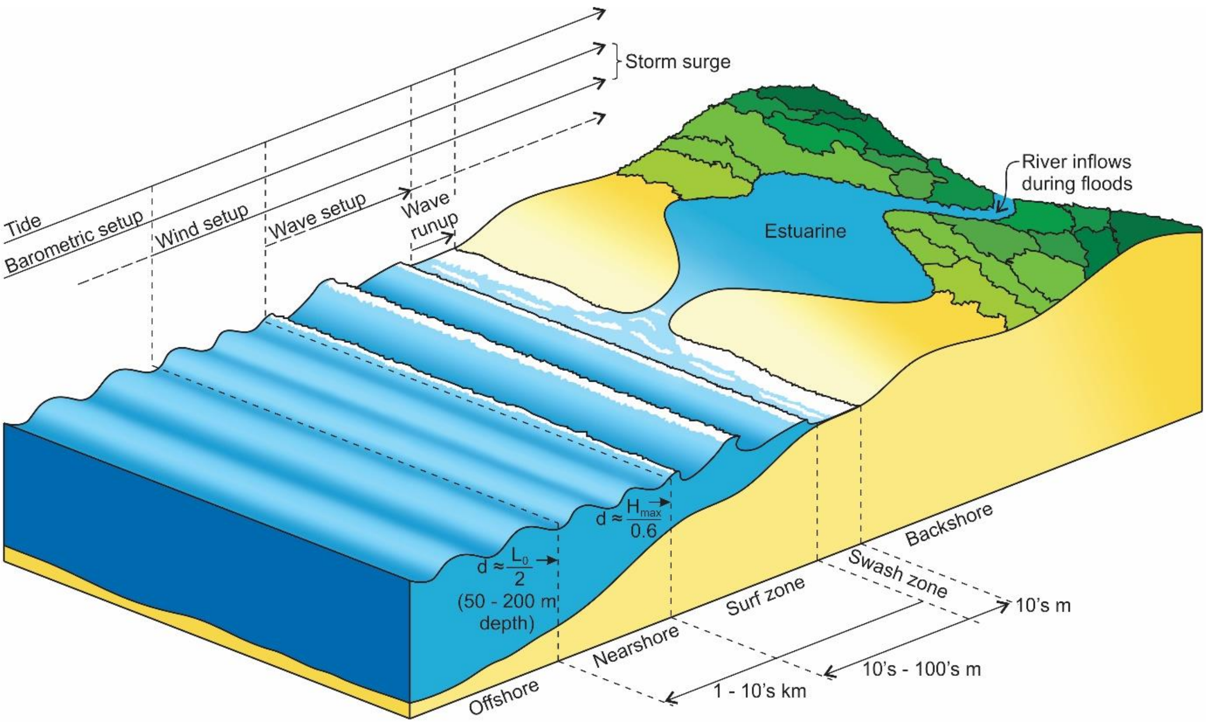

Figure 1: The active coastal zone (illustration by Anna Blacka, UNSW Sydney, Water Research Laboratory)

3.3 Coastal hazards

Where land transport infrastructure interacts with coastal processes, **hazards** can arise and these adversely affect lives, livelihoods, property, transport links, or other aspects of society and the environment.

Processes that may result in coastal hazards include the following:

- 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 flooding: flooding due to a combination of factors including astronomical tide, storm surge caused by wind and low pressure, river flooding and groundwater rise.

- Raised groundwater: the water table is raised near to the ground surface, causing surface flooding or instability, and potential for saltwater intrusion.
- Wave overtopping or over wash: waves run up above the sea level and onto the land behind.
- Tsunami: long-period waves 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 storms. This is discussed further in Section 3.4.

Figure 2 illustrates a view of the complexity of coastal processes, landform type and impacts occurring on a natural coast, and the coast's interaction with aspects of land transport infrastructure (local roads and the state highway), leading to coastal hazards.

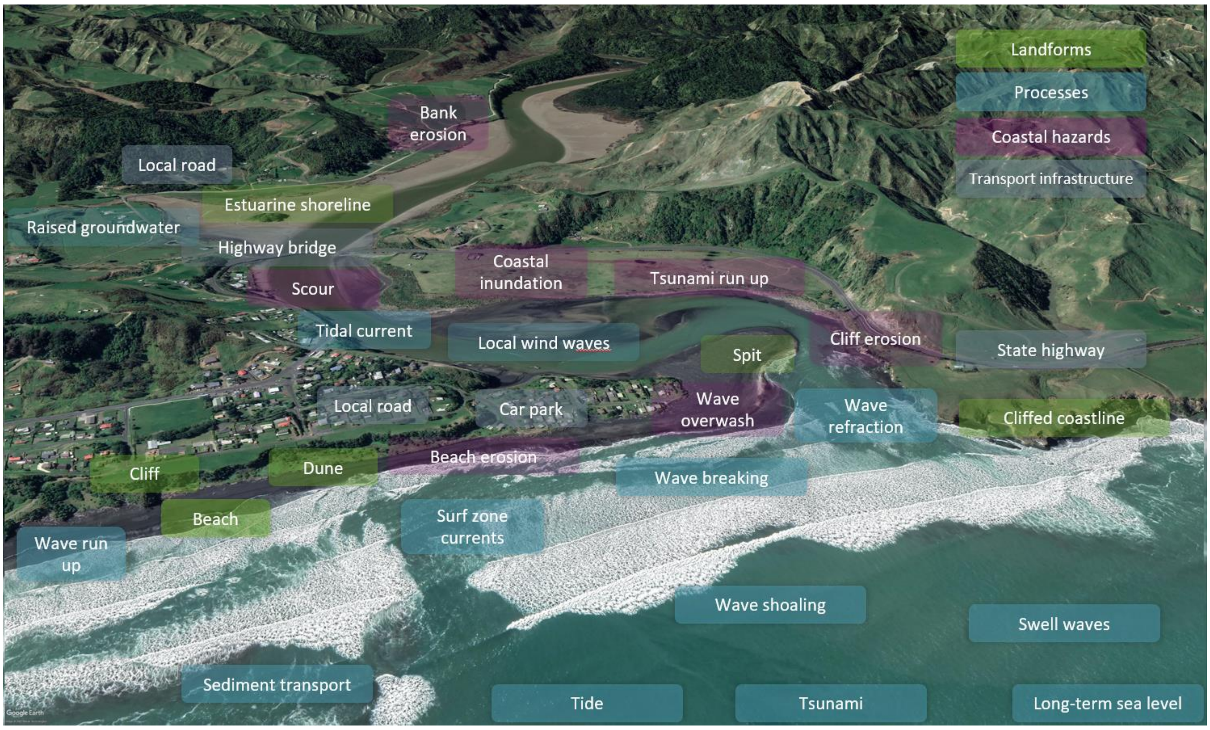

Figure 2: Landforms, processes and hazards that may affect land transport infrastructure in the coastal environment (satellite image: Maxar Technologies, 2020)

3.4 Climate change

Coastal hazards will be exacerbated by climate change impacts such as higher sea levels and more extreme meteorological conditions. These are expected to result in more frequent and severe storms and wave overtopping, which are likely to modify many of the processes that shape our coast. Climate change effects should therefore be considered in the planning, design, construction and maintenance of all coastal infrastructure.

The approach to coastal and climate risk assessment set out in this guide is broadly consistent with the approach outlined in the Ministry for the Environment's *Coastal hazards and climate change guidance*.[1]

Note that all climate change projections provide a range of scenarios, based on differing projections of atmospheric concentrations of greenhouse gases. At least two climate projections should be considered to stress test option selection and design considerations, particularly for high-risk locations

[1] Ministry for the Environment (2024) *Coastal hazards and climate change guidance*.

or where there is a severe consequence of infrastructure failure, consistent with current government direction and relevant design and engineering specifications.

A risk-based approach to planning for the impacts of coastal hazards and effects of climate change is recommended, to support communities and environmental systems to build resilience and cope with uncertain outcomes.

3.5 Risks for land transport infrastructure

Sections of land transport infrastructure corridors in New Zealand have been identified as being potentially exposed to coastal hazard.[2,3] Previous assessments, while made at a high level, indicate between 2–4 percent of state highway infrastructure[4] and over $14 billion of local government infrastructure may be exposed to coastal hazards[5] (see figure 3 below). These areas will increase in extent over time with projected climate change impacts.

The **likelihood** of adverse consequences will depend on the **vulnerability** of the impacted assets as well as **exposure** to coastal hazards. For example, 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 (for example ferries).

The risks associated with 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 **(consequence)**. The combination of the network's sensitivity and capacity for response and recovery defines its vulnerability, or conversely, its resilience.

At a national level, major and extreme natural hazard (including climate change related) to the New Zealand land transport system have been identified in the National Resilience Programme Business Case.[6] This review included coastal hazard risks, predominantly **coastal inundation**, **sea level rise** and erosion. A National Resilience Assessment Tool (NRAT) has been created as part of this work, and provides a useful source of information on potential risks to the NZTA network.

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[2] Parliamentary Commissioner for the Environment (2014) *Preparing New Zealand for rising seas: certainty and uncertainty*.

[3] Paulik, R. et al (2019) *Coastal flooding exposure under future sea-level rise for New Zealand*. Report prepared for The Deep South Challenge.

[4] Tonkin + Taylor (2020) *Coastal exposure assessment – stage 2 exposure assessment for coastal hazards*. Report prepared for the NZ Transport Agency.

[5] Local Government New Zealand (2019) *Exposed: climate change and infrastructure – guidance for councils*.

[6] NZTA (2020) National Resilience Programme Business Case. Prepared by Tonkin + Taylor and Tregaskis Brown for NZTA, 2020.

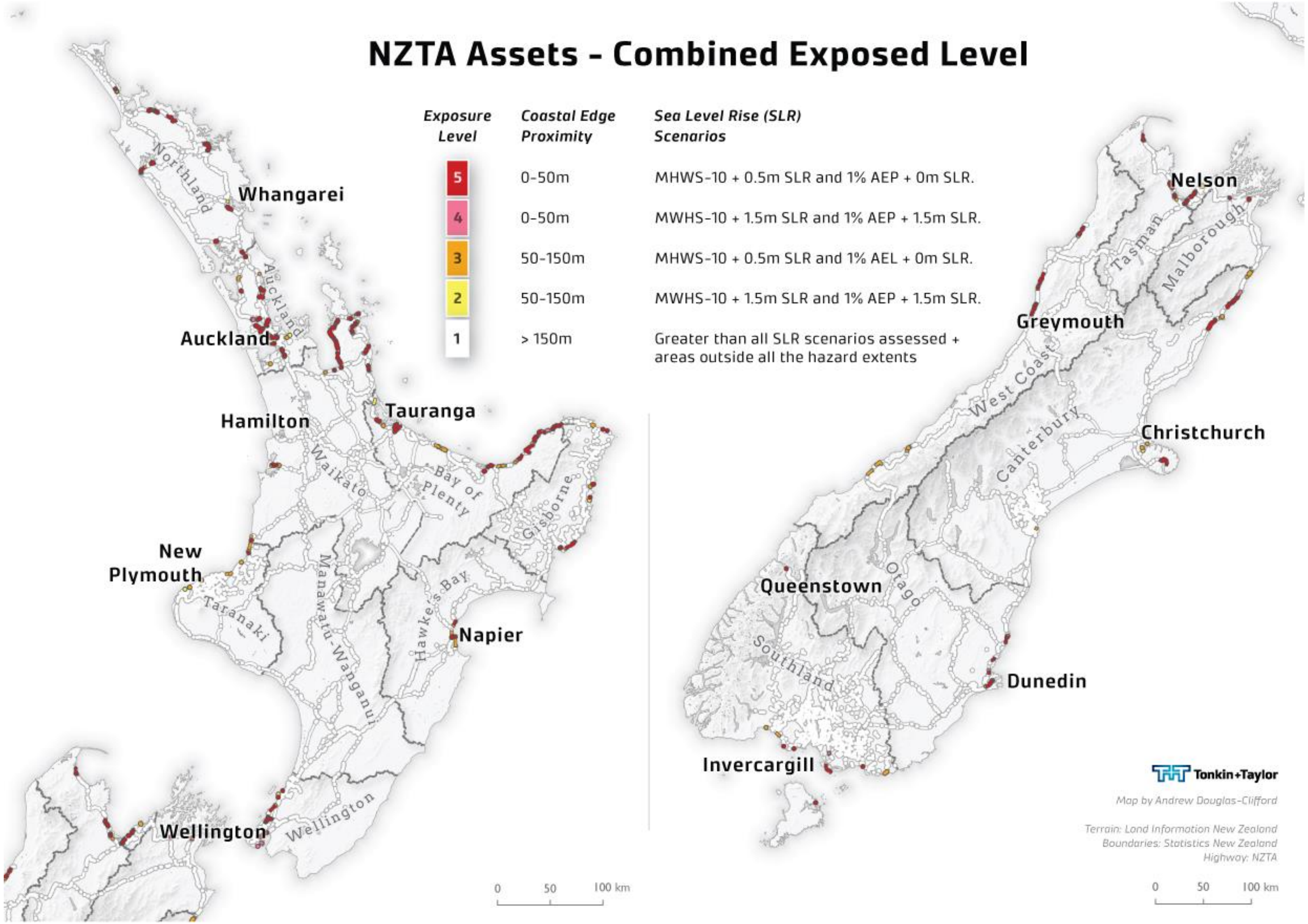

Figure 3: Exposure level of NZTA assets to coastal processes (Tonkin + Taylor, 2020)

4 Identifying, assessing and managing coastal hazards

Three types of technical assessments are required to identify, assess and manage coastal hazards for transport infrastructure at the coast:

- coastal processes and hazard identification
- engineering design
- effects assessment and monitoring.

These three assessments are linked, with inputs iteratively influencing decisions. Appendix 2 contains tables that detail these requirements in greater detail for assessments at each stage of the business case process. General guidance for the content and structure for each type of assessment is attached in appendix 3.

4.1 Coastal processes and hazard identification

Understanding coastal processes and assessing the hazards is fundamental to any project at the coast. A coastal hazard assessment:

- identifies the spatial extent and magnitude of hazards, and
- quantifies the likelihood or timeframe of hazards occurring.

A risk-based approach should determine the hazards and exposure, first through an initial screening, then in more detail where potential risks are identified. A range of hazard magnitudes and likelihoods (scenarios) should be considered to determine the sensitivity of a site and the suitable response. This provides baseline information for engineering design and assessing the effects.

4.2 Engineering design

Designing, constructing and maintaining assets in a harsh and dynamic coastal environment is challenging. Coastal engineering design is informed by the coastal process and hazard analysis, and feeds into the effects assessment.

Given the considerable uncertainty in projecting the effects of coastal hazards including climate change, adaptive approaches to design should be taken. These should consider a range of alternative options or pathways, which respond to different scenarios and timeframes. This allows for adapting the design, or moving to a different option, depending on what happens over time. In many cases a number of stakeholders will need to be involved in developing these pathways.

As set out in the *Coastal hazards and climate change guidance,*[7] adaptation options at the coast can include:

- **Avoid:** stop putting people and assets in harm's way, for example locating a new road away from the active coastal zone.
- **Retreat**: moving existing assets away from the coast in a managed way over time, or as a consequence of erosion and inundation damage after climate-related events.
- **Accommodate:** adjusting existing assets by using measures that anticipate hazard risk, such as raising seawall crest height, or providing alternative access when a coastal road is inundated.
- **Protect:** holding the line using natural buffers like dunes or hard structures like seawalls.

Once an asset has been built at the coast, its service life can be significantly reduced without ongoing monitoring and timely maintenance and repairs. Monitoring performance is crucial to successfully managing these assets over time.

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[7] Ministry for the Environment (2024) *Coastal hazards and climate change guidance*.

4.3 Effects assessment and monitoring

Infrastructure may need to be located in the coastal environment due to functional or operational requirements. By understanding and being sensitive to the environmental, social/cultural and economic values, we can begin to identify the potential effects of infrastructure on these values over its lifetime.

Through the project life cycle, you should assess the environmental effects of the infrastructure. This assessment informs design development and mitigation actions, as well as the resource consent process, where effects on the environment are considered.

5 Technical assessments at each project phase

The following sections give further detail for technical assessments recommended for each phase of the business case process or asset life cycle, and expected outcomes. These can be used as a guide to check that there is enough information, at the appropriate stage, to inform decisions.

A summary of recommendations for emergency response is also included, in section 5.7.

5.1 Type and level of assessment

The three types of technical assessments outlined in section 4 apply regardless of project size; however, input is to be commensurate to the nature and associated risks of the project. It is recommended that throughout the project management process there be regular workshopping between the client and supplier(s) to ensure that the level of assessment and detail is appropriate to the budget of the project.

5.1.1 Initial exposure screening

For all projects potentially within or affecting the coastal environment, it is recommended to carry out an initial exposure screening. This should clearly identify proximity to the coast and potential exposure to hazards and potential project risks, both in the present and over the long term (that is, a 100-year timeframe for large projects or expected asset life for smaller projects).

The points below should be considered when undertaking the initial screening:

1. Determine whether you are working in the coastal environment.
2. Understand coastal influences.
3. Assess coastal risk.
4. Summarise coastal issues for asset management.

For smaller or lower risk projects (refer table 5-2), non-specialists may do the initial screening, following the requirements of *Z/19 Taumata Taiao – Environmental and Sustainability Standard* and environmental screen. For larger and more complex projects, consult subject matter experts (SMEs). SMEs can also advise on recommendations for more detailed analysis (as set out for the subsequent business case phases).

5.1.2 Assessing exposure to coastal processes

Projects that potentially have a moderate to high exposure to coastal processes include those which are:

- located within 150m of the coastal edge, or
- less than 10m New Zealand Vertical Datum (NZVD), or
- identified in national portals such as EQC natural hazard portal, SeaRise website, or in regional hazard assessments, for example in regional coastal plans, district plans, regional risk assessment summary in the National Resilience Programme Business Case.

Timescales and relevant climate change scenarios should also be taken into account.

5.1.3 Risk-based go/no-go decisions

At each step before construction, a risk-based go/no-go decision should be made on whether works will proceed. Where effects are unmanageable – that is, where the severity and/or frequency of impacts cannot be effectively mitigated or adapted using conventional risk management strategies – the project may need to be reassessed.

5.1.4 Assessments at each project phase

Table 5-1 summarises the type of assessment recommended for each phase (colour coded blue, green and yellow for easy reference to each type of technical assessment).

Checklists for these assessments are also provided in appendix 1. Appendices 2 and 3 provide more detailed guidance for the content and structure of each assessment type.

Table 5-1: Type and level of assessment through the coastal project life cycle

Phase in project life cycle		Coastal processes and hazard identification	Engineering design	Effects assessment and monitoring
Programme business case (or initial exposure screening)	Level of assessment	Initial exposure screening	Option screening	Effects screening
Indicative, detailed and single-stage business case		Preliminary exposure assessment	Feasibility design	Preliminary effects assessment
Pre-implementation (preliminary design and consenting)		Detailed process and hazard assessment	Preliminary design	Detailed effects assessment
Implementation (detailed design and construction)		Process and hazard verification	Detailed design	Effects compliance
Long-term management (monitor, maintain and adapt)		Coastal process monitoring	Asset monitoring – remediate or adapt	Monitoring effects

Table 5-2: Indicative scale of assessment relative to project size

Note: This table is a guide and offers general advice to coastal practitioners on the effort and scale required for assessments on NZTA projects, based on the likelihood, risk and consequences of coastal hazards on the network. It is the expectation of NZTA that assessments will generally be commensurate to the size of the project or planned works. Every project will be different, and it is important to discuss budget and reporting expectations with the project manager for the works.

Tier	Project likelihood/risk/consequence	Level of assessment
Tier 1	**Risk:** extreme, very high **Likelihood:** almost certain, likely **Indicative ONF category:** transit corridors, interregional connectors **Consequence of failure: major, catastrophic,** long duration, significant impact on freight, no alternatives in event of road failure (eg life-line road) **Cost of reinstatement:** high *Eg new motorway/highway capital project*	Full assessment following all steps outlined in this guidance document. Assessment of multiple climate change scenarios undertaken by climate and coastal specialists. Full consideration of multiple hazards and their associated interactions.
Tier 2	**Risk:** high risk, moderate risk **Likelihood:** possible **Indicative ONF category:** urban connectors, rural connectors **Consequence of failure: moderate,** medium duration, multiple repairs along road section, limited alternatives available **Cost of reinstatement:** medium *Eg realignment or project with high coastal complexity, multiple coastal infrastructure assets*	Guidance should be followed from appropriate point of entry. Workshop between client and supplier to ensure budget and assessments are appropriate in scale for proposed works. Follow process steps but consideration given to budget, asset lifespan, other stakeholders, resilience, project complexity, interaction with lifeline utilities, nearby communities etc. Screening should be undertaken by a coastal specialist. Regular interaction with project manager regarding budget and scope of investigations/ assessments recommended. If any criteria meet tier 1 thresholds, discuss with project manager and consider undertaking full assessment
Tier 3	**Risk:** moderate, low risk **Likelihood:** unlikely, rare **Indicative ONF:** peri-urban roads, rural roads **Consequence of failure: minor, negligible,** short-duration/ low complexity, alternate routes available to community **Cost of reinstatement:** low *Eg low-cost, low-risk projects, single sea wall or culvert*	Guidance should be followed from appropriate point of entry but assessment at a more basic and abbreviated level. Workshop between client and supplier to ensure budget appropriate for works. Consider budget, asset lifespan and project complexity. Initial screening can be undertaken by a non-specialist. Consider seeking input from specialists.

5.2 Initial exposure screening

An initial screening exercise to identify potential exposure to coastal hazards is recommended for all projects. The purpose of an initial exposure screen is to find the combination of activities that represent the best-value-for-money response to the case for change identified in the strategic case. This provides decision makers with early indication of the preferred option.

Table 5-3: Initial exposure screening

Summary	In the coastal environment, the initial screening involves **establishing whether the project will be exposed to coastal hazards**, in the present and over the long term (ie 100-year timeframe – if applicable). 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 to distinguish between options.	
Outcome	Is the project able to be developed to achieve a resilience and sustainable outcome over the asset life?	
Level and description of assessment	Coastal processes and hazard identification	**Initial exposure screening** High-level screen to identify present and future hazards within project area.
	Engineering design	**Option screening** Consider general approach to managing hazards and scope design requirements where protect or accommodate strategies preferred.
	Effects assessment and monitoring	**Effects screening** Identify potential effects on the environment, using the *Z/19 Taumata Taiao – Environmental and Sustainability Standard* and environmental screen.
Trigger	Project potentially in or affecting/affected by coastal environment, eg located within 150m of the coastal edge, less than 10m New Zealand Vertical Datum (NZVD) or identified by regional hazard assessments.	
Input data and analysis recommended	Desktop assessment based on existing, high-level information, eg in national portals such as EQC natural hazard portal, SeaRise website, or in regional hazard assessments. For smaller or lower-risk projects, non-specialists may do the initial screening. For larger and more complex projects, or projects in areas of medium or high risk within 100 years, consult SMEs.	
Outputs	A. Identify potential project exposure to coastal hazards, in the present and over the appropriate timescale, for relevant climate change scenarios). B. Potential long-term management approaches identified including recognition of the situations where there is substantial uncertainty and adaptive strategies may be needed. Scope design requirements, if the hazard cannot be avoided. C. Complete Z/19 Taumata Taiao – Environmental and Sustainability Standard and environmental screen.	

5.3 Indicative, detailed and single-stage business case

The purpose of the indicative business case (IBC), detailed business case (DBC) and single-stage business case (SSBC) is to refine and confirm the preferred option through more detailed analysis of the costs, risks and benefits.

Table 5-4: Indicative, detailed and single-stage business case

Summary	Investigation and design should enable a confident **selection of a preferred shortlist or option**, if the project is required to be in an area exposed to coastal processes and hazards (and the hazards cannot be avoided). The assessment steps set out below are intended to establish a basis to assess functional requirements, design life and other requirements or constraints. Options should include the ‘do-nothing’ case as the baseline and adaptation options for the long-term resilience of assets (including nature-based solutions). 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.	
Outcome	Is the project feasible while mitigating hazards and managing effects, and how will it adapt in the future?	
Level and description of assessment	Coastal processes and hazard identification	**Preliminary exposure assessment** Screen design options and potential effects on the environment. Where possible, plan works to avoid hazards and effects entirely.
	Engineering design	**Feasibility design** Establish a design basis and a range of options, where the hazard cannot be avoided over the long term.
	Effects assessment and monitoring	**Preliminary effects assessment** Preliminary assessment of effects based on the proposed option(s) and available information
Trigger	Project has potential exposure to coastal processes and hazards, as identified in the initial screening process.	
Input data and analysis recommended	Empirical assessment based on existing, site-specific information, eg local hazard assessment. Likely includes a site visit.	
Outputs	A. Identify exposure of different parts of the project to specific coastal processes and hazards. Understand the current and a variety of future scenarios for coastal hazards over the likely lifetime of the asset. B. Agreed design basis and preferred option, with indicative resourcing. General arrangement – 10% design to prove option viability, cost certainty ±100%. C. Understand level of effect on the coastal environment, including under different climate change outcomes. Identify opportunities to avoid, remedy, mitigate or offset adverse effects and update the environmental screen.	

5.4 Pre-implementation phase (preliminary design and statutory approvals)

The pre-implementation phase is associated with the consenting, property and detailed design phases of a project.

Table 5-5: Pre-implementation phase (preliminary design and statutory approvals)

Summary	Develop the preferred option to the point where you can **apply for statutory approval under the RMA or other regulatory requirements, if required**. This phase typically requires further site investigations (eg geotechnical) and surveys (topography, bathymetry), as well as more detailed engineering design. For projects where coastal hazards cannot be avoided, a more detailed process and hazard assessment will help inform resilient design options and assessment of coastal and environmental effects to support any resource consent requirements.	
Outcome	Is the design feasible, while mitigating hazards to the asset and managing effects of the asset?	
Level and description of assessment	Coastal processes and hazard identification	**Detailed process and hazard assessment** Where hazards or effects cannot be avoided, further detailed analysis is recommended to understand the risk.
	Engineering design	**Preliminary design** Develops one or more preferred options to build resilience over the project planning timeframe
	Effects assessment and monitoring	**Detailed effects assessment** Assess the effects of selected option and identify mitigation requirements, to support a resource consent application (and/or other regulatory requirements).
Trigger	Project (or parts of the project) is exposed to coastal processes and hazards.	
Input data and analysis recommended	Site-specific field data (short-term), eg bathymetry, topography, waves and water levels. Analysis is likely to include empirical and/or numerical modelling to examine hydrodynamic or morphological processes (the type of model to be used should be determined by the level of risk/uncertainty via project team discussion).	
Outputs	A. Quantify likelihood and consequence of coastal hazards on project. B. Design of preferred options(s), including long-term or adaptive management, and guidance on operation and maintenance. 30% design suitable for schedule of quantities and to support effects assessment, cost certainty ±50% C. Level of effects and mitigation measures assessed and quantified, to support statutory approval(s).	

5.5 Implementation phase (detailed design and construction)

This phase covers the delivery of the project, including finalising the preliminary engineering design, building the work, meeting compliance requirements for consent and/or other authorisations, and procurement.

Table 5-6: Implementation phase (detailed design and construction)

Description	**Finalise the design** with construction drawings and specifications, and details of how authorisation requirements (conditions) will be addressed, along with maintenance and operation methodologies, including design approach for addressing asset failure or upgrade needs. Preparation of schedules of quantities to support engineers' estimates will occur at this time. Note: specifications for suitable materials to be used in the coastal environment is a key aspect of the design. **Prepare contract construction documentation.** This will address safe construction through safety in design measures. Any mitigation measures noted in the consent process should be applied during construction.	
Outcome	Can the design accommodate coastal hazards and achieve compliance in managing effects?	
Level and description of assessment	Coastal processes and hazard identification	**Process and hazard verification** Complex or higher risk projects that warrant verification through advanced analysis techniques to support design
	Engineering design	**Detailed design** The level of design suitable for construction
	Effects assessment and monitoring	**Effects compliance** Methods for managing effects and compliance with consent conditions
Trigger	Consented/preferred works option is in the coastal environment. If the project is found to be at medium to high risk of impact by coastal processes or hazards, additional coastal process and hazard verification may be warranted.	
Input data and analysis recommended	Value engineering and compliance management (as appropriate). Additional analysis of site-specific field data (medium- to long-term) and validated numerical and/or physical modelling may be required to resolve complex processes. Note: level and type of modelling to reflect project risk and uncertainty. Project team to determine.	
Outcome	A. Verify processes to input into design and confirm consequence and likelihood of coastal hazards (for residual medium- to high-risk scenarios or complex processes). B. Construction drawings, specification and schedule of quantities. 100% design, cost certainty ±20% C. Confirm compliance with consent conditions, if relevant.	

5.6 Long-term management (monitor, maintain and adapt)

This phase covers monitoring, maintenance, and operation of the asset to support continued performance through its service life, including adaptation to future events such as rising sea levels.

Table 5-7: Long-term management (monitor, maintain and adapt)

Description	**Undertake monitoring and asset condition assessments as per maintenance and operations plans**. A monitoring and maintenance regime allows for continued, acceptable performance, prioritising repairs to reduce or avoid cumulative damage or failure. Where additional works are required, consideration should be given to repair, replacement, decommissioning or adaptation. If necessary, revisit the functional requirement for the asset to be at the coast. Each option has varying costs and wider opportunities (eg use of nature-based solutions, improvements to biodiversity). This may include applying pre-determined design options identified, eg in the pre-implementation phase. If the preliminary design did not include adaptive measures, this may involve returning to the business case process to refine the design options and approach before working on the new solution.	
Outcome	Is the project performing as expected, or having ongoing effects on the coastal environment? Have design requirements for adaptation been identified?	
Type and level of assessment	Coastal processes and hazard identification	**Coastal process monitoring** A programme of monitoring coastal processes over time.
	Engineering design	**Asset monitoring – remediate or adapt** A programme of monitoring environmental and structure condition to inform remediation and future adaptation ('whole-of-life' considerations).
	Effects assessment and monitoring	**Monitoring effects** Monitoring the environment to assess actual versus predicted effects.
Trigger	Asset monitoring should take into account risk of impact by coastal hazards.	
Input data and analysis recommended	Recommendations for coastal process monitoring will depend on the type of hazard and degree of exposure expected. This would generally include analysis of ongoing field data, including asset condition assessments, and comparison with predictions set out during implementation phase. Assets which are not meeting minimum service requirements may require additional design work, including site-verified empirical modelling and development of adaptation works.	
Outputs	A. Collect long-term environmental data. Identify any change in hazard exposure, to inform remediation or adaptation. B. Routine or post-event monitoring of structure condition. Where required, scope design requirements for remediation or adaptation (step through business case or design phases to implement). C. Assess actual effects on environment. Use this information to support consent compliance, along with design requirements for remediation or adaptation (as required).	

5.7 Emergency response

Some circumstances will necessitate an immediate/urgent or emergency response to quickly re-establish access or utility lifelines, or actions to limit risk to other infrastructure or human life.

The Resource Management Act 1991[8] has specific and limited circumstances that are considered an 'emergency'. This allows for certain works to be undertaken prior to necessary resource consents being granted by the consenting authority. These situations generally result from significant events (such as storms) for which immediate response is necessary.

From an RMA perspective, emergency works do not include emergencies which are generally foreseeable (for example, resulting from lack of monitoring and 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 (for example 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 (for example, unnoticed 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 before or after the works)
- longevity of the emergency construction works activity
- effects of the works (are they temporary or permanent)
- alternative designs that achieve co-benefits (for example erosion protection that still retains public access).

The asset design processes should follow the basic steps of this guide, with consideration to the scale and urgency of the issue. These processes should be recorded and reported parallel to the works taking place to ensure an audit trail is available. Note that consents may be required for extended works or if the adverse effects of the activity continue. Regulatory authorities should be consulted at the earliest opportunity to ensure that works remain compliant with relevant rules.

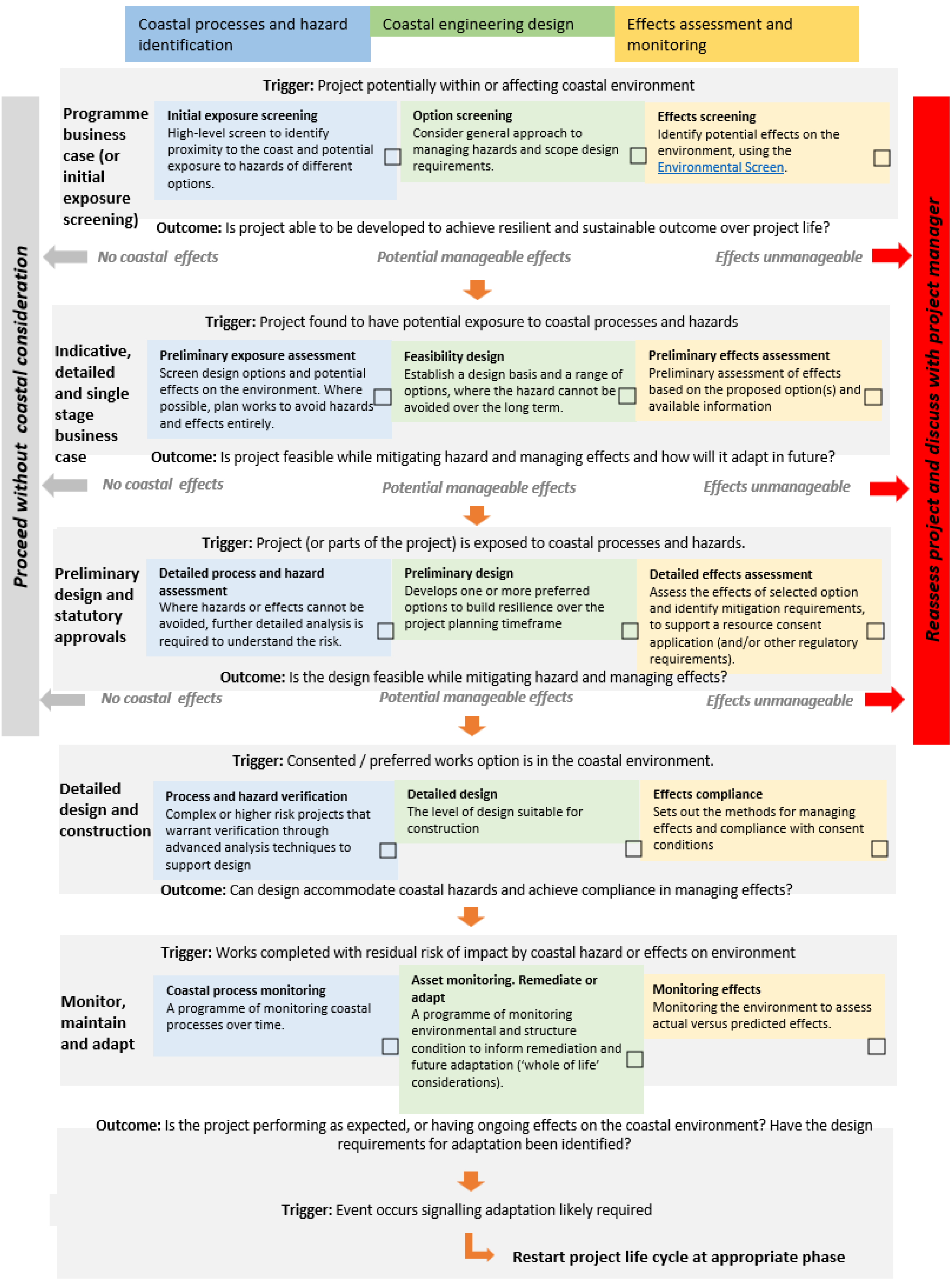
Completion of checklist 2 in appendix 1 will guide the level of coastal assessment needed. The environmental screen should also be completed as it will identify if a land transport option could have environmental and sustainability opportunities and sensitivities.

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

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

Appendix 1: Checklists

Checklist 1: New transport infrastructure at the coast



Checklist 2: Emergency response

Some circumstances will necessitate an immediate/urgent or emergency response to quickly re-establish access or utility lifelines. The approach to these works will depend on the circumstances but generally fall within two categories:

a. Emergency – works necessitated by an event or unforeseen action (e.g., storm, earthquake) which fall within the RMA definition of emergency works. This allows for works to be undertaken prior to any necessary resource consents being granted. This checklist sets out the steps to follow for works undertaken within the RMA definition of emergency works.

b. Urgent – 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). Works which do not fall within the RMA emergency works definition will need to go through the regular process outlined in Checklist 1, with consideration to the scale and urgency of the issue.

Proceed without coastal consideration

Reassess project and discuss with project manager

	Coastal processes and hazard identification	Coastal engineering design	Effects assessment and monitoring
	Trigger: Immediate/urgent or emergency response to quickly re-establish access or utility lifelines required for asset within coastal environment		
Initial exposure screening)	**Initial exposure screening** High-level screen to identify proximity to the coast and potential exposure to hazards of different options. ☐	**Option screening** Consider general approach to managing hazards and scope design requirements. ☐	**Effects screening** Identify potential effects on the environment using the Environmental Screen. ☐
	Outcome: Is project able to be developed to achieve resilient and sustainable outcome over project life?		
	No coastal effects	*Potential manageable effects*	*Effects unmanageable*
	Trigger: Emergency response required with works at risk of impact by coastal hazard or with effect on environment		
Detailed design and construction	*N/A*	**Detailed design** The level of design suitable for construction ☐	**Effects compliance** Methods for managing effects ☐
	Outcome: Design for reinstatement of accommodate coastal hazards and manage effects		
	Trigger: Project (or parts of the project) is exposed to coastal processes and hazards. Project requires consent after emergency response		
Preliminary design and statutory approvals	**Detailed process and hazard assessment** Where hazards or effects cannot be avoided, further detailed analysis is required to understand the risk. ☐	**Preliminary design** If emergency response not suitable long-term response, design of preferred option. Develop one or more preferred options to build resilience over the project planning timeframe ☐	**Detailed effects assessment** Assess the effects of selected option and identify mitigation requirements to support a resource consent application (and/or other regulatory requirements). ☐
	No coastal effects **Outcome:** Is the design feasible while mitigating hazard and managing effects?		
	No coastal effects	*Potential manageable effects*	*Effects unmanageable*
	Trigger: Works completed with residual risk of impact by coastal hazard or effects on environment		
Monitor, maintain and adapt	**Coastal process monitoring** A programme of monitoring coastal processes over time. ☐	**Asset monitoring. Remediate or adapt** A programme of monitoring environmental and structure condition to inform remediation and future adaptation ('whole of life' considerations).	**Monitoring effects** Monitoring the environment to assess actual versus predicted effects. ☐

Outcome: Is the project performing as expected, or having ongoing effects on the coastal environment? Have the design requirements for adaptation been identified?

Trigger: Event occurs signalling adaptation likely required

Restart project life cycle at appropriate phase

Checklist 3: Existing infrastructure at the coast

For an existing asset at the coast, Long Term Management includes:

Monitoring and maintenance – 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.

Adaptation – Where additional works are required, consideration should be given to repair, replacement, decommissioning or adaptation. Revisit the functional requirement for the asset to be at the coast. Each option has varying costs and wider opportunities (e.g. use of nature-based solutions, improvements to biodiversity).

This may include applying pre-determined design options identified e.g. in the pre-implementation phase. If the preliminary design did not include adaptive measures, this may involve returning to the BCA process to refine the design options and approach before working on the new solution.

	Coastal processes and hazard identification	Coastal engineering design	Effects assessment and monitoring
	Trigger: Works completed with residual risk of impact by coastal hazard or effects on environment		
Monitor, maintain and adapt	**Coastal process monitoring** A programme of monitoring coastal processes over time. ☐	**Asset monitoring. Remediate or adapt** A programme of monitoring environmental and structure condition to inform remediation and future adaptation ('whole of life' considerations). ☐	**Monitoring effects** Monitoring the environment to assess actual versus predicted effects. ☐

Outcome: Is the project performing as expected, or having ongoing effects on the coastal environment? Have the design requirements for adaptation been identified?

Trigger: Event occurs signalling adaptation likely required

Restart project life cycle at appropriate phase (see Checklist 1)

Appendix 2: Technical assessment summary tables

This appendix summarises how to identify, assess and manage coastal hazards for transport infrastructure at the coast for:

- coastal processes and hazard identification
- coastal engineering design
- coastal effects assessment.

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

For smaller or lower-risk projects, non-specialists may do the initial screening step, feeding into the environmental screen.

For larger and more complex projects, or projects in areas of medium or high risk over 100 years, consult subject matter experts (SMEs). SMEs can also advise on recommendations for more detailed analysis (as set out for the subsequent business case phases). At each step before construction, you should make a risk-based go/no-go decision on whether works will proceed.

Table A2-1: Coastal processes and hazard identification

Project phase	Level of assessment	Description	Trigger	Input data	Analysis	Output
Initial exposure screening	**Initial exposure screening**	High-level screen to identify present and future hazards within the project (see section 2.5)	Project potentially in or affecting/affected by coastal environment, eg areas identified by regional hazard assessments, or <10m NZVD or within 150m of the coast	Desktop assessment based on existing, high-level information, eg in regional coastal plans, district plans, regional risk assessment summary in the National Resilience Programme Business Case (2020)	Desktop assessment For smaller or lower-risk projects, non-specialists may do the initial screening. For larger and more complex projects, or projects in areas of medium or high risk over 100 years, consult SMEs	Identify potential project exposure to coastal hazards, in the present and over the long term (ie 100-year timeframe with relevant climate change scenarios).
Indicative, detailed and single-stage business case	**Preliminary exposure assessment**	Screen design options and potential effects on the environment. Where possible, plan works to avoid hazards and effects entirely	Project has potential exposure to coastal processes and hazards	Existing site-specific information, eg local hazard assessment. Likely includes a site visit	Empirical assessment	Identify exposure of different parts of the project to specific coastal processes and hazards Understand the current and a variety of future scenarios for coastal hazards over the likely lifetime of the asset.
Pre-implementation (preliminary design and consenting)	**Detailed process and hazard assessment**	Where hazards or effects cannot be avoided, further detailed analysis is recommended to understand the risk	Project is 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: type of modelling should reflect the level of risk or uncertainty. Project team discussion to determine	Quantify likelihood and consequence of coastal hazards on project
Implementation (detailed design and construction)	**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), including asset condition assessments	Additional analysis of field data and validated numerical and/or physical modelling may be required to resolve complex processes. Note: level and type of modelling to reflect project risk and uncertainty. Project team to determine	Verify processes to input into design and confirm consequence and likelihood of coastal hazards
Long-term management (monitor, maintain and adapt)	**Coastal process monitoring**	Recommendations 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 predictions made during implementation phase	Collect long-term environmental data Identify any change in hazard exposure, to inform remediation or adaptation of asset

Table A2-2: Coastal engineering design

Project phase	Level of assessment	Description	Trigger	Input data	Analysis	Outputs
Initial exposure screening	**Option screening**	Consider general approach to managing hazards and scope design requirements where protect or accommodate strategies preferred	Project potentially in or affecting coastal environment, eg areas identified by regional hazard assessments, or <10m NZVD or within 500m of the coast	Initial exposure screening	Desktop assessment of options and responses to hazards over at least 100 years	Potential long-term management approaches identified (eg avoid, accommodate, protect, retreat); including recognition of the situations where there is substantial uncertainty and adaptive strategies may be needed Scope design requirements, if the hazard cannot be avoided
Indicative, detailed and single-stage business case	**Feasibility design**	Establish a design basis and a range of options, where the hazard cannot be avoided over the long term	Project has potential exposure to coastal processes and hazards	Preliminary exposure assessment	Identify design basis screening for a shortlist of viable options Empirical modelling to inform option development	Agreed design basis and preferred option, with indicative resourcing General arrangement – 10% design to prove option viability, cost certainty ±100%
Pre-implementation (preliminary design and consenting)	**Preliminary design**	Develop one or more preferred options to build resilience over the project planning timeframe	Selected options are in the coastal environment and exposed to coastal processes and hazards	Detailed process and hazard assessment	Empirical and or numerical modelling to inform consent design Note: type of modelling should reflect the level of risk or uncertainty. Project team discussion to determine	Design of preferred options(s), including long-term or adaptive management, and guidance on operation and maintenance 30% design suitable for schedule of quantities and to support effects assessment, cost certainty ±50%
Implementation (detailed design and construction)	**Detailed design**	The level of design suitable for construction	Consented works option is in the coastal environment	Process and hazard verification	Validated numerical and/or physical modelling to inform detailed design Value engineering (as appropriate)	Construction drawings Specification Schedule of quantities 100% design, cost certainty ±20%
Long-term management (monitor, maintain and adapt)	**Asset monitoring – remediate or adapt**	A programme of monitoring environmental and structure condition to inform remediation and future adaptation ('whole-of-life' considerations). Design for remediation or adaptation as required	Constructed works are in the coastal environment	Process monitoring	Condition assessment/monitoring informing remediation Site-verified empirical modelling and development of adaptation works, if required	Routine or post-event monitoring of structure condition Where required, scope design requirements for remediation or adaptation (step through business case or design phases to implement)

Table A2-3: Coastal effects

Project phase	Level of assessment	Description	Trigger	Input data	Analysis	Outputs
Initial exposure screening	**Effects screening**	Identify potential effects on the environment, using the environmental screen.	Project potentially in or affecting coastal environment, eg areas identified by regional hazard assessments, or <10m NZVD or within 500m of the coast	Initial exposure screening Option screening	Desktop	Complete environmental screen
Indicative, detailed and single-stage business case	**Preliminary effects assessment**	Preliminary assessment of effects based on the proposed option(s) and available information	Project has potential exposure to coastal processes and hazards	Preliminary exposure assessment Feasibility design	Initial quantification of effects/risks	Understand level of effect on the coastal environment, including under different climate change outcomes. Identify opportunities to avoid, remedy, mitigate or offset adverse effects and update the environmental screen
Pre-implementation (preliminary design and consenting)	**Detailed effects assessment**	Assess the effects of selected option and identify mitigation requirements, to support a resource consent application (and/or other regulatory requirements)	Parts of the project found to have effect on coastal processes or be affected by coastal hazards	Detailed process and hazard assessment Preliminary design	Detailed quantification of effects/risks, and options to avoid, remedy, mitigate	Level of effects and mitigation measures assessed and quantified, to support statutory approval(s)
Implementation (detailed design and construction)	**Effects compliance**	Sets out the methods for managing effects and compliance with consent conditions	Compliance management required, eg by a consent condition or permitted activity standards in a regional plan	Process and hazard verification Detailed design	Compliance management	Confirm compliance with consent conditions (if relevant)
Long-term management (monitor, maintain and adapt)	**Monitoring effects**	Monitoring the environment to assess actual versus predicted effects	Works found to have medium- to high-level effect on coastal processes	Process monitoring – remediate or adapt	Detailed quantification of effects/risks and options to mitigate	Assess actual effects on environment Use this information to support consent compliance, along with design requirements for remediation or adaptation (as required)

Appendix 3: Coastal assessment report structure guideline

General guidance for the content and structure for coastal assessments are set out below. Input is to be commensurate to the nature and associated risks of the project and should address key issues for the site.

Table A3-1: Coastal processes and hazard identification

Section	Sub-section	Overview
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 Hydrogeology	Characteristics of shallow groundwater.
	1.5 Land elevation changes	Recent or historic eustatic, tectonic, seismic changes, or subsidence.
	1.6 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 (typical and extremes).
	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 projected changes in water levels over time as a result of climate change.
	3.2 Meteorological conditions	Observed and projected increase in the severity of storms over time as a result of climate change.
	3.3 Frequency of events	Observed and projected increase in frequency of storms as a result of climate change.
4 Exposure to coastal hazards	4.1 Coastal erosion	Assessment of areas susceptible to erosion.
	4.2 Coastal flooding	Assessment of areas at risk of flooding.
	4.3 Elevated groundwater	Assessment of changes to groundwater.
	4.4 Wave overtopping	Assessment of incoming waves overtopping structures.
	4.5 Tsunami	Assessment of exposure to tsunami.
5 Level of impact of coastal hazards	5.1 Likelihood	The probability or frequency of an event occurring.
	5.2 Consequence	The outcome of an event occurring.
	5.3 Evaluation of level of impact	Through consideration of likelihood and consequence, evaluation of the level of impact for any given hazard. Include consideration of combinations of frequency and severity (and changes over time) of various hazards over time.

Table A3-2: Coastal engineering design

Section	Sub-section	Overview
1 Design basis	1.1 General	Expected level of service, tolerance to outages and repairs, serviceability and permanence.
	1.2 Issues and opportunities	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. At least two climate change scenarios should be considered; refer relevant climate change design specifications
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.
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 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, however, the key principle to be applied 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

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 (Ministry for the Environment 2024).

Preparing New Zealand for rising seas: certainty and uncertainty

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. (Parliamentary Commissioner for the Environment 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*

This is an example of application of shared socio-economic pathways (SSPs) downscaled to a New Zealand context. 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 NZTA 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).

National Resilience Programme Business Case

This report prioritises major and extreme natural hazard (including climate change related) risks in the New Zealand land transport system and recommends an integrated suite of system responses. Appendix F includes summary of physical natural hazard and climate change risks for the NZTA network, including coastal hazard risks.

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 NZTA environmental and sustainability policies, other strategic objectives, outcomes and legal requirements during the development and management of the land transport system.

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

- Landscape and visual assessment guidelines (2013)
- Bridging the gap: NZTA urban design guidelines (2013)
- Historic heritage impact assessment guide for state highway projects (2015)
- Public engagement guidelines (2016)
- Social impact guide (2016)
- Bridge manual (2018)
- Te Ara Kotahi – Our Māori Strategy (2020)
- Ecological impact assessment guidelines (2023)

Appendix 5: Glossary

Term	Definition
Accretion	The build-up of sediments to form land or shoaling in coastal waters or waterways. It may be either natural or artificial. Natural accretion is the build-up of land on the beach, dunes, or in the water by natural processes, such as waves, current and wind. Artificial accretion is a similar build-up of land resulting from built structures such as groynes or breakwaters, or activities such as filling and beach nourishment, or also aggradation.
Active coastal zone	The cross-shore coastal zone that is highly dynamic by the action of tides, waves and wind. It extends from the closure depth up to a fixed land boundary (rock, cliff, seawall). Also called active coastal profile.
Bathymetry	The topography of the seafloor and features.
BCA	Business Case Approach – NZTA's process for developing business cases.
Climate change	A change in the state of the climate that can be identified by changes in the mean variability of its properties, and that persists for an extended period (Intergovernmental Panel on Climate Change (IPCC) 2013).
Coastal environment	An environment in which the coast is a significant part, or element, and includes the coastal marine area, as defined by the RMA. The extent and characteristics of the coastal environment are set out in the New Zealand Coastal Policy Statement, Policy 1.
Coastal hazard	Coastal hazards refer to coastal processes which adversely affect or may adversely affect human life, property, or other aspects of the environment. See also Hazard.
Coastal inundation	Coastal inundation occurs when a combination of marine and atmospheric processes raises the water level at the coast above normal elevations, causing land that is usually 'dry' to become inundated by sea water. Alternatively, the elevated water level may result in wave run-up and overtopping of natural or built shoreline structures (eg dunes, seawalls).
Coastal marine area	As defined in s 2 of the RMA, means the foreshore, seabed, and coastal water, and the air space above the water— (a) of which the seaward boundary is the outer limits of the territorial sea: (b) of which the landward boundary is the line of mean high-water springs, except that where that line crosses a river, the landward boundary at that point shall be whichever is the lesser of— (i) 1 kilometre upstream from the mouth of the river; or (ii) the point upstream that is calculated by multiplying the width of the river mouth by 5.
Coastal processes	Marine, physical, meteorological and biological activities that interact with the geology and sediments to produce a particular coastal system.
Erosion	Erosion is the process of removal of material. At the coast, this is generally from either a cliff face or a dune. This may be due to wave, weathering or bio-erosion processes. Material is deposited elsewhere resulting in accretion. Long-term erosion or recession of a shoreline is generally due to imbalance in the supply (sources) and loss (sinks) of material.
Exposure	The location of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.
Hazard	The potential occurrence of a natural or human-induced physical event that may cause harm. Harm can be both physical and non-physical, such as economic, social and/or cultural.
Mean sea level	The average level of the sea surface over a defined (long) period.
NZVD	New Zealand Vertical Datum, the official vertical datum for New Zealand and its offshore islands.

PBC	Programme business case.
RMA	Resource Management Act 1991.
Risk	Risk is defined as the potential for adverse consequences for human or ecological systems, recognising the diversity of values and objectives associated with such systems (IPCC 2022). Risk is often represented as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur.
Sea level rise (SLR)	An increase in the mean level of the oceans. Relative sea level occurs where there is a local increase in the level of the ocean relative to the land, which might be caused by ocean rising, the land subsiding, or both. In areas with rapid land level uplift (eg seismically active areas), relative sea level can fall.
SME	Subject matter expert.
Vulnerability	The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including susceptibility to harm and lack of capacity to cope and adapt.