The Cocos (Keeling) Islands

Coastal Hazard Risk Management and Adaptation Plan

A Plan for Managing Impact to Settlements and assets from the Ocean

March 2026 [Final Release]

Australian Government

Department of Infrastructure, Transport, Regional Development, Communications, Sport and the Arts

Department of Planning, Lands and Heritage

GOVERNMENT OF WESTERN AUSTRALIA

ACKNOWLEDGEMENTS

This document has been funded and delivered by the Australian Government Department of Infrastructure, Transport, Regional Development, Communications, Sport and the Arts in partnership with the Western Australian Department of Planning, Lands and Heritage for the Shire of Cocos (Keeling) Islands.

Shape Urban acknowledges the Cocos Malay people who inhabit and have connection with and history on the land which we have worked for this project. We recognise their cultural heritage, beliefs and relationship to the islands, and the importance of the islands to the Cocos Malay people today and into the future.

This document has been prepared with the support of many people from the Cocos (Keeling) Islands community. We wish to acknowledge you for your contributions.

STEERING GROUP

Australian Government Department of Infrastructure, Transport, Regional Development, Communications, Sport and the Arts

Western Australian Department of Planning, Lands and Heritage

CONSULTANT TEAM

Shape Urban – Planning, Communications & Stakeholder Engagement

Wavelength – Coastal Planning and Engineering

FAR Lane – Economics/Benefit Distribution

For Noting

This document acknowledges the challenges associated with managing risks in a dynamic coastal environment, together with the need to balance people, planet and prosperity values to ensure the long-term sustainable use and management of the Cocos (Keeling) Islands unique coastlines and environment. The CHRMAP process is designed to be ongoing, with regular updates associated with the emergence and collection of new information, continued engagement and a working relationship between the community, key stakeholders and the Government. This CHRMAP should be reviewed within 5 years.

DOCUMENT CONTROL

NO	AUTHOR	REVIEWED BY	DATE	PURPOSE
1	K Yang	A Kelderman	10 July 2023	First Draft
2	K Yang	A Kelderman	13 September 2023	Revised Draft
3	K Yang	A Kelderman	18 March 2024	Revised Draft - DITRDCSA feedback
4	K Yang	A Kelderman	10 June 2024	Revised Draft - Final
5	K Yang	Project Steering Group	6 August 2024	Revised Draft for public comment
6.1	Anna Kelderman	Project Steering Group	19 November 2025	Final CHRMAP
6.2	Anna Kelderman	Project Steering Group	26 March 2026	Final CHRMAP Release

Disclaimer

This document has been prepared by the Department of Planning, Lands and Heritage on behalf of the Australian Government and is provided for information purposes only. While reasonable care has been taken in the preparation of this document, neither DPLH nor the Australian Government make any representations or warranties as to the accuracy, reliability, completeness or currency of the document.

DPLH and the Australian Government, their officers, employees and agents accept no liability for any loss or damage arising from reliance on, or use of, this document.

The information contained in this document does not constitute professional advice. Independent professional advice should be obtained before applying the information to particular circumstances.

© State of Western Australia

Published by the Department of Planning, Lands and Heritage

Gordon Stephenson House
140 William Street

Perth WA 6000

Locked Bag 2506

Perth WA 6001

Published April 2026

website: www.dplh.wa.gov.au

email: info@dplh.wa.gov.au

tel: 08 6551 8002

fax: 08 6551 9001

National Relay Service: 13 36 77

The Department of Planning, Lands and Heritage owns all photography in this document unless otherwise stated.

This document is available in alternative formats on application to the Department of Planning, Lands and Heritage Communications Branch.

Executive Summary

Coastal hazards, including erosion and inundation, are a current and consistent concern for the community of the Cocos (Keeling) Islands (CKI). Regular flooding is experienced within the Home Island settlement, which is home to the majority of the residents of CKI, with seawater, groundwater, and rainfall inundation significantly impacting infrastructure and community facilities. The West Island settlement Island is also vulnerable to flooding from seawater, groundwater, and rainfall.

The impact of erosion and inundation on the coastline is expected to increase in the future due to storms and continued sea level rises. Bureau of Meteorology data collected at Home Island from 1992 observed an annual sea level rise of approximately 4mm. Sea levels are expected to be 14-18cm higher in 2030, and 40-44cm higher in 2070, compared to the sea level in 1992. These sea level rises pose a significant threat to the long-term suitability of the settlements on both islands, including the homes and livelihoods of the community.

A Coastal Vulnerability Study (CVS), prepared by the Australian Government and other key stakeholders in March 2021, compiled detailed local analysis of the coastal areas and assets at risk of coastal erosion and inundation on CKI over the next 100 years (see *Figure 1* and *Figure 2*).

The Australian Government has partnered with the Western Australian (WA) Department of Planning, Lands and Heritage (DPLH) to develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) for the Shire of CKI (the Shire).

A CHRMAP is a technical assessment used for planning. It recommends ongoing research and study to understand existing and projected coastal impacts. It is a basis for decision making, rather than laying out decisions and implementation plans.

Building on information from the CVS, other coastal studies, and community inputs, the CHRMAP outlines potential response actions for Home and West Islands. It also provides more general actions for the non-inhabited islands of CKI.

The intention of the CHRMAP is to provide a strategic approach to inform community engagement on future actions to address erosion and inundation on CKI, including managing coastal land use, future development of the settlements and the impacts of coastal processes. It will give decision-makers, administrators and land owners on CKI a decision-making framework for sustainable development into the future. It will also help with the preparation of a new Local Planning Strategy and Local Planning Scheme for CKI and amendments to the Shire's Strategic Community Plan.

A CHRMAP is developed in accordance with Western Australian legislation; State Planning Policy 2.6 *State Coastal Planning Policy* (SPP 2.6).

The process and requirements are clearly defined in SPP 2.6 and its associated guidelines. In accordance with SPP 2.6, CHRMAPs are recommended when coastal hazards are projected to be present.

In developing the CHRMAP, there has been comprehensive engagement to inform the community about the extent of potential coastal hazards and the adaptation strategies available to respond to those hazards.

More than 400 people and organisations were engaged directly, with over 180 contributions prior to the draft being prepared. The majority of contributions were from CKI residents directly or in groups. This represents a substantial proportion of the overall population of CKI.

That process has enabled better understanding of community values along the coastline, including cultural and socio-economic values associated with the island way of life.

Engagement has also focused on communication of Australian Government and local government responsibilities, and the capacity to respond to potential coastal hazards. The community and stakeholder participants have provided input to the selection of adaptation strategies to respond to the risks.

While some of the findings are challenging, it is recognised that the health and safety of the community requires that difficult conversations must be had, and complex options be discussed, to ensure preparedness for managing risks, and to think strategically about how to respond.

Aims of the CHRMAP

This CHRMAP provides a land use and development decision-making framework for CKI, to guide the Government, DPLH, the Shire, landowners and other key stakeholders to:

- Ensure land in identified coastal zones is continuously provided for coastal foreshore management, public access, recreation and conservation;
- Ensure public safety and reduce risks associated with coastal erosion and inundation;
- Avoid and address inappropriate land use and development of land within and outside of the settlements at risk from coastal erosion and inundation; and
- Ensure land use and development does not accelerate coastal erosion, exacerbate inundation risks or have a detrimental impact on the function of public reserves.

The Cocos (Keeling) Islands

CKI is located approximately 2,950 km north-west of Perth, and 900 kilometres south-southwest of Christmas Island. There are 27 coral islands with a total land area of 14 square kilometres. CKI has a tropical climate, high humidity, and average rainfall around 2000 millimetres per annum.

The region experiences an average of approximately 2.6 tropical cyclones per year, which have the potential to generate large waves and storm surge. Islands within CKI are sandy and low lying, West Island and Home Island are the only two inhabited atolls on CKI, with a total population of 593 in 2021.

The Australian Government acts as both the Federal and state-level government on CKI. The responsibility extends from managing Australia's ongoing strategic policy interests, to the provision of state-type services, such as education, water, electricity generation and distribution, community services and wastewater.

Essential services are delivered directly, through Service Delivery Arrangements (SDAs) with WA government agencies, or through contractual arrangements with commercial operators. Under the *Cocos (Keeling) Islands Act 1955*, WA law is applied as Federal law.

CHRMAP Findings

Vulnerability

All assets, infrastructure and people on CKI will be significantly impacted by coastal erosion and inundation in the short, medium and long-term. The analysis outlines that there are a large number of assets currently at a 'high' or 'very high' level of vulnerability for both erosion and inundation, meaning that the assets are susceptible to negative consequences of an event (a storm or longer term change in climatic conditions).

Vulnerability will become more acute by 2068, as indicated in *Table 1*.

Table 1: Vulnerability Level for assets identified as being at risk

LOCATION	VULNERABILITY LEVEL	NUMBER OF ASSETS VULNERABLE (TO EITHER EROSION OR INUNDATION)					
		2018		2068		2118	
West Island	Low	0	30	0	30	0	30
	Medium	7	32	0	21	0	3
	High	**178**	**89**	103	33	7	29
	Very High	35	62	**117**	**129**	**213**	**151**
Home Island	Low	0	24	0	24	0	24
	Medium	7	21	0	8	0	1
	High	**106**	**107**	67	37	7	20
	Very High	32	91	**78**	**174**	**138**	**198**

Erosion Vulnerability: Low Medium High Very High

Inundation Vulnerability: Low Medium High Very High

N/A

Areas at Risk on the Settled Islands

Figure 1 and *Figure 2* illustrate erosion and inundation on Home Island and West Island respectively over time. Erosion is mapped from the start of the CVS timeframe (2018) and is the observable current day shoreline, then 2068 and then 2118. 2068 and 2118 are predictions based on current sea level rise trends and show a projected shoreline if no further action is taken.

Inundation mapping is more complex. It shows a prediction of where sea water is projected to come onto the land and how deep the water might be in a severe event in 2068 if no further action is taken.

It does not show how long the water will stay on the land, and this is where it becomes complex: inundation waters may recede in minutes, hours, or longer; days or weeks. The length of time that land is inundated changes how acceptable the level of flooding might be to the people that live there. None of the dates are intended to be exact.

There are limited physical and land use planning controls in place for the protection of the Home and West Island coastlines at the present day. Where there are physical protection measures, such as seawalls, the infrastructure has a short design life, and many structures are in a relatively poor condition (i.e. of 11 seawalls, only three were assessed as able to withstand erosion from a significant storm event).

The analysis also indicated that due to existing vulnerability, hundreds of millions of dollars of economic value will be potentially destroyed by inundation and erosion on CKI by 2068. The replacement cost of infrastructure alone on CKI, which does not include the airport runway and associated assets, is estimated to be at least hundreds of millions of dollars. Most importantly, the total cost associated with responding to the impacts of coastal hazards across CKI is estimated to be in the billions of dollars.

Maintaining the status quo (i.e. no further action is taken) will not address the impacts of coastal erosion and inundation. Immediate actions and significant investment will be needed to support the settlements on CKI. A coordinated and strategic response to the CHRMAP, with input from all Federal, State, Local Government and community stakeholders, will be needed to implement culturally appropriate and respectful actions, within the bounds of what is economically feasible.

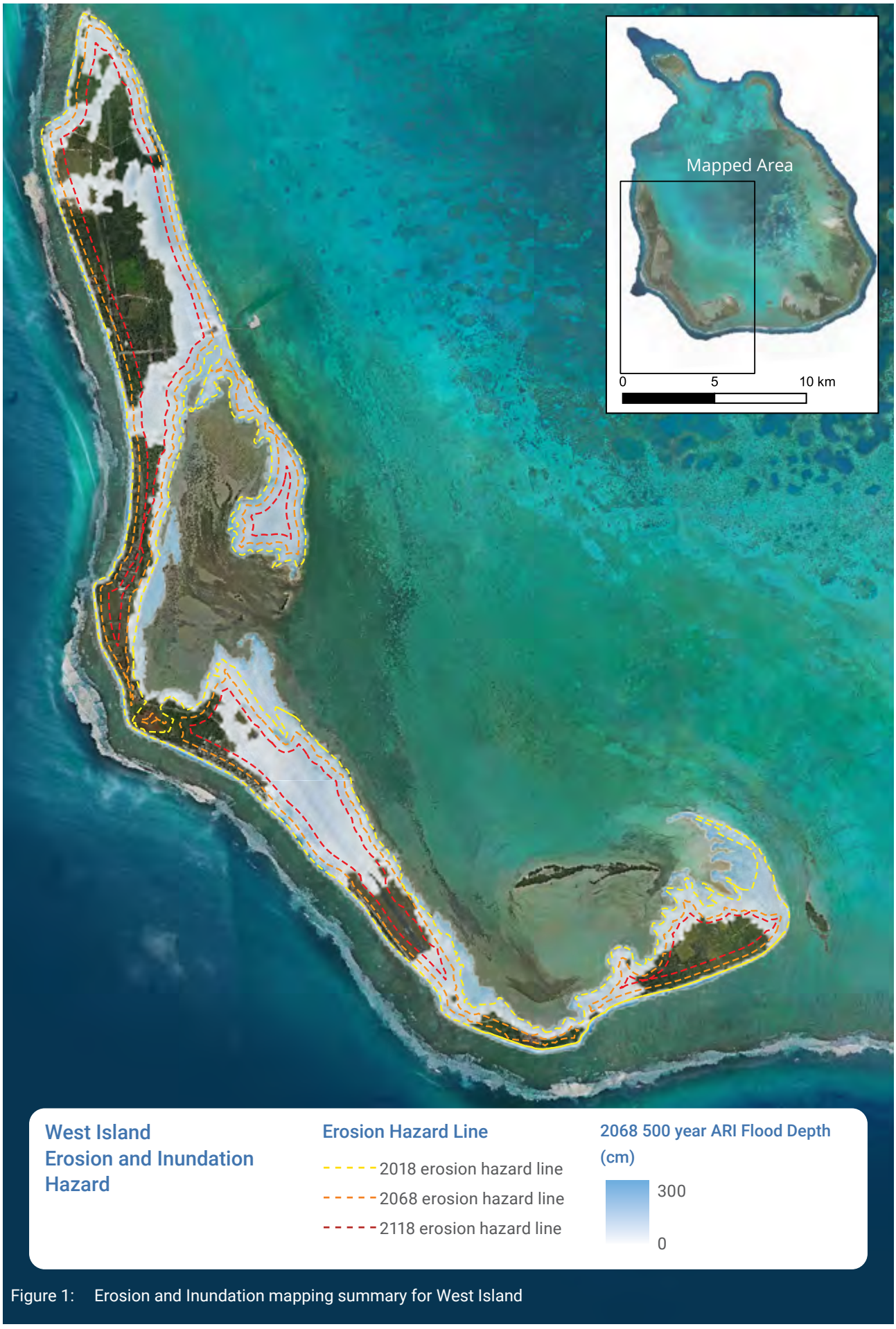


Figure 1: Erosion and Inundation mapping summary for West Island

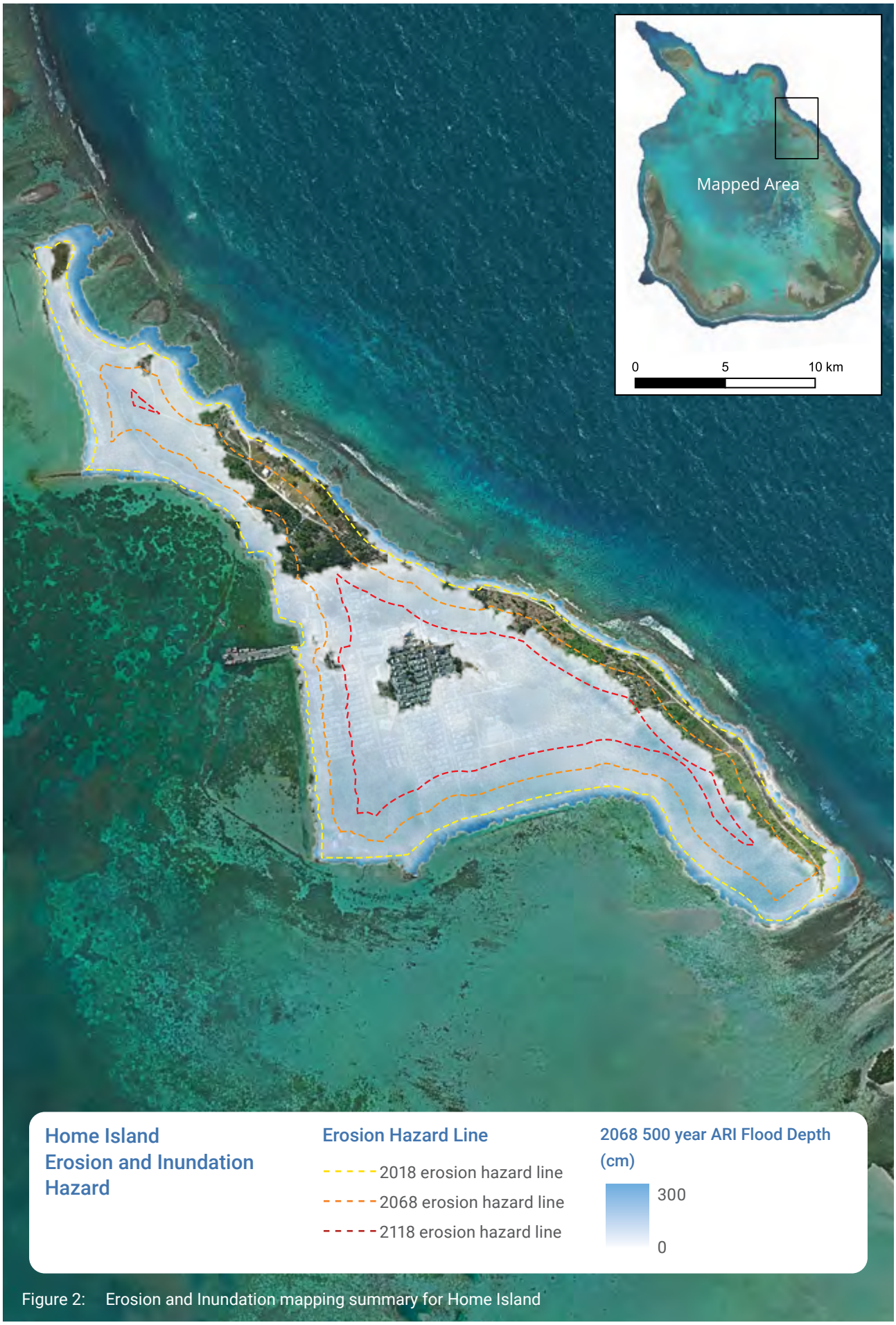


Figure 2: Erosion and Inundation mapping summary for Home Island

Response

Adaptation options will be progressed with ongoing collaboration and partnership with the CKI community. Discussion with the community about how they would like to partner and when they would like to be engaged will be ongoing. The community will be a partner in decision making.

Notwithstanding, it is apparent from earlier engagement and formal submissions on the draft CHRMAP, that immediate strategic planning policy and governance documents are required to to inform sound decision making. This includes: cost-benefit analysis (CBA) of potential options for Home Island, emergency management planning; groundwater studies; sand source and raw materials investigation and heritage management plans.

The preparation of a contemporary land use planning framework is also an immediate response to this CHRMAP, and a primary aim of such would be to plan for the avoidance of intensification or expansion of new permanent residential development and other vulnerable land uses (including associated infrastructure) within areas impacted by coastal hazards.

In the short-term, it is proposed that assets across CKI with the highest economic, cultural, historical and environmental value be protected.

It is important to note that some assets may be so vulnerable that protection is not viable. In these instances, moving the assets to other areas on the Island/s will need to be considered.

Ultimately, the community and all levels of Government will need to work together beyond short-term actions to understand the future of the Settlements on Home Island and West Island, as vulnerability to the combination of erosion and inundation increases over time. It is especially acute for Home Island, as its vulnerability to the combination of erosion and inundation is so great that potential interventions other than relocation of vulnerable assets may be cost prohibitive in the long-term.

Ultimately, actions will be taken in partnership with the community and key stakeholders of CKI to protect lives in a socially, economically and environmentally respectful way.

Response Options

The table below outlines **high level response options** for the short, medium and long-term. While the protect pathway is mostly recommended in the short-term, this may change to a planned and managed retreat pathway in the longer term subject to Long-Term Settlement Planning and level of available funding.. If risks from erosion or inundation are experienced sooner, a trigger may bring adaptation responses forward in time.

Table 2: Response options summary

<table>
<tr><th>TIMING</th><th>HOME ISLAND</th><th>WEST ISLAND</th></tr>
<tr><td rowspan="2">Short-term
(0-10 years)</td><td colspan="2">Consider management and adaptation planning options relevant to all assets, including strategic planning, statutory planning, and policy or governance interventions.
All options require further investigation and detailed design, and ongoing engagement with stakeholders and community.
Intensification or expansion of new permanent residential development and other vulnerable land uses (including associated infrastructure) should be prohibited within areas impacted by coastal hazards
Commence Long-Term Settlement Planning in partnership with the community as soon as possible for vulnerable areas, including land use planning and potential implementation mechanisms.
Relocate minor assets and service infrastructure – areas outside of the settlement areas, with the exception of critical service infrastructure assets that cannot be located.</td></tr>
<tr><td>Protect key community infrastructure, including the Kampong and cemetery, with a combination of seawalls and levees.</td><td>Protect key infrastructure in the Settlement Area, Lagoon, Runway, Rumah Baru, fuel station, power station, potable water and wastewater infrastructure through a combination of reinforcing existing, and building new, seawalls and levees.
Minor Asset Relocation and Services Relocation for at risk assets that can be moved to a lower risk area (i.e. Sydney Highway requires immediate relocation further inland, and will require levees and seawalls for protection).</td></tr>
</table>

Table 2: Response options summary (continued)

TIMING	HOME ISLAND	WEST ISLAND
Medium-term (10-50 years)	• Land use planning instruments to facilitate progressive relocation of minor and service infrastructure assets out of the hazard zone. • In collaboration with the community, progress Long-term Settlement actions as developed in the short-term, noting that there is limited available land of adequate size on Home Island that does not suffer the same issues as the Kampong. • For areas outside of the settlement, move minor and service infrastructure assets that are identified as being within the hazard area.	• Assessment of protect measures and investment in reinforcements (i.e. replacing seawalls and sandbags at the Settlement Area and Runway). • Replace seawalls and other protect measures at the end of the relevant structure design life. • For areas outside of the settlement, move minor and service infrastructure assets that are identified as being within the hazard area in the Northern and Lagoon beaches, and Rumah Baru.
Long-term** (50+ years)	• Long-term adaptation pathways are limited for both West and Home Island. Long-Term Settlement Planning in the Short and Medium-term will confirm the most suitable option to protect lives in a socially, economically and environmentally respectful way in this time frame. • All options will be considered, including resilience measures (revegetation/sand nourishment) and protect options, as well as settlement relocation which may be necessary due to the significant health and safety risks posed by coastal inundation and erosion, and associated flooding.	• Protect essential infrastructure beyond 2068: Continue a protect pathway for the settlement areas and critical service infrastructure assets outside the Settlement Area that can't be easily relocated (Fuel Station, Rumah Baru). • Planned and managed retreat: using land use planning instruments to progressively move assets out of the hazard zone for all non-critical service infrastructure assets. • Protect essential airport infrastructure beyond 2068; Further raise the pavement height to reduce risk of runway flooding.

** Long-term planning and development is contingent on the results of further analysis and scenario planning to determine the level of investment required to support a permanent settlement on CKI.

Future actions

The following tables provide a summary of the adaptation pathways proposed to respond to erosion and inundation for both Home and West Islands.

Immediate (actioned as soon as possible)

Table 3: Adaptation pathways summary (immediate term)

AREA OF INTEREST	ACTION TYPE	RECOMMENDATION	TRIGGER
CKI	Engagement	Develop Community Engagement Plan and communications program to continue information sharing and gathering with the community regarding the CHRMAP and ongoing management	Following the release of the Final CHRMAP
CKI	Planning	Prepare detailed implementation plan	Following the release of the Final CHRMAP
CKI	Investigation	CBA of Home Island and West Island protect pathway versus planned and managed retreat to confirm short-term implementation pathway	As soon as scoped appropriately and funding obtained
CKI	Investigation	Completion of a sand source and raw materials investigation to determine the capacity of local sand supply within the atoll and external options (i.e. importing of basic raw materials)	As soon as scoped appropriately and funding obtained
Home Island	Investigation	Completion of groundwater/flooding investigation to confirm timing for longer term planning	As soon as scoped appropriately and funding obtained
West Island	Investigation	Assess Rumah Baru and the seawall currently protecting the fuel station to inform timing of the upgrade of critical service infrastructure assets at Rumah Baru and the fuel station	As soon as scoped appropriately and funding obtained
West Island	Investigation	Boat ramp assessment to consider maintenance or design alterations in existing sites, or relocation to more appropriate sites	As soon as scoped appropriately and funding allocated by local government
CKI	Planning	Local Planning Scheme – Establish a Special Control Area to control land use planning on land identified as being vulnerable	Local Planning Strategy and Scheme

Table 3: Adaptation pathways summary (immediate term) (continued)

AREA OF INTEREST	ACTION TYPE	RECOMMENDATION	TRIGGER
CKI	Planning	Develop Local Planning Strategy – in collaboration with the community, including detailed engagement on Long-Term Settlement Planning, and ensuring that the vulnerability of the study area is adequately identified in the strategic planning framework	Following the release of the Final CHRMAP
CKI	Planning	Shire Infrastructure Asset Planning to make sure that future assets are sensibly located to manage risk to assets	Ongoing
CKI	Planning	Australian Government infrastructure asset planning to make sure that future assets are sensibly located to manage risk to assets	Ongoing
CKI	Planning	Preparation of an emergency management plan to protect the safety of the community should a significant storm event occur	As soon as scoped appropriately and funding obtained
CKI	Planning and Monitoring	Resilience Planning including monitoring (in some cases immediate) to support natural hazard management through dune vegetation. Monitoring plan development.	As soon as scoped appropriately and funding obtained
Home Island	Planning, design and physical works	Levee protection – south to south west point of Home Island (see map *Figure 3*)	As soon as scoped appropriately and funding obtained
Home Island	Planning, design and physical works	Road raising on the western side of Home Island (see map *Figure 3*)	As soon as scoped appropriately and funding obtained
West Island	Planning, design and physical works	Move Sydney Highway and underground services (see map *Figure 4*)	As soon as scoped appropriately and funding obtained
West Island	Planning, design and physical works	New seawalls on the sea side of West Island (see map *Figure 5*)	As soon as scoped appropriately and funding obtained
West Island	Planning, design and physical works	Levees and seawall in front of settlement (ocean side) (see map *Figure 5*)	As soon as scoped appropriately and funding obtained.

Short-term (0 to 10 years)

Table 4: Adaptation pathways summary (short-term)

AREA OF INTEREST	ACTION TYPE	RECOMMENDATION	TRIGGER
CKI	Planning, design and physical works	Protect pathway design and staging. Protection action including detailed design, confirmation of more accurate timing for staging of upgrades, detailed costing and a monitoring program Settlement Area and critical service infrastructure assets outside of settlement (see map *Figure 3* to *Figure 6*)	As soon as scoped appropriately and funding obtained
CKI	Investigation	Investigate options for the future of the settlement (in collaboration with the community)	Informed by community consultation and other studies
CKI	Planning	Notification on titles to advise property owners where land is identified as being at risk	Ongoing
CKI	Planning	Preparation of a Local Planning Policy to work alongside the Special Control Areas	2026/27
CKI	Investigation	Property Acquisition Investigation	2026/27
CKI	Investigation	Preparation of a Local Heritage Survey and Cultural Heritage Management Plan to understand how to protect or manage loss of cultural heritage values	2026/27
Home Island	Planning and design	Protect pathway design and staging following CBA	On completion of CBA
West Island	Planning, design and physical works	Raise Airfield Road to ensure ongoing access to the Communications Facility west of Scout Park (see map *Figure 6*)	2026/27
CKI	Monitoring	Condition inspection of structures (complementary to avoiding further development in Hazard Zones)	Ongoing (Annually)
CKI	Physical works	Strategic vegetation planting and dune care (out of settlement areas)	Ongoing
CKI	Monitoring	Monitoring of storm events, ocean induced and terrestrial events as set out in Monitoring Plan.	Ongoing (As events occur)
CKI	Monitoring	Aerial photo review	Ongoing (Every 5 years)
CKI	Monitoring	Bi-annual beach profile surveys	Ongoing

Table 4: Adaptation pathways summary (short-term) (continued)

AREA OF INTEREST	ACTION TYPE	RECOMMENDATION	TRIGGER
CKI	Review	Progress Review	Ongoing (<3 years)
CKI	Review	CHRMAP to be updated every 5 years or as new information becomes available, to support decision-making	Every 5 years
Home Island	Planning, design and physical works	Levee protection on the north-western side of the Home Island settlement (see map *Figure 3*)	By 2030
Home Island	Planning, design and physical works	Seawall protection on the western side of the Home Island settlement (see map *Figure 3*)	By 2030
West Island	Planning, design and physical works	Replace existing sandbag seawalls adjacent William Keeling Crescent with a concrete seawall. All existing seawalls should also be assessed at this time (see map *Figure 5*)	By 2030
West Island	Planning, design and physical works	Seawall protection north and south of existing at settlement (see map *Figure 5*)	By 2030
West Island	Planning, design and physical works	Levee protection east side of runway (see map *Figure 5*)	By 2030
West Island	Planning, design and physical works	Levees on the lagoon side near the refuse station (see map *Figure 5*)	By 2030
West Island	Investigation	Condition assessment and monitoring of existing seawalls to determine timing of upgrade	Ongoing
West Island	Monitoring	Ongoing monitoring of Kite Beach, Yacht Club and Scout Park, to confirm timing of when to relocate	Ongoing
West Island	Planning, design and physical works	CKI Runway Upgrade – tie-in seawalls to Materials Offloading Facility located immediately north of Rumah Baru access jetty (see map *Figure 5*)	Ongoing
West Island	Planning, design and physical works	Rumah Baru access road – raise road and pavement above flood level (see map *Figure 4*)	By 2030
Home Island	Planning, design and physical works	Move infrastructure into settlement area	As soon as scoped appropriately and funding obtained

Table 4: Adaptation pathways summary (short-term) (continued)

AREA OF INTEREST	ACTION TYPE	RECOMMENDATION	TRIGGER
Home Island	Planning, design and physical works	Protect the cemetery with seawall and levees, including land reclamation	As soon as scoped appropriately and funding obtained
West Island	Investigate	Investigate the management of existing vulnerable assets on the coastal side	As soon as scoped appropriately and funding obtained

Medium-term (10 to 50 years)

Table 5: Adaptation pathways summary (medium-term)

AREA OF INTEREST	ACTION TYPE	RECOMMENDATION	TRIGGER
West Island	Principle	Transition from planned and managed retreat to a protect pathway for relocatable, critical service infrastructure assets outside of the settlement (Defence site, water treatment plant and refuse station)	As soon as scoped appropriately and funding obtained
West Island	Principle	Planned and managed retreat planning: using planning instruments to progressively move assets out of the hazard zone for all non-critical service infrastructure assets	As soon as scoped appropriately and funding obtained
West Island	Principle	Planned and managed retreat planning for management of existing vulnerable assets, including: • Transmitter site – confirm building floor levels, raise if necessary to lift building higher than flood levels. • Sydney Highway • Assets at Trannies Beach, Big Barge Art Centre	By 2068
West Island	Planning, design and physical works	Relocate by 2068 – Lagoon side assets including two refuse stations, waste water treatment plant, Air Force site, Bureau of Meteorology, airport assets and Geoscience Australia building	By 2068
West Island	Planning, design and physical works	Move existing vulnerable assets including Kite Beach, Yacht Club and Scout Park	As soon as scoped appropriately and funding obtained
CKI	Planning, design and physical works	Planned and managed retreat Planning - Relocate assets within land parcels away from hazard zone (outside of settlement areas), and remove non-critical service infrastructure assets from site	Begin planning: Trigger 1 Begin physical works: Trigger 2
Home Island	Planning, design and physical works	Progress agreed option for the future of the settlement (in collaboration with the community through Long-term Settlement Planning)	As soon as scoped appropriately and funding obtained

Table 5: Adaptation pathways summary (medium-term) (continued)

AREA OF INTEREST	ACTION TYPE	RECOMMENDATION	TRIGGER
Home Island	Planning, design and physical works	Road raising (see map *Figure 3*)	Where assessed as necessary
Home Island	Planning, design and physical works	Levee and Seawall protection (see map *Figure 3*)	Where assessed as necessary
Home Island	Planning, design and physical works	Existing seawall and sandbags replace in 2050/60 (see map *Figure 3*)	By 2060
West Island	Planning, design and physical works	Levee protection Rumah Baru area (see map *Figure 4*)	Where assessed as necessary
West Island	Planning, design and physical works	Replace all seabee seawalls, with crest increased 1 metre (see map *Figure 5*)	By 2050-60
West Island	Monitor	Transmitter site – monitor shoreline, as planned and managed retreat may be necessary	Where assessed as necessary

Long-term (50+ years)

Table 6: Adaptation pathways summary (long-term)

AREA OF INTEREST	ACTION TYPE	RECOMMENDATION	TRIGGER
West Island	Planning and design	Protection design requirements for Sydney Highway, Waste Water Treatment Plant, Refuse Station	Begin planning: Trigger 1 Begin physical works: Trigger 2
West Island	Planning, design and physical works	Protect – likely more levees and new seawalls needed for both lagoon and seaside, runway protection (see map *Figure 5*), seawall protection of moved Sydney Highway (see map *Figure 4*).	As assessed beyond 2068
CKI	Planning, design and physical works	Progress agreed option for the future of the settlement (in collaboration with the community through Long-term Settlement Planning)	As soon as scoped appropriately and funding obtained

Figure 3: **Adaptation Proposed for Home Island Settlement Area over the short to medium-term**

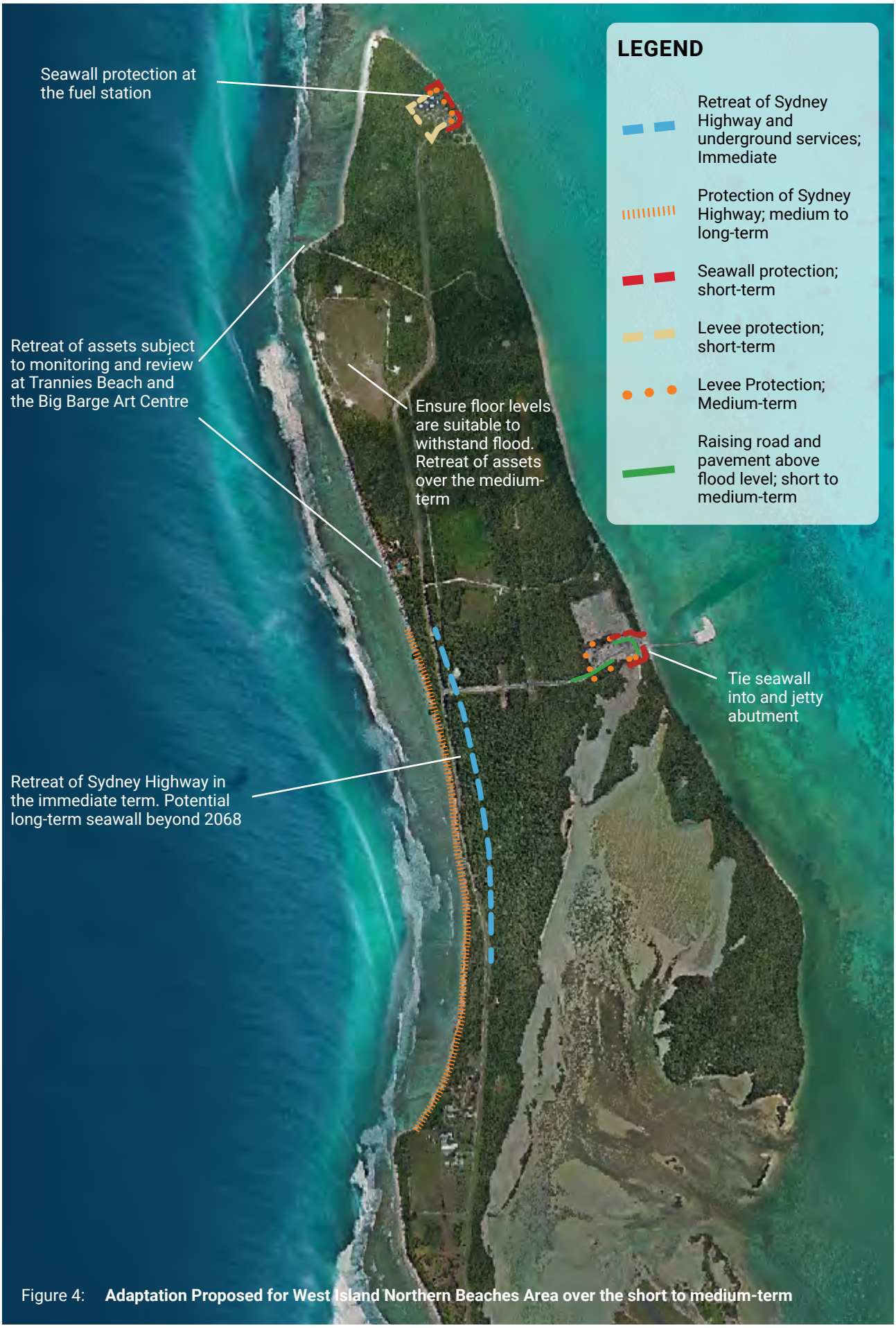


Figure 4: **Adaptation Proposed for West Island Northern Beaches Area over the short to medium-term**

Figure 5: **Adaptation Proposed for West Island Settlement Area over the short to medium-term**

Figure 6: **Adaptation Proposed for Scout Park, Kite Beach and West Island Ocean Beaches Area over the short to medium-term**

Frequently Asked Questions

What is a CHRMAP?

CHRMAP is the acronym for a 'Coastal Hazard Risk Management and Adaptation Plan'. It is a study prepared to communicate information about future coastal planning. It includes a technical assessment to understand the existing and projected coastal processes, includes a social assessment to understand the community values associated with the coastline being studies, and considers financial and environmental implications.

The WA Government's CHRMAP Guidelines (July 2019) provide guidance for decision-makers to develop and implement effective CHRMAPs. These guidelines apply to the CKI.

The CHRMAP estimates where the coastlines are likely to be located in the short, medium and long-term future. By understanding where the coastline is likely to be in the future, it allows us to understand what infrastructure may be impacted by coastal processes and investigate which options for managing these impacts might be appropriate in particular areas.

What are coastal hazards?

The two main coastal processes that are considered hazards are erosion and inundation. The CHRMAP identifies areas that could potentially be impacted by these hazards at different time frames within the next 100 years, relative to storm events and projected sea level rise. Please refer to Chapter 3 Risk Identification for more information.

What are the options for adapting to coastal hazards?

The WA State Government's State Planning Policy 2.6 – State Coastal Planning Policy (SPP 2.6) identifies a hierarchy of four options for adapting to coastal hazards:

Avoid

Identify future 'no build' areas and use planning controls to prevent new development in areas that are vulnerable now or in the future

Planned and Managed Retreat

Withdraw, relocate or abandon assets that are vulnerable; ecosystems are allowed to move landward as sea levels rise

Accommodate

Continue to use the land but accommodate changes by building on piles, converting land uses or growing flood or salt-tolerant plants

Protect

Use hard structures (e.g. sea walls) or soft solutions (e.g. dunes and vegetation) to protect assets from the sea. May be prohibitively expensive, especially in the long-term

Please refer to Section 5 to learn more about these options and the additional options of 'No Regrets' and 'Do Nothing' that have been considered in the risk treatment assessment.

How will this affect me?

Coastal hazards will affect different people in different ways depending on where they live and how they access, use and enjoy the coastline. Please refer to the table for a summary of information.

I AM A…	I MAY BE AFFECTED BY…
Private property owner in the coastal hazard zone	Land Use Planning Controls - The land use planning framework provides for continuation of existing development or land uses until the coastal hazard risk or impacts become unacceptable. The land use planning framework then provides opportunities to introduce less vulnerable forms of use or development.
	Notification on titles - This indicates to current and future owners that an asset is vulnerable, to help them make informed decisions about the level of risk they are willing to accept, and that risk management and adaptation is likely to be required. If a planning or development application is submitted for a lot located in a coastal hazard area then SPP 2.6 enables a notification to be placed on the Certificate of Title as a condition of approval, identifying that the lot may be vulnerable to coastal hazards.
User of the coastline	Some areas of the Cocos (Keeling) Islands coastlines will become vulnerable over the next 100 years. This includes beaches, access ways, footpaths, carparks, jetty areas, toilets, roads and public open space areas. *Chapter 7 Adaptation Options* provides a summary of the recommended short-term management actions to be undertaken. These are largely focused on 'behind the scenes' actions such as monitoring, planning controls, and emergency management plans to better prepare decision-makers for future coastal hazard management . Long-term, adaptation strategies such as protection or planned and managed retreat will be required when coastal hazards are experienced, as explained in *Chapter 7 Adaptation Options* and the Implementation Plan. In areas identified for potential future protection, the construction of structures such as seawalls will mean that the natural sandy beach will eventually be lost in these locations and that access to those stretches of coastline might be affected. In areas identified for future planned and managed retreat, existing infrastructure may gradually be permanently removed or relocated if coastal hazards cause damage during storm events. In those cases the natural sandy beach and dunes will be given room to move, and thus the natural foreshore be retained.
The Cocos (Keeling) Island peoples' Land Trust, held in Trust by the Shire of Cocos (Keeling) Islands* *Identified in the Trust Deed as the Cocos Keeling Islands Council	The Cocos (Keeling) Island peoples' Land Trust is affected in a similar way to private property owners and in the same way as other users of the coastline. This coastal user is also affected as a group by damage to or planned and managed retreat of valued assets such as the family pondoks located on the other islands of the atoll. Development of Trust Land will also be affected by land use planning controls and notification on titles as per the private property owner category. Engagement with the Cocos (Keeling) Islands' Elders will continue to occur to ensure the rights and obligations of the Land Trust are respected.

What will the outcomes of the CHRMAP be?

The CHRMAP is a technical assessment used for planning. It is a basis for decision making, rather than laying out decisions and implementation plans.

It recommends ongoing research and study to understand existing and projected coastal impacts across the inhabited islands of West Island and Home Island and also considers other islands in the atoll, on the basis of current and future use and protection.

The components of a CHRMAP include:

- Coastal hazard risk identification and assessment;
- Coastal risk evaluation based on community and stakeholder engagement and an assessment of community safety;
- Identification of adaptation options to mitigate coastal hazard risk; and
- Assessment of adaptation options to identify preferred options.

The CHRMAP process takes into account the uncertainty associated with predictions of coastal change and provides a flexible decision-making pathway that decision-makers can use over time as coastal hazards emerge.

Who will pay for adaptation?

The CHRMAP itself is a planning tool to inform decision-makers and the community. The support of decision-makers and the community for the CHRMAP recommendations is an important first step towards identifying and implementing an appropriate response.

Further work will be done to consider the CHRMAP findings and recommendations and to identify potential funding sources in response.


OPEN COPRA DRYING SHED
PONDOK INDAH
CHULA SHED

Abbreviation List

AHD	Australian Height Datum
ARI	Annual Recurrence Interval
AS	Australian Standard
BDA	Benefit Distribution Analysis
CBA	Cost Benefit Analysis
CHRMAP	Coastal Hazard Risk Management and Adaptation Plan
CSEP	Community and Stakeholder Engagement Plan
CVS	Cocos (Keeling) Islands Coastal Vulnerability Study (RHDHV, 2021a)
DITRDCSA	Australian Government Department of Infrastructure, Transport, Regional Development, Communications, Sport and the Arts
DPLH	WA State Government Department of Planning, Lands and Heritage
DTMI	WA State Government Department of Transport and Major Infrastructure
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
FAQs	Frequently Asked Questions
GSC	Geotextile sand container
HSD	Horizontal Shoreline Datum
IPCC	International Panel on Climate Change
LPS 1	Shire of Cocos (Keeling) Islands Local Planning Scheme No. 1
MCA	Multi Criteria Analysis
MSL	Mean Sea Level
MU	Management Unit
MWL	Mean Water Level
P&D Act	*Planning and Development Act 2005 (WA)(CKI)*
SLR	Sea Level Rise
SPP 2.6	WA Government State Planning Policy 2.6 – State Coastal Planning Policy
TECs	Threatened Ecological Communities
The Shire	Shire of Cocos (Keeling) Islands
WAPC	Western Australian Planning Commission

Common Definitions

The following definitions apply to these words and phrases through the report:

Acceptable Risk

These are risks that do not need further treatment. The term 'acceptable risk' refers to the level at which it is decided that controls (further restrictions or otherwise altering the activity) is not worthwhile, as the current risk does not warrant further action.

Accommodate

Under the WA State Government's State Planning Policy 2.6 – State Coastal Planning Policy (SPP 2.6), Accommodate is one of the four options in the agreed adaptation hierarchy. This option suggests the continued use of the land supported by changes to building methods, land uses, planting or other way to extend the use and enjoyment of the coastal environment.

Accommodate options aim to utilise design and management strategies which render the risks as acceptable. Requires review of the Local Planning Scheme, with potential inclusion of new planning controls for built form and structures.

Adaptation

Changes made in response to the likely threats and opportunities arising from climate variability and climate change.

Adaptation Pathway

Adaptation planning is about being ready to manage the risks and impacts of coastal processes a location experiences, by planning for the most appropriate decisions and options to implement over time.

A flexible adaptation pathway approach enables the establishment of a decision-making strategy that is made up of a sequence of decision points over time, preventing a decision-maker from being locked into a risk treatment option (and associated risk management measures), which may not be appropriate for dealing with the long-term problem. The intent is for decision-making to be responsive to changing circumstances over time.

Annual Recurrence Interval (ARI)

An annual recurrence interval is sometimes also known as 'return period'. It is the average number of years that it is projected will pass before an event of a given magnitude occurs. For example, a 50 year ARI event would on average happen every 50 years.

Assets

Something that has value to the decision-maker, community and stakeholders – this can be tangible or intangible, includes consideration of risk and liabilities, and can be positive or negative at different stages of the assets life.

Assets may be natural or man-made and include:

- Beach
- Foreshore reserve (including dunes, flora and fauna)
- Foreshore reserve amenity (including things like car parks, paths, public ablutions, barbeque/ picnic/shade areas, playgrounds, infrastructure for public safety and pedestrian access structures such as ramps, stairs and paths)
- Marinas
- Recreational boating facilities
- Facilities to benefit the broader public (such as cafés and restaurants)
- Surf life-saving facilities
- Commercial and residential land
- Protection structures such as groynes, seawalls and sand nourishment.

Atoll

A ring-shaped island, including a coral rim that encircles a lagoon partially or completely. There may be coral islands on the rim.

Avoid

Under SPP 2.6, Avoid is one of the four options in the agreed adaptation hierarchy.

This option aims to eliminate the risk of coastal hazards by avoiding development and assets in areas that are vulnerable to coastal hazards through planning controls. Requires review of the Local Planning Scheme and potential changes to zoned areas or development rights.

CHRMAP (Coastal Hazard Risk Management and Adaptation Plan)

A study that identifies the key hazards and assesses the risk to assets of coastal erosion and inundation.

Prepared under the State Planning Policy 2.6 – State Coastal Planning Policy (found at https://www.wa.gov.au/government/publications/state-planning-policy-26-coastal-planning), and in accordance with the *Coastal Hazard Risk Management and Adaptation Planning Guidelines* (2019).

Coastal Processes

Any action of natural forces on the coastal environment (and for the purposes of a CHRMAP, natural forces that affect land areas).

Coastal Zone

Area of water and land that may be influenced by coastal processes. This includes tidal areas of the lagoon or inland water bodies.

Do Nothing

Under SPP 2.6, Do Nothing assumes that all levels of risk are accepted, that there is no need for change in the existing controls, and therefore no action is implemented (i.e. no controls are implemented to treat known coastal risks).

Erosion

Refers to shoreline movement where the shoreline shifts landward as a result of sediment being transported away by waves, winds and currents, reducing the size (width) of a coastal foreshore reserve and the distance to an asset on the adjoining land.

Fringing Reef

One of the three main types of coral reef. It is distinguished from the other main types – barrier reefs and atolls – in that it has an entirely shallow backreef zone (lagoon) or none at all.

Habitat

The areas in which an organism and/or assemblage of organisms lives. It includes the abiotic factors (e.g. substrate and topography), and the biotic factors.

Inundation

The flow of water onto previously dry land. It may either be permanent (for example due to sea level rise) or a temporary occurrence during a storm event.

Inundation does not include circumstances where groundwater may sit at the surface of land and be unable to infiltrate back into the soil.

Intolerable Risk

Risk that is unacceptable in any circumstance or at any level.

Longshore

Parallel to the shoreline.

Multi-Criteria Analysis

A decision-making tool that supports the prioritisation of risk management options using multiple criteria as reviewed by the community and government stakeholders.

Mean Sea Level (MSL)

The average surface level of coastal bodies of water (from which elevation may be measured).

No Regrets

Under SPP 2.6, no regrets options include a range of assessments and works that may be required to fill gaps in knowledge prior to a preferred risk treatment option being selected. Aims to ensure that ad hoc decisions are not made that impact more beneficial options being implemented.

Planned and Managed Retreat

Under SPP 2.6, Planned and Managed Retreat is one of the four options in the agreed adaptation hierarchy. This option aims to remove vulnerability to coastal hazards by relocating or abandoning assets that are at risk, thus allowing ecosystems to move landward.

In the context of CKI, Planned and Managed Retreat can include any of the following pathways

1. Leaving assets unprotected, assuming that any loss is acceptable and that action will only be taken for minor repairs to maintain public safety.
2. Minor Asset Relocation for items that have shorter life cycles and would typically be replaced before becoming vulnerable. This approach requires sensible asset replacement outside of vulnerable areas.
3. Services Relocation for services (power, water, roads) that will become vulnerable before their typical replacement cycle. This approach requires investment in relocating more expensive services as soon as practical, outside of vulnerable areas.
4. Long Term Settlement Planning for the Settlement areas involving engagement in land use planning, staging and implementation mechanisms. All options will be considered, including resilience measures (revegetation/ sand nourishment) and protect options, as well as settlement relocation which may be necessary.
5. Planning Controls for Managed Retreat, involving the introduction of specific legislation and policy to allow continued use until such time as impacts occur, whilst restricting new development.
6. Voluntary acquisition, where properties are acquired over time to enable removal of development over time, thus removing vulnerability.

Whilst the Guidelines provide instruction for Planned and Managed Retreat in *Appendix 4; Planned or Managed Retreat - existing planning framework and instruments,* in CKI Planned and Managed Retreat is more complex, as any suitable land within the island context is also subject to coastal hazards.

Protect

Under SPP 2.6, Protect is one of the four options in the agreed adaptation hierarchy. This option aims to delay the impact of coastal hazards through the use of hard structures and other soft solutions to modify the land to protect assets from the sea. Protect can include methods such as sand nourishment, groynes, seawalls, reefs, breakwaters, levees, land reclamation and planting and revegetation.

Rehabilitation

The re-establishment of vegetation and other ecological attributes, acknowledging that the area and the environmental asset will remain modified.

S1, S2, S3 and S4

The four data sets used to determine coastal hazards as required by SPP 2.6, where;

S1 - The current risk of storm erosion (based on historical storms).

S2 - Historic shoreline movement trends determined by reviewing available monitoring information and historical coastline photographs.

S3 - The measurement which is required by State Planning Policy to allow for projected sea level rise.

S4 - The allowance for the current risk of storm surge inundation.

Sand Nourishment

Sand nourishment is one possible protection adaptation pathway to coastal hazards. It may be a standalone measure for protection, or be used to improve the beach amenity when used in combination with other adaptation measures such as a seawall.

It is considered to be a 'soft' management option and usually mimics natural beach and dune systems.

Sandy Coast

Comprises unlithified and/or unconsolidated sediments, rock is either not present or not dominant. They typically feature gently to moderately sloping shores and are often backed by dunes or beach ridges, which may contain dune blowouts. The shoreline can quickly alternate between accretion and erosion but is likely to move landward as a result of sea level rise.

Sediment Cell

A length of shoreline in which interruptions to the movement of sediment along the beaches or near shore sea bed do not significantly affect beaches in the adjacent lengths of coastline. Within a sediment cell the sediments sources, transport pathways and sinks should be clearly definable.

Storm Surge

The increase in water level at the shoreline due to the forcing of winds (wind-setup) and atmospheric pressure.

Trigger

A pre-determined point that is set to 'trigger' the commencement of planning and /or implementation action of a risk management option to avoid crossing a 'threshold' into unacceptable risk.

Unacceptable Risk

These are risks that require action or treatment, as the current risk is intolerable to the community, the economy or the environment.

Vulnerability

The underlying properties of an 'asset' which result in susceptibility to a risk source that can lead to an event with a consequence.

Vulnerable Development

Development that is categorised as being at a level of high or extreme vulnerability, and that has limited adaptive capacity in accordance with SPP 2.6.

Wave Overtopping

Water carried over the top of a structure or landform due to wave run-up or surge action exceeding the crest.

Contents

1 Introduction

The Cocos (Keeling) Islands (CKI) is an External Territory of Australia. It is located in the Indian Ocean, approximately 2,950 km north-west of Perth, and 900 kilometres south-southwest of Christmas Island. There are 27 coral islands with a total land area of 14 square kilometres. Apart from North Keeling Island, which is 30kms away from the main group, the islands form a crescent-shaped atoll surrounding a lagoon.

The 26 reef islands that make up the Southern Keeling Islands sit on the reef rim and partially enclose a main central lagoon. The idyllic coral sand islands have an area of 14.2 square kilometres with 26 kilometres of coastline, an average elevation of 1.5 metres (m), and a maximum elevation of 9m respectively.

The lagoon has an area of 102 square kilometres, consisting of a shallow southern region with a mean depth of 3m and a deeper northern section with a water depth of up to 10m to 20m connected to the two major entrances, the Western Channel and the Port Refuge channel (RHDHV, 2021a) (*Figure 7*).

The two inhabited islands are Home Island and West Island. Home Island is home to the Cocos Malay community and the Shire of CKI office, and contains large areas of vacant land which are unutilised or underutilised for storage or similar.

West Island comprises the airport, government offices, homes of government and contracted employees and some private residents, and also contains large areas of vacant land which are unutilised or underutilised.

The two islands are inhabited by approximately 593 people (ABS, 2021). Subsequent references to CKI refer to Home Island and West Island.

The islands sit within a significant natural environment. The Cocos (Keeling) Islands Marine Park was proclaimed under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999* in March 2022. The park covers 467,054 square kilometres of the Indian Ocean surrounding Cocos (Keeling) Islands. Under the EPBC Act, the Director of National Parks is responsible for managing marine parks (supported by Parks Australia).

Economic activity on CKI is limited, with the public sector providing the majority of the employment, through administration, education, health and local government services. The largest private sector activity is the provision of services to the community, often under contract to the Australian Government. Small businesses provide a range of goods and services including accommodation, tourism, workshop/mechanical services, gardening and cleaning (DITRDCSA, n.d.).

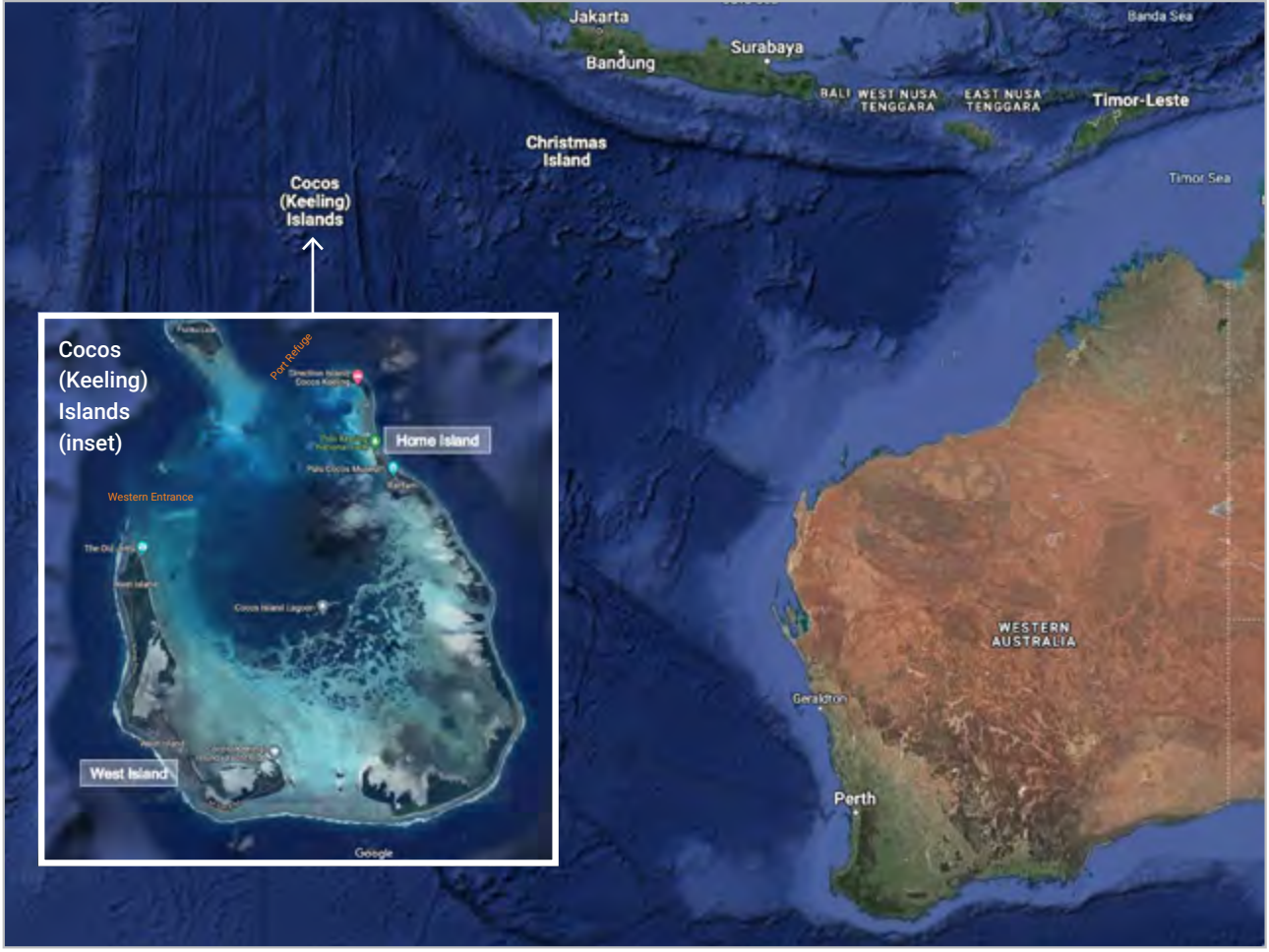


Figure 7: The Southern Keeling Islands and (inset) showing Home Island and West Island (Google, 2022)

CKI is part of the Australian Indian Ocean Territories (together with Christmas Island). Due to an absence of locally specific legislation or regulation applied at the Federal level, and in order to support appropriate decision making, CKI operates predominantly under the legislation of Western Australia, meaning that relevant WA legislation is applied, including planning legislation.

The Australian Government acts as both the Federal and State-level government on CKI. The responsibility extends from managing Australia's ongoing strategic policy interests, to the provision of State-type services, such as education, water, electricity generation and distribution, community services and wastewater. Essential services are delivered through Service Delivery Arrangements (SDAs) with WA Government agencies, or through contractual arrangements with commercial operators.

The *Cocos (Keeling) Islands Act 1955* (the CKI Act) provides the legislative basis for the Territory's administrative, legislative and judicial system, and applies Western Australian (WA) legislation as Australian Federal laws on CKI.

The Australian Government Minister with responsibility for the Territories is vested with all powers under these applied WA laws, as well as the power to vest or delegate those powers.

Since 1992 the Australian and WA Governments have been entering into Service Delivery Arrangements for the provision of services to CKI. As of 1 June 2022, there were 39 arrangements with agencies of the WA Government providing 51 services to CKI. The underlying principle of these arrangements is to ensure that the CKI community are provided with services and infrastructure comparable with those provided to equivalent WA mainland communities.

The Shire of CKI (the Shire) has the same legislative powers and responsibilities as a local government on the Australian mainland under the *Local Government Act 1995 (WA)(CKI)*.

The Coastal Context

It is internationally recognised that the mean sea level has been rising globally since the nineteenth century and is projected to rise at an increasing rate in the future (IPCC, 2021). Rising sea levels and intensifying storm activity will increase the risk of coastal inundation, storm erosion and long-term shoreline recession on CKI.

State Planning Policy No. 2.6 - State Coastal Planning Policy (SPP 2.6) (WAPC, 2013a) is the policy document guiding coastal planning under the applied WA legislation on CKI. SPP 2.6 recognises and responds to regional diversity in coastal types, requires that coastal hazard risk management and adaptation is appropriately planned for, encourages innovative approaches to managing coastal hazard risk, and provides for public ownership of coastal foreshore reserves.

Whilst SPP 2.6 does not fully allow for the site specific challenges of a coral atoll, it is highly likely that the impacts of mean sea level rise will be experienced in a way consistent with the policy. Monitoring over time will enable continued responsiveness to the coral atoll environment.

The objectives of SPP 2.6

- Ensure that the location of coastal facilities takes into account coastal processes, landform stability, coastal hazards, climate change and biophysical criteria;
- Ensure the identification of appropriate areas for the sustainable use of the coast for housing, tourism, recreation, ocean access, maritime industry, commercial and other activities;
- Provide for public coastal foreshore reserves and access to them on the coast; and
- Protect, conserve and enhance coastal zone values, particularly in areas of landscape, biodiversity and ecosystem integrity, indigenous and cultural significance.

SPP 2.6 recommends authorities responsible for management of land and assets within coastal areas develop a Coastal Hazard Risk Management and Adaptation Plan (CHRMAP) to guide land use and development decision making in coastal zones. The WAPC has also developed specific CHRMAP guidelines to assist the preparation of CHRMAPs (WAPC, July 2019).

In 2019 the Australian Government in collaboration with DPLH and the Shire commenced the process of completing a CHRMAP for CKI. The first stage of this was the preparation of the Cocos (Keeling) Islands Coastal Vulnerability Study (CVS) (RHDHV, 2021a) for Home Island and West Island. The CVS identifies present and potential future coastal hazard risks, and assesses the vulnerability of built and natural assets to erosion and inundation hazards, in accordance with the requirements of SPP 2.6 and the CHRMAP Guidelines.

The CVS found that CKI's coastline is exposed and vulnerable to coastal processes, including erosion and inundation. Modelling detailed in the CVS indicates that over time, CKI is likely to become increasingly vulnerable to the impacts of sea level rise, storm surges and any changes in sediment transport and natural sediment stores. As it changes it can affect the infrastructure (e.g. footpaths, roads, houses, tourist accommodation, beach access, services) in the coastal zone, as well as how the coast can be used. So that the coast can continue to be used and enjoyed, it is important to understand coastal hazards and the vulnerability of the coastal area.

A short summary including extracts of the CVS is included in *Appendix A.*

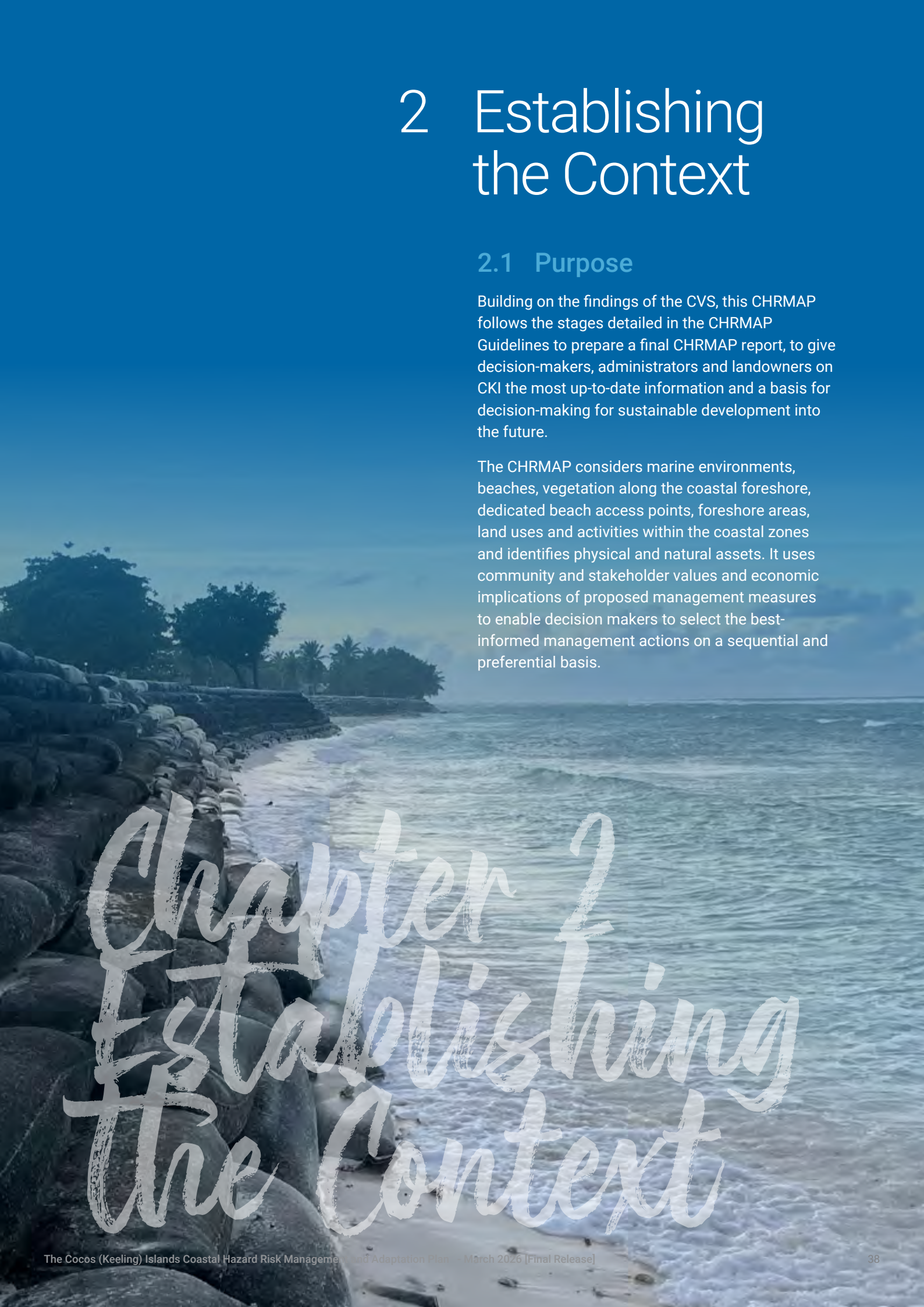
The full CVS is also available here (https://www.wa.gov.au/government/document-collections/indian-ocean-territories-regional-planning).

2 Establishing the Context

2.1 Purpose

Building on the findings of the CVS, this CHRMAP follows the stages detailed in the CHRMAP Guidelines to prepare a final CHRMAP report, to give decision-makers, administrators and landowners on CKI the most up-to-date information and a basis for decision-making for sustainable development into the future.

The CHRMAP considers marine environments, beaches, vegetation along the coastal foreshore, dedicated beach access points, foreshore areas, land uses and activities within the coastal zones and identifies physical and natural assets. It uses community and stakeholder values and economic implications of proposed management measures to enable decision makers to select the best-informed management actions on a sequential and preferential basis.



2.2 Aims and Objectives

SPP 2.6 informs and guides decision making by the WAPC, and guides local governments, state government agencies and other decision-makers on those aspects of policy concerning coastal zones that should be taken into account in land use planning decision-making.

SPP 2.6 recommends coastal hazard risk management and adaptation planning be undertaken by responsible management authorities or proponents in an area that is at risk of being affected by coastal hazards over the planning timeframe (100 years).

It provides for implementation through state planning policy, regional strategies, local planning strategies and regional and local planning schemes. Implementation will also occur through the day-to-day decision-making on zoning, structure plans, subdivision, strata subdivision and development applications, and actions of decision-makers in carrying out their responsibilities.

Aims

The aim of this CHRMAP is to provide a land use and development decision-making framework for CKI, to guide the Australian Government, the Shire, landowners and other key stakeholders to:

- Ensure land in identified coastal zones is continuously provided for coastal foreshore management, public access, recreation and conservation;
- Ensure public safety and reduce risks associated with coastal erosion and inundation;
- Avoid and address inappropriate land use and development of land within and outside of the settlements at risk from coastal erosion and inundation; and
- Ensure land use and development does not accelerate coastal erosion or inundation risks or have a detrimental impact on the functions of public reserves.

Objectives

The specific objectives of the CHRMAP are to:

- Improve the understanding of coastal features, processes and hazards in the study area;
- Gain an understanding of the vulnerability of the coastal zones;
- Identify significant vulnerability trigger points and respective timeframes for the study area management units (MUs) to establish when short and long-term risk management and adaptation action is required;
- Identify assets (natural and man-made) and the services and functions they provide in the coastal zones;
- Identify the value of the assets that are vulnerable to adverse impacts from coastal hazards;
- Determine the likelihood and consequence of the adverse impacts of coastal hazards on the assets and assign a level of risk, identify possible management and adaptation measures ('actions') and how these can be incorporated into decision making;
- Engage stakeholders and the community in the planning and decision-making process; and
- Ensure that stakeholders understand the implications of possible treatment options including trade-offs, costs and possible negative aspects.

These objectives align with the Shire's Strategic Community Plan 2016 – 2026 and Corporate Business Plan 2018/2019 – 2020/2021 which identify key strategic objectives and desired outcomes for four key areas (economic, social, environmental and civic leadership).

For 'environment', one of the objectives is to advance CKI while keeping its island character, with associated outcomes of retaining the islands environment and for future development to be sympathetic to this environment.

Identified challenges include protecting the natural environment and planning for and adapting to climate change, including coastal erosion. Strategies include increasing the environmental credentials of CKI, protecting the island environment and limiting activities that exacerbate coastal erosion.

The CHRMAP objectives address the Shire's identification of coastal erosion and adapting to climate change as key issues. The CHRMAP also works to a strategic approach to managing coastal land use, future development and the impacts of coastal processes.

2.3 Scope

The CHRMAP adds to the present understanding of CKI's coastal hazard risks evaluated in the CVS, and provides a framework of adaptation pathways and management options so decision-makers can make strategic, well-informed and proactive decisions to adapt to the anticipated changes to the coastline and coastal zones from natural coastal processes and human activities.

The CKI CHRMAP assessment is structured in the following CHRMAP stages (*Figure 8*), and the risk management process flow chart adapted from the CHRMAP Guidelines (WAPC, July 2019) at *Figure 9*.

Figure 8: CHRMAP stages per the CHRMAP Guidelines (WAPC, 2019)

Stage 1 – Establish the Context

1. Project Initiation – confirm the purpose, objectives, scope, study area, community and stakeholder engagement.

Stage 2 – Risk Identification

2. Hazards and assets – review and update (as required) the hazard and assets identified in the CVS, group assets sharing values or management actions (where appropriate), and prepare fit for purpose mapping and infographics to share vulnerability information and contextualise value exercises for the community and stakeholder engagement process.

Stage 3 – Vulnerability Assessment

3. Review likelihood and consequence – based on outcomes of consultation, review likelihood and consequence scales in the CVS, update assets' exposure and sensitivity to coastal hazards and consequences of each asset being affected by erosion/inundation.
4. Update risk assessment to incorporate changes to identified assets and to the likelihood and consequence scales for the assets, and add additional assets and values to hazard maps and risk evaluation process.

Stage 4 – Risk Evaluation

5. Identify existing controls/mitigations already in place which may reduce the potential impacts of coastal hazards.
6. Determine acceptable vulnerability levels for each asset or asset group affected by coastal hazards.
7. Identify assets for which risk treatment is required to reduce risks to an acceptable level.

Stage 5 – Risk Treatment

8. Identify adaptation options – potential risk management and adaptation measures to reduce risks to an acceptable level using the management controls hierarchy in SPP 2.6.
9. Evaluate adaptation options - the suitability of risk management and adaptation options using a Multi Criteria Analysis (MCA); a Cost Benefit Analysis (CBA) if staging of options is relevant; and a Benefit Distribution Analysis (BDA) if a proposed adaptation option can be demonstrated to substantially benefit a group of stakeholders that can be reasonably isolated as vulnerable due to a lack of action.

Stage 6 – Implementation

10. Prepare implementation strategy (adaptation pathway and implementation plans) – develop adaptation pathways for decision making strategies that are responsive to changing circumstances, with subsequent development of short (0-25 years), medium (25-50 years) and long-term (50-100 years) implementation plans required to reduce risks to an acceptable level. This includes the identification of key performance indicators, action triggers and monitoring requirements.

Stage 7 – Monitor and Review

11. Develop monitoring plan – monitoring and review requirements to ensure risk management measures remain relevant, aligned with the short-term implementation plan and to provide for decision making strategies that are responsible to changing circumstances over the medium and long-term.

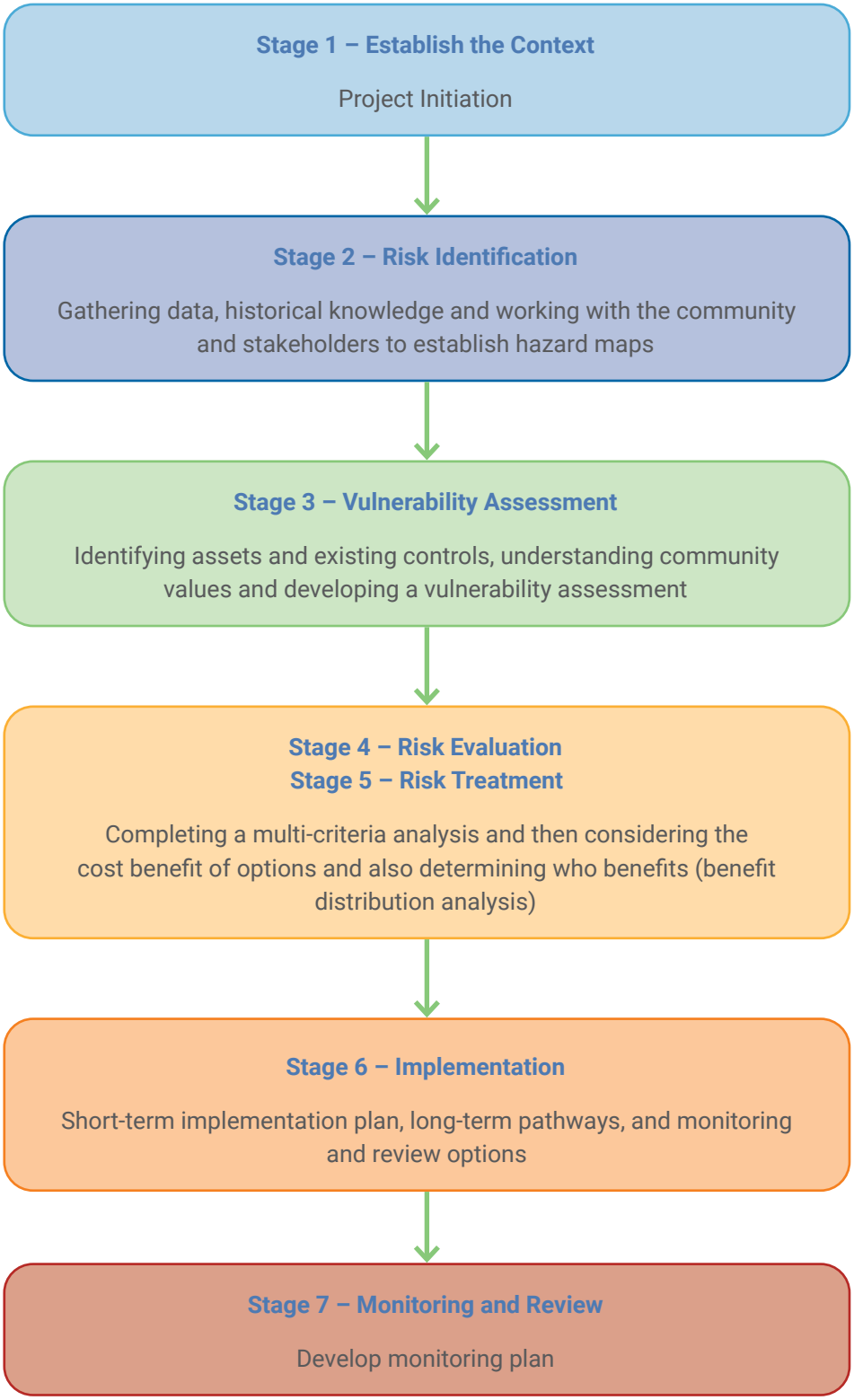


Figure 9: CHRMAP stages, adapted from CHRMAP Guidelines (WAPC, 2019)

2.4 Study Area

The CHRMAP study area is focused on Home Island and West Island in the South Keeling Islands (see *Figure 7* for regional context).

Islands within CKI are sandy and low lying with an average elevation of 1.5m above mean sea level. The highest elevation present across the islands is 9m above mean sea level.

South Keeling Islands are surrounded by a coral fringing reef, broken up by two deep entrances known as the Western Entrance and Port Refuge. *Figure 10* provides a more detailed map of the many islands making up the CKI atoll (note: errors and omissions are entirely unintentional).

Shorelines within the South Keeling Islands are either ocean facing shores around the external perimeter of the atoll or lagoon facing shores around the internal perimeter of the atoll.

Previous coastal investigations undertaken on CKI have identified that due to its remote Indian Ocean location as well as its low-lying geography, vulnerability to coastal hazard and the potential impacts of climate change are perhaps the most critical issues affecting the future sustainability of human settlement on CKI (RHDHV, 2021a).

Cocos (Keeling) Islands Marine Park, proclaimed in March 2022, protects extensive coral reef and lagoon habitats surrounding the Cocos (Keeling) Islands and many migratory, threatened and endemic species supported by these habitats.

2.4.1 Home Island

Home Island is located on the eastern side of CKI. It is low lying and susceptible to coastal flooding, especially the foreshore adjacent to the lagoon. Most shorelines on Home Island have been stable and infrastructure on the ocean coast is reasonably setback in most locations. Some infrastructure adjacent to the lagoon coast has a narrow foreshore, especially Jalan Pantai (see *Figure 11* and *Figure 12*). Three seawalls have been built on lagoon facing beaches in the last ten years including along Jalan Pantai.

The northern shoreline of Home Island has been altered through human modification. The northern end of Home Island, known as Pulu Gangsa, was once a separate island that was joined to Home Island in the late 1940s by filling in the shallow causeway between the two islands. Over time sand has slowly filled the gap between the two islands and they have merged into one island. Since the reclamation Pulu Gangsa has suffered significant erosion on its northern and western sides. (RHDHV, 2021a)

North of Pulu Gangsa is Prison Island. After the reclamation and joining of Home Island and Pulu Gangsa, Prison Island eroded. Today it is a small sand island with little remaining vegetation (see *Figure 13*). The erosion is likely to be a result of changes to longshore sand transport pathways following the joining of Pulu Gangsa to Home Island (RHDHV, 2021a)

Figure 10: The Study area, including local island nomenclature (Source: The Clunies-Ross Cocos Chronicle) and approximate location of family Pondoks in red (Calmy Planning and Design 2015 and CHRMAP author observations) (island shown in grey are disappearing or no longer extant) (Aerial Image Source Google 2023)

Figure 11: Jalan Pantai on Home Island prior to seawall construction (1) indicating the low elevation of the road and narrow foreshore, 29 May 2009 (DoT, 2010)

Figure 12: Jalan Pantai on Home Island prior to seawall construction (2) indicating the low elevation of the road and narrow foreshore, 29 May 2009 (DoT, 2010)

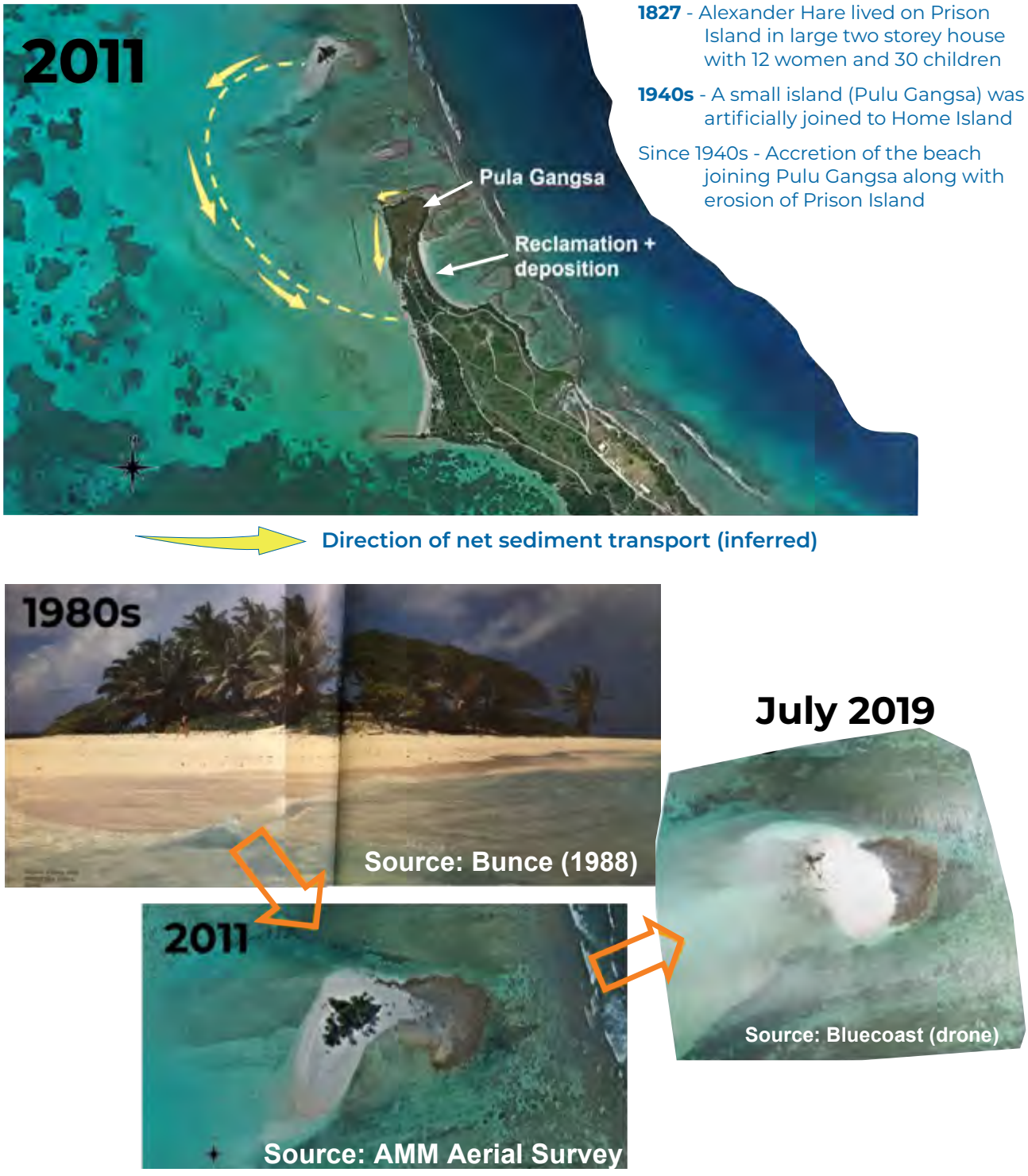


Figure 13: Erosion of Prison Island and the joining of Home Island and Pulu Gangsa (RHDHV, 2021a)

2.4.2 West Island

West Island is the largest island in the CKI group. It has an elongated shape with predominately sandy shoreline. Development is concentrated around the airport and West Island Settlement in the southern part of the island.

Development on West Island along the ocean coast has a very narrow foreshore buffer. The island has a history of chronic erosion along the western ocean facing shore. Construction of coastal protection structures on the island since the 1970s indicates that beach erosion has been an ongoing concern (see *Figure 14*). Coastal protection structures on West Island have been predominately built to protect the settlement.

Erosion and coastal flooding during storm events has been recorded in the last decade. Two large storm events in 2013/2014 resulted in erosion threatening the road on West Island. In July 2018 the islands were subject to another large storm event that resulted in widespread coastal erosion and coastal flooding. During this event existing coastal protection structures failed, and roads were damaged (see *Figure 15* and *Figure 16*).

2.4.3 Study Area Management Units

The study area has been divided into nine management units. The management units define sections of the coastline which share similar characteristics and provides a natural framework for adaptation and management.

Table 7 provides a description of the characteristics of each management unit and they are shown spatially in *Figure 17* and *Figure 18*. Typical photos of each unit provided in *Figure 19*. Further information on the characteristics of each management unit can be found in RHDHV (2021a).

Whilst the remaining islands in the atoll have not been formally assessed for this CHRMAP, some assumptions are made for the impacts of coastal hazards on these islands, and they are discussed under 'uninhabited islands'.

The management units are consistent with the sectors used by RHDHV (2021a).

Figure 14: Trannies Beach erosion and failure of seawall following July 2018 event (RHDHV, 2021a – source: Karen Willshaw)

Figure 15: Recent erosion at West Island settlement (circa 2021) and coastal protection structures introduced to protect the West Island settlement (a) older vertical seawall (b) Seabee seawall (c) GSC revetment and (d) older groynes (RHDHV, 2021a)

Figure 16: Airforce Road flooding during July 2018 storm event (RHDHV, 2021a – source: David McKinney)

Table 7: Management Unit Characteristics.

MANAGEMENTUNIT	CHARACTERISTICS
MU1 West Island Settlement	This ocean facing shoreline is adjacent to the main settlement on West Island. This shoreline has experienced chronic erosion and is largely protected by coastal structures.
MU2 West Island Ocean Beaches North	This ocean facing coastline on the northern half of West Island has experienced erosion with relatively large erosion rates for the northern extents. The coastline is largely undeveloped but contains several important assets vulnerable to erosion including recreational assets (Trannies Beach) and infrastructure assets (Sydney Highway).
MU3 West Island Lagoon Beaches	The northern lagoon beaches are dynamic and eroding while central and southern sections are more stable. The shoreline is largely undeveloped except for areas adjacent to the airfield and Old Fuel Jetty.
MU4 West Island Rumah Baru	The Rumah Baru Port facility was constructed in 2011 as a ferry terminal for services to Home Island and Direction Island. This section of shoreline has been relatively stable, with some recent accretion in the lee of the offshore ferry terminal leading to siltation at the boat ramp, which is no longer operational as a result.
MU5 Scout Park/Kite Beach	This section of shoreline has been accreting (growing) over recent years. It also has little exposure to storm waves and is not susceptible to storm erosion. It is an important recreational area for tourists as this is where lagoon tours depart from and visiting kite boarders can often be found.
MU6 West Island, Ocean Beaches South	This section of coastline contains the narrowest section of the island that is low-lying and susceptible to both inundation and erosion . The main assets in this section are the road which provides access to the Defence site, Scout Park and Kite Beach and the southern extent of the runway.
MU7 Home Island Settlement	This lagoon facing shoreline covers the length of the settlement including the Jalan Pantai seawall and the southern coastline. The shoreline here has been relatively stable, and inundation is the greater coastal hazard at this location.
MU8 Home Island Ocean Beaches	This ocean facing shoreline has been stable or accreting in recent years but is susceptible to coastal erosion as it has the greatest exposure to storm events and tropical cyclones.
MU9 Turtle Beach	The lagoon facing shoreline on the north of the island is eroding in the north but accreting to the south. It is used for sand extraction for coastal management and other purposes across the islands. It is also an important recreation beach.
Uninhabited Islands	The uninhabited islands of the CKI atoll each have a lagoon facing shoreline and a ocean facing shoreline, with varying degrees of exposure to significant storm events and tropical cyclones. Many of these islands have small structures, known as pondoks, which are used by locals for recreation, cooking and camping. Like the inhabited islands, the ocean facing shorelines are susceptible to coastal erosion. The lagoon facing shores of the northern-most islands, including Direction Island and Horsburgh Island are also susceptible to erosion, whilst the southern-most islands are experiencing some limited accretion on lagoon facing shores.

Figure 17: Management Units for West Island

Figure 18: Management Units for Home Island

MU1: West Island Settlement - unmanaged

MU1: West Island Settlement - GSC sandbag seawall

MU1: West Island Settlement - Seabee seawall

MU 2: West Island Ocean Beaches - unmanaged

MU 2: West Island Ocean Beaches - GSC sandbag seawall under repair

MU 2: West Island Ocean Beaches - GSC sandbag seawall Trannies Beach

MU 2: West Island Ocean Beaches - Trannies Beach infrastructure

MU3: West Island Lagoon Beaches

MU 4: West Island Rumah Baru

Figure 19: Typical photos of each management unit

MU 5: Scout Park/Kite Beach - Yacht Club

MU 5: Scout Park/Kite Beach - Recreation and tourism activities

MU6: West Island, ocean-facing (south)

MU 7: Home Island Settlement - Jalan Pantai seawall

MU 7: Home Island Settlement - Ferry wharf and infrastructure

MU 8: Home Island Ocean Beaches

MU 9: Turtle Beach

Uninhabited Islands - erosion at Direction Island

Uninhabited Islands - Pondok at Horsburgh Island

Figure 19:Typical photos of each management unit (continued)

2.5 Community and Stakeholder Engagement

It is imperative to complete coastal hazard planning alongside the community affected by the decision-making process. The engagement process for this CHRMAP provided multiple opportunities for the community on CKI to be involved. It also provided opportunities for stakeholders on CKI, in Perth and in locations associated with Australian Government functions to be involved.

The most desirable outcome of the CHRMAP process is cross-government support for specific land use planning controls and actions for areas vulnerable in the short-term (0 – 10 years) and for specific planning and implementation pathways and triggers for longer term risks. These decisions are based on stakeholder consultation and engagement plus economic, environmental and cultural considerations.

The project team has carried out stakeholder engagement throughout the CHRMAP stages. *Figure 20* and *Table 8* depicts an overview of engagement approach in each of the CHRMAP stages to affirm the deliverables.

Further details on engagement activities undertaken including methods and specific feedback per stakeholder group and location (i.e., Home Island, West Island) is presented in the CKI CHRMAP Engagement Outcomes Summary Report (*Appendix C*).

Figure 20: Engagement approaches in CHRMAP Stages adapted from the CHRMAP Guidelines (WAPC, 2019)

Table 8: Engagement in each of the CHRMAP stages

CHRMAP STAGE	ACTIVITY	STAKEHOLDER/ AUDIENCE	ENGAGEMENT METHODS
Stage 1 – Establish the Context	Develop Community and Stakeholders Engagement Plan	Project Control Group Australian Government	Meetings
	Build on information - check values related to coastal assets	Australian Government State Government Elected Members Shire CRG Community groups incl Elders Landowners Businesses General community Schools Service providers Funding bodies Other coastal stakeholders	Shire webpage Online platform - maps, asset points, surveys Introductory letter/email Supporting material (posters, infographics in English and Cocos Malay, reproduction of Coastal Vulnerability Assessment maps) Social media - primarily Facebook Stakeholder meetings in Perth and on-island Workshops in Perth On-island workshops, information sessions and drop-in sessions Meetings/ telephone calls Open Days on-island Elected Member briefings
Stage 2 – Risk Identification	Updated list of coastal assets		
Stage 3 – Vulnerability Assessment	Update risks, vulnerability and consequences		
Stage 4 – Risk Evaluation	Consider tolerances and acceptance of vulnerability in relation to values, assets and Australian Government needs		
Stage 5 – Risk Treatment	Identify adaptation options and pathways for valued assets Multicriteria analysis considering values, assets and needs Cost benefit analysis of risk treatment options Benefit Distribution Analysis of risk treatment options Assess funding options		
Stage 6 – Implementation	Prepare short-term implementation plan Identify long-term pathways		
Stage 7 – Monitor and Review	Develop monitoring plan	Coastal managers (TBD) Australian Government through Service Delivery Arrangements with WA Agencies.	NA
CHRMAP Reporting and Finalisation	Integrate information into draft CHRMAP Advertise draft CHRMAP Finalisation and adoption of CHRMAP	All audiences	Project webpage, formal communications channels, emails and social media. Elected Member briefings

2.5.1 Engagement Objectives

Engagement objectives were adapted from the overall objectives in the CHRMAP Guidelines (WAPC, July 2019), which are to:

- Ensure that development and the location of coastal facilities takes into account coastal processes, landform stability, coastal hazards, climate change and biophysical criteria;
- Ensure the identification of appropriate areas for the sustainable use of the coast for housing, tourism, recreation, ocean access, maritime industry, commercial and other activities;
- Provide for public coastal foreshore reserves and access to them on the coast; and
- Protect, conserve and enhance coastal zone values, particularly in areas of landscape, biodiversity and ecosystem integrity, indigenous and cultural significance.

The overall objective of the engagement process is to facilitate an understanding of coastal challenges, hazards and vulnerability, and to select appropriate adaptation strategies to respond to the identified coastal risks.

Specific engagement objectives are to:

- **Inform** the community and stakeholders about the extent of potential coastal hazards and the adaptation strategies available to respond to those hazards;
- **Explain** Australian, state and local governments' responsibilities and capacity to respond to potential coastal hazards, per the CKI governance framework;
- **Understand** community and stakeholder values along the coastlines; and
- Invite the community to bring their **local knowledge, expertise and lived experience** to the process and give them adequate opportunity to contribute in a way that suits their needs and circumstances.
- Ensure that the community and stakeholders' **advice and recommendations are incorporated into the decisions** to the maximum extent possible, and that this encourages a sense of community ownership for the CHRMAP
- Ensure the engagement is **fair, equitable, transparent and honest**
- **Develop positive relationships** between all tiers of government and the community
- Gain an understanding of the community's preferred methods of **continued engagement** with local, state and Australian governments

2.5.2 Meaningful Outreach

For this project in particular, it was (and remains) crucial that engagement with members of the community who are culturally and linguistically diverse is tailored appropriately.

Explaining the scientific concepts of coastal processes can be challenging generally. It is more so where many community members are English as a Second Language (ESL) speaking population. According to Census 2021 for CKI, there are 86 households (70.5%) where a non-English language is used at home and amongst them, 126 persons (21.2%) identified as 'Uses other language and speaks English not well or not at all' (ABS, 2021). The dominant language spoken is Cocos Malay, a dialect which has its dominant origins in Malay and Betawi language.

Translation services for both written and spoken content were used in all stages of engagement:

- Home Island community representatives (predominantly ESL) told the CHRMAP project team that the Home Island community wished to be engaged on the CHRMAP through an 'Elders reference group' with appropriate translation support for ESL members.
- The CHRMAP project team held two workshops with Home Island Elders which were delivered through translation services by Imam Haji Adam and Adim Hajat (Shire of Cocos (Keeling) Islands Community Development Coordinator).
- The CHRMAP's on-island communication program with ESL community members was equivalent to engagement with English-speaking sectors of the community, albeit the presentation materials were more graphically-focussed in representation of technical concepts.

Additionally, CHRMAP communications targeting ESL community members were incorporated as follows:

- Project communications in 'The Atoll' newsletter were translated into Cocos Malay by local translators;
- The Shire of Cocos (Keeling) Islands posted project launch posters/information in English and Cocos Malay at the supermarket and other key locations on Home Island, at the ferry terminal and on the blackboard on West Island, and at its offices on both islands;
- The Community Resource Centre shared project communications materials provided by the project team with ESL community members and the Shire also engaged directly with ESL community about the project and advised them of on-island engagement and how to register to be involved.
- The draft CHRMAP Summary document was translated to Cocos Malay by local translators.

Significant support was provided for this project by local native Cocos Malay speakers. Notwithstanding the variety of methods used, it is apparent that the language used to described a CHRMAP is not easily translated in the Cocos Malay language, with many words required to explain certain concepts, and in some cases sentences including the same word more than once (e.g. 'hazard' and 'risk' both translate to 'danger', creating a heightened sense of concern amongst the community even in the document title).

Ongoing engagement as the CHRMAP progresses will need to continue to find ways to be accessible for all members of the community.

2.5.3 Coastal Values Engagement

Stakeholders were provided an opportunity to share their coastal values in Stage 2 of the project via an online platform project page, at information sessions, and at community and stakeholder values workshops on CKI and in Perth.

Online, the community and stakeholders were able to place values at/on specific locations along the coastline on an interactive online project website linked to the Shire's website. The online platform was also shared in local and Australian government newsletters, e-News and The Atoll, and on the Shire's social media. More than 100 people contributed in this stage.

Survey questions, mapping tool exercises and other values gathering activities were aligned with the CHRMAP Guidelines (WAPC, July 2019) and the values it articulates for consideration through this stage of the CHRMAP and specifically to be incorporated into the MCA in *Section 6.2 Multi-Criteria Assessment*.

These engagement outcomes provided the project team an understanding of community and stakeholder sentiment and confirmed values established in the CVS and any updates to values to be considered. These values informed the development and refinement of management actions for the CHRMAP.

2.5.4 Options Assessment Engagement

Once options were developed, further engagement on-island in Stage 5 of the project allowed for an open discussion about the various options available to the community for reducing vulnerability.

The engagement allowed for community to discuss options directly with planners, coastal engineers, and key decision makers, and shared how the MCA is completed and the associated cost to each treatment option.

The community and stakeholders were able to contribute to the MCA criteria and openly shared feedback on the short-term and long-term options.

It also allowed community members to recognise that each of the proposed adaptation options in the SPP 2.6 hierarchy has pros and cons, and that selection comprises a complex comparison of benefit, cost, who pays, how options impact established community values and the negative consequences of various options (e.g., the maintenance frequencies and effectiveness of seawalls and scouring at the terminus of different seawalls).

Engagement included direct discussions with Elders, Seniors and the schools, as well as drop-in sessions. In total, more than 70 people attended activities.

Preferred options in the short-term included sea walls, monitoring, revegetation, and minor asset relocations. In the long-term, protect (reclaim) and planned and managed retreat were both raised.

Whilst protect is preferenced, planned and managed retreat was not excluded, due to the high costs and disruption of reclaim options.

Community members on Home Island expressed that enjoyment is regularly impacted and is already intolerable around flooding events.

2.5.5 Draft CHRMAP Engagement

The final draft CHRMAP was advertised from January to June 2025. More than 400 people and organisations were engaged directly during that time, with more than 180 contributions prior to this final draft CHRMAP being prepared. Through this, the community has expressed a strong desire to be a partner in long-term planning for CKI.

A detailed summary report of that feedback can be found alongside this draft plan here.

2.6 Existing Controls

This section describes the natural, physical and planning controls that are in place and/or that are applicable to CKI and to the CKI CHRMAP.

There are limited physical and planning controls currently in place for the protection of the CKI coastlines and that would assist with land use and development decision-making within the coastal zones. Physical controls are primarily limited to seawalls made of Geosynthetic Sand Containers (GSC). GSCs have a relatively short design life (typically 10 to 15 years) which is largely determined by the condition of the fabric and bags, interlocking of the structure and local wave conditions.

Planning controls are limited to Federal and WA legislation, policy and guidelines as applied on CKI and provisions that articulate coastal processes and adaptation considerations, however, there is an absence of specific development controls in the local planning framework to deal with coastal hazard risk management and adaptation planning.

Recent storm events have severely damaged GSC structures on the islands, and there was noticeable increased erosion and inundation impacts on the coastlines observed by the project team in May 2022 since the earlier CVS. GSC structures are regularly repaired and replenished as required, however this is in response to site specific coastal hazards. Roles and responsibilities for strategic planning and maintenance of coastal protection structures are not clearly defined.

The upkeep of existing coastal protection structures and the funding and implementation of additional physical controls and management actions is not occurring through a planned and managed process on-island.

Section 7.2 Area-based Options details the specific coastal hazard triggers and management actions to respond to these, in accordance with SPP 2.6 and the applicable planning frameworks for CKI, and considering the identified coastal values (as informed by the community and stakeholders).

These management actions are linked to technical studies (*Chapter 3 Risk Identification*) that formed a part of the CHRMAP process, coastal management research into progressive and best practice management approaches, and coastal values on CKI.

Management actions for coastal protection over short and medium to long-term timeframes enable planning and decision making (with associated roles and responsibilities) that have associated economic, environmental and social benefits, for example protecting valued assets for the community and stakeholders, providing certainty of coastal protection for tourism industries on-island.

2.6.1 Natural coastal protection services

There are a number of natural features that have the capacity to support coastal protection, that are present on the islands.

The extensive coral reef surrounding CKI is part of the Cocos (Keeling) Islands Marine Park and provides some protection from waves. Coral are living structures that respond to ocean conditions including the water level, and historically rise as sea levels rise. Coral reefs act as natural breakwaters, reducing the strength of incoming ocean waves.

Whilst there are concerns around the ability of coral to keep pace with sea level rise due to ocean warming and acidification (see *Section 3.1*), there is also emerging research on supporting coral growth.

In the absence of a confirmed coral growth solution, the community can nevertheless work towards protecting the corals of the reef, by working with visitors and tourists to avoid damaging the reef as they swim, snorkel and recreate in boats.

Likewise, the right type of coastal vegetation is an important natural protection. This includes strong and deep rooted vegetation including mangroves which have a positive effect on wave action (dispersal). The community can protect coastal vegetation by keeping off coastal dunes, replanting vegetation and avoiding vehicle movement across vegetation. Access paths to the beach should be created sparingly.

The seagrass and reef habitats within the waters of the CKI Marine Park are also natural coastal protection services. Continued education on seagrass habitats, and protection of reef systems from human recreation activities can aid in the long-term preservation of these natural protective functions.

Finally, the retention of sand in the sediment transport system is important. As was seen by the loss of Prison Island, the sand in the system can be shifted out of equilibrium creating negative flow-on effects. Sand should only be harvested from the system if it can be proven that flow-on effects will be unlikely.

Image 1 Coral Reefs near the Direction Island

2.6.2 Constructed Controls

At the beginning of 2022, there were 14 coastal protection structures on CKI protecting built assets and foreshore land, ten on West Island and four on Home Island. The majority of the recorded coastal protection structures are seawalls built from GSC which are large bags locally filled with beach sand (*Figure 21*).

Seven GSC seawalls have been built in the last decade. The spatial location of each coastal protection structure can be found in *Figure 22* and *Figure 23*, and details of each asset can be found in *Table 9*.

Although most of the GSC seawalls have been constructed relatively recently, many are showing signs of deterioration and damage. GSCs have a relatively short design life (typically 10 to 15 years) which is largely determined by the condition of the fabric and bags, interlocking of the structure and local wave conditions. During a large storm event in July 2018 some GSC structures were severely damaged, and although subsequent repairs were undertaken many structures remain in a relatively poor condition.

Only three of the seawall structures were assessed as part of the CVS and CHRMAP as able to withstand erosion from a 100-year ARI event; William Keeling Geotextile Sand Container (GSC) seawall and the concrete slab seawall (seabee seawall) on West Island in the settlement, and Jalan Pantai GSC seawall on Home Island. These seawalls were assumed to have a remaining functional life of 15 years, assuming on-going maintenance. This design life is important, as some eight years have passed since the CVS.

The remaining functional life is an important consideration as it provides an indication of how long the protection structure can be expected to act as a 'control' reducing the vulnerability to erosion.

To support a range of uses across the islands, including filling of bags for GSC seawalls, a source of beach sand is needed. Sand is currently extracted from Turtle Beach and Rumah Baru for these uses (shown in *Figure 22* and *Figure 23*).

Figure 21: Photo of William Keeling GSC seawall as an example of a typical GSC seawall (RHDHV 2021b)

Figure 22: Existing controls on West Island

Figure 23: Existing controls on Home Island

Table 9: Summary of controls on Home Island and West Island (modified from RHDHV, 2021a)

CONTROL	TYPE	MANAGE-MENT UNIT	DATE CONSTRUCTED	CONDITION AS OF 2017	REMAINING DESIGN LIFE (APPROX.)
West Island					
Fuel farm seawall	GSC seawall	3	2012	Fair	8
Trannies seawall	GSC seawall	2	2012	Poor*	3
Sydney Highway seawall	GSC seawall	2	2015	Good	15
Settlement groynes (1 to 4)	Concrete planks between steel piles	1	1980s	Poor	5
Hospital seawall	GSC seawall	1	2013	Fair	8
William Keeling seawall	GSC seawall	1	2017	Good	15
Settlement concrete seawall	Seabee seawall	1	2000	Good	20
Settlement concrete seawall	Concrete planks between steel piles	1	1975	Poor	5
Runway seawall	GSC seawall	6	2012	Good†	15
Twiss seawall	GSC seawall	6	2017	Good‡	15
Rumah Baru	Sand extraction	4	N/A	N/A	N/A
Home Island					
Turtle Beach	Sand extraction	9	N/A	N/A	N/A
North lagoon seawall	GSC seawall	9	2013	Good	15
Nek Jamil seawall	GSC seawall	7	2017	Good	15
Jalan Pantai seawall	GSC seawall	7	2013	Good	15

* condition downgraded following damage during July 2018 storm event
† damaged during July 2018 storm event, repairs were undertaken and current condition assumed to be good
‡ damaged during July 2018 storm event, repairs were undertaken and current condition assumed to be good

2.6.3 Planning Controls

The following section describes the Australian, State and local strategic and statutory planning documents that make up the planning framework that either directly inform coastal management or that consider this management as part of their broader remit.

The CHRMAP has regard for the relevant legislated planning requirements and strategic planning frameworks including:

- Environment Protection and Biodiversity Conservation (Indian Ocean Territories Marine Parks) Proclamation 2022
- State Planning Strategy 2050
- Planning and Development Act 2005 (WA)(CKI)
- Planning and Development (Local Planning Schemes) Regulations 2015
- WA Coastal Zone Strategy
- State Planning Policy 2.6 – State Coastal Planning Policy
- State Coastal Planning Policy Guidelines 2020
- Coastal Hazard Risk Management and Adaptation Planning Guidelines 2019
- Our Cocos (Keeling) Islands 2030 Strategic Plan
- Shire of Cocos (Keeling) Islands Strategic Community Plan 2016 - 2026
- Shire of Cocos (Keeling) Islands Corporate Business Plan 2018/2019 – 2021/2022
- Shire of Cocos (Keeling) Islands Local Planning Scheme No. 1
- Cocos (Keeling) Islands Master Plan Report
- Cocos (Keeling) Islands local planning policies;
  - > Asset Management Policy CPR6
  - > Coastal Development Policy CPP6

These policies are described below, both for their consideration of coastal management requirements and for the possible controls that could form a part of the management suite of actions for the CHRMAP.

The Shire also has a series of other local planning policies in its policy manual (here) that are not specifically related to the CHRMAP or to coastal planning but that may be able to be used in the scope of adaptation option management through planning controls. This includes policies like the Home Island Housing Policy and the Building Heights Policy.

2.6.3.1 Statutory Planning Controls

Environment Protection and Biodiversity Conservation (Indian Ocean Territories Marine Parks) Proclamation 2022

Cocos (Keeling) Islands Marine Park is one of a national network of Australian marine parks managed by Parks Australia under the direction of the Commonwealth Director of National Parks.

These marine parks have been established in Commonwealth waters across all Australian marine regions as part of Australia's National Representative System of Marine Protected Areas (NRSMPA). The Cocos (Keeling) Islands Marine Park Management Plan was finalised in February 2025.

Commonwealth marine areas, which includes Commonwealth marine parks, are listed as a matter of national environmental significance under the EPBC Act.

Planning and Development Act 2005 (WA)(CKI)

Provides the overarching state planning framework for guiding planning and development within WA, and accordingly for CKI. The *Planning and Development Act 2005* (P&D Act) provides the power for creating subsidiary state and local planning frameworks including state planning policies, regional and local planning schemes.

Planning and Development (Local Planning Schemes) Regulations 2015 (WA)(CKI)

Provides the framework and standard provisions for all local planning schemes in WA, and CKI.

Shire of Cocos (Keeling) Islands' Local Planning Scheme No. 1 (LPS 1)

Gazetted 30 July 2007 sets out the Shire's planning aims and intentions for the scheme area, sets out land as reserves for public purposes and zones land for various land uses, and sets out processes to guide land use and development within the Shire.

Part 4.12 details development requirements for coastal development. It requires all coastal development to comply with the provisions of SPP 2.6 and that SPP 2.6 applies as if it were part of the scheme (in accordance with section 77(1)(b) of the P&D Act).

All management actions recommended in this CHRMAP are in accordance with the SPP 2.6 planning guidance and hierarchy of controls and requirements relating to coastal zones, with Part 4.12 of LPS 1 enabling these actions to be contained in LPS 1.

Special Control Areas (SCAs)

LPS 1 provides for Special Control Areas (SCAs), but does not currently have any in effect that relate to coastal development or management. SCAs are areas identified as being subject to special controls to address constraints and/or achieve certain development outcomes in local planning schemes.

LPS 1 maps

The land adjacent to the coast on West Island and Home Island is zoned Residential, Special Use (with associated land uses outlined in Schedule 2 of LPS 1), Commercial and General Rural. Local reserves primarily include Parks and Recreation and Public Purpose reserves including Cemetery, Hospital, Australian Government, Waste Disposal, Fuel Depot - see *Figure 24* and *Figure 25*.

Shire of Cocos (Keeling) Islands Asset Management Policy CPR6

This policy acts to set the guidelines for implementing consistent asset management processes to attain positive and sustainable service outcomes for the range of built assets that the Shire manages on behalf of the community. This includes transport (roads, paths, drainage, boat ramps), property (land and buildings), recreation (ovals, parks, playgrounds) and fleet and IT assets (vehicles, plants, equipment, computers, etc).

Proposed asset management e.g. end of life relocation (if selected as a management option) is considered in the context of policy provision that asset management by the Shire aims to ensure that adequate provision is made for their long-term replacement.

Figure 24: Land use map – West Island South (LPS 1)

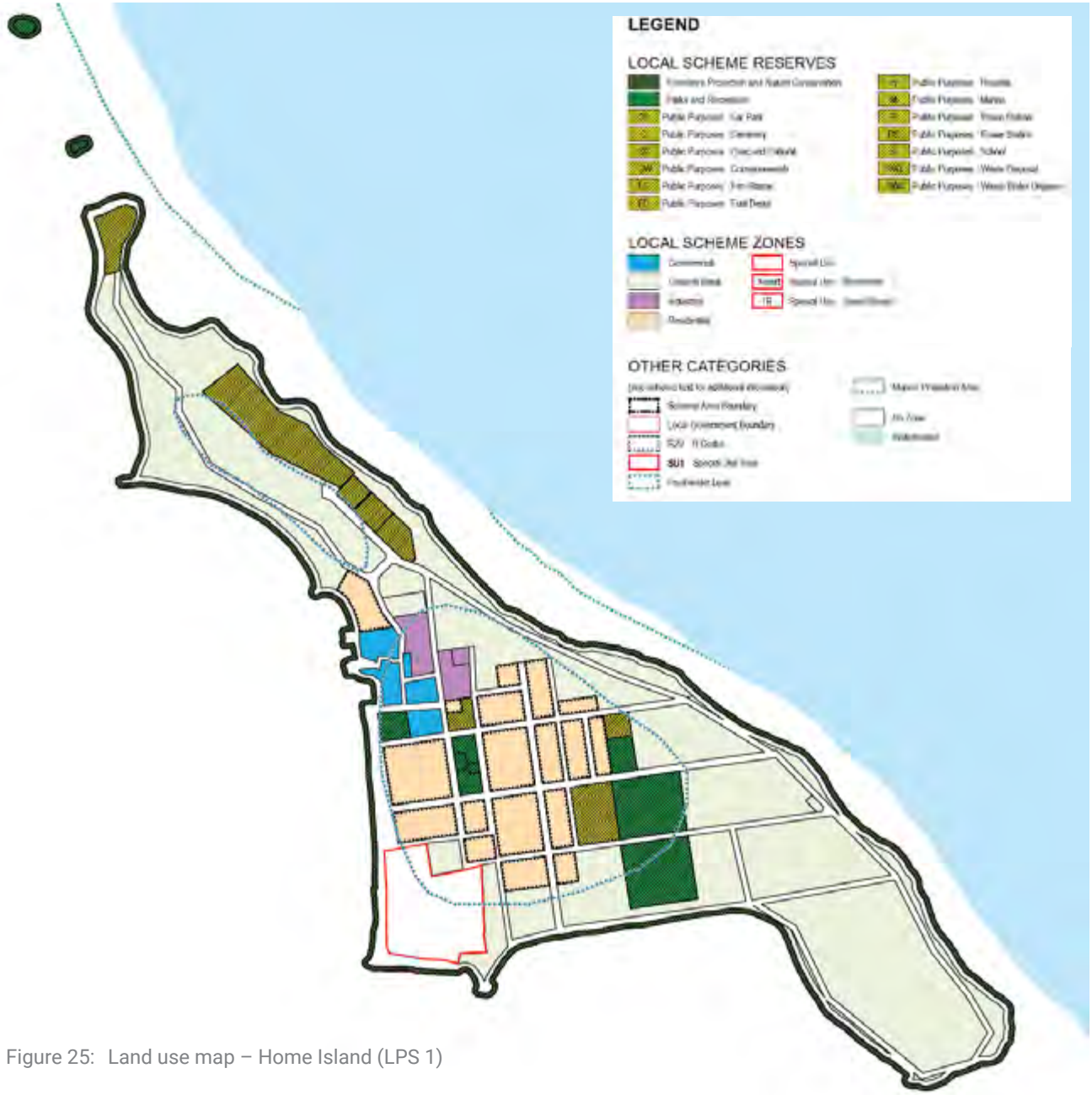


Figure 25: Land use map – Home Island (LPS 1)

Shire of Cocos (Keeling) Islands Coastal Development Policy CPP6

Considers coastal risks associated with developments in coastal zones and notes that early consideration of coastal hazards and the management of appropriate planning responses can provide economic, environmental, and social benefits.

The policy quotes SPP 2.6 and its requirement for a risk management approach and framework provision for a CHRMAP, and that a potentially wide range of policy considerations may be considered when deciding what management strategies to adopt in response to coastal vulnerability, including financial constraints and social factors.

The policy provides that planning requirements will be per planning merit and will be informed by the CVS and the CHRMAP (this project) and that until such time as these documents are finalised, Council will consider all of the islands to be at vulnerable to coastal inundation and erosion.

Notwithstanding, the policy has not been adopted under the P&D Act 2005 (WA)(CKI) or the Planning and Development (Local Planning Schemes) Regulations 2015 (WA)(CKI). As such, it has limited effective control.

2.6.3.2 Strategic Planning Controls

Indian Ocean Territories Regional Development Organisation's Our Cocos (Keeling) Islands 2030 Strategic Plan

Provides actions to assist CKI deliver a sustainable future. Realised engagement values were the community's love of CKI's beautiful and pristine environment, the ocean and lagoon and turquoise water, natural environment/nature, climate, community, lifestyle, unique Cocos Malay heritage and water sports/recreation activities.

Coastal erosion, rising sea levels and marine pollution were identified as ongoing significant threats, with mitigation responses to be reviewed/ managed.

One of the strategies to meet the aims of the plan is to maintain and monitor efforts to mitigate coastal erosion, building on environmental education initiatives, revegetating where appropriate, and maintaining a sustainable fishing resource. Identified KPIs are addressing coastal erosion and sea level rise implications being understood by the CKI community.

The CHRMAP addresses these KPIs and provides recommended implementation strategies for the short and medium to longer term.

State Planning Strategy 2050

Provides a strategic framework, principles, strategic goals and strategic directions for planning and development in WA (and thereby for CKI).

The approach to climate change seeks to achieve development and adoption of risk management strategies for natural hazards in the context of climate change patterns and trends. Aspirations listed for mitigation and adaptation planning for areas vulnerable to coastal landform change include:

- Special controls continue to be in place for vulnerable species and areas most affected by climate change.
- Climate change adaptation and mitigation strategies continue to be developed and implemented to minimise impacts on the State's key assets.
- Vulnerable areas continue to be secured and managed to foster ecosystem resilience.
- Risk management strategies continue to be developed and adopted for natural hazards in the context of climate change patterns and trends.

The Implementation Plan for the CHRMAP is intended to ensure that management actions strike the appropriate balance to ensure sustainable adaptation measures for assets most valued by the community.

WA Coastal Zone Strategy

Released in 2017, in recognition of the need for a strong land-use planning framework to ensure that coastal development can be sustainable in the long-term to meet community, economic, environmental and cultural needs.

Provides a whole-of-government integrated framework for collective action to manage and adapt to threats and pressures along the coast, complimenting existing State legislation, strategies and policies, including SPP 2.6. It outlines the key issues affecting the coast and defines stakeholder roles and responsibilities for coastal stewardship.

It states that all levels of government, as well as individuals, businesses, and the community, each have important and complementary roles in adapting to coastal hazards. The following principles are relevant to this CHRMAP:

- Private parties are responsible for managing risks to their private assets; and
- Governments (i.e.: the Shire), on behalf of the community, are primarily responsible for managing risks and impacts to public goods and public assets which they own and manage; they should also seek to:
    - Develop local policies and regulations consistent with state adaptation approaches.
    - Facilitate building resilience and adaptive capacity within the local community.
    - Work in partnership with community to identify and manage risks/impacts.

State Planning Policy 2.6 – State Coastal Planning Policy (SPP 2.6)

Provides guidance for land use and development decision-making within the coastal zone along the WA coast, and applicable to CKI. Requires that coastal hazard risk management and adaptation is appropriately planned for, encouraging innovative approaches to managing coastal vulnerability, and providing for public ownership of coastal foreshore reserves.

SPP 2.6 provides detailed information to evaluate the risk of coastal inundation and erosion and specifies the storm events to be considered for these analyses. SPP 2.6 is supported by the CHRMAP Guidelines (WAPC, 2019).

However, the inability of SPP 2.6 to account specifically for atoll biomorphology on CKI, and in particular to predict future robustness of coral growth, is a gap in knowledge on CKI that is recognised in this study.

SPP 2.6 aims to avoid future development within areas identified to be vulnerable within the planning timeframe, generally 100-years. For vulnerable areas, all potential adaptation options need to be identified under the risk management categories of Avoid, Planned and Managed Retreat, Accommodate and Protect to manage acceptable risks. The ultimate aims of the policy are to ensure all future development considers coastal hazards, climate change, and landform stability.

This CHRMAP has been prepared in accordance with SPP 2.6 and the CHRMAP Guidelines.

The State's coastal planning policy adaptation preferences in order of priority, as outlined in SPP 2.6, are:

Avoid (first), then Planned and Managed Retreat, then Accommodate and then Protect (last)

The State's strong preference towards adaptation options that minimise coastal process interference and away from those that may leave legacy issues and management strategies that preserve the natural coastline and move development away from the active coastal zone is noted. The strategy steers planners away from protection options and provides strict rules for the consideration of protection works.

Of particular relevance to the CHRMAP process is the user pays principle, whereby those who benefit most from protection must provide the greatest financial contribution. This arrangement applies to any area of the coast and can include incidences where the coastal foreshore reserve is being protected as a buffer to private assets.

The CHRMAP follows the recommended adaptation hierarchy approach to risk management. It also accords with the principle and objectives around building resilience and working in partnership with the community to identify and manage risks and impacts.

Coastal Hazard Risk Management and Adaptation Planning Guidelines 2019 (CHRMAP Guidelines)

The CHRMAP Guidelines supports SPP 2.6 and provides guidance on the development of CHRMAPs, their documentation and the required stakeholder engagement. The guidelines detail the processes and function and form of CHRMAPs, as well as standard approaches to undertake the hazard assessment, adaptation option development and implementation.

This CHRMAP has been developed in accordance with the CHRMAP Guidelines. The engagement approach in the CHRMAP Guidelines has been used to inform and guide the community and stakeholder engagement approach for this CHRMAP.

Planned or Managed Retreat Guidelines (CHRMAP Guidelines - Appendix 4)

In accordance with the principles for sustainable land use and development on the coast and adaptive risk management as required by the P&D Act and SPP 2.6, the following principles are detailed in the CHRMAP Guidelines - Appendix 4:

- To ensure land in the coastal zone is continuously provided for coastal foreshore management, public access, recreation and conservation.
- To ensure public safety and reduce vulnerability associated with coastal erosion and inundation.
- To avoid inappropriate land use and development of land at vulnerable to coastal erosion and inundation.
- To ensure land use and development does not accelerate coastal erosion or inundation risks; or have a detrimental impact on the functions of public reserves.

In accordance with SPP 2.6, the guidelines provide that a comprehensive CHRMAP process be undertaken to inform and enable the adoption of a planned and managed retreat policy to guide implementation. The planning mechanisms outlined to enact planned and managed retreat are:

- **Structure planning** – Where redevelopment of land is proposed or possible, structure plans are typically prepared to guide that development. Structure planning can consider the risks identified in the CHRMAP process and include a response in subdivision conditions which may, for example, address land requirements to accommodate coastal risks.
- **Local planning scheme (LPS) amendment** – The CKI LPS guides land use and development on CKI. The LPS can be amended to include the provisions of SPP 2.6, to inform users about vulnerable areas. This would include introducing a Special Control Area (SCA).
- **Special control area (SCA)** - An SCA can identify areas which are significant for a particular reason (in this case, coastal vulnerability) and where special provisions in the LPS may need to apply.
    - > The purpose of establishing an SCA is to enable vulnerable land use and development to be identified; establish the intended coastal hazard adaptation response(s) in this area; and provide a statutory planning instrument to implement the approach.
    - > An SCA classification can be included in the LPS to facilitate land use changes and development control within that area.
    - > An example of a Coastal Hazard SCA text can be found in the CHRMAP Guidelines Appendix 4 *Planned and Managed Retreat existing planning framework and instruments*.
- **Acquiring land** – Acqusition of land may be considered where other adaptation options are unable to reduce vulnerability of populations. Triggers for initiating this process should be included in any policy arising from the CHRMAP process which is proposed to support implementation of planned and managed retreat. The cost of taking land needs to be in agreement with the requirements under section 168 of the *Land Administration Act 1997 (WA) (CKI)*.
- **Planning Control Area (PCA)/Improvement Plan and Scheme** – In some cases the management of land in vulnerable areas requires a more unique and targeted response. A PCA or Improvement Plan and Scheme provide for a different level of state government control, enacted through mechanisms set out in the P&D Act, over/for the relevant area.

Shire of Cocos (Keeling) Islands Strategic Community Plan 2016 – 2026 (SCP)

Strategic objectives and desired outcomes for four key areas (economic, social, environmental and civic leadership) are detailed in the SCP, based on consideration of capacity of Shire resources along with future demographic anticipation.

The SCP informs how the Shire uses its resources to deliver services to the community and is the primary driver for all other planning undertaken by the Shire. Strategies and actions in the SCP are linked to the Shire's Corporate Business Plan.

The SCP identifies that the community strongly value the natural environment and uniqueness of CKI. For 'environment', an objective is to advance Cocos while keeping its island character, with associated outcomes of retaining the islands environment and that future development be sympathetic to this environment. Strategies to achieve these outcomes include increasing the environmental credentials of CKI, protecting the islands environment and minimising coastal erosion.

The Shire is in the process of preparing its next SCP – The Cocos (Keeling) Islands Strategic Community Plan 2022 – 2032. Project engagement with the community saw concerns about coastal hazards and risks and the need for management to both protect coastal values and contribute to clarity in decision making and management requirements (and the according economic, environmental and social benefits that will ensue). The draft SCP has been prepared to align with the CHRMAP development.

Shire of Cocos (Keeling) Islands Corporate Business Plan 2018/2019 – 2021/2022 (CBP)

Provides information on the actions the Shire will undertake to deliver the community identified aspirations in the SCP. It provides direction and priorities for the annual budget and is reviewed annually.

Challenges include protecting the natural environment and planning for and adapting to climate change, including coastal erosion. The identified objective is to foster and support partnerships with stakeholders and the community in their efforts to care for the natural environment. Identified actions and proposed timeframes for their actioning are detailed in *Table 10* below.

Table 10: Corporate Business Plan strategic actions timeframes

Strategy Reference	Action	18/19	19/20	20/21	21/22	Ongoing
E3.1.1.1	Partner with the Department of Planning to carry out coastal hazard assessments and mapping that considers social, cultural, economic and environmental implications	√	√	√	√	√
E3.1.1.2	Partner with the Commonwealth to continue the reclamation of at risk areas on Home and West Islands	√	√	√	√	√
E3.1.1.3	Develop and foster a collaborative relationship with Parks Australia to ensure appropriate environmental management of the Northern and Southern Atolls	√	√	√	√	√
E3.1.1.4	Develop a Junior Ranger program	-	-	√	√	√
E3.1.1.5	Develop an "Adopt a Beach" program	-	-	√	√	√
E3.1.1.6	Establish and implement a Community Clean up fundraiser program	√	-	-	-	-
E3.1.1.7	Investigate options for Re-vegetation programs in partnership with Parks Australia and other relevant agencies	-	√	√	√	√

Cocos (Keeling) Islands Master Plan Report 2019 (CKI Master Plan)

The Australian Government's CKI Strategic Plan informed the development of the CKI Master Plan by the Shire.

The master planning process involved community engagement to determine what projects the community would like to see, the preparation of plans that identify these projects across Home Island and West Island, and the development of a tool for the Shire to use to prioritise projects based on criteria. The project was underpinned by a focus on liveability and sustainability.

The project opportunities identified by community members are listed in *Appendix D*, see examples in *Figure 26*. Not all of the identified opportunities are the responsibility of the Shire.

A number would need to be delivered by the Australian Government or the private sector. Additionally, the plan acknowledges the limited budget and the need for investigation of feasibility of project opportunities and prioritisation of the viable projects, on the basis of value to the community and ease of implementation.

Project opportunities that may be affected by coastal hazards are identified in blue text in *Appendix D*. Development of the CHRMAP contributes to the investigation of feasibility of projects in the coastal zones, in terms of location in the coastal zone, hazards and risks, and what management actions are proposed to respond to the risks.

Figure 26: Excerpt of CKI Master Plan Home Island where most opportunities are affected by coastal hazards.

2.7 Success Criteria

The most desirable outcome of the CHRMAP process will be cross-government support for specific land use planning controls and actions for vulnerable areas in the short-term (0 – 10 years) and for specific planning and implementation pathways and triggers for longer term vulnerability. These decisions will be based on stakeholder consultation and engagement plus economic, environmental and cultural considerations.

The key success criteria are:

1. The outcomes of the CHRMAP are understood and supported by key stakeholders and decision-makers.

   Measurement: CHRMAP agreed by Project Steering Group.

2. The outcomes of the CHRMAP are understood and supported by the community.

   Measurement: Community provide feedback as part of the engagement activities in the engagement program.

3. The outcomes of the CHRMAP are supported by the Australian Government, WA State Government and the Shire.

   Measurement: CHRMAP options/actions are supported by the Australian Government and DPLH, with relevant options incorporated into relevant tiers of government policy including the Shire's strategic policies, LPS, structure plans, local planning policies, operational plans and budget.

4. The lifestyle enjoyed by the people on-island is protected.

   Measurement: CHRMAP considers priority community values and provides options that enable their continuation.

5. The CHRMAP details roles and responsibilities for proposed coastal risk management measures, to maintain ongoing capability of the various coastal land managers.

   Measurement: CHRMAP details roles and responsibilities for management actions, endorsed by Australian Government.

Chapter 3
Risk Identification

3 Risk Identification

The Cocos (Keeling) Islands' coastal environment is characterised by vistas of the water and beaches from almost every location, due to the low lying nature and narrow land mass of the islands.

This same connection with tropical blue waters, white sands and corals is also the cause of the vulnerability that is present, and experienced daily by the community.

This stage of the CHRMAP process establishes an understanding of potential risks that may occur as a result of coastal hazards.

This chapter summarises the following:

1. **Existing environmental factors** – the various sources of coastal hazards, including the specific factors associated with the coral atoll setting, water levels, waves, climate and other factors.
2. **Coastal hazard identification** – a review of, and update to, the hazards identified in the CVS.
3. **Community and stakeholder coastal values** – the review and confirmation of local community and stakeholders values. A critical part of this project is engagement with the local community and relevant stakeholders to ensure the consequence ratings established in the vulnerability assessment reflect community and stakeholder values.
4. **Hazard mapping** – updated mapping and to share vulnerability information with the community and stakeholders.

Risk identification is an essential precursor to understanding which values and assets are likely to be impacted and require either immediate or longer term risk management. This baseline information must be established before an assessment of vulnerability can be undertaken, which is subsequently described in Chapter 4.

3.1 Existing Environment

Natural coastal protection services are provided by atoll reef-island systems. This includes wave processes and sediment transport (coastal processes), and sediment productivity (reef growth/decline). The capacity of these natural processes to contribute to coastal management, for example through mitigating ocean wave energy is being researched and has been considered through this CHRMAP process.

The Cocos (Keeling) Islands Marine Park was declared in March 2022 to protect the extensive coral reef and lagoon habitats surrounding the Cocos (Keeling) Islands and the many migratory, threatened and endemic species supported by these habitats. The park extends across 467,054 square kilometres of ocean, safe-guarding much of the islands' inshore waters as well as offshore deep-sea seamounts, plains and ridgelines.

Coastal processes are a broad term that can simply be defined as the movement of sand and water along the coastline. These processes occur over a range of timeframes and are largely driven by the winds, waves, tides and currents.

Coastal processes on CKI are characterised by the following elements:

SECTION AND ELEMENT	CONSIDERATIONS
3.1.1 Coral atoll setting	Significant differences in exposure to coastal hazards for islands on opposite sides of the atoll
3.1.2 CKI climate	Role of strong seasonal winds in CKI and their effect on wave climate
3.1.3 Water levels	Tides, mean sea level variation and lagoon currents
3.1.4 Waves	Sea and swell waves, and tropical cyclone waves
3.1.5 Extreme water levels	Unique surge characteristics for islands during storms, such as reduced wind setup vs. continental coasts
3.1.6 Sea level rise	Response of islands to sea level rise not well captured in SPP 2.6: a living reef atoll might grow at the same rate as Sea Level Rise.
3.1.7 Sand transport	Cross shore, longshore and lagoon circulation

3.1.1 Coral atoll setting

The CKI sit atop an ancient volcanic seamount which rises from the surrounding seafloor which is at depths of approximately 5,000m (RHDHV, 2021a). The volcanic seamount (an underwater mountain formed by volcanic activity) was initially surrounded by fringing reefs. As depicted in *Figure 27*, over time the volcanic island core erodes while the fringing reefs surrounding the island become barrier reefs and finally coral atolls (RHDHV, 2021a).

Fringing coral reef surrounds all of the CKI lagoon, apart from two breaks in the reef corresponding to deep entrances between the northern top of West Island (Western Entrance) and Direction Island (Port Refuge). The fringing reef also features a series of shallow channels in the reef between islands which connect the ocean with the lagoon.

The shoreline around CKI can be divided into ocean shores that occur around the perimeter of the atoll and face the open ocean, and lagoon shores that flank the lagoon (RHDHV, 2021a). The lagoon is shallowest in the southeast, deepening toward the two main entrances in the northwest (RHDHV, 2021a).

Ocean beaches are generally steep and backed by a ridge built by ocean wave run-up. The distance between the beach and reef varies throughout CKI. Typically, there are no established dunes however windblown dunes have been observed in some locations (RHDHV, 2021a).

Ocean beaches are typically composed of coarser sands indicating the higher wave energy these beaches are exposed to.

Some of the beaches along the ocean side of West Island and Home Island consist of coral gravel and coral boulders with very little sand, particularly in areas where the reef edge is closer to the shoreline (e.g. The Shack, West Island) (RHDHV, 2021a).

The lagoon beaches on CKI are characterised by narrow white sandy beaches. They are sheltered beaches containing fine grained sand that has deposited in the low energy wave conditions within the lagoon (RHDHV, 2021a).

The sand on oceanward beaches is newer and originates from the reef, whereas sands on lagoon beaches have been broken down as they were transported from the ocean beaches into the lagoon.

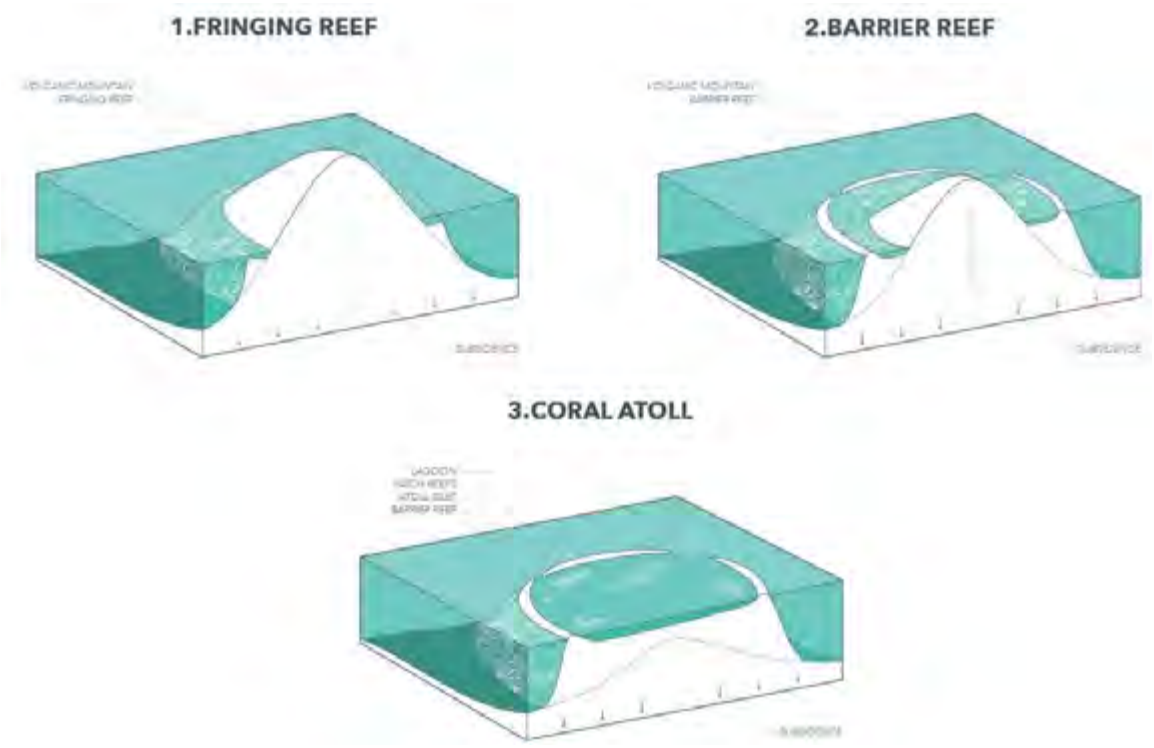


Figure 27: Coral atoll formation (The Plan Journal, 2017)

3.1.2 CKI climate

The CKI climate is tropical. It experiences a hotter period from December to March, and a relatively cool period from June to October. The warmest months are February and March. Relative humidity is always high at a mean of 75% (RHDHV, 2021a).

Trade winds, dominated by easterly and south easterly trade winds are sustained for 85 per cent of the year. The trade winds have a greater intensity in the coolest months (July and August) and a lower intensity in the warmest months (February and March) (RHDHV, 2021a).

There is no dry season, however rain is more abundant from January to July. Maximum rainfall is experienced in March and April. The drier months are typically September to November (RHDHV, 2021a).

The Bureau of Meteorology Southern Hemisphere Tropical Cyclone Data Portal (BoM, 2024) shows that 139 tropical cyclones have passed within 500km of the CKI, at an average of 2.62 tropical cyclones per year from 1969/70 to 2021/22. The tropical cyclone season at Cocos Islands occurs between November and May with cyclones most frequently occurring between December and March (RHDHV, 2021a).

Tropical cyclones have the potential to generate large waves and storm surge, predominately from the North and East (RHDHV, 2021a, Figure 70). The highest peak wind speeds recorded on CKI occur during tropical cyclones (DAL, 1999). The worst tropical cyclone in CKI occurred in 1909 with winds gusts of 225 km/h (Maunsell, 2009).

3.1.3 Water levels

RHDHV (2021a) undertook a comprehensive data collection program on CKI between July 2018 and December 2019 to measure waves, currents and water levels at eight locations (see *Figure 28*). The primary objective of monitoring was to characterise the wave climate at West Island and Home Island and waves and water level variation on the reef top. RHDHV also undertook current monitoring in shallow reef channels near Home Island and West Island to measure tidal and non-tidal currents.

Detailed plots of waves, winds and currents can be viewed in the CVS in Section 3.

Table 11: Summary of oceanographic measurements at CKI (modified from RHDHV, 2021a, Section 3)

SITE ID	MEASUREMENTS	PURPOSE AND DESCRIPTION	FINDINGS
CK01a	Waves, currents and water levels	To characterise the wave climate affecting the ocean side of West Island by measuring incoming south to south-westerly Indian/Southern Ocean swells.	Wave measurements show a unidirectional long period swell wave climate with high energy. Current speeds were relatively high, and surface current speeds were faster than seabed speeds. Currents were mostly in an alongshore/offshore (west north-west) direction.
CK01b	Waves and water levels	To measure waves and water level variation (including wave set-up) on the reef top. This is important for understanding coastal erosion and wave overwash on unprotected shorelines, wave overtopping on protected shorelines and for the calibration of wave and hydrodynamic models in the lee of fringing reefs.	Measurements show wave driven setup up to 1.1m above MSL across the reef, that most wave energy dissipates during breaking at the reef crest (~70%), and that some swell waves and short period waves propagate over the reef. Infragravity waves with periods of between around 30s to 1000s were also found.
CK01c	Waves and water levels		
CK02	Waves, currents and water levels	To measure the incident wave climate affecting Home Island. Located on the ocean (east) site of Home Island this site measured the persistent south to south-easterly waves (seas and swells) generated by the trade winds.	Wave measurements show a combined sea and wind (i.e. short period) swell wave climate of moderate energy. This site is exposed to the waves generated by trade winds to the east and south-east. Refraction of the incoming waves occurred. The currents measured were tidally affected and follow an alongshore/reef direction. There is a bias for higher speeds to the north-west which may be because of the trade winds.
CK03	Waves, currents and water levels	The primary objective of this site is to measure tidal and non-tidal currents in the Western Channel area. A secondary objective is to measure the wave climate within the channel.	Wave measurements were composed primarily of heavily refracted swell waves of moderate to low energy. A mildly bi-modal wave climate was observed with a lower energy and shorter period wind wave component observed coming from the east to south-east. These wind waves are generated by the persistent trade winds blowing over the lagoon. Currents are tidally dominated. However, a strong ebb tide bias was observed (i.e. ebb tide current speed asymmetry).

Table 11: Summary of oceanographic measurements at CKI (modified from RHDHV, 2021a, Section 3) (continued)

SITE ID	MEASUREMENTS	PURPOSE AND DESCRIPTION	FINDINGS
CK04	Currents and water levels (and waves)	The primary objective of this site is to measure tidal and non-tidal currents at the southern end of the CKI lagoon. This helps characterise the circulation patterns within the lagoon.	Currents measured show lagoon-ward flow during the entire record with speeds correlated to offshore swell waves. The wave climate measured in the first deployment was composed of small energy wind waves (periods less than 3 seconds) generated within the lagoon. Waves in the swell range frequencies, or lower, were also recorded but at a very small height.
H3	Currents	The primary objective of these sites is to measure tidal and non-tidal currents within two of the 15 shallow cross-reef channels that separate the coral sand islands between Direction Island and West Island.	Both H3 and H8 recorded unidirectional lagoon-ward flow. At H3 the speed of the current appears to be influenced by both tide and offshore wave conditions and may also be influenced by the trade winds. H8 shows similar observations but shows less variability.
H8	Currents		

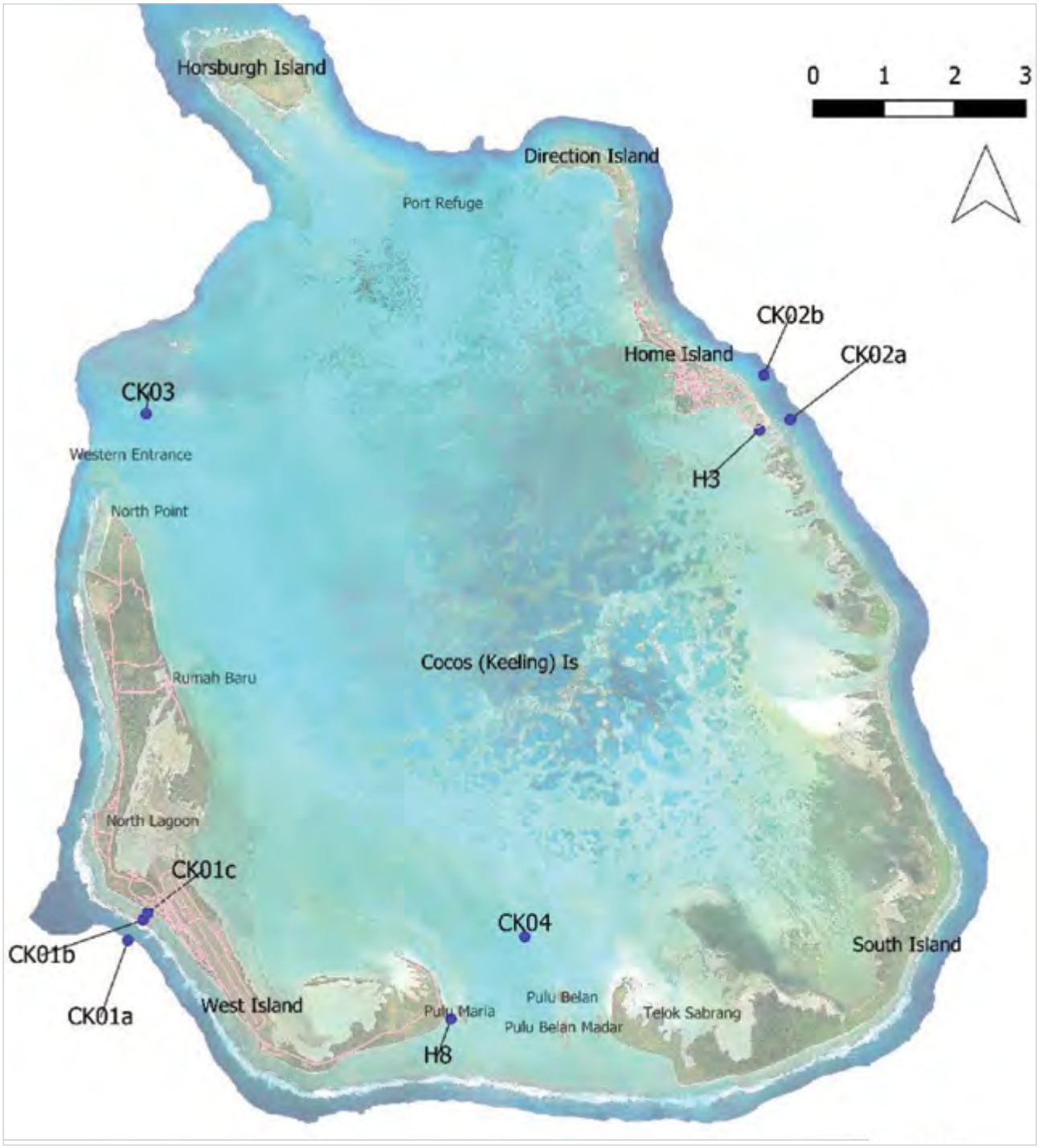


Figure 28: Location of oceanographic monitoring sites (blue dots) on CKI (RHDHV, 2021a)

Tides

CKI has a semidiurnal micro tidal environment with mean neap and spring tidal ranges of 0.5 and 0.7 metres, respectively, with a maximum range of 1.2 metres (RHDHV, 2021a, Section 6.6.2). There is a permanent tide gauge on Home Island that records water level information.

Mean sea level variation

The mean sea level at CKI varies on a monthly timescale due to the influence of climatic conditions related to the Southern Oscillation Index and the Indian Ocean Dipole (RHDHV, 2021a).

Seasonal mean sea levels can vary up to approximately 0.5m at CKI (detailed plots can be viewed in the CVS). Mean sea levels typically peak from August to November and are generally lowest from January to April.

Lagoon currents

Currents and circulation within the lagoon are driven by waves, wind and tides. General circulation within the lagoon is illustrated in *Figure 29*. Current passages into the lagoon are higher with higher ocean wave height and periods, and with higher tides.

During site visits RHDHV (2021a) observed that circulation of the shallow southern lagoon is predominantly driven by wind and wave processes while tidal currents appear to be limited. On Home Island, currents in the channels located to the north and south of the island were observed flowing in a lagoonward direction.

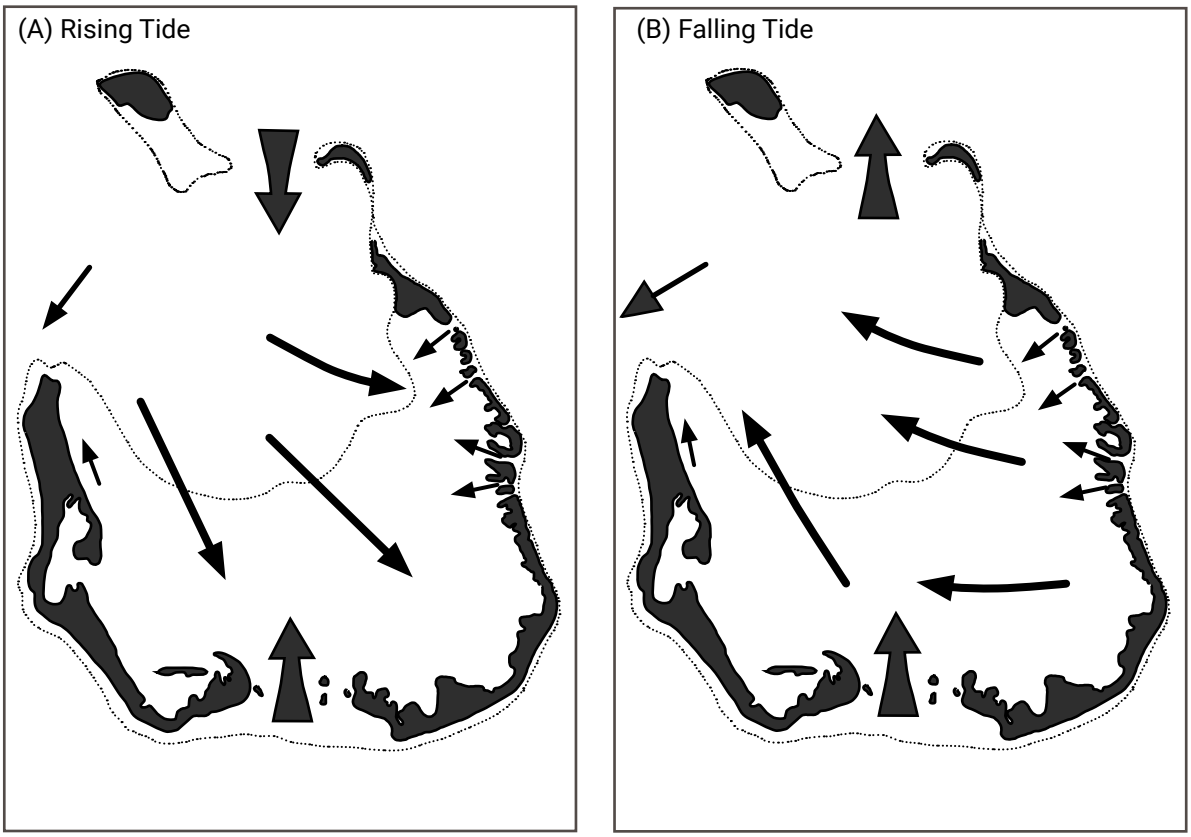


Figure 29: General circulation of the Cocos (Keeling) Islands lagoon on the rising and falling tide (Kench 1994 in GHD 2017 - *modified for quality 2024*).

3.1.4 Waves

Sea and swell waves are created by the movement of winds over the ocean surface. The local wave climate at CKI can generally be described as consisting of:

- ambient wave conditions generated by local winds and swell waves propagating from the open ocean; and
- extreme wave events that occur intermittently due to the passage of tropical cyclones.

Sea and swell waves

RHDHV (2021a) were able to collect data by monitoring at numerous sites over 18 months (2018-2019), including a swell event in July 2018.

Swell waves are generated by distant storms in the Indian Ocean that propagate towards CKI. Swell waves arrive at the CKI from a south-westerly direction and dominate the wave climate. The south-westerly swells occur year-round but are highest in winter. The waves typically have peak periods in the range 10 to 18 seconds. Occasionally, westerly swells occur. The swell waves primarily effect West Island and South Island and occasionally the lagoonward facing shorelines of Direction Island and Home Island (RHDHV, 2021a).

Sea waves are created by winds blowing over a local wind fetch. The height and period of the locally generated sea waves are influenced by the fetch length (distance over water) and wind speed and as such are likely to vary from season to season depending on the dominant wind direction.

Persistent south-easterly trade winds produce south-easterly sea and swell waves typically in the range 6 to 10 seconds, predominately between May and October. Ocean generated sea waves predominately effect Home Island, the eastern side of South Island and the other eastern atoll islands (RHDHV, 2021a).

Tropical cyclone waves

Tropical cyclones have the potential to generate large waves on CKI. Due to the different exposures of the eastern and western coastlines of CKI they are likely to be impacted by waves generated from cyclones with different approaches.

Existing wave records on CKI are too short and sparse to quantify extreme tropical cyclone waves. RDHDV (2021a) undertook numerical modelling of tropical cyclone waves on CKI estimating 100 year ARI extreme wave heights (Hs) of 6.8m on the eastern coast and 6.1m on the western coast. They were also able to test their model using the passage of Tropical Cyclone Savannah in March 2019.

3.1.5 Extreme water levels

Extreme water levels occur during storm events as a result of two mechanisms (*Figure 30*):

1. Short-term storm surge due to inverse barometric pressure effects such as those experienced during tropical cyclones allowing the water level to increase, with the sea level rising 1 cm for every hectopascal (hPa) less in the cyclone centre.
2. Extreme wind and wave setup at the shoreline - Extreme winds, wave heights and water levels are also strongly linked on the coastline. Strong winds blowing across the water surface can cause the water level to pile up against the shoreline, raising the water level. This process is called wind setup. Large waves breaking on the coast also cause water levels to pile up against the shore, which increases the total water level at the shoreline. This process is called wave set up. Wave and wind set up in turn allow larger waves to reach the shore, as there is more water depth available prior to the waves breaking.

Extreme water levels on ocean shores at CKI are typically dominated by wave driven water levels (wave setup and wave run-up), while extreme water levels on lagoon shores are typically be dominated by still water levels (tides and storm surge) (RHDHV, 2021a). The key coastal inundation processes are detailed in *Figure 31*.

Extreme water levels at CKI can occur due to storm surges as a result of tropical cyclones however non-cyclonic surges of a similar magnitude also occur. The highest surges recorded at CKI have been just over 0.4m but most extreme surge levels measured are in the order of 0.2m to 0.4m (RHDHV, 2021a). The highest water levels and surges CKI coincide with month-long increases in mean sea level.

During cyclonic events storm surges occur due to the inverse barometer effect where the localised drop in sea level pressure results in an increase in the water level. Very little contribution from wind driven sea level setup has been identified on ocean facing shorelines due to the deep water surrounding the atoll (RHDHV, 2021a).

Some wind setup is likely to occur in the shallower lagoon, particularly during cyclone events. Based on width and depth of CKI lagoon it is possible that a 0.2 to 0.3m wind setup in a cyclone event could occur.

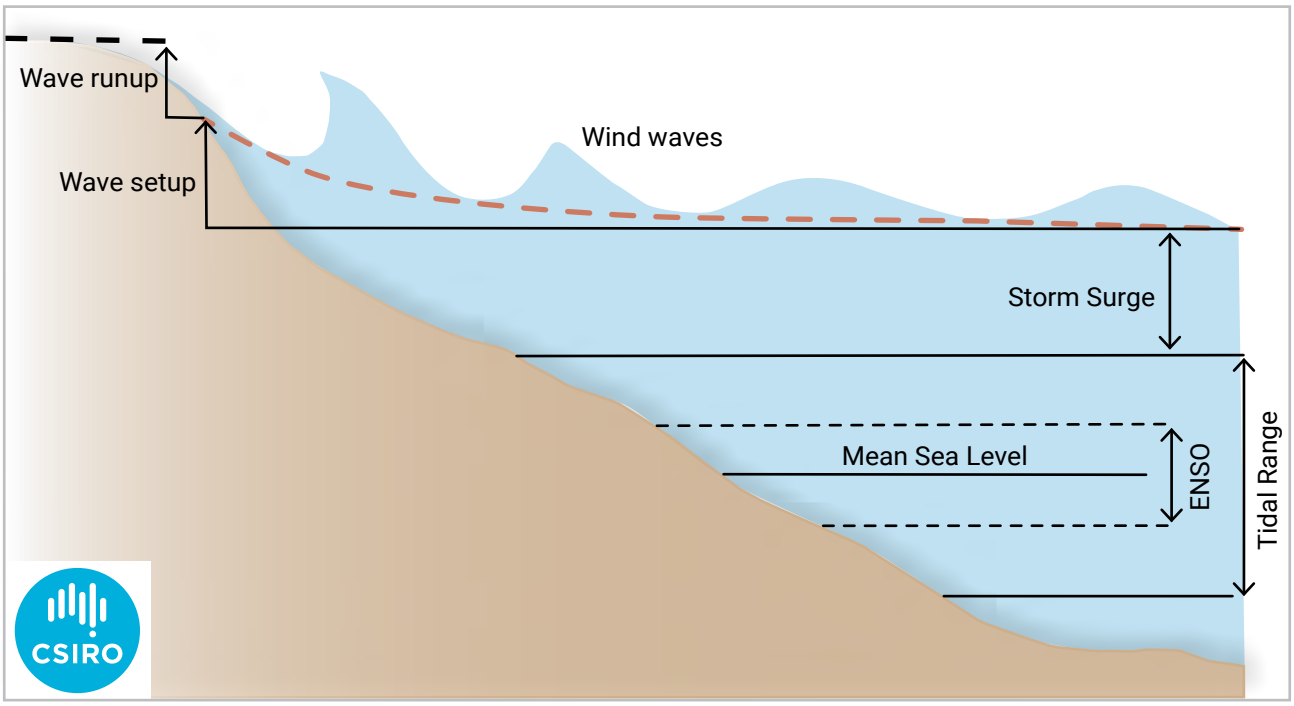


Figure 30: Causes of extreme water levels (CSIRO, 2020) *modified for quality 2024*).

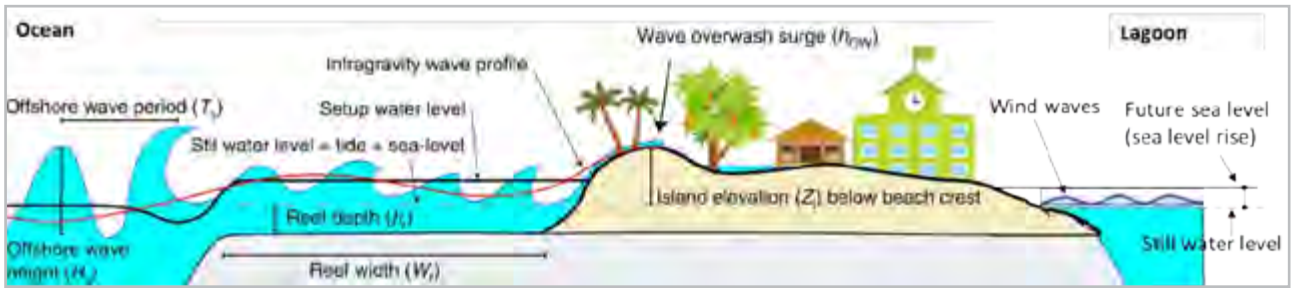


Figure 31: Diagram of ocean and lagoon coastal inundation process at CKI (RHDHV, 2021a)

RHDHV (2021a) determined that peak wind speeds and associated extreme wave heights are generated some distance away from the eye of tropical cyclone impacting CKI, concluding that the extreme tropical cyclone generated surges at CKI and extreme tropical cyclone generated wave heights do not coincide.

SEA (2001) undertook detailed storm surge modelling, predicting a 500-year ARI water level at the Home Island jetty of 0.99m above MSL and 1.18m at Rumah Baru on West Island. RHDHV (2021a) estimated a 500 year ARI water level at the Home Island Jetty of 1.21m, based on a longer water level record.

While previous studies (RHDHV, 2021a) have identified that significant non-cyclonic surges occur at CKI no further study or quantification of has been made. This CHRMAP presently uses the more conservative 500 year ARI extreme water level estimate of 1.21m determined by RHDHV (2021a).

Wave-driven sea levels

At oceanward beaches on CKI offshore waves interact with the reef crest and the resulting waves travel across the reef crest and are associated with wave setup, wave runup, over wash and overtopping at the shoreline.

Overtopping of coastal structures and wave overwash of unprotected shorelines leads to coastal inundation by wave-driven processes on CKI.

(SEA, 2001) identified that wave setup in the lee of the reef is the largest component of non-tidal sea levels along ocean exposed areas of the CKI shoreline. Analysis of wave and water level data collected by RHDHV (2021a) in front of the West Island settlement measured up to 1.1m of wave driven setup on the reef-top.

Rising sea levels (Section 3.1.6) and extreme weather events will combine to increase the risks associated with coastal hazards, which will be dominated by wave-driven water levels along ocean-facing shorelines (i.e. wave set-up and height) and still water levels (i.e. tide and storm surge) on the lagoon side.

Pressure-driven sea levels

One of the main causes of increased water levels is through a process called the inverse barometric pressure effect. Tropical cyclones have very low pressures at their centre, which means there is less air pressure pushing down on the sea surface. This allows the water level to increase, with the sea level rising 1 cm for every hectopascal (hPa) less in the cyclone centre.

3.1.6 Sea level rise

Sea level rise (SLR) is the climate change impact considered in SPP 2.6. The Department of Transport (DoT, 2010, now DTMI) has recommended that a vertical SLR of 0.9m be adopted in Western Australia when considering the impact of coastal processes over a 100-year planning timeframe (2010 to 2110).

SLR projections vary regionally across the globe with some locations projected to experience higher SLR then other locations. Recent regional SLR projections released by IPCC (2021) do not indicate substantial variation between SLR projections for CKI and Western Australia (see *Figure 32*).

It is further confirmed via the CVS (RHDHV, 2021a), which considered Bureau of Meteorology (BoM) tide gauge data collected at Home Island since 1992, observing a long-term trend of 4mm annual sea level increases (i.e. more than 12cm at the current day).

Sea level rise (SLR) rates are projected to increase, with estimates consistent with the tide gauge data of 14-18cm at 2030 and 40-44cm at 2070.

Given this, the DTMI 2010 SLR projections for Western Australia are considered suitable for the CKI CHRMAP. The CVS recommends the DTMI estimates of a vertical sea level rise of 0.4m be adopted for the 50-year planning timeframe (i.e. 2068) and 0.9m rise be appropriate for the 100-year planning timeframe (2118). This CHRMAP uses these values to determine the relative hazards from erosion and inundation due to climate change over the next century.

In the consideration of sea level rise impacts on low lying coral atolls, land subsidence also needs to be considered. There is some evidence to suggest that CKI is experiencing land subsidence in locations, the result of which would be an apparently higher SLR impact for CKI. Notwithstanding this, the projected SLR for CKI is still within the recommended 0.9m over 100 years and long-term ongoing monitoring of land subsidence and measured sea level rise are required to confirm these trends. Land subsidence and SLR are two separate issues and should be noted as such .

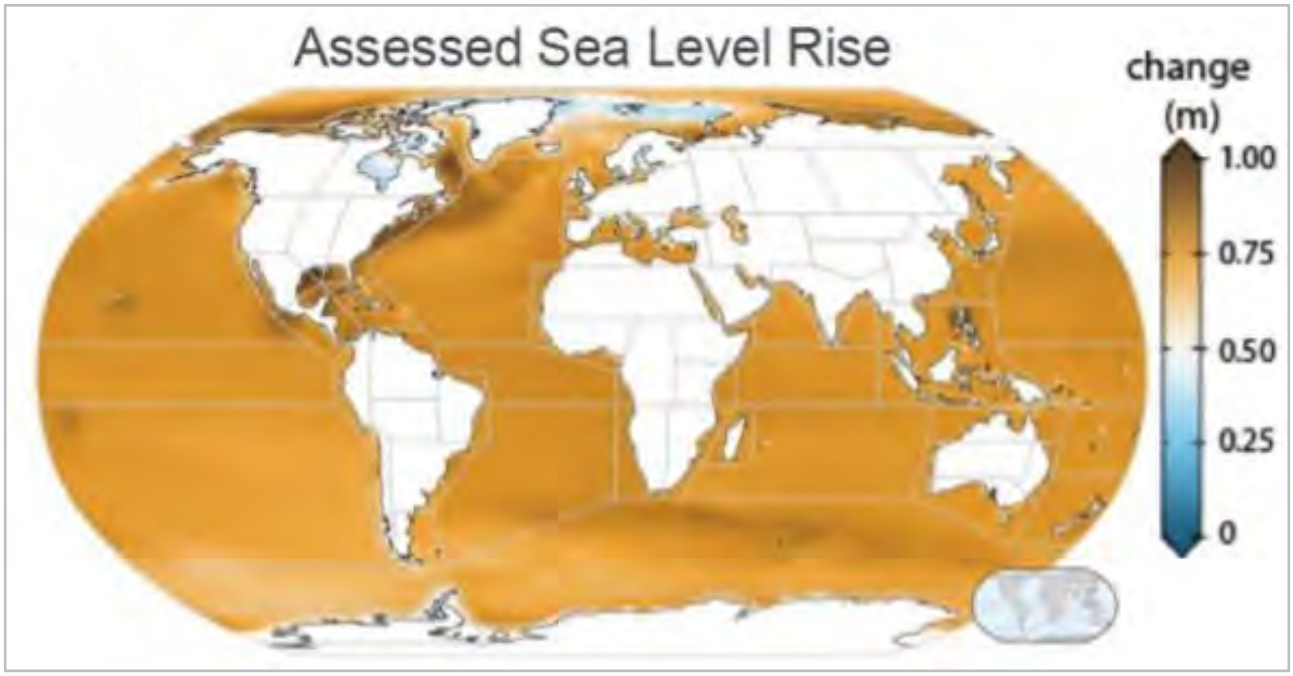


Figure 32: Regional variation and projected changes in sea level rise by 2081-2100 (IPCC, 2021)

3.1.7 Sand transport

Data collected over several decades on CKI allowed examination of types of sediment (sand) and its production to understand how coastal processes sustain and shape the CKI shorelines.

The main processes which affect sand transport on CKI are summarised below and in *Figure 33*:

- Cross shore sand transport across the coral reef system (black arrows);
- Wave induced currents (green arrows)
- Long shore sand transport driven by wave induced currents (red arrows); and
- Lagoon circulation driven by tidal flood and ebb tides (blue arrows).

The black and red arrows in *Figure 33* describe where sediment moves, while the blue and green arrows help describe which processes (waves or tides) drive sediment transport.

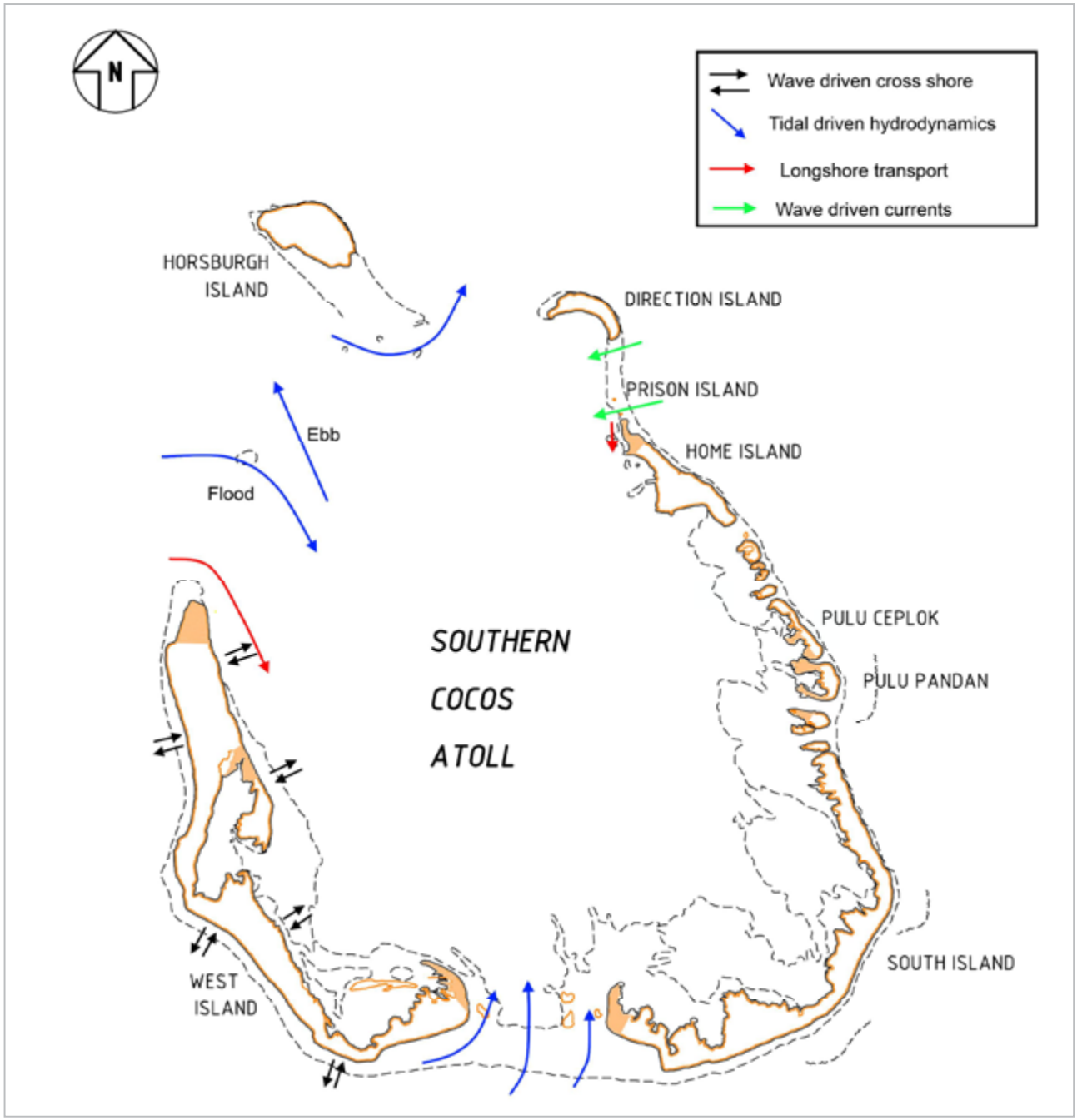


Figure 33: Sediment transport process (GHD, January 2017)

3.1.7.1 Cross shore coastal processes

RHDHV (2021a) assessed metocean conditions (the combination of meteorological and oceanographic conditions) using data collected at CKI over several decades to calibrate the modelling tools and validate new data and model simulations.

A detailed breakdown of the cross shore coastal processes occurring across the atoll is provided below and in *Figure 34*.

The islands on the CKI atoll have been formed from sand derived from the physical breakdown of the adjacent coral reefs by waves, and grazing from parrot fish and urchins. Sand may also be produced from the shells and skeletons of organisms that live on the reef. Ongoing supply of sand is dependent on a healthy reef system. (Perry et al, 2011 in RHDHV, 2021a).

Sand production at CKI contributes to island building and maintenance (Perry et al, 2011 in RHDHV, 2021a). The shape and position of islands reflect the interaction of waves with the coral reefs and the sand available. Sand produced on the reefs is transported onshore by waves; high waves push this sand up into beach ridges. Growth and maintenance of the islands relies on this process.

Erosion and inundation of the island occurs due to heavy swell and rough seas during cyclones. These processes can carry increased quantities of sand alongshore, onshore and offshore.

Coral reefs act as natural breakwaters, reducing the strength of incoming ocean waves. Reefs are living structures and can grow vertically upwards, however, there is very high confidence that this capability will be weakened due the impacts of ocean warming and acidification (see Section 3.1.8).

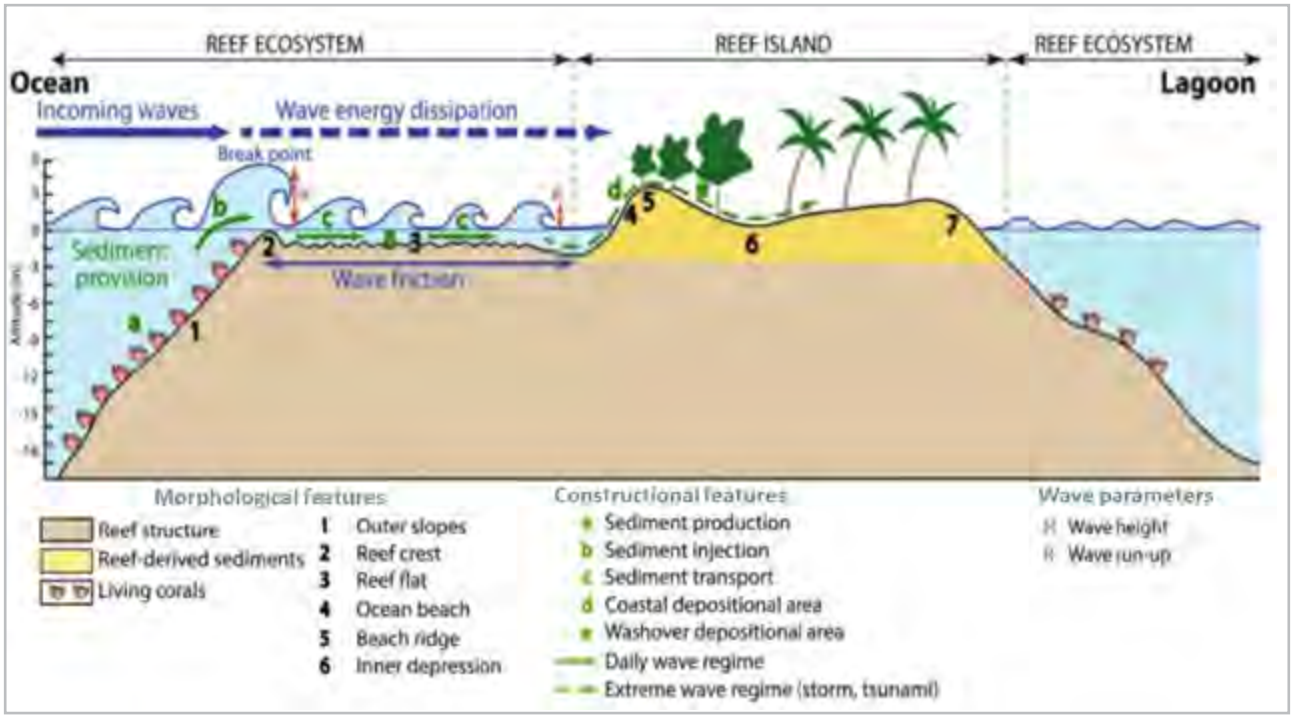


Figure 34: Conceptual model of atoll cross shore coastal processes (RHDHV, 2021a)

3.1.7.2 Longshore sand transport

Waves are important for the transport of sand along the CKI shorelines. Longshore sediment transport is the process of sand moving in an alongshore direction and is driven by wave arriving oblique to the shoreline. An overview of longshore sand transport in the southern CKI atoll is shown in *Figure 35* and indicates northwards transport along the oceanward sides of islands on the east and west of the atoll and transport into the lagoon through the southern side of the atoll.

Longshore sand transport on Home Island is driven by wind waves from the east and south-east and is summarised in *Figure 36* and described as:

- Northwards sand transport along the eastern ocean coast that wrap around the northern tip of the island (Pulu Gangsa) and deposits into Turtle Beach.
- Eastwards sand transport along the southern coast that deposits into the lagoon.
- Diverging sand transport at the south eastern tip on Home Island.

Longshore sand transport processes on West Island are driven by south-west swell waves and are summarised in *Figure 37* and described as:

- Northwards sand transport along the western coast.
- Southerly movement of sand into the lagoon at the Northern tip of West Island. Movement of this sand occurs as a sand slug along the eastern lagoon shore (Maunsell 2009).
- Eastwards sand transport along the southern coast.
- Diverging sand transport at the southern tip of West Island
- Sand deposition in the southern lagoon.

3.1.7.3 Lagoon sand transport

Sand is transported in a one-way direction by currents through shallow passages in the fringing reef into the lagoon, leading to a slow accumulation of sand inside the lagoon (RHDHV, 2021a).

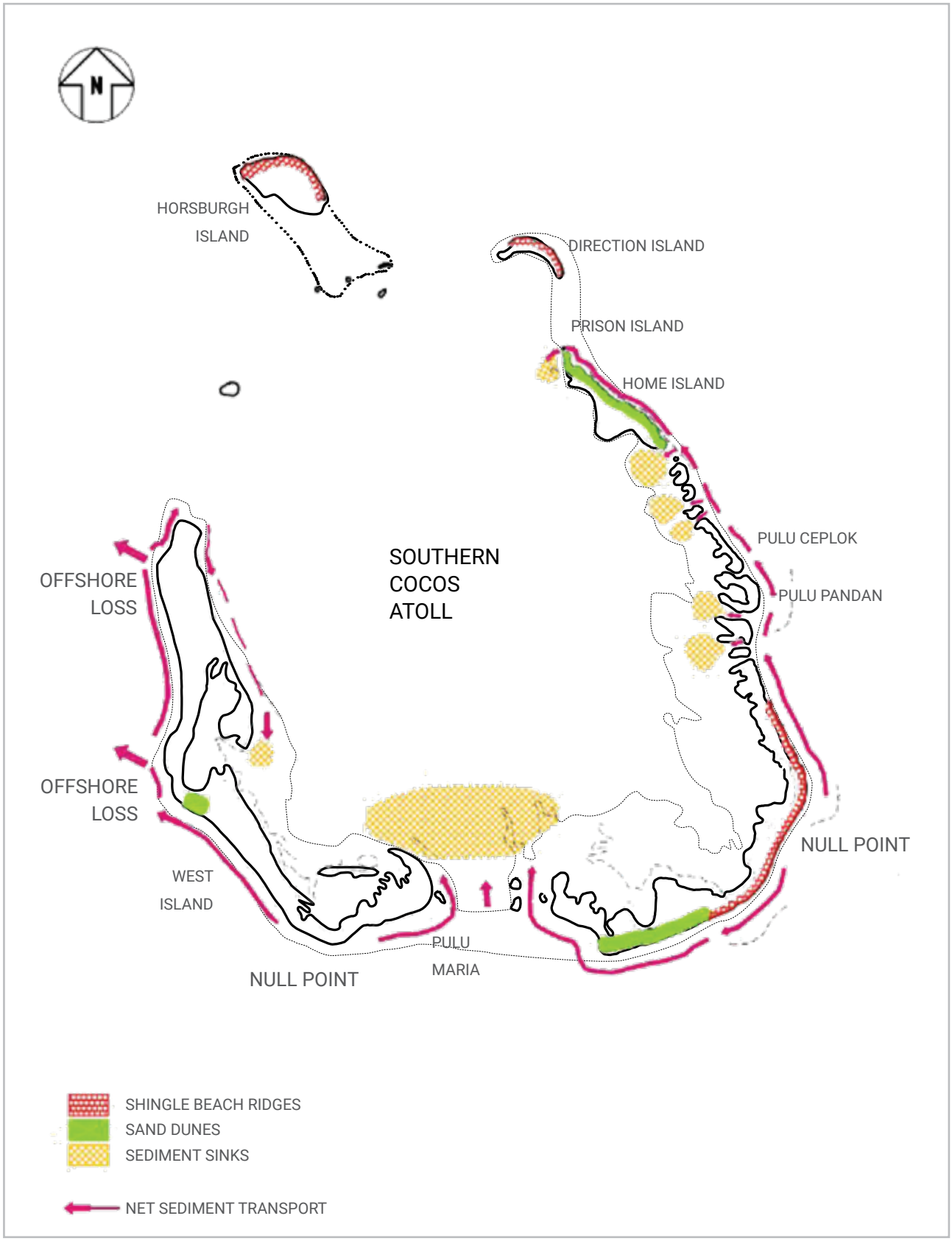


Figure 35: CKI sediment transport overview (GHD 2000 in GHD 2017 - *modified for quality 2024*).)

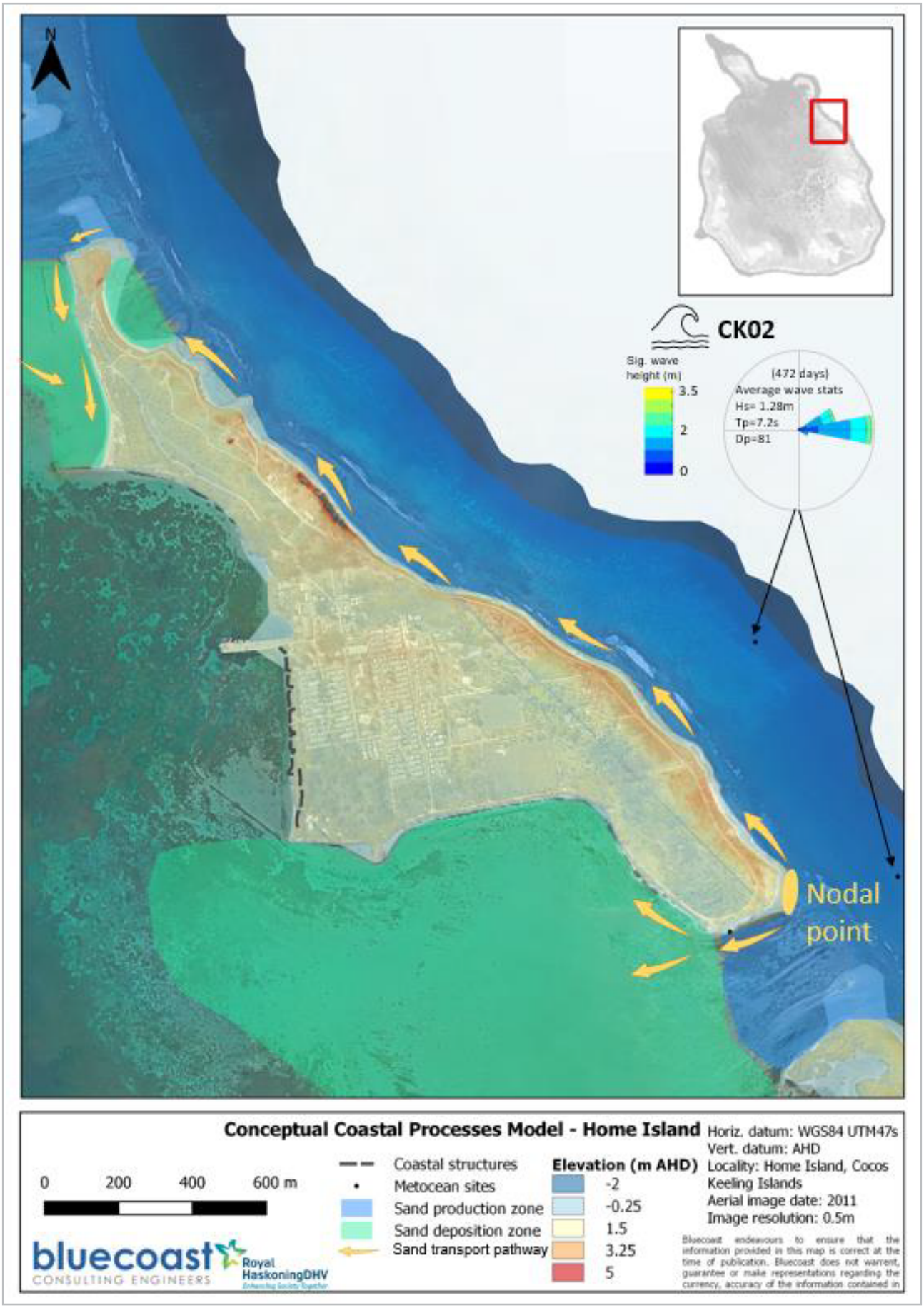


Figure 36: Conceptual coastal processes model, Home Island (RHDHV, 2021a)

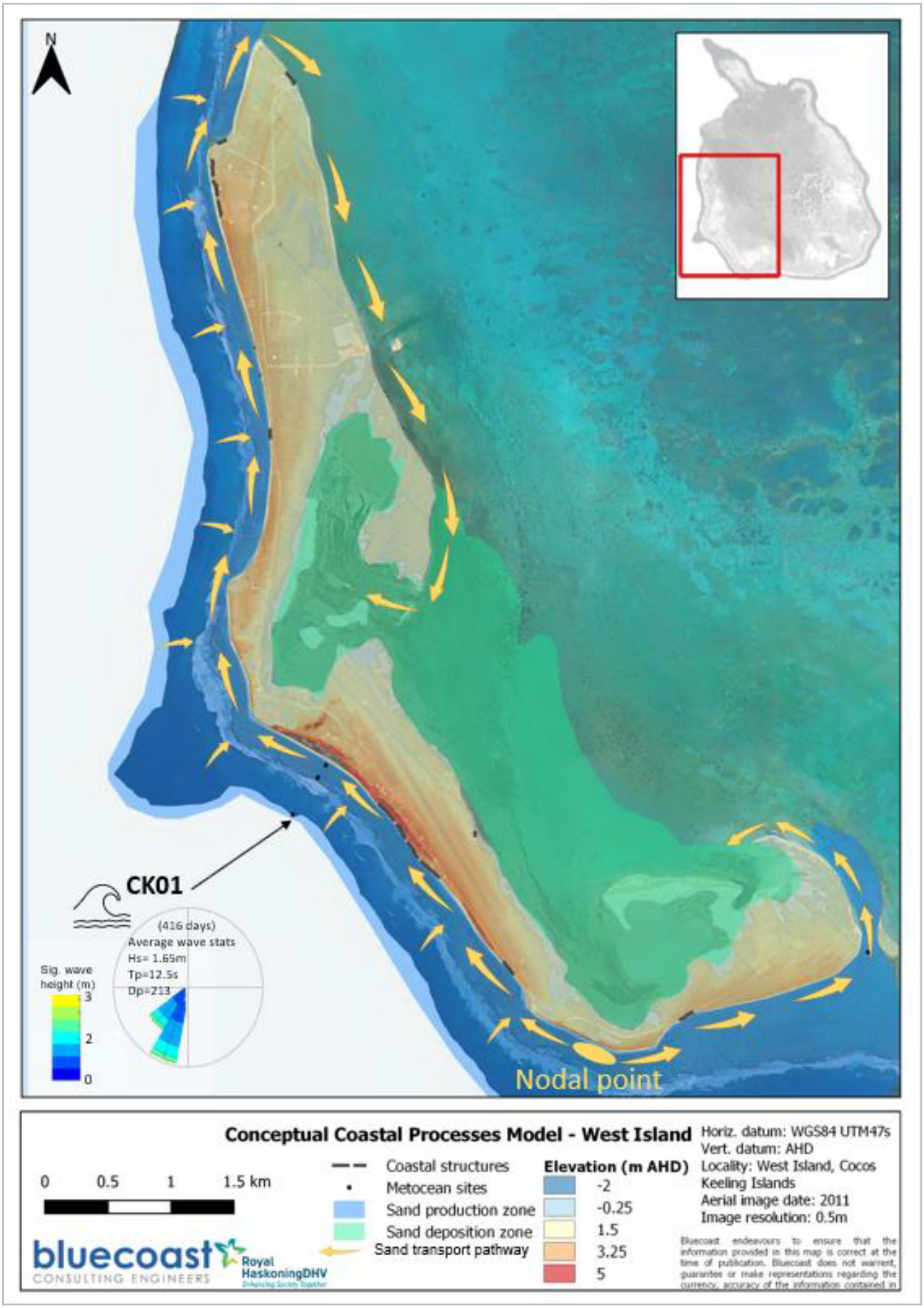


Figure 37: Conceptual coastal processes model, West Island (RHDHV, 2021a)

3.1.8 Coastal Classification

Following the review of historical information, the CKI coast can broadly be classified as a Sandy Coast in accordance with SPP 2.6 (WAPC, 2013a)

While the CKI coast is sandy there are additional features of the coastal geomorphology that may influence the response of this coastline to coastal hazards.

Observations by RHDHV (2021a) indicate that almost all sandy beaches on CKI are underlain by coral shingle or coral boulders. An example is provided in *Figure 38*, in which the sandy beach is shown to be underlaid by a coral boulder beach at The Shack. Ground investigations are required to confirm the extent and elevations of these deposits. However, RHDHV (2021a) concluded their presence is significant as an underlying ridge of less erodible material will greatly reduce the vulnerability to erosion and shoreline recession.

The coral reef surrounding CKI provides sediment to the islands and protection from waves. Additionally, they are living structures that respond to ocean conditions including the water level. Understanding the resilience of the CKI coral reef to climate change is important to understanding the coastal vulnerability of CKI.

Sea level rise controls reef growth; in the past most coral reefs seem to have kept pace with recent sea level rise (IPCC, 2014). Given past rates of coral reef growth, IPCC (2014) predict a number of coral reefs will keep up with the maximum rate of sea level rise projected for the end of the century but there is very high confidence that this capability will be weakened due the impacts of ocean warming and acidification.

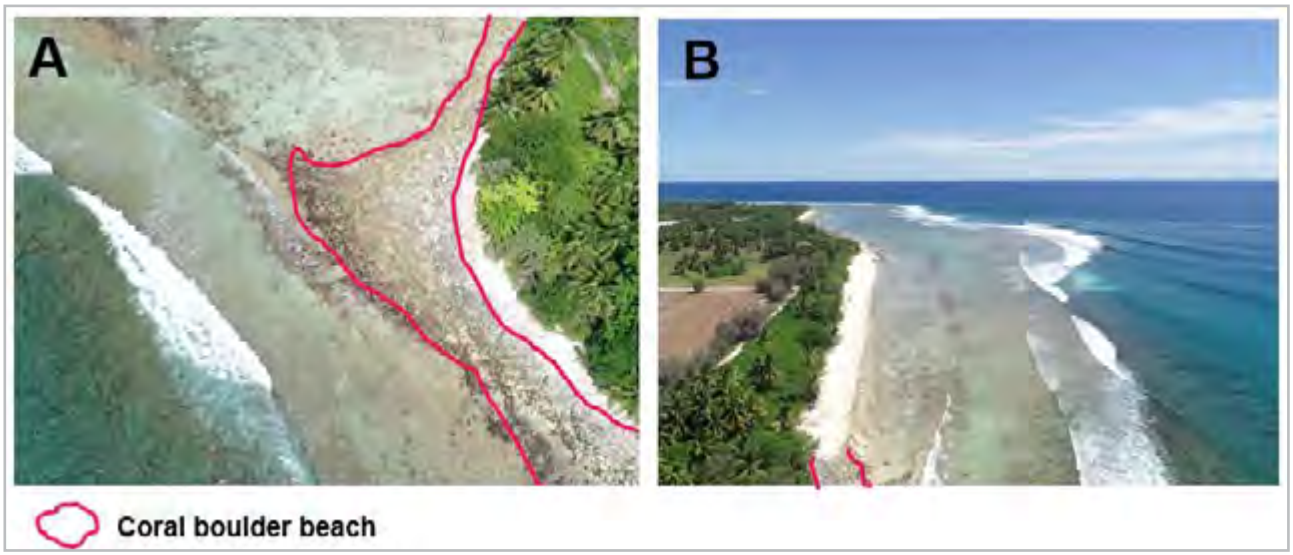


Figure 38: Drone image of a beach nearby The Shack, West Island showing (A) a coral boulder beach and (B) the same beach transitioning to a sandy beach (RHDHV, 2021a).

The response of CKI to SLR, sediment supply and ocean conditions is another important aspect to consider when understanding the coastal vulnerability of CKI:

- Research by Masselink et al (2020 in RHDHV, 2021a) considered the effect of sea level rise on the atoll islands like CKI. Masselink et al results found that islands exposed to periodic low to moderate volume overtopping will build vertically at nearly the same rate as sea-level rise. In contrast, episodic high-volume overtopping can flatten islands and increase hazard exposure. The research determined that island topography can increase in height (adjust vertically) and migrate landward via the rollover process. It follows that storms can be important phenomenon that can either increase or decrease natural resilience to sea-level rise, depending on intensity and frequency (RHDHV, 2021a).
- Island habitability also depends on the island planform area, which, without sediment input from the reef structure, may reduce as a result of rollover (RHDHV, 2021a).
- Islands with artificial shoreline defences compromise the ability of shorelines to undergo natural adjustment (RHDHV, 2021a).

3.2 Coastal Hazards

3.2.1 Risk Assessment Framework

To provide a transparent and logical basis for determining adaptation planning priorities, risk assessments were undertaken based on the Australian Standard guideline Climate change adaptation for settlements and infrastructure – A risk based approach (AS5334-2013), and the CHRMAP Guidelines (WAPC, 2019).

As illustrated in *Figure 39*, vulnerability was assessed in relation to likelihood, consequence and adaptive capacity. Likelihood was assigned using the results of the CVS (RHDHV, 2021a) and consequence ratings were informed by public consultation. Risk is the combination of likelihood and consequence, and adaptive capacity is an assets potential to adjust or be modified to address vulnerability. Upon establishing the risk level and asset adaptive capacity, an asset or group of assets' overall vulnerability to climate change can be determined.

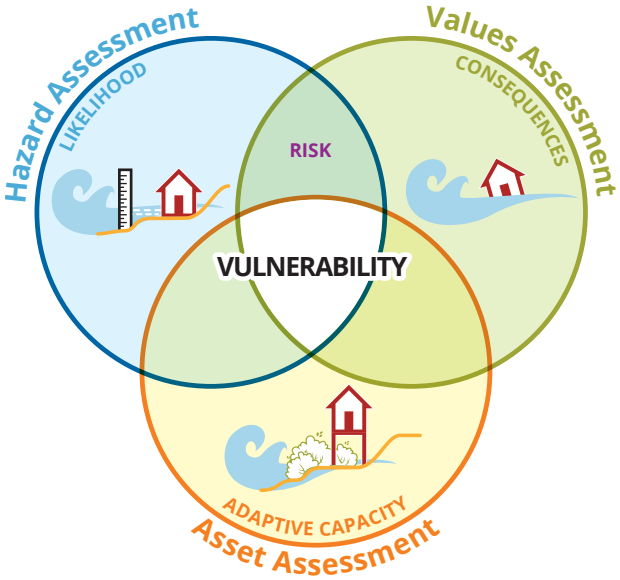


Figure 39: Vulnerability assessment, adapted from CHRMAP Guidelines (WAPC, 2019)

3.2.2 Coastal Hazard Modelling

A quick reminder:

Erosion

When sediment (sand) is transported away by waves, winds and currents, reducing the size (width) of a coastal foreshore reserve and/or the distance to an asset on the adjoining land.

Inundation

The flooding of a portion of previously dry land with ocean water. It may be a temporary occurrence during a storm event or high tide, or permanent due to sea level rise.

The potential extent of erosion and inundation has been based on the hazard modelling undertaken in the CVS which was completed for the timeframes:

- 2018
- 2068
- 2118

Although 2018 is a past timeframe, this is the first timeframe modelled by the CVS, and continues as the 'base year' in this CHRMAP. This recognises that coastal hazards are still evolving slowly. Notwithstanding, the elapsed period has provided further evidence of the hazards modelled.

Additionally, an interim period at 2031 was assessed (Bluecoast Consulting Engineers, 2021), but shows very minimal change to present day conditions and has not been considered further.

To consider the differing potential impacts of erosion and inundation, assessment of the two hazards was undertaken independently. Further to this, for ease of use separate maps have been prepared for hazard impacts for both Home and West Island.

The methodology adopted by RHDHV in the CVS to develop the hazard maps follows the requirements of SPP 2.6, whereby the extent of erosion and inundation is determined by considering the sum of the following key factors:

Erosion modelling – identifies the shoreline movement where the shoreline shifts landward reducing the width of a coastal foreshore reserve and/or the distance to a fixed feature on the adjoining land.

The extent of erosion at each of the timeframes is estimated as the sum of the following factors:

- **Current risk of storm erosion (referred to as S1)** – this considers the rapid erosion, sometimes termed the 'storm bite' which can occur during a significant storm event. In some instances, the shoreline may subsequently recover from this erosion. (*Figure 40* illustrates the extent of erosion fronting West Island settlement on the ocean facing foreshore).
- **Historic shoreline movement trend (referred to as S2)** – this considers the long-term historical change in the shoreline based on review of aerial photography .
- **Future sea level rise (referred to as S3)** – this considers the likely erosion of the shoreline which will occur as sea level rises.

Inundation modelling – identifies the flow of water onto previously dry land. It may be permanent (for example due to sea level rise) or a temporary occurrence during a storm event.

The extent of inundation at each of the timeframes is estimated as the sum of the following factors:

- **Current risk of storm surge (referred to as S4)** – this considers the temporary inundation which can occur during a significant storm event..
- **Future sea level rise** – this considers the increased inundation which is likely to occur as sea level rises.

Erosion and inundation maps for the relevant SPP 2.6 planning timeframes for both Home and West Island are presented in *Appendix B* and *Section 3.2.3.*

Figure 40: Chronic erosion of ocean facing foreshore fronting settlement in West Island

3.2.2.1 Groundwater Levels – rainfall flooding

It is generally accepted that sea level rise will cause groundwater levels adjacent to the coast to also increase. This is separate to sea water inundation, and can occur through large rainfall events that are not tied to coastal hazards. This can have a number of impacts including:

- **Seawater intrusion** (migration inland of the freshwater/saline water interface);
- **Increased salinity** in groundwater dependent ecosystems;
- **Impacts on drainage infrastructure**; and
- **Contamination of water production bores**.

There have been numerous anecdotal observations of high groundwater levels on Home Island, with residents identifying the problem as unacceptable at present day. High groundwater levels and standing water has also been observed on West Island, but to a lesser extent.

A terrestrial flood and groundwater shoaling study has been commenced for the two islands (particularly Home Island) to confirm the present day and future vulnerability of assets to terrestrial flood risk and groundwater shoaling, as well as the joint probability of these processes with coastal inundation (see *Chapter 7 Adaptation Options*).

Images of groundwater events observed in 2022 and 2023 are shown in *Figure 41* and *Figure 42*.

Figure 41: Groundwater levels May 2022 near Oceania House

Figure 42: Groundwater levels in the Home Island Kampong, March 2023, (source Shire of Cocos (Keeling) Islands)

3.2.3 Coastal Erosion Allowance

Table 12 provides the summary of erosion allowances estimated by RHDHV (2021a) using Horizontal Shoreline Datum (HSD). Maps depicting these coastal hazard allowances are presented in detail in *Appendix B*

Examples of the erosion mapping are presented in *Figure 43* and *Figure 44*.

Table 12: RHDHV (2021a) Hazard Assessment Assumptions and Calculated Erosion Allowances (in metres from present day HSD*)

CKI COASTAL MANAGEMENT UNITS			SPP 2.6 PLANNING TIMEFRAME		
			2018	2068	2118
WEST ISLAND	MU1	Settlement	6	71	146
	MU2a	Ocean Beaches North	1	51	111
	MU2b	Ocean Beaches North	1	66	141
	MU3	Lagoon Beaches	2	52	112
	MU4	Rumah Baru	2	52	112
	MU5	Scout Park/Kite Beach	0	40	91
	MU6	Ocean Beaches South	7	57	117
HOME ISLAND	MU7a	Settlement North Side	1	51	111
	MU7b	Settlement South Side	0	50	110
	MU8	Ocean Beaches	12	62	122
	MU9	Turtle Beach	1	51	111

**The HSD varies across the two settled islands and has an approximate height of +1 to +1.5 mAHD.*

The levels and allowances were developed by RHDHV (2021a) on the following assumptions and principles:

- The allowance distances set out in *Table 12* are calculated in meters setback from the predetermined HSD. The HSD is defined as the seaward shoreline contour representing the peak steady water level under storm activity, and is often depicted as the base of the erosion scarp on an eroding shoreline, the vegetation line or the crest of a protection structure.
- The coastal erosion hazards assessment has been completed for a 100-year Average Recurrence Interval (ARI) event in accordance with SPP 2.6 requirements (i.e. a 1% probability of occurring each year)
- The erosion distances were applied from the present day limit of the shoreline under storm activity (horizontal shoreline datum). This is typically the back of the beach, often the toe of dunes or the start of vegetation.
- SPP 2.6 requires coastal protection structures to be considered within CHRMAP. This is particularly relevant for the formal (or engineered) coastal protection structures that protect part of the West Island and Home Island settlements.

For the section of coastline:

> **With coastal protection structures**, three seawall structures have been assessed as being in good condition and able to withstand erosion from a 100-year ARI event; William Keeling Geotextile Sand Container (GSC) seawall and the settlement seabee concrete seawall on West Island and Jalan Pantai GSC seawall on Home Island. These seawalls were assumed to have a remaining functional life of 15 years, assuming on-going maintenance. The erosion extents are limited to the seawall crests over this functional life, after which the three erosion allowances have been applied.

> **Without coastal protection structures**, it has been assumed that the current shoreline is a sandy coast as per SPP 2.6 and therefore erodible.

> The smaller and less formal coastal protection structures that exist (e.g. GSC seawalls which have not been designed to any specification) have been treated as being in poor/very poor condition and are expected to fail during extreme erosion events.

- As required by SPP 2.6 a 0.2 m/year allowance for uncertainty has been included in the calculation of erosion extents.

Figure 43: Home Island erosion allowance

Figure 44: West Island erosion allowance

3.2.4 Coastal Inundation Allowance

Table 13 provides the summary of inundation extents estimated by RHDHV (2021a). Maps depicting these coastal hazard allowances are presented in *Appendix B*.

Examples of the inundation mapping are presented in *Figure 45* and *Figure 46*.

The levels and allowances were developed by RHDHV (2021a) on the following assumptions and principles:

- SPP 2.6 requires that developments consider the potential effects of an event with an Annual Encounter Probability (AEP) of 1 in 500-year ARI event. (i.e. a 0.2% probability of occurring each year)
- Inundation Allowances have been adopted for the ocean exposed, west-facing (West Island) and east-facing coasts (Home Island), as well as lagoon facing coastlines for each of the SPP 2.6 planning timeframes.
- RHDHV (2021a) assumes that the coral reef crest and platforms are static, given that a high level of uncertainty remains for the ability of the fringing coral reef to vertically grow as sea levels rise.

Table 13: RHDHV (2021a) Hazard Assessment Assumptions and Calculated Inundation Allowances (Peak steady water level + wave driven water level [m AHD])

SHORELINE LOCATION	SPP 2.6 PLANNING TIMEFRAME		
	2018	2068	2118
Ocean facing shoreline (Western)	3.5	3.7	4.0
Ocean facing shoreline (Eastern)	2.7	3.1	3.6
Lagoon facing shoreline	1.2	1.6	2.1

Figure 45: Home Island 2068 inundation allowance

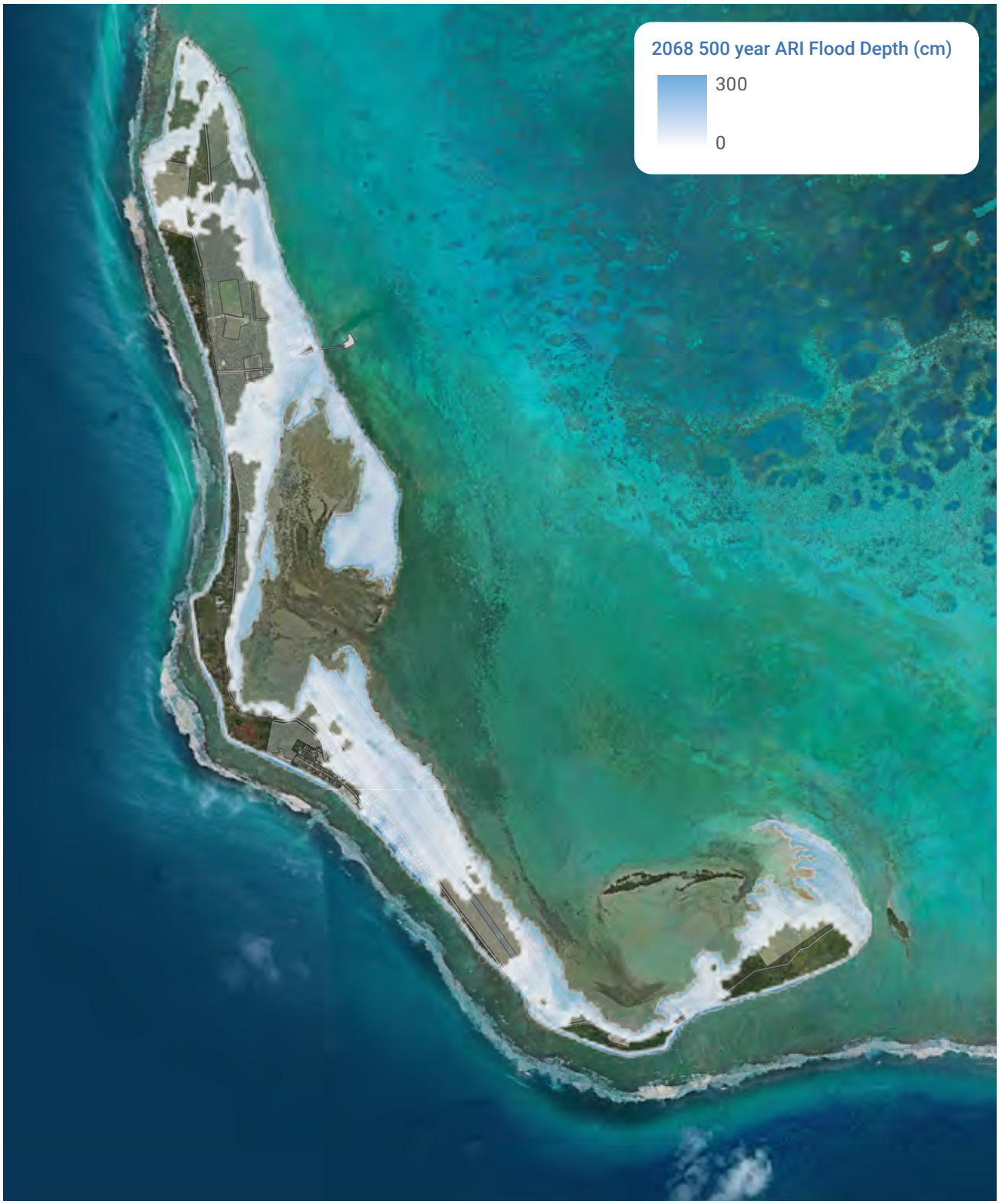


Figure 46: West Island 2068 inundation allowance

Figure 47: Community members participating in the value mapping activity

3.3 Assets and Values Identification

This section provides an overview of the assets that may potentially be impacted by coastal hazards over the next 100 years. Asset grouping was undertaken in the initial vulnerability assessment by RHDHV (2021a) in line with CHRMAP Guidelines (WAPC, 2019). This CHRMAP builds on the previous work by incorporating the findings of the CKI Community Strategic Plan and CHRMAP engagement outcomes.

For CKI, many of the values held *are* the asset being considered during the vulnerability assessment. For example, the community strongly value their way of life on the islands; which is under direct threat. The asset in this case is more than a physical asset that could be replaced, or a value that could be moved nearby.

3.3.1 Stakeholder Engagement – Assets and Values

The CHRMAP engagement was undertaken from August 2022 to February 2023. Approximately 187 in-person and 346 unique stakeholders have participated in the community and stakeholders engagement. The key values identified during the engagement period included:

- **Recreation** - The use of beach and foreshore areas for recreation, fishing, boat launching and recreational sporting activities are highly valued on both islands
- **Environment** - The ocean, lagoon, views, landscapes, foreshore vegetation and protection of the natural environment and vegetation are highly valued
- **Amenities and infrastructure** - The yacht, jukong and sailing clubs and other sporting/ recreation clubs are highly valued
- **Access** - There is a strong desire to maintain access along the coastal and lagoon foreshore areas, including for boat launching and access to other islands
- **Cultural and religious significance of Pulu Gangsa** - the cemetery and the mosque on Home Island were raised, particularly in discussions with the local Elders. Elders described concerns with regular inundation experienced, affecting daily life with consequential concerns about community safety, including health risks and concerns regarding underground power becoming dangerous.
- **Coastal process changes** - The CKI community is concerned about the impacts of coastal change, with community members observing felled trees around the coastlines of the islands, sandbags that had been impacted and how much the coastlines on Home Island and West Island have changed over time.
- **Coastal management** - The CKI community had a clear consensus on things being done to manage vulnerability risks (beyond making plans)
- **Marine management** - Cocos (Keeling) Islands Marine Park including the islands' inshore waters and offshore deep-sea seamounts, plains and ridgelines. The local Cocos Malay community have an ongoing multi-generational connection to the marine environment that is of enormous cultural and socio-economic significance.

Figure 48 and *Figure 49* show the valued assets identified in the engagement activities.

Further details on engagement activities undertaken including methods and specific feedback per stakeholder group and location (i.e. Home Island, West Island) are presented in the CKI CHRMAP Engagement Outcomes Summary Report (*Appendix C*).

3.3.1.1 Home Island Assets and Values Mapping

Figure 48 is the Home Island map showing all assets collated with values identified from the online mapping tool and engagement workshops. The map is also showing 2018, 2068 and 2118 erosion hazard lines and 2068 inundation hazard risk area.

PRIORITISED ASSETS

1. Pulu Gangsa Cemetery
2. Mosque
3. Seawater Production Bores
4. Refuse stations
5. Potable water pump station
6. Water treatment and potable water facility
7. Fuel station
8. Power station
9. Oceania House
10. Home Island Jetty
11. Doctor
12. Shire Offices, Supermarket, Museum
13. Watchtower
14. Cyclone shelter, police station and shops
15. School and ovals

WATER BASED ACTIVITIES

1. Boogie boarding
2. Sandy Point picnic area
3. Swimming spot
4. Sailing club
5. Jukong racing

BEACH BASED ACTIVITIES

1. Pondok Nek Jamil picnic spot
2. Pondok Abang viewing platform
3. Ujung Waru picnic area

FORESHORE BASED ACTIVITIES

1. Fishing/netting spot
2. Beach debris collection area
3. KampongBaru - Jukong launch area
4. Jalan Balok Mem - fitness use
5. Local boat ramps
6. Beach debris project - Pasir Nek Ayak
7. Park

NATURE BASED ACTIVITIES

1. Bird watching area

SOMETHING ELSE/OTHER

1. Green waste and rubble site
2. Revegetation area
3. Tanah Tinggi - highest point on island
4. Large native calophyllum trees
5. Submerged breakwater
6. Reclaimed foreshore
7. Heritage listed area
8. Old Bungalow site - Copra Manager
9. Chicken and Garden Plots
10. Old Home Island School building
11. Local Pondok

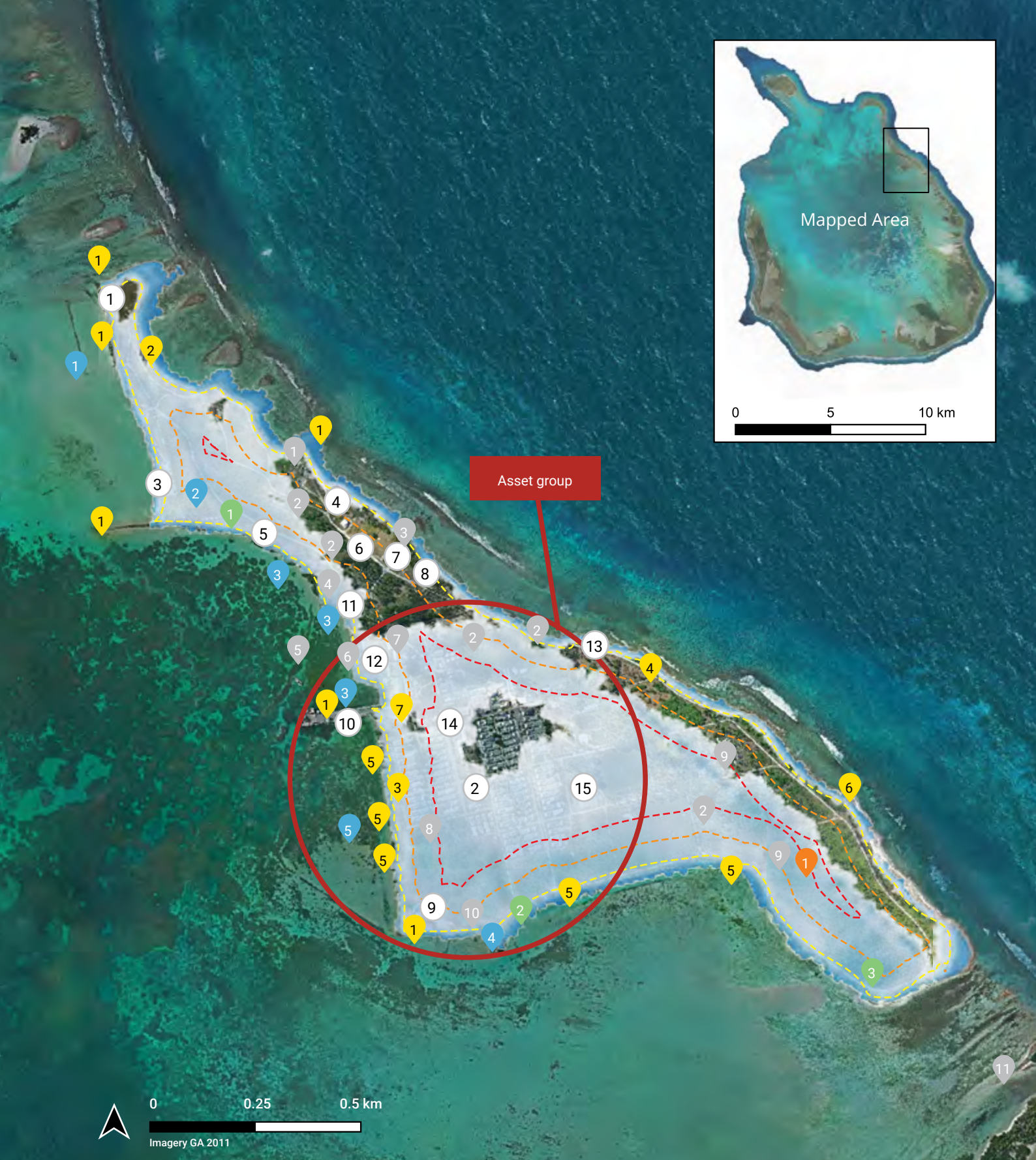


Figure 48: Asset and value mapping summary for Home Island

3.3.1.2 West Island Assets and Values Mapping

Figure 49 is the West Island map showing all assets collated with values identified from the online mapping tool and engagement workshops. The map is also showing 2018, 2068 and 2118 erosion hazard lines and 2068 inundation hazard risk area.

PRIORITISED ASSETS

1. Fuel station
2. Trannies beach reserve
3. Transmitter station
4. Rumah Baru jetty and port offices
5. Sydney Highway, power and fuel line
6. Wastewater treatment plant
7. Airfield storage
8. GA geomagnetic observatory and Bureau of Meteorology site
9. GA GNSS Mark
10. GA Seismic station
11. Communication array
12. Twiss Memorial Plaque
13. Substation
14. Access road
15. Scout Park reserve
16. Boat ramp
17. Yacht club
18. Pondok (shelter)
19. Runway
20. Power Station and industrial area
21. Settlement (Cocos Club, schools, police station accommodation, supermarket, tourist centre)
22. Desalination Treatment plant site and Seawater Bores
23. Water treatment plant and potable storage tanks

WATER BASED ACTIVITIES

1. Swimming spot
2. Local boat launch
3. Boat ramp
4. Surfing spot (The Spot)

BEACH BASED ACTIVITIES

1. Picnic area
2. Camping area
3. Cocos Islands Adventure Tours

FORESHORE BASED ACTIVITIES

1. Fishing/netting spot
2. Sunset viewing spot
3. Bicentennial track
4. Bob's Folly - old anchorage area
5. Shore walk
6. Small boat ramp

NATURE BASED ACTIVITIES

1. Bike and car track
2. Bird watching area
3. Massive fig tree
4. Beach combing, turtle watching
5. Pulu Maria snorkelling spot

SOMETHING ELSE/OTHER

1. Big Barge Art Gallery
2. Red Claw Farm
3. Firewood collection (pemphis)
4. Iron wood trees
5. Golf course

Figure 49: Asset and value mapping summary for West Island

3.3.2 Asset type and grouping

The vulnerability assessment (RHDHV, 2021a) identified assets with common values, or where adaptation is likely to consider a group of assets as a whole and grouped these for simplicity. These included:

- **Environment:** Natural foreshore parks and spaces (Reserved for Parks and Recreation in LPS1), beaches and inshore Cocos (Keeling) Islands Marine Park
- **Social:** Foreshore amenity (picnic facilities, BBQ, toilets), residential development, hospital, school, cyclone shelter, club house, cemetery, mosque/church
- **Economic:** Roads, Jetties and boat ramps, Pump station, wastewater disposal, waste disposal, desalination plant, power generator, fuel depot, Commercial/ and Australian Government infrastructure

Following the stakeholder and community engagement activities, this CHRMAP has adopted the following main changes for the consideration of asset type grouping (see *Table 14*) to reflect the values as perceived by the local community and asset owners:

The consideration for the environmental asset 'foreshore reserves and beaches' has been expanded to include ocean, views, landscapes and foreshore vegetation which are highly valued by the community.

Further to this, flora and fauna in these areas were identified as a high priority to protect by the community, through natural management measures such as revegetation. This supports:

- Bird watching
- The shade and amenity that foreshore vegetation and trees provide
- Specific foreshore locations providing breeding grounds for birds and fish

Further, the importance of the recreation value of the foreshore and beach as identified by local community has been captured.

This comprises the following uses:

- Fishing which is highly valued on both islands
- Boat launching which is highly valued by the two island communities
- Surfing, swimming and snorkelling spots which are highly valued on both islands - with specific mention of the Yacht Club and Trannies Beach on West Island and the inner lagoon foreshore area on Home Island

The importance of access to beach and waterways has been captured and included in the 'social' asset grouping, given the following was identified as a priority by the community:

- Boat launching
- Maintaining access to other islands
- Desire to access fishing spots on both islands (onshore and offshore)

The social value of specific foreshore and marine infrastructure assets have been captured to reflect community sentiments.

This comprises the following uses:

- The yacht, jukong and sailing clubs are highly valued by the community
- The jetties on both islands are highly valued, with community expressing a desire to protecting these assets as a priority to maintain between island access

The cemetery and the mosque on Home Island have been categorised separately from assets such as the school, club house and cyclone shelter (as previously grouped) given their cultural and religious significance to the community.

During engagement, Elders noted regular concerns with inundation in the cemetery area, and a strong desire for protecting this important cultural heritage asset.

The asset types and function/ values adopted for the CHRMAP are presented in *Table 14*, the subsequent consequence ratings assigned to each asset group rationale is presented in *Section 4.2 Sensitivity/ Consequence*.

Table 14: Description of asset type and functions/values

ASSET	FUNCTIONS, SERVICES AND VALUES
Environmental assets: • Foreshore • Land Reserved for Parks and Recreation in LPS1 • Beaches • Foreshore flora and fauna • Cocos (Keeling) Islands Marine Park	The environmental value of the foreshore flora and fauna is recognised by the CKI community (habitat, conservation and biodiversity). The social value of ocean, lagoons and the foreshore in terms of vista, landscapes meeting grounds and providing ongoing access was recognised as of very high value to the CKI community. Recreational activities such as fishing, surfing, swimming, snorkelling and walking are highly valued on both islands.
Foreshore amenities: • Picnic tables • Gazebos • Toilets • Playgrounds • Fish cleaning stations • BBQs • Pondoks (shelters)	The listed foreshore amenities are considered to be of high value to the CKI community as they provide support to much loved social and recreational activities. The exposure of these assets vary across islands and sections of coastline, the opportunity to relocated these assets landward are investigated per location in risk treatment assessment (Section 5).
Residential development	Provides housing for resident population and tourism. However, given the remote location of CKI, replacing residential buildings is difficult and as such these the sensitivity to impact is significant.
Community buildings/ assets: • School • Cyclone shelter • Club house • Yacht clubs • Jukong and sailing clubs	The social and recreational values these assets provide was identified by the CKI community. The buildings are typically costly to build and fit out, making relocation of the physical asset difficult.
Cultural and religious assets: • Mosque • Cemeteries	The cultural and religious significance of Pulu Gangsa was identified by the CKI community. A zero tolerance to coastal hazards for these assets is to be adopted.
Roads	Provides transport services and evacuation routes.

Table 14: Description of asset type and functions/values (continued)

ASSET	FUNCTIONS, SERVICES AND VALUES
Jetties and boat ramps	Identified as high value to the CKI community as provides: • recreation facilities (fishing, boating) • transport services (access to other islands) These facilities are also required for import of freight.
Essential services assets and infrastructure: • Pump station and fuel depot • Water treatment • Potable water supplies and bores • Waste disposal • Desalination infrastructure • Power generator • Airport • Hospital	The listed assets are vital/essential service to social health and general function of the islands. A zero tolerance to coastal hazards for these assets is to be adopted.
Commercial Industrial Australian Government infrastructure	Local government buildings on Home Island and Australian Government buildings on West Island. A number of temporary construction facilities are also proposed to support the Airport runway upgrade to be undertaken by the Department of Defence.

3.3.3 Adaptation options

There was divergence of preferences for management options for Home Island and West Island.

Home Island

Home Islanders support natural and softer options including revegetation and education in the short-term, and prioritise effective protection for the settlement area.

However, the community recognises the coastal hazards that already exist at the present day and continue to explore a variety of planned and managed retreat, accommodate and protect options for the longer term.

It was observed that people will adapt to the most applicable and safe options, e.g. the community is adapting to the loss of pondoks (shelters) by camping instead.

West Island

West Islanders prefer protection, via engineering options including sandbags and seawalls.

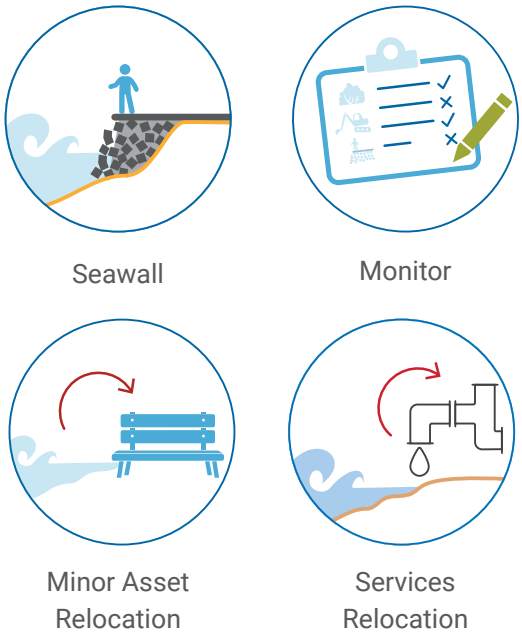
The community expressed a need for certainty and transparency to help them make long-term plans, including whether to invest or move away from the islands.

Short-term; protection preferred

Both island communities prioritised settlement protection, with keen interest for the 'seabee' type seawalls (which are in-situ already and observed to work well).

The CKI community also expressed the importance of protection of the Yacht Club and Rumah Baru jetty areas on West Island.

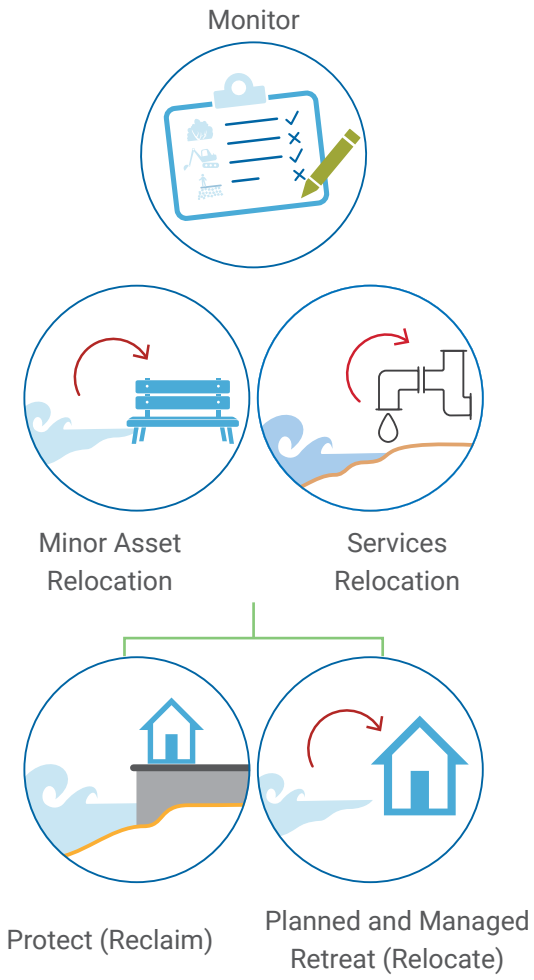
Preferred Short-Term Options



The vulnerability of CKI to coastal inundation and erosion requires a unique timeframe of short-term adaptation within the next 0 to 10 years.

- Avoid is not possible where assets are already in place, but can be achieved for undeveloped areas.
- Planned and managed retreat (relocation) of Minor Assets and some Services infrastructure is possible.
- Planned and managed retreat of settlements may be possible to consider longer term, and Long-Term Settlement Planning can commence for this option, but in such a short period this option will incur significant social upheaval, and will take time to implement regardless.
- Protect and Accommodate are possible for continued enjoyment in the short-term until the existing way of life is substantially impacted by coastal hazards that cannot be mitigated against.

Preferred Medium to Long-term Options



It is challenging to maintain the short-term options of Accommodate and Protect over the medium to long-term for the following reasons:

- Groundwater impacts are likely to be experienced in tandem with erosion and inundation.
- High levees will impact on views of the water and access to boat ramps (and the water), and do not have the effect of halting groundwater flooding.
- Increasing the ground level (filling with sand) across the settlement areas will be disruptive to existing settlements, resulting in population scale relocation during development and severing community connection to land and waterfronts.

The community recognised the challenges of these Accommodate and Protect options through engagement, albeit that they continued to suggest a variety of ways that they could be achieved, both tested and untested in the local environment.

Notwithstanding, the feedback indicates a continued desire to remain on the islands.

Ongoing monitoring and detailed engagement on the long-term options is required to determine the most appropriate solution and timing for the future of the island settlements.

3.3.4 Community Concerns

Groundwater and Flooding

Increased frequency and severity of rainwater flooding, high ground water levels and storm inundation has detrimentally affected the daily activities of the Home Island community.

Funding and Ownership

Funding for options is a key consideration. However, the Home Island community do not consider themselves in the position to make decisions as they do not own their houses or have a long-term substantial funding source.

Increased Erosion severity

Many changes along the coastlines have been observed by the community in both short and long-term periods, including the vegetation loss of Prison Island, and storm-exacerbated erosion near settlements.

Runway Upgrade

Both island communities are aware of the runway upgrade project and would like to have certainty about its ramification to the island's future, including its effect to local community and the flow on effects to coastal risks.

Image 2 Groundwater and flooding has an increased in frequency on Home Island

Image 3 The islanders have a unique historic bond to the atoll, not ownership.

Image 4 Impact of coastal processes

Image 5 Sandbags that have been impacted

3.4 Hazard Mapping

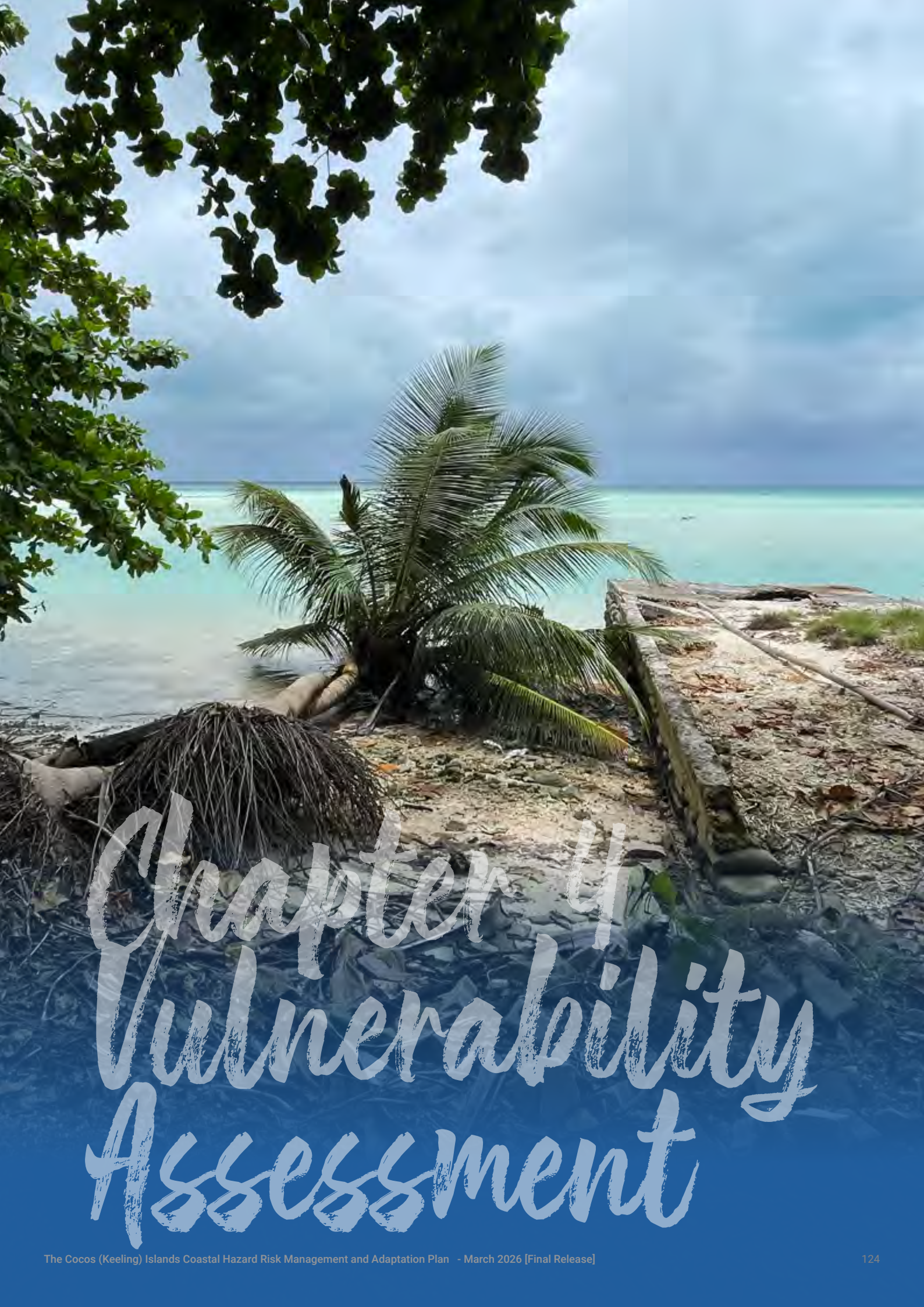
The erosion and inundation hazard maps have been collated as a single appendix for ease of review – these are at *Appendix B*.

Additionally, it is important to note that these predictions are based on a suite of assumptions and have varying degrees of uncertainty, which may influence the likelihood of the projected extent of erosion or inundation occurring at each planning horizon.

These assumptions include the fringing coral reefs of CKI. As noted in *Section 3.1.8* external factors such as coral reef growth (coral 'rising' with sea levels) may influnce the extent of erosion and inundation occurring over the long-term.

SPP 2.6 requires revision of the CHRMAP every 10 years (or sooner if required), including a review of hazard estimates using the most up to date information, the findings of specialist investigations undertaken, changes to projected sea level rise, climate change effects and any changes to the use of the foreshore.

Due to the existing hazards being experienced, this CHRMAP recommends review at an earlier timeframe, in line with the next review of the Local Planning Scheme (approximately 5 years).



Chapter 4
Vulnerability Assessment

4 Vulnerability Assessment

A vulnerability assessment defines the degree of impact coastal hazards are likely to have on coastal assets over the planning timeframe. The vulnerability of a coastal asset to coastal hazards is related to its exposure to the hazard, its sensitivity to that exposure, and the ability of the asset to be modified or adapted to manage this exposure.

This chapter summarises the following:

1. **Likelihood and consequence** – review likelihood and consequence scales in the CVS, update assets' exposure (likelihood) and sensitivity (consequence) to coastal hazards.
2. **Update risk assessment** – establish potential impact based on the likelihood and consequence scales.
3. **Assess the Adaptive Capacity** – of the assets to cope with coastal hazards.
4. **Identifies Vulnerability** – establish vulnerability to coastal impacts, so the community can understand potential impact, even if they are willing to accept certain risks.

This is illustrated in *Figure 50*; the input components are displayed in blue.

Inundation and erosion hazards are considered separately for Home Island and West Island. Assets are grouped according to classification for ease of interpretation. Ratings have been presented to and discussed with the community to ensure they are reflective of community views.

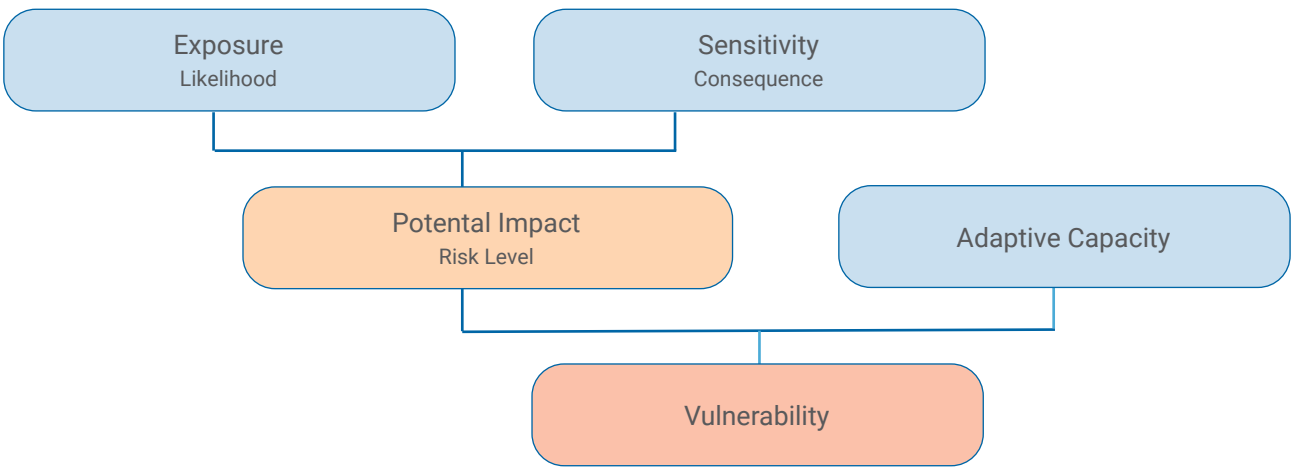


Figure 50: Vulnerability assessment components (reproduced from Allen Consulting, 2005)

4.1 Exposure/Likelihood

Likelihood is the term used to describe the chance of something happening (Australian Standard (AS) 5334-2013 Climate Change Adaptation for Settlements and Infrastructure – A Risk Based Approach). Within the context of a vulnerability assessment, it is used to consider the exposure of an asset to coastal hazards.

As likelihood can be subjective, the likelihoods were defined based on the projected hazard extents for the various planning timeframe as recommended in WAPC (2019).

This approach assumes that for any given planning timeframe the likelihood of the hazard occurring up to the calculated hazard line for that timeframe is at least 'possible'. The likelihood scale adopted is presented in *Table 15*. The adopted likelihood rating for each planning timeframe is provided in *Table 16*. A graphical example is shown in *Figure 51*.

Table 15: Exposure/Likelihood rating description for erosion and inundation

LIKELIHOOD RATING	DESCRIPTION	ANNUAL EXCEEDANCE PROBABILITY
Almost Certain	Expected to occur in most circumstances	>90%
Likely	Impact to asset for a given planning timeframe is likely	50-90%
Possible	Impact to asset for a given planning timeframe is possible	10-50%
Unlikely	Impact to asset for a given planning timeframe is unlikely	1-10%
Rare	May occur in exceptional circumstances	<1%

Table 16: Adopted likelihood rating for the planning timeframe(source: WAPC, 2019)

LIKELIHOOD RATING		PLANNING TIMEFRAME		
		2018	2068	2118
Erosion Hazard Line	2018	Possible	Likely	Almost Certain
	2068	Unlikely	Possible	Likely
	2118	Rare	Unlikely	Possible

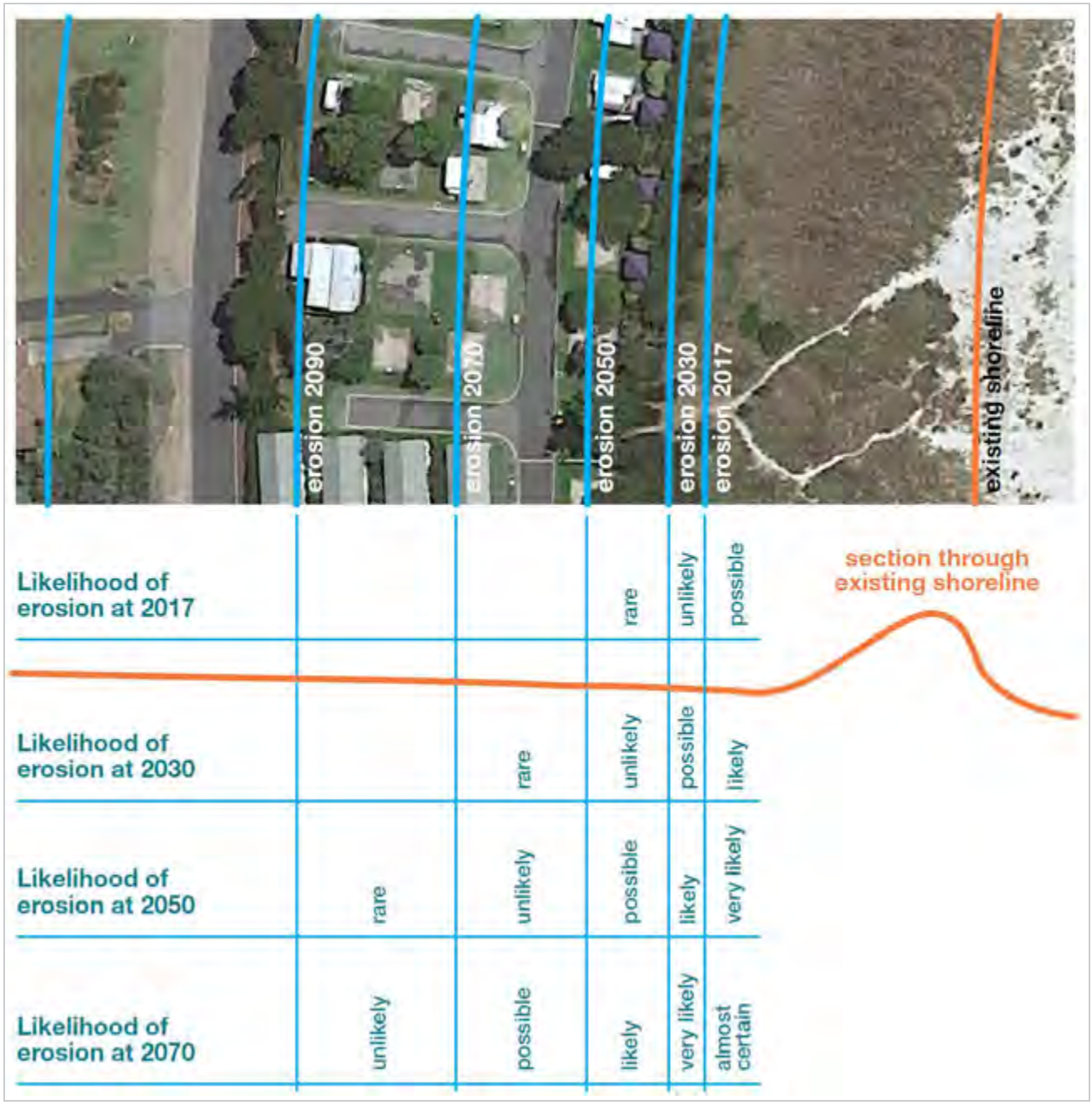


Figure 51: Example of likelihood (or exposure) of erosion hazard for different timeframes (source: WAPC, 2019)

4.2 Sensitivity/Consequence

The consequence is defined as the outcome of an event or change in circumstances affecting the achievement of objectives (DLG, 2013).
In the context of a vulnerability assessment, consequence is used to consider the sensitivity of an asset to coastal hazards. The consequences may be both immediate, with outcomes during a storm event, or with impacts only being realised after the event. In this context it is useful to understand whether the consequence will be short-lived and if the impacts are reversible, versus persistent, long-term impacts.

When considering a broad range of consequences, the impacts of erosion and inundation have been evaluated for each asset group using the consequence scale shown in *Table 17*. The consequence scale was developed for the study area based on the scales presented in the CHRMAP guidelines (WAPC, 2014) AS 5334, and DLG (2013), incorporating the results of the community values consultation (*Section 3.3* and *Appendix C The Cocos (Keeling) Islands Coastal Hazard Risk Management and Adaptation Plan Engagement Outcomes Summary Report*) and to reflect an atoll coastal environment. The subsequent consequence scale rating for each asset group for both erosion and inundation hazards is presented in *Table 18*.

Table 17: Consequence Scale

CONSE-QUENCE	PEOPLE'S HEALTH AND SAFETY	SOCIAL AND CULTURAL	PROPERTY AND FINANCIAL	NATURAL ENVIRONMENT
Insignificant	No Injury	Minimal or no loss/damage/ interruption to services, recreational activities, employment, wellbeing, culture or heritage. Little or no disruption to the community. Less than 5% of community affected.	Inconsequential or no damage to infrastructure, property, equipment or tourism activities. Less than $10,000 or 2% of annual operating budget	Negligible to no loss of flora, fauna or land-form. Scenic, naturalness of the environment unchanged
Minor	One or more minor injuries such as first aid treatments.	Short-term, temporary loss/ damage/interruption to services, recreational activities, employment, wellbeing, culture or heritage. Minor disruption to the nearby community. 5 - 10% of community affected.	Localised damage rectified by internal arrangements. Loss or damage to infrastructure, property, equipment or tourism activities of $10,000 - $100,000 or 2 - 5% of annual operating budget	Short-term loss of flora, fauna or landform (strong recovery) with local impact. Localised or minor impact on the scenic, naturalness of the environment
Moderate	One or more injuries, not severe, such as those requiring minor medical treatments.	Medium-term, temporary loss/ damage/ interruption to services, recreational activities, employment, wellbeing, culture or heritage. Significant disruption to the nearby community. 10 - 25% of community affected. Island impact, limited alternative sites or facilities exist.	Localised damage rectified by internal and external arrangements. Permanent loss or damage to infrastructure, property, equipment or tourism activities of $100,000 - $2 million or 5 - 10% of annual operating budget	Medium-term loss of flora, fauna or landform (recovery likely) with island impact. Moderate loss of scenic, naturalness of the environment.
Major	One or more severe injuries such as temporary or permanent disabilities	Long-term, prolonged loss/damage/ interruption to services, recreational activities, employment, wellbeing, culture or heritage. Substantial disruption to widespread community. 25 - 50% of community affected. Island impact, no alternative sites or facilities exist on individual island.	Significant damage requiring external resources. Permanent loss or damage to infrastructure, property, equipment or tourism activities of $2 - $5 million or 10 - 20% of annual operating budget.	Long-term loss of flora, fauna or landform (limited chance of recovery) with island impact. Widespread or major loss of scenic, naturalness of the environment
Catastrophic	One or more fatalities or multiple severe injuries	Permanent, prolonged loss/ damage/interruption, recreational activities, employment, wellbeing, culture or heritage. Major/ multiple disruption to widespread community. More than 50% of community affected. Atoll impact, no suitable alternative sites or facilities exists on CKI.	Extensive damage resulting in a prolonged period of recovery. Permanent loss or damage to infrastructure, property, equipment tourism activities of more than $5 million or 20% of annual operating budget	Permanent loss of flora, fauna or landform (no chance of recovery) with atoll impact. Total loss of scenic, naturalness of the environment

Table 18: Consequence scale applied to each asset group for erosion and inundation hazard

ASSET	EROSION CONSEQUENCE	INUNDATION CONSEQUENCE
Environmental	Major	Insignificant
Foreshore amenities	Major	Minor
Residential development	Major	Major
Community buildings and assets	Major	Major
Cultural and religious assets	Catastrophic	Catastrophic
Roads	Major	Major
Jetties and boat ramps	Major	Major
Essential services and infrastructure	Catastrophic	Catastrophic
Commercial, industrial and Australian Government infrastructure	Major	Major

4.3 Potential Impact (Risk Level)

Risk level, or potential impact, is calculated as the product of exposure and sensitivity (see *Table 19*). It provides a classification of the potential impact of coastal hazards on identified assets, which should be determined for each considered planning timeframes. Level of risk is evaluated mainly based on its tolerability (i.e., consequence). Definitions of each Risk Level are provided in *Table 20*.

Table 19: Risk level (potential impact) matrix as product of sensitivity (consequence) and exposure (likelihood)

LIKELIHOOD	CONSEQUENCE				
	Insignificant	Minor	Moderate	Major	Catastrophic
Rare	Low	Low	Low	Medium	Medium
Unlikely	Low	Low	Medium	Medium	High
Possible	Low	Low	Medium	High	**Extreme**
Likely	Low	Medium	Medium	High	**Extreme**
Almost Certain	Low	Medium	High	**Extreme**	**Extreme**

Table 20: Risk Level definition

RISK LEVEL (POTENTIAL IMPACT)	DESCRIPTION
Low	Acceptable risk. A level of risk that is low and manageable without intervention outside routine asset maintenance.
Medium	A level of risk that may require intervention to mitigate, such as changes to design standards or asset maintenance. Short to medium-term action required.
High	A level of risk requiring significant intervention to mitigate in the immediate to short-term.
Extreme	Immediate action required to reduce risk to acceptable levels

4.4 Adaptive Capacity

An asset's adaptive capacity defines its ability to accommodate the potential impacts of coastal hazards with minimum disruption or additional cost (OEH, 2011).

The adaptive capacity of each asset on CKI was evaluated using the scale shown in *Table 21*, the adaptive capacity scale has been adopted from the vulnerability assessment (RHDHV, 2021a) and originally adapted from the CHRMAP Guidelines (WAPC, 2014) and AS 5334 (Australian Standards, 2013).

The scale takes into consideration the design, function of the assets as confirmed through the site visit and outcomes of the engagement activities. The adaptive capacity of each asset to accommodate the impacts of erosion and inundation have been considered independently.

For CKI, this assessment also notes that whilst coral reefs have typically kept pace with recent sea level rise (IPCC, 2014), there is very high confidence that this capability will be weakened due the impacts of ocean warming and acidification, and should not be relied on as stable.

Table 21: Adaptive capacity scale

ADAPTIVE CAPACITY	DESCRIPTION
Very High (can adapt easily)	Impact of coastal hazard will cause minimal or no reduction in asset's function or performance
High (can adapt)	Impact of coastal hazard will cause short-term or localised reduction in asset's function or performance. Minor modifications may be required but could be undertaken as part of routine maintenance. Early renewal of 10-20% of infrastructure may be required.
Moderate (may adapt)	Impact of coastal hazard will cause medium-term or moderate reduction in asset's function or performance. Minor modifications will be required. Early renewal of 20-50% of infrastructure may be required.
Low (difficulty adapting)	Impact of coastal hazard will cause long-term or significant reduction in asset's function or performance. Major modifications will be required. Early renewal of 50-90% of infrastructure may be required.
Very Low (challenging to adapt)	Impact of coastal hazard will cause complete loss of asset's function or performance. Asset will require redesign, rebuilding and/or relocating. Early renewal of more than 90% of infrastructure may be required.

4.5 Vulnerability

Vulnerability ratings define the degree to which an asset is susceptible to, and less adaptable to adverse effects of coastal hazards.

The vulnerability rating for each asset in this CHRMAP was determined by combining the risk rating (to account for the potential impacts of the coastal hazards) and the adaptive capacity rating (*Figure 52*), using the vulnerability matrix shown in *Table 22*.

The vulnerability tolerance scale presented in *Table 23* provides an indication of the susceptibility of assets to the impacts of coastal hazard.

Low vulnerability indicates the asset is likely to be able to accommodate the impacts of coastal hazards with minimal or no additional management. or is at a low risk regardless. Alternately, assets identified with Very High vulnerability are likely to be unable to withstand impacts without significant adaptation.

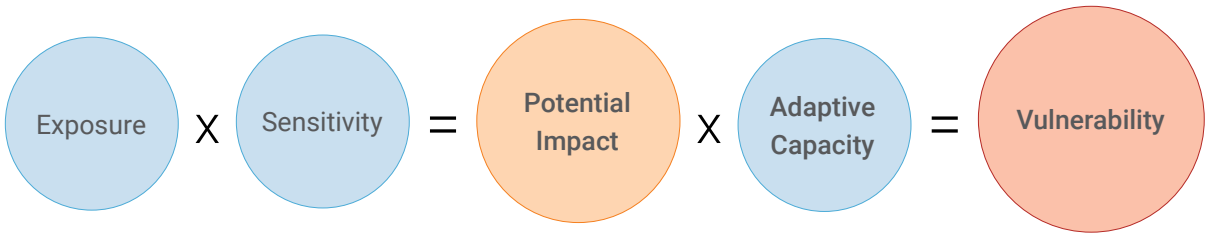


Figure 52: Vulnerability relationship

Table 22: Vulnerability matrix

RISK LEVEL (POTENTIAL IMPACT)	ADAPTIVE CAPACITY				
	Very High Can adapt easily	High Can adapt	Moderate May adapt	Low Difficulty adapting	Very Low Challenging to adapt
Low	Low	Low	Low	Medium	High
Medium	Low	Low	Medium	High	Very High
High	Low	Medium	High	Very High	Very High
Extreme	Medium	High	Very High	Very High	Very High

Table 23: Vulnerability tolerance scale

VULNERABILITY LEVEL	PRIORITISATION	TOLERANCE LEVEL
Low	Asset has high resilience, it is able to cope with the impacts of coastal hazards without additional support. No immediate action required. Likely to be adequately managed by routine procedures.	**Acceptable**
Medium	Asset has some ability to cope with the impacts of coastal hazards. However short to medium-term actions are likely to be required to reduce vulnerability to acceptable levels. Observing, assessing and improving current controls and procedures is likely to be required.	**Monitor**
High	Asset has limited ability to cope with the impacts of coastal hazards. Immediate to short-term adaptation is likely to be required to reduce risk to acceptable levels. Establishment and implementation of controls is likely to be required.	**Urgent action is required**
Very High	Asset has minimal ability to cope with the impacts of coastal hazards without additional support. Adaptation will need to be considered as a priority. Establishment and implementation of controls is likely to be required.	**Unacceptable**

4.6 Assets Requiring Adaptation

As outlined in the vulnerability tolerance scale (*Table 23*) urgent action is required to address the unacceptable risk posed to assets with a High to Very High vulnerability ranking.

Given the large number of assets that are currently at urgent (High) or unacceptable (Very High) levels of vulnerability on both islands, the risk treatment (adaptation approach) will need to consider the trade-offs of different adaptation pathways to mitigate coastal vulnerability for the various asset types on current populations.

For example, hard protection options have different trade-offs depending on the asset type (i.e. retaining a beach vs. retaining private residential development).

The early engagement undertaken in this stage allowed for preliminary discussion of trade-offs of adaptation options. This understanding of community and stakeholder appetite of various adaptation options informs the criteria to assess the risk treatment option in the following stages of the CHRMAP process.

Table 24 provides a summary of the number of vulnerable assets on each inhabited island for erosion and inundation hazards, respectively, showing large numbers of existing vulnerable assets in 2018 and then increasing over the planning period.

Section 4.6.1 Vulnerable Assets summarises the assets that are vulnerable, whilst detailed maps showing asset vulnerabilities are provided in *Appendix B*.

Table 24: Vulnerability Level for assets identified as being at risk

LOCATION	VULNERABILITY LEVEL	NUMBER OF ASSETS VULNERABLE (TO EITHER EROSION OR INUNDATION)					
		2018		2068		2118	
West Island	Low	0	30	0	30	0	30
	Medium	7	32	0	21	0	3
	High	178	89	103	33	7	29
	Very High	35	62	117	129	213	151
Home Island	Low	0	24	0	24	0	24
	Medium	7	21	0	8		1
	High	106	107	67	37	7	20
	Very High	32	91	78	174	138	198

Erosion Vulnerability: Low Medium High Very High

Inundation Vulnerability: Low Medium High Very High

4.6.1 Vulnerable assets

The risk identification and vulnerability assessment has identified *an increased number of assets* at a high or very high vulnerability for both erosion and inundation across the islands compared to the CVS.

The main factors influencing this include:

- An improved understanding of community and stakeholder values for both build and natural assets.
- Onsite ground truthing of the assumptions presented in the CVS.

Based on the risk and vulnerability analysis and the evaluation of existing controls this section provides a summary of the key assets requiring additional management controls.

4.6.1.1 Home Island and West Island

Table 25, *Table 26* and *Table 27* provide a summary of the erosion and inundation existing vulnerability rating for impacted assets over a 100 year timeframe at both Home Island and West Island. This rating takes into account the influence of existing controls.

Assets found to have a high or very high vulnerability rating are assumed to have an unacceptable vulnerability level and are likely to require management actions in order to further reduce their vulnerability.

Given the large number of assets at high or very high vulnerability, particularly within the settlement areas of both Home and West Island, a unified approach is required when considering adaptation of these areas. That is, the consideration for risk treatments (adaptation pathways and options) will be assessed for all assets within the settlement of West Island rather than individual risk treatments per asset, likewise for Home Island.

Outside of the settlement areas, individual risk treatments of trade-offs will be considered per asset type (e.g., the risk treatment and consideration for trade-offs will be separate for Trannies Beach and Rumah Baru).

4.6.1.2 Uninhabited Islands Vulnerability

Whilst the vulnerability of pondoks and recreation infrastructure on most of the uninhabited islands is likely to be almost certain, the consequence of the impact is generally insignificant to minor, with loss of life expected to be none, limited interruption to services, and only minor cost from property damage and impact to the environment that would be expected in the coastal location. The adaptive capacity of most infrastructure is also good. For most of the uninhabited islands, vulnerability is expected to be quite low.

One exception to this is the jetty on Direction Island (Pulu Tikus) where the cost from damage and impact to tourism activity could have a moderate to major consequence (based on the consequence scale in *Table 17*).

This asset may require ongoing monitoring and potentially more detailed assessment via a CHRMAP, should any further development of the island be proposed.

It is also recognised that Horsburgh Island (Pulu Luar) contains artefacts that have an historical value to the story of the Cocos (Keeling) Islands which have already been substantially impacted by the hazards of the coast. Existing historical records are likely to remain the primary record of this history over the planning horizon as the coastline changes.

In addition, Cocos (Keeling) Islands support a population of the Christmas Island Blue-tailed Skink and two self-sustaining populations of C. egeriae. The C. egeriae (captive-bred) from Christmas Island and Taronga Zoo) were translocated to Pulu Blan in September 2019 and to Pulu Blan Madar in March 2020 as an assisted colonisation trial. They have been successfully established, representing free-living insurance populations protected from their key threatening processes (wolf snakes).

Table 25: Vulnerability Rating for West Island Settlement - Management Unit 1 and Management Unit 3

MANAGEMENT UNIT	ASSET	VULNERABILITY		
		2018	2068	2118
MU1 West Island Settlement	Coastal Structures (Motel CIBR groyne, Seabee Wall and GSC seawall)	Very High / Very High	Very High / Very High	Very High / Very High
	Power station (2)	N/A / Medium	N/A / Very High	N/A / Very High
	Freehold properties (3)	High / Very High	Very High / Very High	Very High / Very High
	Airport associated infrastructure (5)	Very High / Very High	Very High / Very High	Very High / Very High
	Roads (including Sydney Highway) and carparks	High / Very High	Very High / Very High	Very High / Very High
	Parks and Recreation Reserves under LPS1	High / Medium	Very High / High	Very High / High
	Medical Centre	High / Very High	High / Very High	Very High / Very High
MU3 West Island Lagoon Beaches	Fuel Station (1)	Very High / Very High	Very High / Very High	Very High / Very High
	Airport (runway, IOTT tower, water treatment plant potable storage tanks) (4)	Very High / Very High	Very High / Very High	Very High / Very High
	Transfer Station (8)	Very High / Very High	Very High / Very High	Very High / Very High
	Roads	Very High / High	Very High / Very High	Very High / Very High
	BoM Weather Station Building & geomagnetic observatory (7)	High / Very High	Very High / Very High	Very High / Very High
	Air Force Communications Array (8)	Very High / Very High	Very High / Very High	Very High / Very High
	Wastewater Treatment Plant (9)	High / High	Very High / High	Very High / Very High
	Parks and Recreation Reserves under LPS1 and crown land	Very High / Low	Very High / Low	Very High / Low

Erosion Vulnerability: Low, Medium, High, Very High

Inundation Vulnerability: Low, Medium, High, Very High, N/A

Figure 53: West Island Settlement Vulnerable Priority Assets

Table 26: Vulnerability Rating for West Island Outlying - Management Unit 2 and Management Units 4, 5 and 6

MANAGEMENT UNIT	ASSET	VULNERABILITY		
		2018	2068	2118
MU2 West Island Ocean Beaches North	Parks and Recreation Reserves under LPS1 and Pondok (1)			
	Transmitter Site (2)			
	GSC Seawall			
	Freehold properties			
	The Big Barge Art Centre			
	Cemetery			
	Roads (including Sydney Higway)			
MU4 West Island Rumah Baru	Rumah Baru and associated infrastructure (3)			
	Roads			
	Freehold properties			
MU5 Scout Park/ Kite Beach	Parks and Recreation Reserves under LPS1 (5)			
	Boat ramp (6)			
	Yacht Club (7)			
	Pondoks (8)			
MU6 West Island, Ocean Beaches South	GSC seawall			
	Communications Facility (4)			
	Parks and Recreation Reserves under LPS1			

Erosion Vulnerability: Low Medium High Very High

Inundation Vulnerability: Low Medium High Very High

N/A

Figure 54: West Island Outlying Vulnerable Priority Assets

Table 27: Vulnerability Rating for Home Island - Management Units 7, 8 and 9

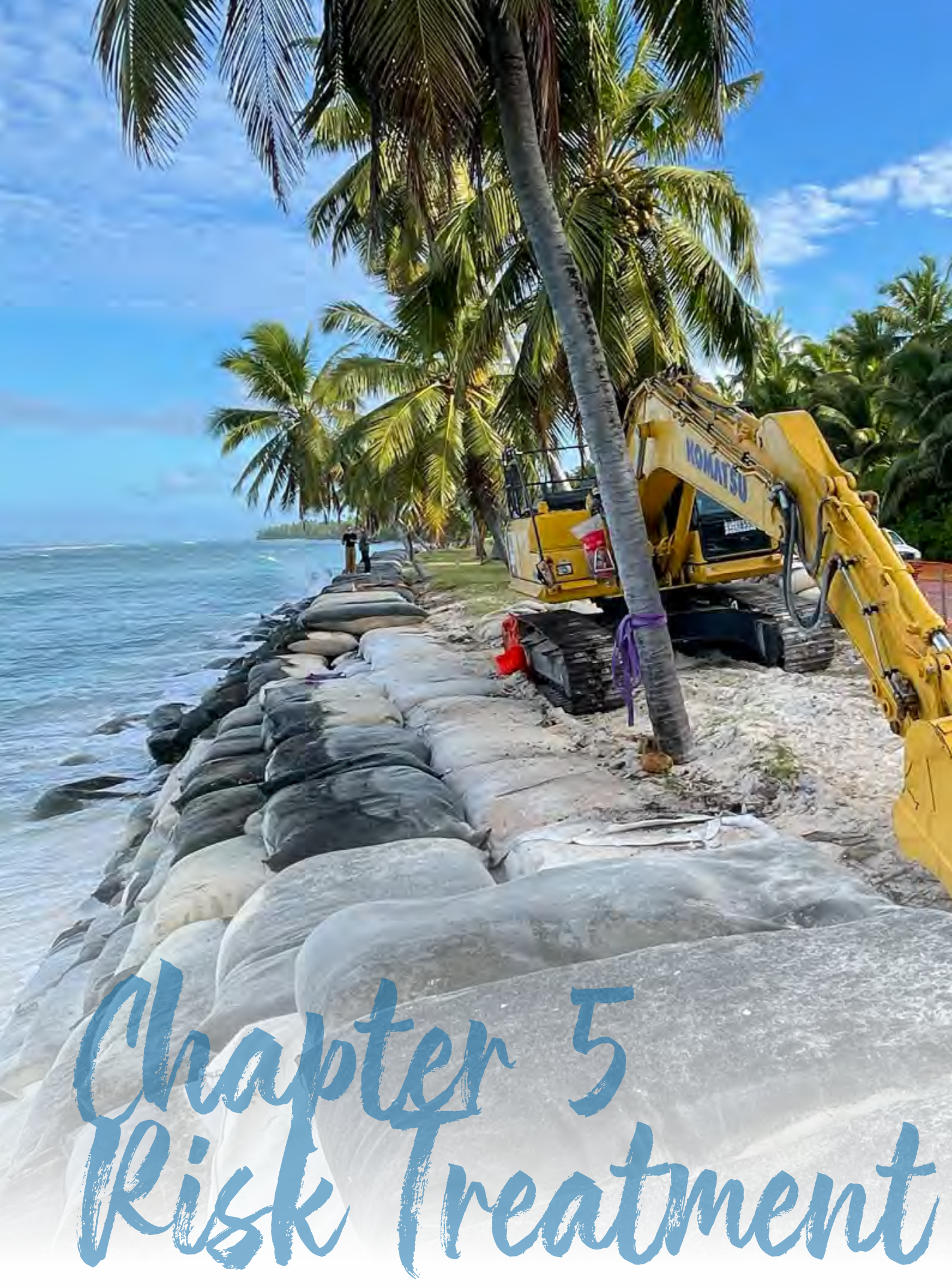
MANAGEMENT UNIT	ASSET	VULNERABILITY		
		2018	2068	2118
MU7 Home Island Settlement	Kampong, Mosque and Shops (2)			
	Home Island Jetty and boat ramps (9)			
	Oceania House (10)			
	Yacht Club (11)			
	Roads			
	Mobile Network Tower			
	A number of Pondoks, picnic tables reserve seating and historical monuments			
MU8 Home Island Ocean Beaches	Cemetery (1)			
	Refuse Station (4)			
	Potable Water Pump Station (5)			
	Roads			
	Water treatment plant and potable water facility (6)			
	Fuel Station (7)			
	Power Station (8)			
	Freehold properties			
	Boat Yard			
	Historical monuments			
MU9 Turtle Beach	Seawater production bores (3)			
	Pondoks and historical monuments			

Erosion Vulnerability: Low Medium High Very High

Inundation Vulnerability: Low Medium High Very High

N/A

Figure 55: Home Island Vulnerable Priority Assets



Chapter 5
Risk Treatment

5 Risk Treatment

SPP 2.6 provides a hierarchy of adaptation pathways to guide decision making in coastal areas to minimise coastal vulnerability and subsequent risks at the local level.

The objectives of SPP 2.6 are to:

- Ensure that the location of coastal facilities takes into account coastal processes, hazards and climate change projections;
- Ensure the identification of appropriate areas for the sustainable use of the coast;
- Provide for public coastal foreshore reserves and access to them on the coast; and
- Protect, conserve and enhance coastal zone values, particularly in areas of landscape, biodiversity and ecosystem integrity and cultural significance.

Avoid

Identify future 'no build' areas and use planning controls to prevent new development in areas that are vulnerable now or in the future

Planned and Managed Retreat

Withdraw, relocate or abandon assets that are vulnerable; ecosystems are allowed to move landward as sea levels rise

Accommodate

Continue to use the land but accommodate changes by building on piles, converting land uses or growing flood or salt-tolerant plants

Protect

Use hard structures (e.g. sea walls) or soft solutions (e.g. dunes and vegetation) to protect assets from the sea. May be prohibitively expensive, especially in the long-term

Figure 56: Adaptation hierarchy (adapted from WAPC, 2019)

5.1 Adaptation Hierarchy

The hierarchy, presented in *Figure 56*, outlines risk management categories of **Avoid**, **Planned and Managed Retreat**, **Accommodate** and **Protect**. It should be noted that there is no legal obligation for the Government to protect private assets from coastal erosion, with the CHRMAP guidelines indicating a clear preference **against** the adoption of **Protect** as a **long-term** adaptation pathway. This preference is in accordance with the policy measures in SPP 2.6, and the CHRMAP Policy Guidelines.

Generally, avoiding the placement of sensitive development within areas that are vulnerable to coastal hazards provides the most resilience to future risk arising from coastal hazards.

Conversely, using protection structures to allow sensitive development within areas that would otherwise be vulnerable to coastal hazards reduces the flexibility of future decision-makers to address risk arising from coastal hazards (WAPC, 2019).

Further to the risk management and adaptation hierarchy identified in SPP 2.6 and *Figure 56*, **No Regrets** and **Do Nothing** are two risk treatment options that are relevant to the CHRMAP process and have been considered in the risk treatment assessment.

5.1.1 Avoid

Avoid (AV) option aims to avoid the construction of new public and private assets within areas identified to be vulnerable to coastal hazards. The project lifetime of a new asset should be a key consideration in deciding the suitability of locating new assets in vulnerable areas. For example, the construction of new public assets, such as picnic facilities and public toilets, should be avoided where these assets are likely to be impacted by coastal hazards within the lifetime of the asset.

Similarly, the construction of new private assets which are likely to be vulnerable to coastal hazards over their projected lifetimes should not be permitted. The option of avoid can be applied to manage coastal erosion and inundation vulnerability.

5.1.2 Planned and Managed Retreat

Planned and Managed Retreat (PMR) aims to relocate or remove assets which are located in vulnerable areas, in an orderly manner, where hazard risks are likely to be unacceptable over relevant planning timeframes.

In recognition of the increased risk to assets in the coastal zone, the Western Australian Planning Commission provides guidance on how to implement a policy of planned and managed retreat (WAPC, 2019).

Planned and managed retreat is mostly applicable to developed areas, where there is less potential to adapt to coastal hazards through development planning controls, such as coastal setbacks in undeveloped areas. The strategy of planned and managed retreat is based on social, environmental and economic sustainability, and ties into the SPP 2.6 objectives and adaptation hierarchy. It allows for continuing public access to beaches, beach amenity, and the provision of a coastal foreshore reserve.

The CHRMAP Guidelines (WAPC, 2019) suggest a range of mechanisms for achieving planned and managed retreat in developed areas, including special control areas, planning policies or compulsory or voluntary acquisition provisions outlined in WA legislation.

Planned and managed retreat is an option that can be applied to manage coastal erosion and inundation hazards; however, this option can require a significant investment of public resources to fund acquisitions or relocation plans.

Under SPP 2.6, Planned and Managed Retreat is one of the four options in the agreed adaptation hierarchy. Aims to remove vulnerability to coastal hazards by relocating or abandoning assets that are at risk, thus allowing ecosystems to move landward.

In the context of CKI, Planned and Managed Retreat can include any of the following pathways

1. Leaving assets unprotected, assuming that any loss is acceptable and that action will only be taken for minor repairs to maintain public safety.
2. Minor Asset Relocation for items that have shorter life cycles and would typically be replaced before becoming vulnerable. This approach requires sensible asset replacement outside of vulnerable areas.
3. Services Relocation for services (power, water, roads) that will become vulnerable before their typical replacement cycle. This approach requires investment in relocating more expensive services as soon as practical, outside of vulnerable areas.
4. Long Term Settlement Planning for the Settlement areas involving engagement in land use planning, staging and implementation mechanisms. All options will be considered, including resilience measures (revegetation/ sand nourishment) and protect options, as well as settlement relocation which may be necessary.
5. Planning Controls for Managed Retreat, involving the introduction of specific legislation and policy to allow continued use until such time as impacts occur, whilst restricting new development.
6. Voluntary acquisition, where properties are acquired over time to enable removal of development over time, thus removing vulnerability.

Whilst the Guidelines provide instruction for Planned or Managed Retreat in *Appendix 4; Planned or Managed Retreat - existing planning framework and instruments,* in CKI Planned and Managed Retreat is more complex, as any suitable land within the island context is also subject to coastal hazards.

Therefore, land managers, landholders, and the broader community should be aware of the risks in any decisions they make about managing, developing, or purchasing land in coastal areas

5.1.3 Accommodate

Accommodate (AC) options aim to utilise design and management strategies which render the risks from identified coastal hazards as acceptable. Design and management strategies include minimum finished floor levels to minimise inundation risks. In this way, the Accommodate option allows landholders to continue to use land until hazard risks become unacceptable.

Accommodate design and management strategies can be facilitated through modifications to local planning frameworks. These planning frameworks need to provide clear direction for planning authorities when assessing applications for new development and for affected landholders.

Planning frameworks might include the introduction or modification of the following instruments:

- Special control areas, to ensure planning discretion over new development
- Clear development assessment criteria, to ensure that new development gives due regard to coastal processes
- Notification on titles, to inform current and future property owners of hazard risks
- Time or event limited planning permits, to allow the continued use of land until hazards become unacceptable

Accommodate is an option that can be applied to help minimise the effect of coastal inundation hazards however is more challenging for erosion hazards, where the shoreline is allowed to recede directly impacting the physical or natural asset.

An additional consideration to the **Accommodate** option, particularly in regard to managing coastal erosion, is that the current WA legislative framework applied on CKI means that permanently inundated private land does not become Crown land, unlike in other Australian states (Robb et al 2017, Robb et al 2018).

Therefore, where the shoreline is allowed to recede beyond private property boundaries, issues of public access and trespass may arise. This should be a consideration when assessing the appropriateness of the **Accommodate** option.

5.1.4 Protect

Protect (PR) option aims to stabilise the position of the shoreline using hard or soft coastal protection measures such as seawalls, groynes, offshore breakwaters, geotextile sand-containers, sand renourishment and levee banks. Protection is an option that can be applied to manage both coastal erosion and inundation hazards.

The adaptation hierarchy considers the construction of new protection measures as the least preferred option of all potential options listed in the hierarchy. Protection measures, particularly hard measures such as rock groynes and seawalls, interfere with local coastal processes and can have detrimental effects on local ecological systems.

Protection measure can also exacerbate erosion impacts down drift of the structure, 'shifting the problem' along the coastline. Subsequently, careful consideration and planning needs to be adopted for staging of protection structures, to understand and mitigate likely flow on impacts (increase coastal erosion vulnerability) of proposed structures.

Protection measures can also inflate property values in hazard areas, create expectations that the measures will be maintained into the future, and may limit the capacity of future decision-makers to change decisions as the situation evolves.

Where public and private assets are proposed to be constructed inland of interim protection measures, the design life of the protection measure should be a key factor in determining the appropriateness of the proposed asset or development.

The agency or landowner who develops protection measures assumes legal responsibility for their maintenance, and possibly some liability if failure of the protection measures results in damage to people or property.

5.1.5 No Regrets

No regrets (NR) options cover a period of time where assessments are required or are being undertaken to determine a preferred risk treatment option, prior to implementing specific asset risk management measures.

This is particularly pertinent where a more costly or difficult risk treatment option, or better understanding regarding the level of vulnerability to an asset, may be required (WAPC, 2019).

No regrets options are cost effective in the current day and provide flexibility for more resilient and appropriate long-term management options to respond to coastal hazard risks.

5.1.6 Do Nothing

Do Nothing (DN) assumes that all levels of vulnerability are accepted and that no further action will be taken. A do nothing option provides the basis for comparison of all other risk treatment options.

A **Do Nothing** option may also be reflected in reality where the selection of another option (e.g. protect) and the subsequent trade-off considerations are unacceptable to the relevant coastal manager. In this case, the selection of an option that is considered unacceptable results in 'nothing happening' despite recommendations in a CHRMAP. This needs to be considered when selecting the most appropriate option to address vulnerability.

5.2 Hierarchy Summary

Maintaining public access to the shoreline near settlements is one of the main objectives of SPP 2.6 and is also identified as a key value of the Cocos (Keeling) Islands community.

As discussed, the current WA legislative framework which applies on CKI means that where the shoreline recedes beyond private property boundaries, issues of public access and trespass are likely to arise. In this case public authorities have two main adaptation options available to them for preserving public coastal access:

- Planned and managed retreat i.e., Maintaining a foreshore reserve through public acquisition and then relocation of private development; or,
- Protect i.e., Preventing the shoreline from receding beyond private property boundaries by stabilising the current shoreline position using various protection measures (e.g., seawalls, levees).

Where public authorities cannot commit to either of these options over the long-term, it is likely that public authorities will need to Accommodate, by modifying local planning frameworks to help ensure that new development is appropriately designed and located. Public authorities in this situation may also choose to consider the appropriateness of interim Protection measures to preserve public interests by delaying shoreline recession and minimising the effect of regular nuisance inundation events on existing development and infrastructure, where possible.

5.3 Summary for Decision-Makers

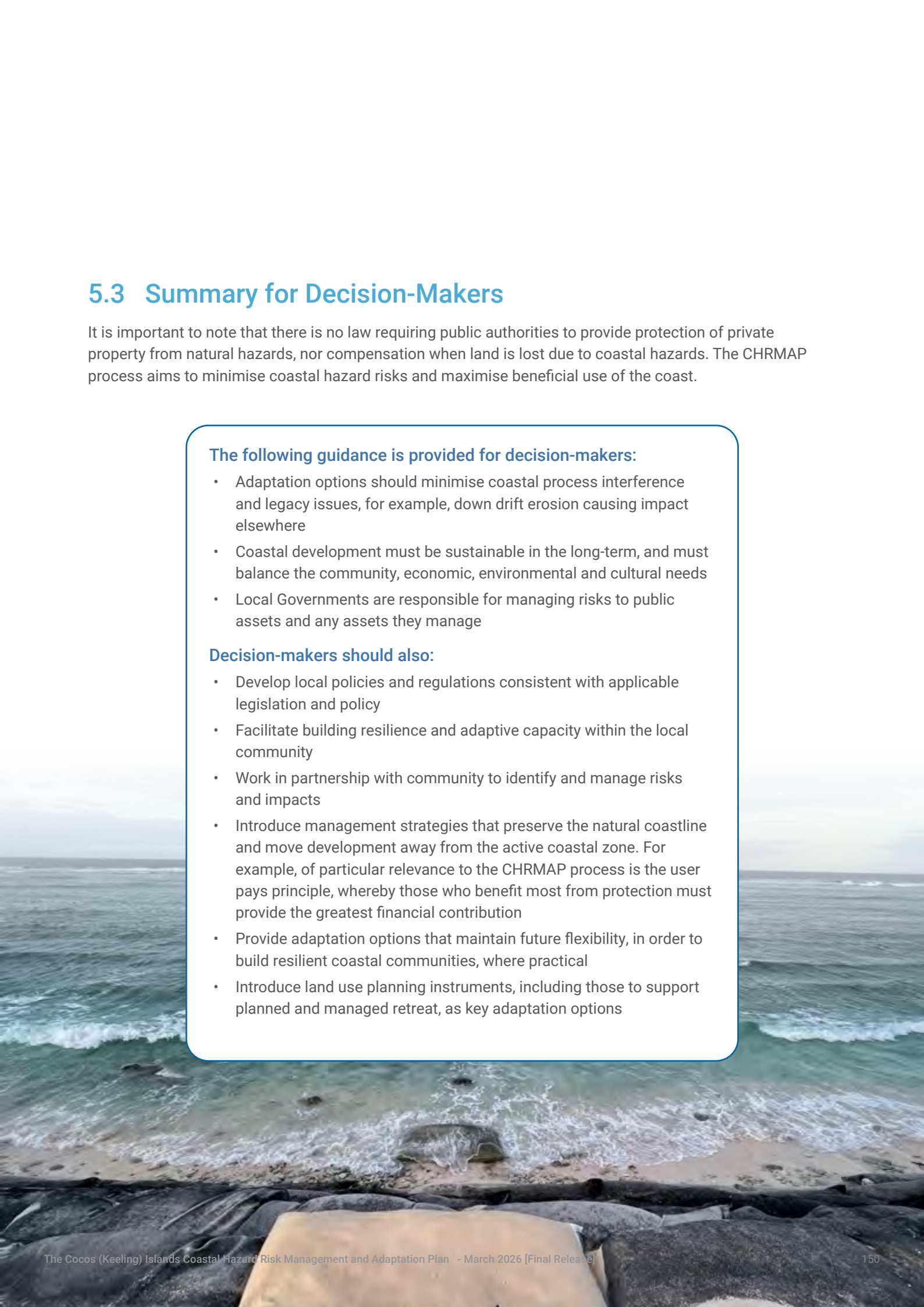
It is important to note that there is no law requiring public authorities to provide protection of private property from natural hazards, nor compensation when land is lost due to coastal hazards. The CHRMAP process aims to minimise coastal hazard risks and maximise beneficial use of the coast.

The following guidance is provided for decision-makers:

- Adaptation options should minimise coastal process interference and legacy issues, for example, down drift erosion causing impact elsewhere
- Coastal development must be sustainable in the long-term, and must balance the community, economic, environmental and cultural needs
- Local Governments are responsible for managing risks to public assets and any assets they manage

Decision-makers should also:

- Develop local policies and regulations consistent with applicable legislation and policy
- Facilitate building resilience and adaptive capacity within the local community
- Work in partnership with community to identify and manage risks and impacts
- Introduce management strategies that preserve the natural coastline and move development away from the active coastal zone. For example, of particular relevance to the CHRMAP process is the user pays principle, whereby those who benefit most from protection must provide the greatest financial contribution
- Provide adaptation options that maintain future flexibility, in order to build resilient coastal communities, where practical
- Introduce land use planning instruments, including those to support planned and managed retreat, as key adaptation options



Chapter 6 Risk Treatment Options

6 Risk Treatment Options

SPP 2.6 provides a hierarchy of adaptation pathways to guide decision making in coastal areas for use by planning authorities and development proponents when considering adaptation options to minimise coastal hazard vulnerability at the local level. Not all of these options are suitable in every case.

This chapter presents a list of generally available adaptation options suitable in CKI (*Table 28*). These relate to both short and long-term adaptation to coastal hazards. The columns on the right-hand side provide some discussion as to the possibility of the options suitability for the study area.

Whilst the risks and their corresponding adaptation options are assessed separately, triggers to implement the option can be modified to suit the circumstances at any given point in time, for example, if risks from erosion or inundation are being experienced sooner, a trigger may bring adaptation responses forward in time.

Table 28: Available Adaptation Options

SPP 2.6 OPTION CATEGORY	OPTION CODE	OPTION NAME	DESCRIPTION	SUITABILITY AND COST CONSIDERATIONS
Avoid	AV	Avoid development	Avoiding new development within the coastal hazard zone and locating assets in areas that will not be vulnerable	Limited opportunity for an avoid pathway within settlement areas on both Home and West Island. Applicable for areas outside of settlements, financial resources will not be required to be spent on risk management.
Planned and managed retreat	PMR1	Leave assets unprotected	Accept loss following hazard event. Only implement repairs to maintain public safety.	Saves financial resources for alternative uses, and allows for retreat that enables natural recession of the shoreline over the long-term
	PMR2	Minor Asset Relocation	Assets located in the hazard zone are permanently removed or relocated.	For items that have shorter life cycles and would typically be replaced before becoming vulnerable, this option enables the social and economic values of assets to be retained until such time that the asset needs to be relocated. Can often coincide with asset replacement, and allows the cost of relocation to be shared with the cost of asset replacement.
	PMR3	Services Relocation	Assets located in the hazard zone are permanently removed or relocated.	For services (power, water, roads) that will become vulnerable before their typical replacement cycle. This approach requires investment in relocating more expensive services as soon as practical, outside of vulnerable areas.
	PMR4	Long-Term Settlement Planning	Strategic planning to determine future settlement patterns in ares which are affected by coastal hazards.	Fore Settlement, this options involves engagement in land use planning, staging and implementation mechanisms. All options will be considered, including resilience measures (revegetation/sand nourishment) and protect options, as well as settlement relocation which may be necessary.
	PMR5	Planning controls for planned and managed retreat	Use planning controls to allow continued use of the current infrastructure, but restrict further or new development to forms that are less vulnerable to coastal hazards.	This enables existing development and use rights to continue, until such time that vulnerability arising from coastal hazards is unacceptable. Includes mechanisms for ensuring that the Shire, landowners and prospective buyers are made aware of the vulnerability. This option would follow on from PMR4 - Long Term Settlement Planning and would be the mechanism by which strategic settlement planning is implemented..
	PMR6	Voluntary acquisition	This risk treatment option results in the acquisition of affected properties, on a voluntary basis.	This enables public management of private property asset(s) located within a land use zone that would otherwise allow development to be permitted, and where alternative risk treatment options are not viable for the property and adjacent land.

Table 28: Available Adaptation Options (continued)

SPP 2.6 OPTION CATEGORY	OPTION CODE	OPTION NAME	DESCRIPTION	SUITABILITY AND COST CONSIDERATIONS
Accommodate	AC1	Design assets to withstand impacts	Design of assets to withstand the impact of inundation	This is aimed at retaining existing assets in locations but reducing the consequences of the inundation hazard. It is cheaper to mitigate the impacts with initial design outcomes as opposed to retrofitting (adapting) existing assets in the future. Design and management strategies may include a mix of structural or non- structural approaches, including building houses on stilts or raising building pads above the expected inundation levels, enhancing the natural environment and policy updates
	AC2	Planning controls for accommodation	Amend local planning frameworks to require assets to be designed to be able to accommodate hazards	Indicates to current and future landholders that an asset is vulnerable to coastal hazards over the planning timeframe and that risk management and adaptation is likely to be required at some stage. Helps owners to make informed decisions about the level of risk they are willing to accept. Low cost option that does not prohibit the use of other management options in the future.
Protect	P1	Beach Nourishment – Initial, significant campaign	Placement of large volumes of sand on the beach, dunes or nearshore. May be undertaken pre/post storm event. Requires available sources of compatible sand. Aims to restore or enhance the beach profile to provide a natural buffer to absorb the impacts of storm events.	This option is a measure which requires regular and ongoing maintenance, and thus can be considered somewhat temporary. It can be more effective in association with other options. The sand may be from within the CKI atoll area, however suitability in terms of similarity (if the nourishment sand is significantly finer than the existing beach sand the nourishment sand will be lost quickly) needs to be considered. Further to this, potential environmental and coastal hazard impacts from removing large volumes of sand from the existing environment, including in or adjacent to Cocos (Keeling) Islands Marine Park should be considered. If an external source (from the mainland or a considerable distance away) is considered, costs are increased.
	P2	Beach Nourishment – On-going campaigns	As described in P1 above however is the placement of smaller volumes of sand on the beach, dunes or nearshore at more frequent intervals.	The considerations outlined in P1 above apply, frequency of ongoing nourishment is likely to be high given the rate in which sand is moving along the coast and the erosion vulnerability for the present day. The more frequent a nourishment campaign, the greater the cost over time. A combined approach of P1 and P2, where a large initial campaign is undertaken following by regular and ongoing 'top up' campaigns would be typical. Could be supported by dunes revegetation. The rate at which sand is lost fronting existing coastal structures (seawalls) is high and therefore reduces the effectiveness of this option where protection structures are already present.

Table 28: Available Adaptation Options (continued)

SPP 2.6 OPTION CATEGORY	OPTION CODE	OPTION NAME	DESCRIPTION	SUITABILITY AND COST CONSIDERATIONS
Protect	P3	Offshore structures – Artificial reefs Detached break-waters/ headlands	Construct offshore reef(s) / breakwater(s) or raise existing natural nearshore reef structures to maintain level of protection as sea level rises.	Hard protection generally diverts erosion issues elsewhere and may have significant impact on coastal ecosystems in adjacent areas. Reefs are unlikely to be effective over time as sea levels rise, or the crest would need to be raised in height in response. Reefs are also very expensive to design, build and maintain. Assessment of this option needs to consider long-term maintenance, as this will extend the life of the structure.
	P4	Groynes	Structures perpendicular to the shore which extend into the water. Range of construction materials (including rock, concrete, steel sheet pile, timber, geotextile sand filled tubes/ bags). Aims to trap sand moving along the coast.	Hard protection diverts erosion issues elsewhere, such as to the down drift side of a groyne. Groynes are not effective as a means of managing short-term storm erosion, in particular storm induced erosion. Groynes can be expensive and materials are unlikely to be readily available or affordable. Assessment of this option needs to consider long-term maintenance, as this will extend the life of the groyne. May not be suitable in an island environment that is vulnerable to both erosion and inundation, especially as sea levels rise and if erosion impacts are more commonly experienced from cross shore sediment transport. Previous groynes established on CKI are in a condition of disrepair.
	P5	Seawalls	Involves construction of a seawall usually along an entire section of shoreline. Aims to create a hard barrier to erosion impacts.	Hard protection generally diverts erosion issues elsewhere, such as to beaches either side of, and directly in front of, a seawall. They can also have significant impact on coastal ecosystems. Seawalls can be constructed from non porous materials such as concrete or sheetpile or by revetment which is constructed to allow porosity and reduce reflection. Seawalls are expensive and change the nature and appearance of the coast, typically resulting in long-term loss of the beach in front. Materials are unlikely to be readily available or affordable. Assessment of this option needs to consider long-term maintenance, as this will extend the life of the wall. Several seawalls existing within CKI including Geotextile Sand Container (GSC) (P5a) and a seabee concrete (P5b) seawall.

Table 28: Available Adaptation Options (continued)

SPP 2.6 OPTION CATEGORY	OPTION CODE	OPTION NAME	DESCRIPTION	SUITABILITY AND COST CONSIDERATIONS
Protect	P6	Levees	Involves construction of a levee usually along an entire section of shoreline. Levees can prevent coastal inundation of low-lying areas	Levees designed to mitigate coastal inundation can be set back from the coastline, if the space is available, limiting the need for construction of a seawall and associated impact to the coastal processes (i.e. preventing diverting erosion issues elsewhere). Levees are typically constructed with earth fill and a clay liner cap to maintain the levee in-situ. Levees are expensive, as materials are unlikely to be readily available or affordable, and the need for long-term maintenance should also be considered for the cost of this option. Levees can change the way an environment looks creating a feeling of separation from the coast. Drainage also needs to be considered in the design to prevent increase impacts of terrestrial flooding (i.e. flood waters unable to regress to coastal waters).
	P7	Land reclamation	Involves raising or reclaiming low-lying land to prevent inundation. This option is usually completed in conjunction with levees and/ or seawalls.	Requires significant volumes of sand to raise land levels, sourcing of sand would need to consider environmental impacts of extracting such large volumes to the ecosystems and broader atoll. Sand sourced from external locations would have significant costs. Planning and logistics to execute a staged approach to land raising would require significant costs to support sound design and management. Significant social disruption as residents would need to move into temporary accommodation whilst settlement areas and supporting infrastructure are raised.
No Regrets	NR1	Monitoring	Long-term baseline monitoring and event-based monitoring following storm erosion events	Monitoring enables assessment of the frequency and severity of events, the impact and consequences on various land uses, to revise vulnerability levels and determine the effectiveness or appropriateness of risk management measures over time. Regular monitoring will support the identification of triggers for risk management measures to be implemented.
	NR2	Protection structure audit	Involves undertaking an audit of existing protection structures, to determine their current condition, effectiveness and future protection potential	Depending upon the expected life and future protection from existing protection structures, there may be updates to the hazard estimates. This will flow on to affect other risk treatment options, including implementation of risk management measures

Table 28: Available Adaptation Options (continued)

SPP 2.6 OPTION CATEGORY	OPTION CODE	OPTION NAME	DESCRIPTION	SUITABILITY AND COST CONSIDERATIONS
No Regrets	NR3	Notification on titles	Using the *Planning and Development Act 2005 (WA)(CKI)* and the *Land Administration Act 1997 (WA) (CKI)* to place a notification on the titles of potentially affected properties.	Indicates to current and future landowners that an asset is likely to be affected by coastal erosion and / or inundation over the planning timeframe. Helps current and future owners make informed decisions about level of risk they are / may be willing to accept, and that risk management is likely to be required at some stage within the planning timeframe.
	NR4	Emergency evacuation plans	Establishing emergency evacuation management plans where existing assets may be affected by erosion and / or inundation to manage the safety of community and stakeholders	This option is a low-cost option in addressing the consequences of erosion / inundation regarding safety to lives as the impact occurs.
Do Nothing	DN	Do nothing	The asset will be lost after a hazard event. Repairs are carried out for public safety purposes only. Take no action. No limitations on development or implementation of adaptation planning.	Does not involve any new actions. Where existing levels of vulnerability are low, accepting the risk may be appropriate. However, it may not be appropriate for high-vulnerability locations / assets. The cost of 'do nothing' may be substantially greater in the future than the current cost of implementing planning controls.

6.1 Approach

The assessment of adaptation options in the CHRMAP process follows four key steps:

Table 29: Adaptation Options Assessment Process

STEPS	DESCRIPTION	CONSIDERATIONS
Step 1	Establishing a multi-criteria analysis (MCA) framework.	Step 1 is important in developing any CHRMAP. The suitability of certain measures from an engineering or scientific perspective is imperative. Step 1 assesses options for individual or grouped assets based on rigorous technical analysis (including rejecting options that are unsuitable if necessary). Pre-screening of adaptation options (*Section 6.1.3*) removes those options not considered effective in reducing erosion or inundation risks to vulnerable assets.
Step 2	Utilising the Multi-Criteria Assessment (MCA) framework to cross-check assessment approach with the community	Step 2 is critical to ensure that some rigour and local knowledge is applied to the assessment, as community values are often intrinsic and experienced-based and cannot be so easily measured. The study committed to testing of community values with stakeholders in the study area. The engagement tasks undertaken and the confirmed values, feedback and shared information is captured in the Engagement Outcomes Report (*Appendix C*). In addition to technical assessment of criteria, MCA workshops were held with the Cocos Malay Elders and with the community reference group (with translation as required), to confirm the criteria, approach to weighting, and to receive feedback on the scores applied.
Step 3	Developing preliminary cost estimates for preferred adaptation options	Costing of options can be challenging, as the remote location, skills and resource availability, changing nature of supply chains and construction costs create unknowns; however, as options are costed in comparison to each other, it is the relative comparison that is important.
Step 4	Determining implementation timeframes	Implementation timeframes are often determined in an iterative manner and through a cost benefit analysis framework, with ongoing coastal monitoring determining the need; these are typically an indication only.

6.1.1 Considerations

Available adaptation options and pathways are considered against the following:

- Both Erosion / Inundation vulnerability independently
- Asset locations (whole of settlements vs individual asset)
- Short-term options
- Long-term options

CKI vulnerability to coastal inundation and erosion requires assessment for a unique series of timeframes, including:

- Short-term adaptation time frame within next 0 to 10 years, recognising that vulnerability is already very high in many locations and some action is required immediately to maintain public safety.
- Medium-term adaptation time frame within 10 to 50 years (to 2068) , following planning, studies and investigations undertaken in the short term to determine the most appropriate pathways forward with the community.
- Long-term adaptation time frame within 50 to 100 years (to 2118), assuming pathways have been agreed in collaboration with the community over the short and medium-term and action is responsive to the most contemporary data at the time the decision is made

6.1.2 Asset Locations

Given the large number of vulnerable assets or groups of assets within the settlement areas of both Home and West Island and the timing in which these assets are at risk (High to Extreme risk identified in 2018) it was necessary to develop and assess the adaptation options for the settlement as a whole on each island rather than consider and assess options for each asset. Specifically for West Island, this also includes the airport, airport runway and associated assets.

Subsequently, assets outside of the settlement area were considered either grouped with neighbouring assets if of similar value and purpose or assessed individually.

The shortlisted adaptation options are assessed based on the following asset locations:

- MU1 West Island Settlement (*Figure 57*)
- MU7 Home Island Settlement (*Figure 58*)
- Individual asset treatment outside of settlements

Figure 57: West Island whole of settlement

Figure 58: Home Island whole of settlement

6.1.3 Pre-screening Results

Pre-screening of possible adaptation pathways looked at feasibility and effectiveness. A key outcome of the engagement scope was confirmation of the preferred short-to-medium and long-term options by the community and stakeholders.

- **Avoid** and **Planned and Managed Retreat** have been determined unsuitable for the majority of existing assets in the short-term. Avoid is suitable for undeveloped areas. Retreat may be considered for minor infrastructure.
- **Protect**, **Accommodate** and **No Regrets** were assessed as suitable options in the short-term.

The pre-screening stage (*Table 30*) indicates options for the settlement areas that have been assessed as unsuitable.

Table 30: Pre-screening: Settlement Wide Available Pathways (adapted from WAPC, 2019)

OPTION CATEGORY	DESCRIPTION	FEASIBILITY	
		Does the option reduce erosion and inundation risks to Settlement?	Advance to specific Options Assessment?
Avoid 	Eliminate vulnerability to coastal hazards by using planning controls to prevent new development in areas that are vulnerable now or in the future	Not feasible at present or into future as existing assets currently at high risk of erosion and inundation are already in place	Not suitable for existing assets
Planned and managed retreat 	Progressively withdraw, retreat or relocate existing development; involves relocating or sacrificing infrastructure, both public assets and private property. Includes prevention of further development in risk areas	Not feasible for whole of Settlement, as insufficient high ground outside Settlement. Potentially feasible for individual assets within Settlement.	Not suitable in the short-term
Accommo-date 	Utilise design and management strategies which render vulnerability acceptable.	Partially effective Structural options can be used to reduce vulnerability to inundation and will be partially effective against erosion. Non-structural options, such as enhancing the natural environment, can help to reduce vulnerability to erosion	Short-list pathway for specific options assessment

Table 30: Pre-screening: Settlement Wide Available Pathways (adapted from WAPC, 2019) (continued)

OPTION CATEGORY	DESCRIPTION	FEASIBILITY	
		Does the option reduce erosion and inundation risks to Settlement?	Advance to specific Options Assessment?
Protect 	Protect assets from damage resulting from erosion and recession and storm surge inundation.	Different protect options effective at managing erosion and inundation vulnerability	Short-list pathway for specific options assessment
No Regrets 	A range of assessments and works required to determine preferred risk treatment options, prior to implementing specific asset risk management measures.	Partially effective Won't stop erosion and inundation vulnerability to existing assets but can be used while preferred risk treatment options are investigated or implemented	Short-list pathway for specific options assessment
Do Nothing 	Assumes no change in existing planning controls, and no actions are implemented (i.e. no controls are implemented to treat known coastal vulnerability).	Not feasible for whole of Settlement, including individual properties	Not suitable - assets and values at very high levels of vulnerability

6.1.3.1 Short-to-Medium-term Options

Following the pre-screening, three adaptation pathways were shortlisted for Multi-Criteria Assessment for the Short-to-medium-term:

- Accommodate
- Protect
- No Regrets

The short-to-medium-term option preferred by the community was **Protect** (Seawalls and Levees).

It should be noted that the community expressed familiarity and support for the seabee seawall on CKI, as many locals had been involved in their original construction. Cost of construction will be a factor in any design, and the seabee method is a locally recognised and achievable option.

6.1.3.2 Long-term Options (2118)

Although preferred by most stakeholders, the following factors will make implementation of the preferred **Protect** pathway challenging over the medium - longer term (2068), as:

- Groundwater impacts are likely to be experienced in tandem with erosion and inundation.
- High levees are likely to result in impact to views of the water and access to boat ramps (and the water), and do not have the effect of halting groundwater flooding.

In the long-term it will be challenging to maintain the Accommodate and Protect pathways.

Protect and **Planned and Managed Retreat** pathways are considered technically implementable, if not affordable in the short-to-medium-term.

Protect

Planned and Managed Retreat
Which may include relocation within CKI or relocation away from CKI, in accordance with Long-Term Settlement Planning

6.2 Multi-Criteria Assessment

Successful risk management and adaptation planning requires identification and assessment of suitable options to ensure selection of the best adaptation pathway. The chosen option should mitigate vulnerability to an acceptable level whilst maximising the values that were identified as being important to the stakeholders.

The information collected from the community throughout engagement processes was used to inform the progression of adaptation options for the islands, through a multi-criteria assessment (MCA) process. The resulting risk treatment options form the main recommendations in this CHRMAP.

6.2.1 MCA Criteria

Table 31 describes the eight criteria selected for the MCA process.

Section 6.2.2 MCA Scoring and *Table 32* illustrate the scoring matrix used the asses options against the eight criteria.

Table 31: MCA Scoring Criteria

CRITERIA	DESCRIPTIONS	CONSIDERATIONS
Implementation	How easy is the option to implement? Can it be made on the island using readily available, local resources?	• Implementation timeframe • Local use of products • Logistics and delays to import material • Maintenance of option into future • Carbon miles • Re-use of existing material
Environmental impact	How significant are the environmental impacts?	• Amenity and public health (noise, dust, noise, odours) impacts - distance to sensitive receptors • Scale of disturbance to marine habitat, water quality, vulnerable/ protected species • Scale of disruption to commercial fisheries
Social impact (property)	How significant are the impacts on properties?	• Residential property losses • Property access
Social impact (way of life)	How significant are the impacts on daily life?	• Impact on community values • Impact on access to important social and cultural areas (i.e. beach access, boat launching, views etc) • Scale and duration of disturbance to community areas/ activities
Economic impact	How significant are the impacts on businesses and the local economy?	• Impact to island amenity which impacts potential economic income through tourism • Impact to property which impacts potential economic income through accommodation • Subsequent impact to wages and revenue
Flexibility	Is the option reversible/ adaptable in the future?	• Reversibility of option • Adaptable to unforeseen changes in climate conditions • Alignment with potential long-term adaptation pathways, including reclamation with seawalls
Effectiveness	How effective is the solution at mitigating erosion and inundation risks?	• How certain is it that the option will be effective
Financial	How much does the option cost?	• Combined capital and maintenance costs and potential for external funding sources

6.2.2 MCA Scoring

Table 32: MCA Scoring Matrix

MULTI CRITERIA ASSESSMENT - KEY CRITERIA SCORING MATRIX					
SCORES	**5**	**4**	**3**	**2**	**1**
Impacts	**Insignificant**	**Minor**	**Moderate**	**Major**	**Severe**
Risk	**Very Low**	**Low**	**Medium**	**High**	**Very High**
Implementation	Abundant and sustainable source of material on island	A significant portion of material available on island	Some material available on island	Only a small portion of material available on island, majority of material needs to be imported	No material on island, all materials need to be imported
Environmental Impact	Preserves and repairs	Maintains status quo	May result in impact and damage	Likely to result in impact and damage	Will result in impact and damage
Social Impact (Property)	0 houses lost	1-10 houses lost	11-19 houses lost	20-40 houses lost	>40 houses lost
	Does not affect property access		Minor impact to property access		Major impact to property access
Social Impact (Way of Life)	Does not affect any community values and/or improves access	Minor impact to community values and/or access	Loss of access to some community assets that partially affects overall intrinsic community value	Loss of access to certain assets that affects overall intrinsic community values	Will definitely affect key values of area and overall intrinsic community values
Economic Impact	No loss of existing businesses		Protects or maintains as long as possible		Loss of existing businesses
Flexibility	Easily reversible or adaptable	Reversible or adaptable	Reversible or adaptable but with some cost	Difficult to reverse or adapt	Irreversible or not adaptable
Effectiveness	Effective, long-term mitigation	Effective, mid-term mitigation	Effective, short-term mitigation	Limited effectiveness	Ineffective and/or suitable only for minor events
Financial	<$5 million	$5 to $15 million	$15 - $30 million	$30-$50 million	>$50 million
Performance	**Excellent**	**Good**	**Sound**	**Poor**	**Very Poor**
	No impacts on criterion	Minor short-term impacts on criterion	Manageable short-term adverse impacts on criterion	Short-term adverse impacts on criterion, not easily managed	Long-term adverse major impacts on criterion, not easily managed

6.2.3 Shortlisted Short-to-Medium-term Adaptation Options

This section summarises adaptation options which achieved a positive score in the MCA to respond to erosion and inundation hazards for West Island and Home Island in the short-to-medium-term.

As previously outlined, for the purpose of this CHRMAP short-term is considered to be the next 0 to 10 years, with medium-term from 10 to 50 years.

Table 33 presents the viable adaptation options for further consideration.

The following are to be considered in parallel to ALL short-to-medium-term options:

- PMR5 - Planning controls for planned and managed retreat (prevention of further development)
- NR1 - Monitoring
- NR2 - Protection structure audit
- NR3 - Notification on titles
- NR4 - Emergency evacuation plans

Table 33: Adaptation Options to Proceed to MCA

ADAPTATION OPTIONS	MU1 West Island Settlement and MU7 Home Island Settlement	Non-Critical Infrastructure and Assets Outside of the Settlement areas (e.g., The Spot, Trannies Beach, Scout Park, Kite beach)	Critical Infrastructure and Assets Outside of the Settlement areas (e.g., the fuel station, Rumah Baru, Sydney Highway)
Planned and managed retreat - PMR2, PMR3, PMR4 Demolition/removal/ relocation of assets	Not suitable in the short-term, however, proceed for further consideration	Proceed for further consideration	Not Suitable. Critical infrastructure required for population
Accommodate - AC1 Structural - Design assets to withstand hazards	Proceed for further consideration	Proceed for further consideration	Not Suitable. Cost to replace infrastructure substantial
Protect - P2 Beach Nourishment - On-going campaigns	Proceed for further consideration	Proceed for further consideration	Proceed for further consideration
Protect - P5a Geotextile Sand Container (GSC) seawalls	Proceed for further consideration	Proceed for further consideration	Proceed for further consideration
Protect - P5b Seawalls	Proceed for further consideration	Proceed for further consideration	Proceed for further consideration
Protect - P6 Levees	Proceed for further consideration (in conjunction with other Protect options)	Not Suitable. Cost of levees for individual assets is prohibitive	Proceed for further consideration

6.2.4 Shortlisted Long-term Adaptation Options

In the longer term (approximately beyond 50 years) adaptation pathways have been considered for the islands as a whole (i.e. treatment for West Island or Home Island and all assets collectively), given the severity of hazard risk and vulnerability to assets and infrastructure.

It should be noted that longer term adaptation options may be required in the short-to-medium-term (before 2068) should the groundwater shoaling or terrestrial flood risks become unacceptable.

Long-term options will need to be actioned in response to Long-Term Settlement Planning studies, ongoing community engagement, and monitoring to decide appropriate timing.

6.2.4.1 West Island

Given the Australian Government's current investment in strategic infrastructure and assets located on West Island the assumption is that Retreat is not suitable in the short-term, and is likely to remain that way *for at least the medium-term*.

The below presents the viable long-term options that achieved a positive score in the MCA:

- P5b - Protect - Seawalls AND P6 - Levees; OR
- P5b - Protect - Seawalls AND P7 - Land raising / reclamation

Notwithstanding, long-term planned and managed retreat may be the only viable and feasible option to prevent unacceptable impacts by coastal hazards on vulnerable development, land uses and populations by the end of the century.

Viability will need to be determined over time, as the cost to manage coastal hazards may exceed any social or environmental benefit of protection, and the health and safety risks to the population may be unacceptable.

6.2.4.2 Home Island

The Home Island community currently enjoys an idyllic way of life, with social, cultural and economic connection to the coastline and values held in island living. However, the persistent flooding of the Kampong and, more specifically, homes, is increasingly unacceptable to the community.

Continued protection of the islands using seawalls is unlikely to improve this, due to the low lying nature of the island. As such, more robust options are required to prevent unacceptable impacts on vulnerable development, land uses and populations.

The below presents the viable long-term options that achieved a positive score in the MCA:

- P5b - Protect - Seawalls AND P7 - Land raising / reclamation
- PMR2, PMR3, PMR4 - Planned and managed retreat - Relocation and/or demolition and removal of assets

For Home Island, retreat will impact physical connection to the island and the Cocos Malay peoples' way of life, although the community's social, cultural and economic connection to the islands will remain, albeit in a different way. It is likely to be less costly and will permanently remove risk to life and infrastructure.

Viability will need to be determined over time in accordance with Long-Term Settlement Planning.

6.2.4.3 Both Islands - Reclaim and Protect

For both islands, reclaim and protect requires a technical response where ground levels are increased via filling with sand (or other material) across the settlement areas, and then protecting with walls and levees.

This will be disruptive to existing settlements, resulting in population scale relocation during development and limiting community connection to the islands and their existing way of life for a significant period of time. It will also be very costly.

6.2.5 Preliminary Cost Estimate

Preliminary cost estimates were prepared specifically to inform the rating of the Cost criteria in the options assessment.

Costing of options can be challenging, particularly for a remote island settlement where importing material and ongoing construction and costs create significant unknowns. As such, relative comparison of costs is recommended for the assessment and selection of adaptation pathways and options.

Cost estimates were developed based on the following assumptions and limitations:

Net Present Value (NPV) analysis

- NPV analysis provides an indication of the relative costs of the pathways over time, considering capital and on-going costs.
- Order of magnitude capital and recurrent maintenance cost estimates for the adaptation pathways have been estimated at 10 year intervals to 2068. These costs are then taken as inputs to a NPV analysis.
- A discount rate of 5% was used in the NPV calculations.

Rates*

- Relevant rates (e.g. GSC seawall costs) and construction costs (e.g. new stilted house costs) were sourced from the Shire, from previous consultancy reports (where available) and other industry reports (PRIF, 2017).
- The costs use unit rates for typical options, factored to the management unit / area they are being applied to.
- Sand for GSC seawalls and nourishment were assumed to be available from West Island. Sand for reclamation was assumed to be dredged from the lagoon. Importing sand for these options would significantly increase their cost.
- Geotextile clay layers for levees were assumed to be imported from off island.

A cost criteria has been applied for the purposes of comparison between options and to understand order of magnitude costs. Detailed costs would need to be undertaken to support the successful implementation of any of these options.

A cost range per adaptation option for the short-to-medium-term and separately for the long-term are summarised in *Table 34* and *Table 35*.

The existing coastal hazard vulnerability is such on CKI that 'doing nothing' in the short-term is not an option in order to maintain use and enjoyment of the islands. Delaying solutions in the short-term lead to more expensive medium-term solutions (*Table 34*).

All long-term solutions require a short-to-medium-term solution as well. As such, *Table 35* presents long-term options that follow after a shorter term solution. E.g., These long-term options are not 'short-to-medium-term' OR 'long-term', but 'short-to-medium-term' AND 'long-term'. Costs in *Table 35* should therefore be considered as additional to the short-to-medium-term costs.

*It is acknowledged that rates used in this cost estimate are likely out of date due to the time which has elapsed, the remoteness of CKI and its demand for construction work, the nature of the remote supply chains the CKI and the rapidly changing global construction environment. As noted in this CHRMAP, cost has been applied for the purposes of *comparison* between options and to understand order of magnitude costs. As options are costed in comparison to each other, it is the relative comparison that is important. Detailed costing of preferred options will be required and may result in a change to preferred adaptation pathways in the planning, design and delivery phase. This will be reiterated in the Implementation Section of this CHRMAP.

Table 34: Cost of viable short-to-medium-term options

LOCATION	OPTION		COST			
			Present Day		Medium-term (to 2068)	
MU1 West Island Settlement	AC1	Structural - Design assets to withstand hazards	$	$50 million to $100 million	$	More than $100 million
	P6+P2	Levees with on-going nourishment	$	$1 million to $10 million	$	$50 million to $100 million
	P6+P5a	Levees with seawalls (GSC seawalls costed)	$	$1 million to $10 million	$	$50 million to $100 million
	P6+P5b	Levees with seawalls (concrete seabee seawalls costed)	$	$1 million to $10 million	$	$50 million to $100 million
MU2-MU6 West Island – Outside of Settlement	PMR2, PMR3	Relocation of assets from inside hazard area (where applicable)	$	Less than $250,000	$	$250,000 to $1 million
	AC1	Accommodate (where applicable)	$	$250,000 to $1 million	$	$250,000 to $1 million
	P6+P2	Levees with on-going nourishment	$	$1 million to $10 million	$	$10 million to $50 million
	P6+P5a	Levees with seawalls (GSC seawalls costed)	$	$1 million to $10 million	$	$10 million to $50 million
	P6+P5b	Levees with seawalls (concrete seabee seawalls costed)	$	$1 million to $10 million	$	$10 million to $50 million
MU7 Home Island Settlement	AC1	Structural - Design assets to withstand hazards	$	$50 million to $100 million	$	$50 million to $100 million
	P6+P2	Levees with on-going nourishment	$	$1 million to $10 million	$	$1 million to $10 million
	P6+P5a	Levees with seawalls (GSC seawalls costed)	$	$1 million to $10 million	$	$1 million to $10 million
	P6+P5b	Levees with seawalls (concrete seabee seawalls costed)	$	$1 million to $10 million	$	$1 million to $10 million

Table 34: Cost of viable short-to-medium-term options (continued)

LOCATION	OPTION		COST			
			Present Day		Medium-term (to 2068)	
MU8-MU9 Home Island – Outside of Settlement	PMR2, PMR3	Relocation of assets from inside hazard area (where applicable)	$	Less than $250,000	$	Less than $250,000
	AC1	Accommodate (where applicable)	$	$250,000 to $1 million	$	$250,000 to $1 million
	P6+P2	Levees with on-going nourishment	$	$1 million to $10 million	$	$10 million to $50 million
	P6+P5a	Levees with seawalls (GSC seawalls costed)	$	$10 million to $50 million	$	$10 million to $50 million
	P6+P5b	Levees with seawalls (concrete seabee seawalls costed)	$	$10 million to $50 million	$	$10 million to $50 million

Table 35: Cost of viable long-term options

LOCATION	OPTION		COST	
MU1-MU6 West Island	AC1 and then P5b	Following short-term accommodate pathway: Protect with seawalls	$	More than $100 million
	P5b and then P5b	Following Protect with seawalls short-term option: Protect with seawalls	$	More than $100 million
	AC1 and then P7 + P5b	Following short-term accommodate pathway: Reclaim Land and protect with seawalls	$	More than $250 million
	P5/P6 and then P7 + P5b	Following Protect short-term option: Reclaim Land and protect with seawalls	$	More than $350 million
MU7-MU9 Home Island	AC1 and then P7	Following short-term accommodate pathway: Reclamation on HI Settlement	$	More than $500 million
	P6 + P5 and then P7	Following Protect with seawalls and levees short-term option: Reclamation on HI Settlement	$	More than $500 million

6.3 MCA Result and Options Summary

The following sections summarise the intended outcome of risk treatment options from the MCA (details in *Section 6.2)* for the three asset locations.

The Full MCA evaluation is detailed in *Appendix E*.

6.3.1 Home Island Settlement (MU7)

The Home Island settlement area is at threat of coastal inundation at an increased frequency. Reflecting the need to preserve the important social values of the community, especially the daily interaction with the water, the MCA for the Home Island Settlement considers a number of short-term options.

The preferred short-term options assume continued enjoyment of the island way of life can be sustained in the short to medium-term, with accommodate and protect options available providing this short-term outcome.

However, over time, more robust options are required to prevent unacceptable impacts on vulnerable development, land uses and the population.

Long Term Settlement Planning will need to be undertaken in partnership with the community as soon as possible to establish longer term pathways.

Whilst all options will be considered, including resilience measures (revegetation/sand nourishment) and protect options, relocation may also be viable and feasible.

Medium-to-long-term options are presented to indicate subsequent costing involved in further options assessment.

6.3.2 West Island Settlement (MU1)

The West Island settlement area is at threat of severe erosion and many important public and private infrastructure items and assets are already vulnerable. The MCA result for West Island Settlement considers a number of short-term options.

Given the strategic infrastructure and assets located on West Island that underpin the habitation of the islands (airport and port) the assumption is that Retreat is not acceptable in the short-term, with 'protect' options reflecting that.

Long Term Settlement Planning will need to be undertaken in partnership with the community as soon as possible to establish longer term pathways.

Whilst all options will be considered, including resilience measures (revegetation/sand nourishment) and protect options, relocation may also be viable and feasible.

Medium-to-long-term options are presented to indicate subsequent costing involved in further options assessment.

6.3.3 Assets outside of settlement

There are two types of assets outside of the settlement areas; non-critical infrastructure and critical infrastructure.

For non-critical infrastructure a number of opportunities exist, including:

- Avoiding further activity in known areas of risk
- Relocating within property boundaries, or relocate when the asset reaches end of life
- Sand nourishment to extend asset life in-situ
- Accommodate or Protect; which are both very expensive for any single asset

Levees and seawalls were not identified as suitable for any non-critical infrastructure given the significant cost for individual assets.

For critical infrastructure, sand nourishment and protect options such as seawalls and levees are suitable options. All options are very expensive, but the infrastructure provides essential services for the islands, and may be feasible for that reason.

6.4 Benefit Distribution Analysis

This CHRMAP identifies coastal hazards and recognises that the community is vulnerable in some areas to these hazards.

Where coastal hazards are deemed a risk to a community, a range of interventions may occur to mitigate this vulnerability. These includes consideration of options to avoid impacts, planned and managed retreat, accommodate or to protect.

SPP 2.6 and it's supporting suite of guidance introduces the concept of 'User Pays'. This establishes a principle that the beneficiaries of adaptation options should pay for them, as they stand to gain the most. Where adaptation options are designed to protect specific sections of coastal land and assets that is primarily to benefit private property it is recommended that the decision maker determines who should contribute and how much.

A Benefit Distribution Analysis (BDA) (*Appendix G*) was undertaken to systematically estimate benefits to different parties as the result of these possible interventions for CKI (protection only).

The BDA was developed to:

- Develop a shared understanding of who will benefit from coastal hazard interventions.
- Ensure a broad understanding is developed by capturing a range of benefits from different perspectives.
- Inform any future decision-making relating to funding contributions for interventions.

The BDA quantified relevant proportional benefits accruing to relevant groups of asset holders against a 'Do Nothing' base case, associated with existing and proposed protection works identified in this CHRMAP.

In the BDA benefit is defined as "the continued existence and operation of an asset, at its existing full functionality, landholding, service, or economic/ commercial outcome as at the time of the BDA".

A key assumption of the BDA is that coastal management interventions will result in beneficiaries continuing to enjoy these benefits in perpetuity, although it is well understood that for CKI this is highly unlikely to be achieved for all stakeholders.

6.4.1 The Significance of the BDA

BDA is significant in the context of the substantial expenditure proposed in the CHRMAP. The cost of most adaptation options far exceeds the budgetary capacity of the Shire of Cocos (Keeling) Islands or the community of CKI.

CKI is an External Territory of Australia, and usually ineligible for other State or Territory funding mechanisms.

The BDA considers the current economic value of environmental (community) amenity, private property (residential and commercial), potential revenue (rates etc) and wages received from commerce (a proportion of which is assumed to be returned to the community through expenditure). It then estimates the percentage benefit to each of these indices, and attributes that percentage as a benefit.

For example, an adaptation option that protects (benefits) $750,000 worth of private residential property, $200,000 worth of community amenity (a park etc) and creates $50,000 worth of revenue (from rates) has a total value of $1 million in benefit. 75% of the benefit is attributed to the private residential development, and 25% to the broader community.

Although simplistic, in this case, the cost of the option should be funded at a rate of 75% from those private owners with the balance from other funding sources.

Using the simple example above, this would leave 25% of the funding still to be sourced through other funds which will need to include local rates (i.e. rate payer expenditure) combined with other funding such as grants.

CKI is unusual in that private individual ownership of land is rare (most in Trust, otherwise Crown land, with a small number of individually-owned Freehold).

So in the above example, the 75% private beneficiary and the 25% public beneficiary, would essentially have to be sourced from the same party; although much of the benefit is noted as preserved for private dwellings, most of the benefit ultimately flows to the Trust and Australian Government interests.

It is also recognised that the Trust does not provide a source of income other than rental income; which is entirely insufficient for the hazard management requirements of the CHRMAP. As such, an assessment of who will need to contribute to the community benefit portion has not been made in the BDA.

The BDA also excludes essential infrastructure which is required to maintain settlement on CKI - this is essential service infrastructure. Examples of essential services infrastructure include infrastructure for water, fuel and ports (particularly important given CKI imports most of its food and all fuel by sea).

The BDA excludes these infrastructure as without these infrastructure items, there would be no continued habitation on-island for any user. These items have an approximate value of $1.5 billion.

The full BDA is provided in *Appendix G*.

Considerations for Benefit Distribution on CKI;

- Some infrastructure - essential services - are fundamental to supporting habitation. Without this infrastructure the Islands would no longer be habitable. This infrastructure has a replacement value of approximately $1.5 billion, much of which will need to be replaced within 50 years.
- The replacement value of other infrastructure on Home and West Island that is likely to be vulnerable to coastal hazards is approximately $92 million.
- Approximately $182 million of economic value (amenity, property value, revenue and wages) will potentially be impacted by coastal hazards over the time frame of the CHRMAP.
- The cost of coastal adaptation options is likely to be in excess of $1 billion, subject to further investigations.

6.4.2 Home Island

Home Island's vulnerability to the combination of erosion and inundation is so great that potential interventions will be cost prohibitive over the long-term.

The BDA indicates that approximately $92 million of economic value (amenity, property, revenue and wages) will potentially be impacted over the next 100 years, with the estimated cost of replacement for current infrastructure at nearly $42 million. The cost of replacement excludes essential services infrastructure, which is estimated at $500million for Home Island.

Short-term interventions are possible to extend the enjoyment of the coastal lifestyle but are likely to be sacrificial in the long-term. Notwithstanding, the BDA assesses the value of protection proposed to mitigate the risk and finds that approximately 65% of the benefit of providing coastal hazard adaptation would be apportioned to private interests, predominantly the Trust, who should be obliged to contribute to temporary protection measures.

The BDA notes that planned and managed retreat options mean that no intervention is being proposed that assures "the continued existence and operation of an asset, at its existing full functionality, landholding, service, or economic/commercial outcome as at the time of the BDA".

As such, it notes that if settlement relocation is considered in the long-term, BDA is not suitable for considering the preserved benefits of Home Island through continued existence of current 'functionality, landholding, service, or economic/commercial outcome'; i.e. there is no long-term beneficiary. Notwithstanding, it is possible that some economic return could be achieved through alternative land uses on Home Island, such as tourist accommodation and other tourism activities provided with off-grid services.

Long-term adaptation requires a more sophisticated response to funding, including consideration of how best to effect long-term relocation of vulnerable private assets through negotiated agreements when impacts on those private assets become unacceptable.

6.4.3 West Island Settlement

The Settlement on West Island (parts of Management Units 1 and 3) is vulnerable to coastal hazards, and relocation of vulnerable assets over the long-term may be necessary, however, it is recognised that some significant essential Australian Government assets are likely to be retained on-island for the foreseeable future.

It is acknowledged that the Australian Government is currently proposing a significant upgrade of the airport runway to service the settlements, which will have the effect of protecting that asset, as a separate and independent project. The runway upgrade includes increasing the height of lower lying portions of the runway to reduce flooding risk over the next 15 years. Further raising of the runway after 15 years will likely be required to maintain and/or regain resilience against inundation during storm surge.

The BDA indicates that approximately $90 million of economic value (amenity, property, revenue and wages) will potentially be impacted by coastal hazards over the next 50 years, with the estimated cost of replacement for current non-essential services infrastructure when the impacts become unacceptable at approximately $50 million. The cost of replacement excludes essential services infrastructure, which is estimated at at $1billion for West Island.

The BDA assesses the value of protection proposed to mitigate the risk and finds that approximately 72% of the benefit of providing coastal hazard adaptation would be apportioned to private interests, including the Trust, who should be obliged to contribute to temporary protection measures.

However, the BDA notes that no intervention is being proposed that assures “the continued existence and operation of [all assets], at its existing full functionality, landholding, service, or economic/commercial outcome as at the time of the BDA”.

In this case, some protection works will protect some areas, but it is unlikely that the full value of the Trust land can be retained, and as such, the Trust as beneficiary is limited from retaining full and continued enjoyment.

Long-term adaptation requires a more sophisticated response to funding, including consideration of how best to effect long-term relocation of vulnerable private assets through negotiated agreements when impacts on those private assets become unacceptable.

6.4.4 West Island north

West Island north (parts of Management Units 2, 3 and 4) comprises significant essential services infrastructure, but is generally lightly inhabited. Essential services infrastructure, such as the jetty at Rumah Baru, is considered separately.

The BDA indicates that approximately $2.5 million of economic value (amenity, property, revenue and wages) will potentially be impacted over the next 50 years, with the estimated cost of replacement for current private infrastructure when the impacts become unacceptable at approximately $7.3 million.

The BDA assesses the value of protection proposed to mitigate the risk and finds that approximately 26% of the benefit of providing coastal hazard adaptation would be apportioned to private interests, including the Trust.

However, as no intervention is being proposed that assures “the continued existence and operation of [all assets], at its existing full functionality, landholding, service, or economic/commercial outcome as at the time of the BDA”, it is unlikely that the full value of the Trust land can be retained, and as such, the Trust as beneficiary is impacted from retaining continued enjoyment.

In real terms, there is very limited private individual interest maintained in West Island North, the Trust

is majority beneficiary with the exception of assets such as the Big Barge Art Centre and the Coconut Farm.

6.4.5 West Island south

West Island south (parts of Management Units 3, 5 and 6) comprises significant community assets and some services infrastructure, i.e., public utilities infrastructure, but is lightly inhabited. The tourism function of the area is important and predominant in terms of land use.

The BDA indicates that under $1 million of economic value (amenity) will potentially be impacted over the next 50 years, with the estimated cost of replacement for current privately owned infrastructure at approximately $4 million.

The BDA assesses the value of protection proposed to mitigate the risk and finds it is all Trust land i.e., “private interests”.

6.4.6 Uninhabited Islands

The analysis indicates that approximately $5 million of economic value (amenity) will potentially be impacted over the next 50 years.

The BDA assesses the value of protection proposed to mitigate the risk and finds the community and the Trust benefiting from continued social and tourism use.

6.4.7 Benefit Distribution Analysis Summary

The analysis indicates that approximately $190 million of economic value will potentially be destroyed by inundation and erosion on CKI by 2068. Private dwellings (predominantly owned by the Trust) and lost economic activity from lost wages are the highest preserved values, with total replacement cost of infrastructure on CKI (excepting essential services infrastructure such as the airport runway and Rumah Baru) at more than $100 million.

CKI is predominantly Freehold land held in Trust by the Shire. Crown land and land owned by Government is next. There are very few parcels held in Freehold by individual proprietors (*Figure 59*). The majority of the residents are renters in houses owned by the Trust.

Figure 59: Crown land and Trust owned land on CKI.

Therefore, while much of the benefit is noted as preserved for private dwellings, most of this benefit ultimately flows to the Trust, which has limited capacity to pay for any adaptation. Any capacity that the Trust has to raise capital through sale or transaction of land is affected by the coastal hazards being considered by this CHRMAP.

Short-term interventions are possible to extend the enjoyment of CKI's coastal lifestyle. Notwithstanding, should any protection be proposed to mitigate risk, 94.3% of the benefit of providing coastal hazard adaptation would be apportioned to private interests (including the Trust), who should be obliged to contribute to protection measures.

In the case of planned and managed retreat, no intervention is being proposed that assures "the continued existence and operation of an asset, at its existing full functionality, landholding, service, or economic/commercial outcome as at the time of the BDA".

The BDA suggests caution should be applied in applying user pays principles on CKI. Long-term adaptation requires a more sophisticated response to funding, including consideration of how best to effect long-term relocation through negotiated land agreements.

6.5 Cost Benefit Analysis

Cost Benefit Analysis (CBA) assists in the decision of when is the best time to implement adaptation, as well as which interventions against sea level rise provide the greatest benefit relative to costs.

This analysis involves forecasting future cash flows associated with each measure (both the cost of implementing a measure, and the flow of future benefits) and discounting based on an assumed time period.

As CKI is a small island community under immediate threat of coastal erosion and inundation, this CHRMAP identifies that the best time to implement the required interventions to combat the threat for the majority of assets is the present.

Noting this, only two assets exist with positive scores where a CBA may inform timing of interventions. These assets are:

- The cemetery on Home Island, which potentially could have levees and reclamation proposed either now or towards 2035-40. However, there is little value conducting a CBA before a Local Heritage Survey is complete and a Cultural Heritage Management Plan established.
- Sydney Highway, which requires relocation somewhere between now and 2030. Given the immediacy of the need for interventions, there is also little need for a CBA.

Two critical pieces of infrastructure that support CKI's community and economy are the fuel jetty which handles all fuel entering CKI, and Rumah Baru jetty. Short-term protection is recommended for the fuel jetty, and the runway upgrade project proposed a significant Materials Offloading Facility adjacent to Rumah Baru in the short-term, which will impact all options for that asset. A CBA is therefore not required to analyse investment timing for these assets.

A note regarding CBA is detailed in *Appendix F*.

Chapter 7 Adaptation Options

7 Adaptation Options

7.1 Overarching Actions

All assets (physical and natural) on both Home Island and West Island become more vulnerable over time.

This requires consideration of management and adaptation planning options that may be relevant to all assets, rather than individual asset management.

The following section summarises the key strategic planning, statutory planning, and policy or governance interventions that the Shire will need to implement regardless of the proposed adaptation options chosen per area or asset.

Action 1: Ongoing Community Engagement and Communications

Action 1 is thedevelopment of a community engagement plan and a suite of communications materials as soon as practical.

Ongoing delivery of the coastal hazard planning pathways requires a partnership approach between the community, stakeholders and all levels of Government. Managing and adapting to the coastal hazard challenges present on CKI will require a collaborative effort. Every member of the CKI community is affected by coastal hazards in some way, and more than half of the CKI community have directly indicated a strong desire to be involved in decision making that affects them.

Action 1 enables the delivery of all other Overarching Actions and specific Area-based Options, by creating a platform for increased and authentic engagement amongst and across community and stakeholder groups.

The community engagement plan should include a long-term program for community involvement in reference groups or committees (or similar named structure). These may be convened on an action-by-action basis or as a participatory group with rolling membership as would normally be the case for committees of local government. It is anticipated that reference group functions will be convened and facilitated by the Australian Government.

Engagement will be guided by ongoing CHRMAP project actions but could include engagement regarding Long Term Settlement Planning (PMR4 - including the Local Planning Strategy and Scheme), drainage and flood mitigation, cultural heritage, Minor Asset Relocation (PMR2) and Services Relocation (PMR3), and ongoing CHRMAP review.

Additional engagement included in the plan would involve regular opportunities for broader community engagement, and more targeted engagement with specific groups and organisations impacted by the actions proposed in the CHRMAP.

Communications materials should also be developed and shared with all local property owners and residents regarding identified hazards so that they understand the vulnerability of land on CKI. These materials should include a series of frequently asked questions and simple fact sheets, which may include:

- Regular electronic and hard copy (The Atoll) CHRMAP project updates including information about ongoing engagement, monitoring results and outcomes of studies recommended in the CHRMAP.
- A fact sheet on how to develop in the future on CKI.
- A fact sheet on who is responsible for coastal hazard management.
- A fact sheet on what impacts may be experienced in the future, regardless of adaptation options in the short term.
- A fact sheet for citizen science monitoring programs which may be employed.

All communication should be in both English and Cocos Malay languages and supported by visual representation in simple format.

All property owners should receive this information, as should any real estate agent known to be operating on CKI.

(Options: PMR4 - Long Term Settlement Planning)

Action 2: Complete investigations into terrestrial flood and groundwater shoaling impacts to confirm trigger for longer term planning.

The present day and future vulnerability of assets to terrestrial flood and groundwater shoaling is not well understood. The joint probability of these processes with coastal inundation is also a significant knowledge gap.

Combined terrestrial, groundwater and coastal inundation impacts are likely to be more severe than coastal inundation alone. This is particularly relevant for Home Island settlement, which already experiences significant flooding in heavy rainfall, with inundation risk increasing in combination with sea and groundwater levels. These combined factors could result in inundation becoming unacceptable to residents sooner than anticipated, requiring implementation of the long-term adaptation pathway (i.e. reclamation or relocation at Home Island).

A terrestrial flood and groundwater shoaling study is currently underway for Home Island to confirm the implementation trigger timeframe. This study includes:

- Assessment of immediate flood risk.
- Assessment of the potential impact of the proposed coastal adaptation options.
- Consideration of longer-term climate resilience needs.
- Consideration of land use planning mechanisms to mitigate flood risk into the future.
- Preparation of a water management report

In addition to the current study, further investigations are recommended to ensure long term decision making is evidence based. These investigations should include:

- Terrestrial flood and groundwater shoaling study for West Island.
- Development of short to medium-term options that mitigate the combined impacts of terrestrial flooding and ocean inundation.
- Cost benefit analysis comparing costs of short to medium-term options against implementation of longer term adaptation.
- Identification of trigger timeframes to implement longer term adaptation options (i.e. when the frequency and depth of inundation events become unacceptable).

(Options: No Regrets)

Action 3: Special Control Area

Amend the local planning scheme (LPS) to introduce a Special Control Area (SCA) over all land identified as being vulnerable to coastal erosion and/or inundation. The SCA should be applied to relate specifically to land subject to coastal processes (as recommended in WAPC, 2019) and would be delineated by the position of either the erosion setback line or the worst case inundation extent in the year 2118, whichever is the more landward.

An SCA is a planning layer that applies in addition to the underlying zoning and land use permissibility of the land. It identifies areas which are significant for a particular reason and where special provisions in the Scheme may need to apply in addition to any other requirements relevant to the underlying zone.

A SCA classification can be included in a scheme to facilitate land use changes and development control within that area.

WAPC (2019) provides draft amendment text in the *CHRMAP Guidelines Appendix 4 Planned or Managed Retreat existing planning framework and instruments*, however, the objectives require some modification to reflect the island environment. The purpose of the SCA is to provide guidance as to the appropriate scope of land use and development to be permitted within a vulnerable area.

Its objectives would be:

- To support coastal foreshore management, public access, recreation and conservation of land in the coastal zone to retain enjoyment for the foreseeable future.
- To ensure public safety and reduce vulnerability associated with coastal erosion and inundation.
- To avoid inappropriate land use and development of land which is vulnerable to coastal erosion and inundation.
- To ensure land use and development does not accelerate coastal erosion or inundation risks; or fundamentally impact public reserves.

The SCA would include additional provisions such as:

- The requirement for a notification on titles (see *Action 7*).
- Subdivision of land is managed to ensure it won't lead to an intensification of vulnerable development within the hazard-affected areas.
- Proposed development within the SCA requiring approval in all cases to ensure it won't lead to an intensification of vulnerable development within the hazard-affected areas.
- Any planning application should be referred to the DTMI, the Western Australian Planning Commission (WAPC) and any other relevant authority for advice and comment on coastal vulnerability.
- Minimum finished floor levels for habitable rooms, for example Queenslander style development with rooms such as laundries and parking permitted at ground level. Minimum finished floor levels would be subject to further technical assessment against the allowances described in *Table 13*.

Regardless of the SCA requirements, other development standards may apply such as minimum heights for water and power supply outlets, subject to other relevant legislation.

In addition to the above, any development proposed and approved in the SCA could be conditional, based on both a time limit and an event limit with a notification on titles (see *Action 7*).

Time limited approvals are permitted under the Planning and Development (Local Planning Schemes) Regulations 2015 (Schedule 2, Part 9 Cl. 72). For this CHRMAP, time proposed on the approval would be the period in which the subject lot is identified as reaching a 'High' level of vulnerability according to the CHRMAP (see *Chapter 4 Vulnerability Assessment*).

The applicant could later apply for a further time limited approval, which could be granted if the vulnerability to coastal processes was still considered acceptable to the applicant.

The event limited approval would be tied to external factors including a public road no longer being available/legal access no longer being available to the property, or when water, sewerage or electricity to the lot is no longer available as they have been removed/decommissioned by the relevant authority due to coastal hazards. The event limited approval should also include damage associated with a storm event that exceeds expected impacts for the timeframe.

Time and event limited approvals require removal and/or rehabilitation of the development to the way the site was before the approval.

It is recognised that this recommendation has the potential to cause concern amongst the community, especially for landowners, which is a natural response from citizens trying to protect property values. However, it must be noted that there is no obligation on Government to compensate land lost due to coastal hazards, and it is much more proactive for the relevant decision-making authorities to identify vulnerable land and take appropriate action.

For landowners who may be considering purchasing or developing lands, it is important to note that they should not assume any funds will be forthcoming to support future protection.

NB: Given the extensive geographical coverage of the SCA in this case (i.e. almost the entirety of the islands), there are merits in considering scheme provisions that apply to the whole scheme area. This will require further investigation during preparation of a Local Planning Strategy and a full review of LPS1.

(Options: PMR5 - Planning controls for planned and managed retreat / Prohibit expanding existing use rights, AC3 - Planning controls for accommodation).

Action 4: Sand Source/Raw Materials Investigation

The long-term settlement of Home Island largely depends on the ability to reclaim the land (raise the land levels) given the combined, erosion, inundation, groundwater and terrestrial flooding risk.

Several vulnerable assets also include possible sand nourishment (importing sand from elsewhere) as a management option, however, it is acknowledged that the availability of sand for nourishment is not well understood, and that local sources may contribute to erosion within the local island system.

The Australian Government has commenced scoping materials and sand availability studies to determine the capacity of local sand supply within the atoll and external options (shipped from mainland), for reclamation purposes and reasonable costs..

(Options: P 1 – 7 Protect options, No Regrets).

Action 5: Shire Infrastructure Asset Planning

It is recommended that the Shire ensure that all future infrastructure assets placed in areas vulnerable to coastal hazard impacts either be sacrificial or have a design life that ensure the asset will be redundant before the risk becomes almost certain. This can be done through the Shire's Asset Management Planning either spatially or via a database.

This will ensure that hard assets such as seating, pathways, toilets, playgrounds etc, as well as soft assets such as landscaping, be developed in such a way as to allow continued enjoyment of the coastal zone for as long as possible, whilst also reducing or removing the vulnerability of assets. Noting this is of particular relevance for assets outside of the West Island and Home Islands settlements, such as beach infrastructure at Trannies Beach.

An asset management pathway should enable:

- Progressive relocation of non-critical service infrastructure assets away from the coastal hazard zone once they reach the end of asset life or replace assets with suitably durable and/or sacrificial infrastructure.
- Plans for the relocation of critical service infrastructure outside of the coastal hazard zone once they reach the end of asset life, or at a minimum, modify the service infrastructure asset so that it does not run parallel to the coastline and can be progressively removed when exposed to unacceptable risk levels.

(Options: PMR2 - Minor Asset Relocation, PMR3 - Services Relocation, NR2 - Protection structure audit).

Action 6: CKI Boat Ramp Assessment

Maintaining access to waterways has been identified by the community as a high priority and social value of importance. It was also clear through the engagement process that the condition of boat ramps, particularly on West Island, are not providing adequate serviceability for the community.

A review of the condition and operational constraints of boat ramps is suggested, including recommendations for maintenance and/or design alterations to improve access to waterways. The assessment should also include an options assessment, whereby alternate locations may be identified as more suitable, to reduce longer term maintenance requirements.

Action 7: Notification on Titles

All Freehold land identified as being vulnerable to impact from coastal processes (in the SCA) should have a notification placed on its Certificate of Title to make the owner and future landholders aware of the potential for the land to be impacted.

Section 165 of the *Planning and Development Act 2005 (WA)(CKI)* enables the WAPC to place a notification on the Certificate of Title of land to make owners and future owners aware of hazards or other factors seriously affecting the use or enjoyment of that land. This is able to occur through placement of a notification to be a condition of development or subdivision approval, but cannot be done in the absence of an application.

However, placement of a notification on the Certificate of Title could take place at any time with owner consent (i.e. with owner's goodwill) under the *Land Administration Act 1997 (WA)(CKI)*. This may be well suited to Trust land.

Current wording recommended by the WAPC and in accordance with SPP 2.6 is as follows:

"This lot is located in an area likely to be subject to coastal erosion and/or inundation over the next 100 years from the date this notification is registered."

(Options: PMR5 - Planning controls for planned and managed retreat / Prohibit expanding existing use rights, AC3 - Planning controls for accommodation NR3 - Notification on titles).

Action 8: Resilience Planning and Monitoring

A number of the assets vulnerable to coastal hazards in the short-term could include management options that are already ongoing Shire management processes. This includes sand nourishment, and dune rehabilitation and protection.

Ongoing dune rehabilitation will be subject to securing funding, which the Shire can continue to apply for, support and manage.

These options were the preferred options across all criteria. This aligns with community preferences for more natural options. This action would reflect a sensible foreshore management approach.

It is recommended that the Australian Government and the Shire work collaboratively to develop a strategy to respond to this recommendation, including:

- A schedule and funding pathway for delivery of natural resilience measures such as sand nourishment and dune revegetation and rehabilitation.
- A schedule and funding pathway for monitoring over the following 5 years.
- An event response plan.

See also Section 9 Monitoring and Review.

(Options: NR2 - Monitoring).

Action 9: Local Planning Policy

Prepare or update a local planning policy (LPP) to guide the Shire's decision-making for coastal development within an identified area, including the type of permanent or temporary assets it is prepared to accept within the coastal reserve and/or on land subject to coastal processes, in line with the SCA.

LPPs are prepared and adopted according to the provisions in Part 2 Division 2 of the Deemed Provisions of LPS 9. The Shire may prepare an LPP in respect of any matter related to the planning and development of the Scheme area.

An LPP can provide more detail and guidance on what sort of development would be acceptable within the SCA and will also assist the local government in making planning decisions on coastal development requiring the exercise of discretion.

For example, on land vulnerable to erosion within the life of a proposed development the LPP may encourage use of structures that can be disassembled and/or transported should erosion come within a specified distance of the structure, or may encourage short-term commercial uses. The policy would identify the local government's intention to require notification on titles as a condition of development approval.

(Options: PMR5 - Planning controls for planned and managed retreat / Prohibit expanding existing use rights, AC3 - Planning controls for accommodation).

Action 10: Local Planning Strategy

It is recommended that the Shire progress preparation of its Local Planning Strategy, which provides an excellent opportunity to identify the vulnerability of the study area in the strategic planning framework.

This will help to guide ongoing planning and development in the area, and provide an important signal to landowners and developers that the land in the study area has risks associated with coastal hazards. This may also serve to identify areas where some relocated development may occur. This is an important first step to including known vulnerability in the statutory planning framework.

(Options: PMR5 - Planning controls for planned and managed retreat / Prohibit expanding existing use rights, AC3 - Planning controls for accommodation).

Action 11: Long-Term Settlement Planning

It is suitable to begin a planned and managed retreat pathway for non-critical assets and services (PMR2 - Minor Asset Relocation and PMR3 – Services Relocation). This can and should occur as part of normal asset management programs, with the addition of contemporary data included in the CHRMAP.

Engagement around the planning for the main settlements on both Home Island and West Island is foreshadowed in Action 1. This Long-Term Settlement Planning, done as a partnership between all levels of government and the community, may include staged approaches with different actions taken in the short, medium and long-term subject to the planning process.

Settlement planning could include the following:

- Potential location of the settlements.
- Potential land uses, and future land use changes within the settlements.
- Potential location of essential service infrastructure (e.g. power, water).
- Potential location of emergency shelters.
- Potential acquisition of private land as it becomes available on the public market.
- Potential location of protection structures, and prioritisation of protection structures.
- Potential adaptation of culturally significant places such as the Cemeteries.

For privately owned land outside of the two settlement areas, it is also suitable to begin liaison with landowners regarding long-term land use and development provisions, which may include planning for managed retreat, relocation or voluntary acquisition.

Such property could then be converted to a leasable asset and continue to be utilised up to the time when the risk becomes unacceptable.

Collaborative development of Long-Term Settlement Planning would result in a measured and considered approach that is flexible to the needs of the community and the need for adaptation over time.

(Options: PMR2 - Minor Asset Relocation, PMR3 - Services Relocation, PMR4 – Long-Term Settlement Planning, PMR5 - Planning Controls for Managed Retreat, PMR6 - Voluntary Acquisition).

Action 12: Emergency Management Plan

It is recommended that the Australian Government and Shire prepare an emergency management plan with support from the WA Department of Fire and Emergency Services to cover unexpected events, significant coastal erosion and / or inundation and resulting emergency asset repair or removal.

This plan could be undertaken in line with *Action 8* and include resilience planning and monitoring activities.

(Option: NR4 - Emergency evacuation plans).

Recommendation 13: Cultural Heritage Management Plan

Significant cultural heritage is likely to be lost as a result of coastal hazards. A detailed analysis of cultural heritage, recording of details and assets, both photographic and potentially by removing assets from in-situ locations should they become vulnerable to permanent destruction, and a full recording of oral histories may be necessary to preserve the knowledge of place and culture of the Islands.

A Cultural Heritage Management Plan, or similar as appropriate, is recommended by this CHRMAP, before further damage occurs to key assets.

To support the Cultural Heritage Management Plan, a Local Heritage Survey should be undertaken in accordance with the Western Australian planning framework. This would align with the development of a Heritage List for SoCKI.

A significant asset of note are the cemeteries, which hold significant cultural value and connection to the islands.

For Home Island, a protect pathway (seawall with levees) would require land reclamation (raising of the land levels) to mitigate the future groundwater and terrestrial flooding impacts. Given the potential cultural heritage impacts to adopting a land reclamation pathway, further engagement with the Elders and broader Home Island community via a cultural heritage assessment is recommended to inform actions.

7.2 Area-based Options

This section describes the adaptation actions proposed for the assets which are identified as vulnerable. Options are provided for individual assets as appropriate.

This section introduces the concept of 'triggers'. Triggers are an indicator of increasing vulnerability to an asset and are consistent with the 'S1' factor from SPP 2.6 – the extreme storm erosion factor.

Implementation Timeframe

The actions recommended for implementation have been categorised as:

- Short-term - worth pursuing in the next 0 to 10 years (to 2033)
- Medium-term - after a review of the impact of the short-term options, 10 to 50 years (to 2068)
- Long-term - after relevant catalyst trigger points are reached, 50 to 100 years (to 2118).

The short to medium-term adaptation pathways are outlined in this section. The risk management measures identified in these sections are focused in the short to medium-term (to 2068), however, also include measures that allow the community and stakeholders to choose the most appropriate risk treatment options at future decision points for the medium to long-term risk management pathways.

Flexible Adaptation

It should be noted that the CHRMAP policy preferences the most flexible adaptation pathways; the pathways that provide for the broadest possible decision making at the time when a decision becomes necessary.

For this reason, recommended options favour Avoid and Planned Retreat where these are available. Notwithstanding, when an avoid or planned and managed retreat option is recommended, many other options remain valid.

This is the direct benefit of preferencing more flexible adaptation options, because it retains the greatest possible decision making available for a later time when the trigger has been met.

Regardless of the recommended option, planning can continue to be undertaken on all valid options until the point a decision is to be made. Every option recommended remains subject to detailed design and investigation, which will confirm the specific design and design life, the likely impacts to adjacent areas and detailed costings.

In many cases, the onus of the detailed design may be a partnership between landholders.

The risk treatment actions outlined in Section 7.1 provide a number of tasks that can be undertaken independent of the area or asset based options – this will contribute to providing greater levels of certainty regarding particular options.

This CHRMAP also requires regular review, at which time the recommended pathways should again be considered.

Risk Management Pathways

This section describes risk management options and the pathways for the two island settlements and for the areas outside of the settlements (as described by management unit) and the associated triggers for risk management measures to be established.

These management pathways provide the Australian Government and the Shire with a decision-making pathway that is made up of a sequence of decision points over time and at the appropriate time. This allows the decision-making bodies to be responsive to changing circumstances in the future and decisions can be planned, prioritised and prepared for.

Each coastal section includes:

- Key vulnerable assets
- Existing or proposed management pathway summary
- A visual representation of timing and decision making
- The risk management (adaptation) pathway

SPP 2.6 and the CHRMAP Guidelines provide guidance on the appropriate triggers or criteria to commence a particular management response. Types of triggers include:

Proximity trigger: Where the most landward part of the Horizontal Shoreline Datum (HSD) is within the Storm Erosion Allowance (S1) of the most seaward point of a public asset of interest or private property lot boundary.

Replacement trigger: Where an existing coastal adaptation option has reached the end of its life cycle and needs either replacement or significant upgrade.

Access trigger: Where a public road is considered no longer available or able to provide legal access to the property.

Utilities trigger: When water, sewage, communications or electricity to the lot is compromised due to coastal hazards.

Damage trigger: Any property within the hazard zone that is damaged by a coastal hazard from an extreme weather event shall require Shire approval before being repaired.

This list is sequential. That is, a Proximity Trigger is recommended over a Damage Trigger. The following triggers have been adopted and applied to each management unit, and are represented graphically in *Figure 60*.

Trigger 1	Proximity Trigger – the most landward part of the Horizontal Shoreline Datum (HSD) is within S1 of the most seaward point of a development or structure. Decision needs to be made soon.
Trigger 2	Proximity Trigger – HSD plus S1 reaches 2068 vulnerability line.
Trigger 3	Replacement Trigger – End of design life of accommodation or interim protection measure. Monitoring will inform timing and a recommendation to act per the CHRMAP (and its reviews).
Trigger 4	Access, Utility or Damage Trigger – The event-based trigger (access is lost, utilities are no longer available, or storm damage) is a recommendation to act per the CHRMAP (and its reviews).

All triggers are assessed based on how acceptable the risk is; i.e. how much impact the community may be willing to experience.

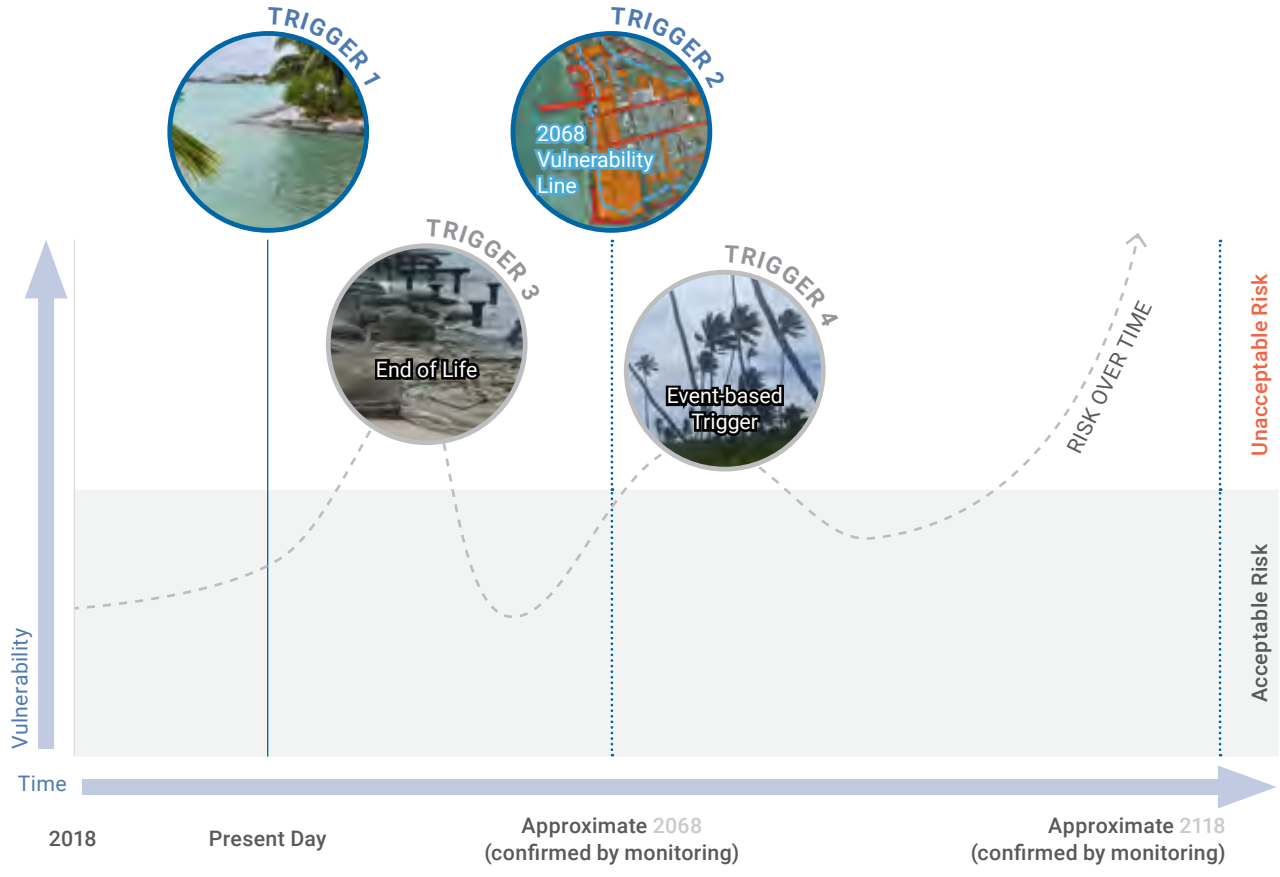


Figure 60: Triggers and How they apply

7.2.1 MU1 West Island Settlement

Options set out below apply to the entire West Island settlement, airport runway and airport infrastructure and assets.

The recommended management actions for West Island settlement are:

- AV – Avoid further development
- P5b + P6 – Protect (seawalls with levees)
- PMR5 – Planning Controls for Managed Retreat
- NR1 – Monitoring and investigate groundwater and terrestrial flooding
- NR2 – Protection structure audit
- NR3 – Notification on titles
- NR4 – Prepare emergency evacuation plans for the affected areas

The adaptation pathway for MU1 is presented in *Figure 61*.

It is recommended that a protect pathway is executed as soon as funds become available given that vulnerability is currently at an unacceptable level. Whilst appropriate funding models are assessed and confirmed, detailed design should be progressed with a focus on staging, identification of priority sections and planning associated with replacement (or upgrade) of existing protection structures (NR2).

The detailed design will also need to consider likely timing for protection structure upgrades (increase in heights) to identify ongoing subsequent costs, accompanied by a robust monitoring program to identify adaptation triggers.

Figure 62 provides an overview of the levee and seawall alignment required to 2068, which is summarised below.

At present, the following structures are required on the western settlement shoreline to manage erosion and inundation risks:

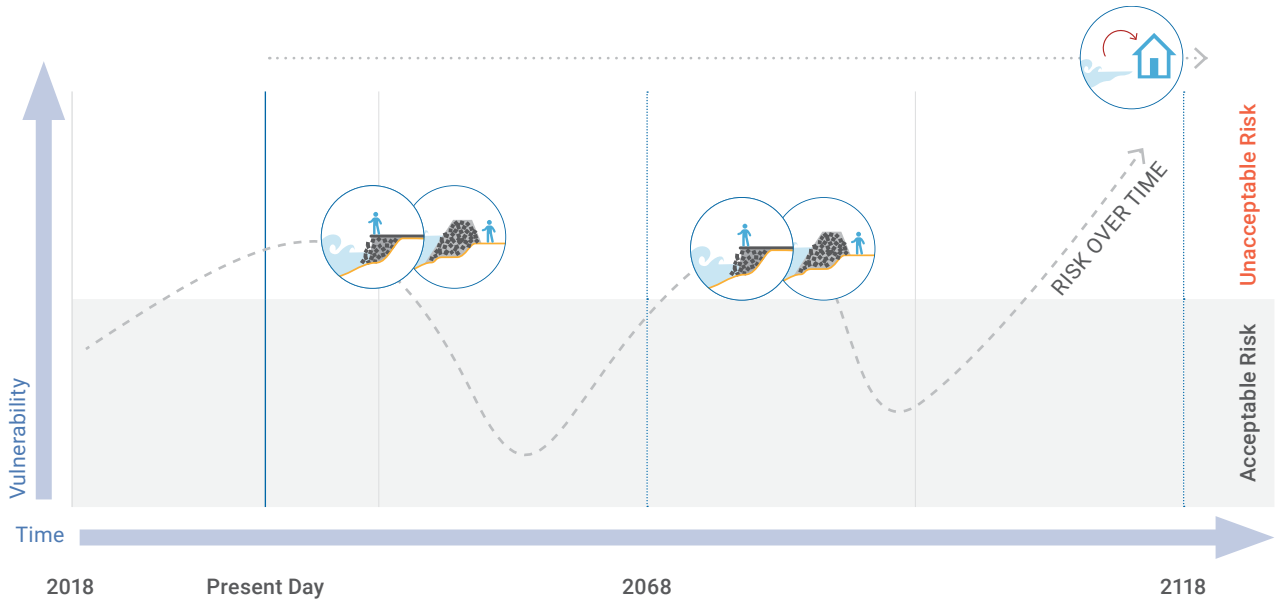
- Approximately 900m of levee in the centre and south
- Approximately 1,130m of concrete seabee seawalls north and south of the current seawalls

By approximately 2030, the existing GSC seawalls adjacent William Keeling Crescent should be replaced by a more structured (concrete) seawall in the centre of the western shoreline.

It's assumed that the concrete seawalls above would be replaced after 20 years (i.e. in 2050 and 2070) and the crest would be increased by 1m each time to accommodate increased overtopping from sea level rise.

Figure 63 provides an overview of the protection pathway beyond 2068 to 2118, further investigation in groundwater and terrestrial flooding will confirm the viability of a protection pathway to 2118.

For the eastern settlement shoreline, it's assumed that the runway project (and future projects) will raise the levels a sufficient height to prevent coastal inundation and erosion from the lagoon to 2118.



Pathways and Actions		
Undeveloped Areas	**Avoid –** AV / PMR5 Avoid further development, implement planning controls to prevent new development	
Developed Areas	**Protect –** P5b + P6 Seawall and Levees	**Protect –** P5b + P6 Seawall and Levees
All Scenarios	**No Regrets** – NR1, NR2, NR3 and NR4 Monitoring and Assess	

Figure 61: MU1 West Island Settlement adaptation pathway

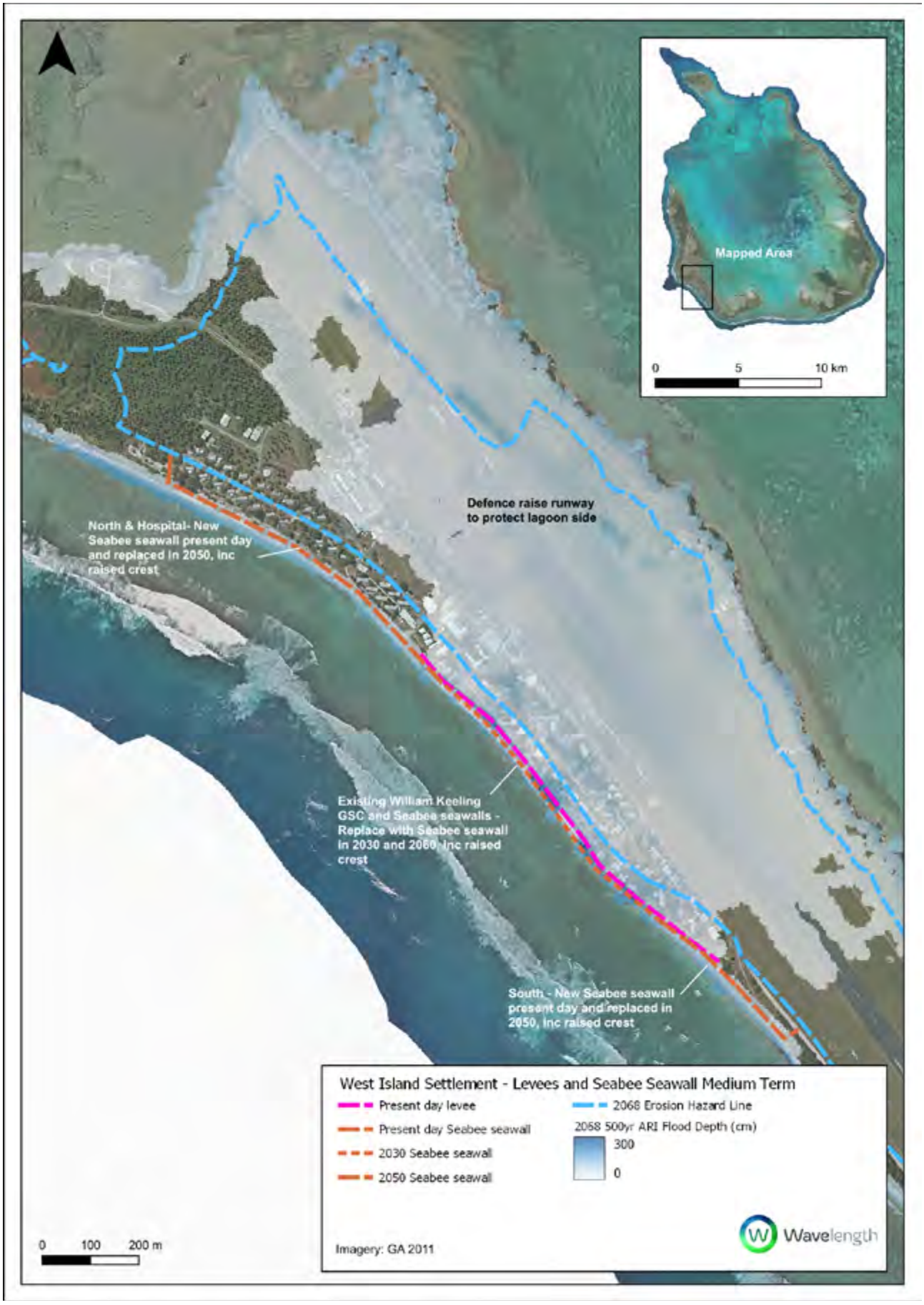


Figure 62: Overview of Protect adaptation pathway (Medium-term 2068)

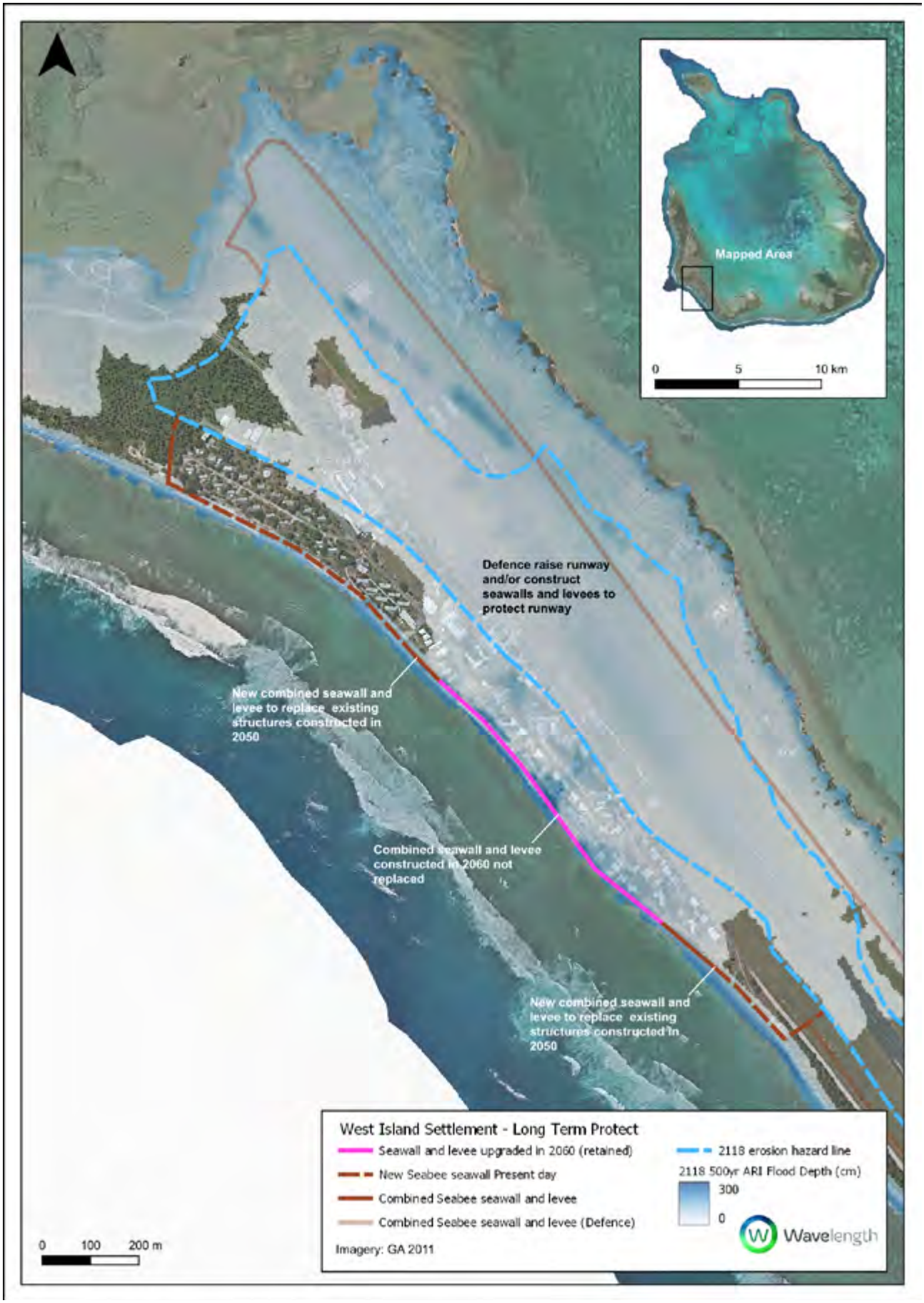


Figure 63: Overview of Protect adaptation pathway (Longer term 2118)

7.2.2 MU2 West Island ocean beaches north

The recommended management actions for West Island ocean beaches north to 2068 include:

- AV – Avoid further development
- PMR2 – Minor Asset Relocation
- PMR3 – Services Relocation
- NR1 – Monitoring
- NR2 – Protection structure audit
- P5b + P6 – Protect (concrete seawalls with levees)

The adaptation pathway for MU2 is presented in *Figure 64*.

Adequate space exists to relocate assets from the medium-term (2068) hazard area and therefore a planned and managed retreat pathway is recommended.

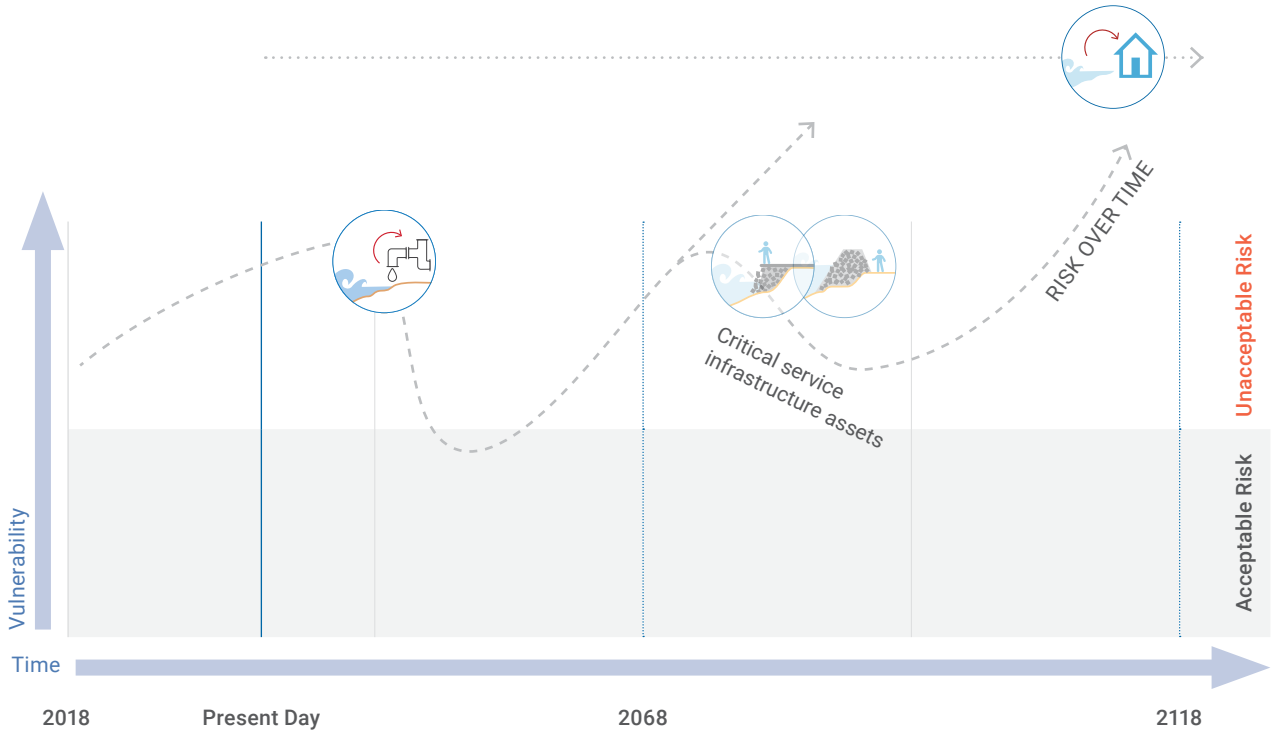
Figure 65 and *Figure 66* demonstrate the required adaptation pathways for Sydney Highway and the assets within the transmitter site to 2068 respectively.

Long-term relocation potential for assets has only considered impacts from coastal hazards, and this report does not assert that all land tenure, environmental, or other legislative factors are resolved.

Beyond 2068 limited space is likely to be available to continue to relocate assets from the hazard area, particularly the southern section of Sydney Highway. Given the critical service infrastructure assets to the north (Fuel Station and Rumah Baru) and the need to maintain access via Sydney Highway, a transition to a protection pathway (P5b + P6 levees and concrete seawalls) is likely to be required.

A robust monitoring program will be required to identify adaptation triggers. For the non-critical service infrastructure assets beyond 2068, a PMR2 (Minor Asset Relocation) and PMR3 (Services Relocation) pathway is recommended.

Monitoring of the beach levels and the ongoing rate of erosion will confirm if the transition to a protect and retreat pathway is likely to be sooner or later than currently projected.



Pathways and Actions

Undeveloped Areas		**Avoid –** AV / PMR5 Avoid further development, implement planning controls to prevent new development	
Developed Areas	Sydney Highway	**Planned and managed retreat –** PMR3 - Services Relocation	**Protect –** P5b + P6 Seawall and Levees
	Remaining assets	**Planned and Managed Retreat –** PMR2 - Minor Asset Relocation PMR3 - Services Relocation Relocation of assets from inside hazard area	
All Scenarios		**No Regrets** – NR1, NR2, NR3 and NR4 Monitoring and Assess	

Figure 64: MU2 West Island ocean beach north adaptation pathway

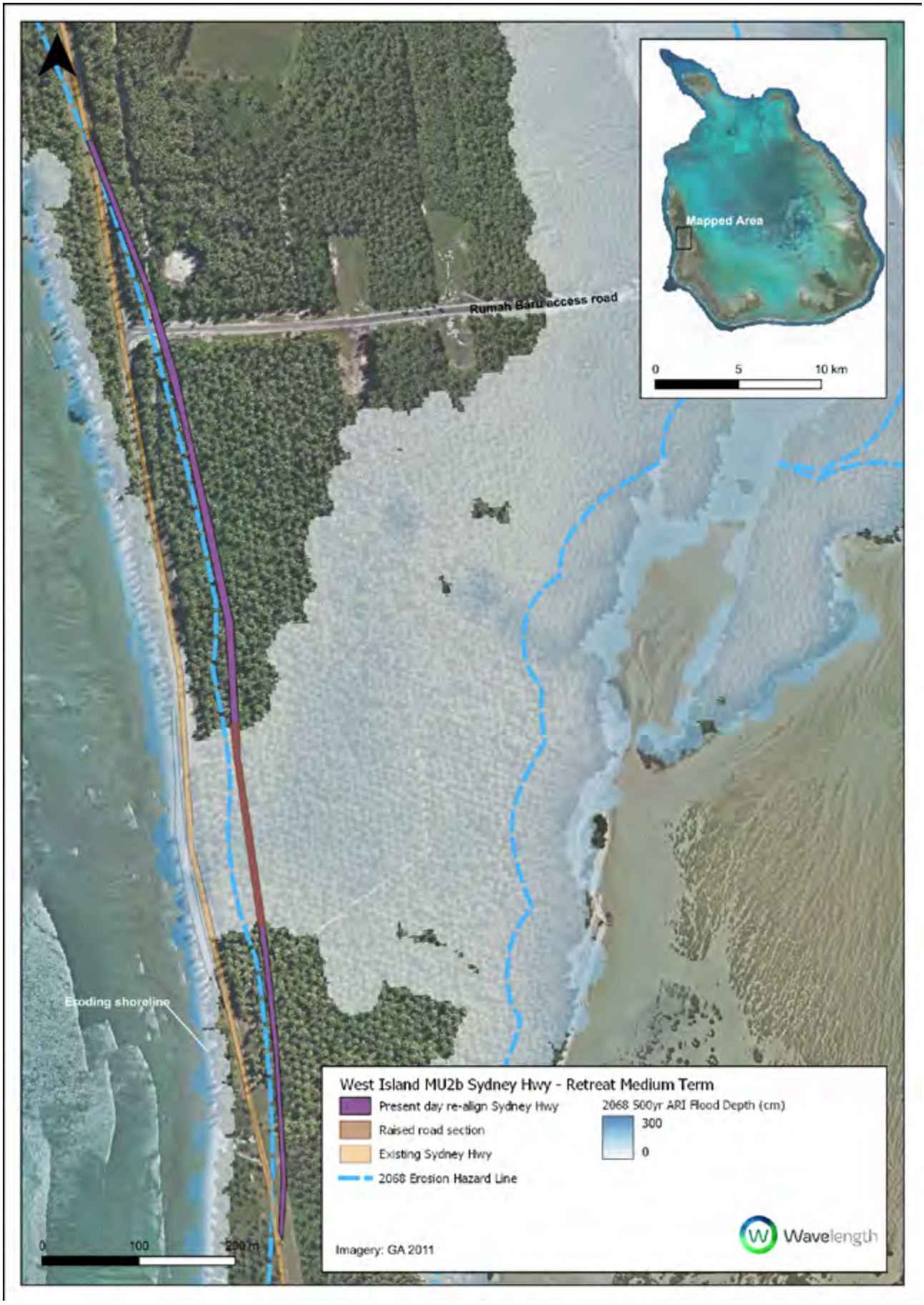


Figure 65: Example adaptation pathway for Sydney Highway (medium-term - 2068)

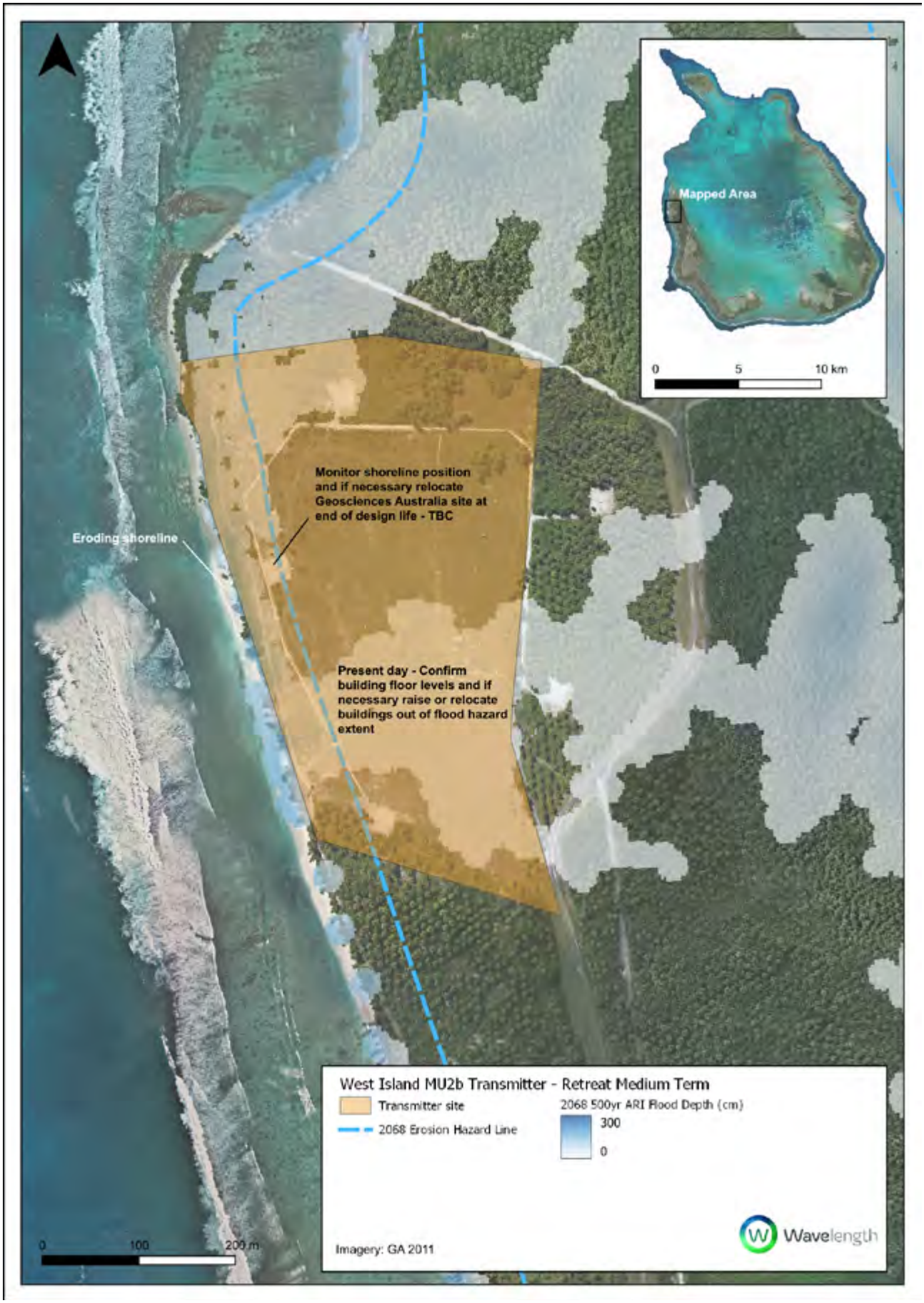


Figure 66: Example adaptation pathway for transmitter site (medium-term - 2068)

7.2.3 MU3 and MU4 West Island lagoon beaches and Rumah Baru

The recommended management actions for West Island lagoon beaches and Rumah Baru to 2068 include:

- AV – Avoid further development
- PMR2 – Minor Asset Relocation
- PMR3 – Services Relocation
- P5b + P6 – Protect (concrete seawalls with levees) for the critical service infrastructure assets (fuel station and Rumah Baru)
- NR1 – Monitoring
- NR2 – Protection structure audit

The adaptation pathway for MU3 and MU4 is presented in *Figure 67*.

A protection pathway is required for critical service infrastructure assets Rumah Baru and the fuel station. The condition of the existing GSC seawall currently protecting the fuel station will need to be considered to inform the timing of the upgrade. Seawall staging and extents will need to be developed with consideration for broader coastal impacts (i.e. increasing erosion rates downdrift). Consideration will also be required to tie-in seawalls with the proposed Materials Offloading Facility abutments to be located immediately north of the Rumah Baru access jetty.

Figure 68 and *Figure 69* demonstrate examples of the required adaptation pathways for Rumah Baru and the fuel station to 2068.

A protection pathway is proposed in the short to medium-term for the BoM sites and refuse station, with longer term planned and managed retreat proposed.

Figure 70 and *Figure 71* demonstrate examples of the required adaptation pathways for BoM sites and refuse station prior to 2068.

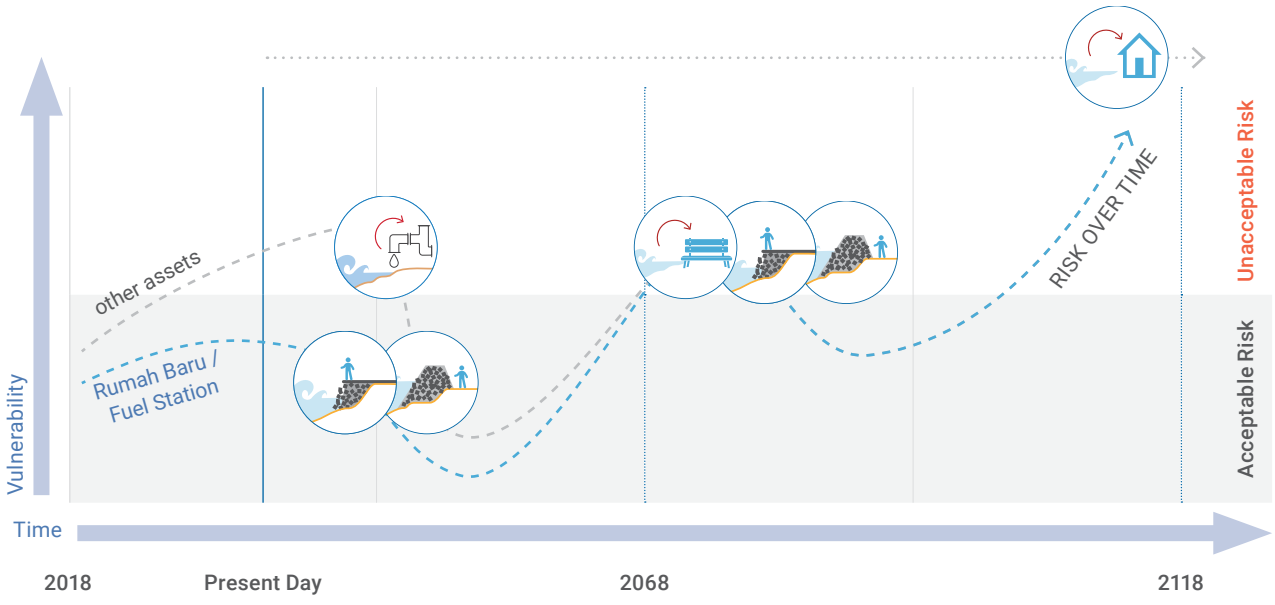
Adequate space exists outside of the vulnerable areas for the assets on the lagoon side; the two refuse stations, Waste Water Treatment Plant, Air Force site, Bureau of Meteorology (BoM), airport assets and Geoscience Australia (GA) building to be repositioned within existing land parcels outside of the hazard area beyond 2068.

Long-term relocation potential for assets has only considered impacts from coastal hazards, and this report does not assert that all land tenure, environmental, or other legislative factors are resolved.

A robust monitoring plan will be imperative to confirm the timing to transition to a protection or planned and managed retreat pathway particularly given that protection structures proposed north (updrift) are likely to influence the rate of erosion.

Beyond 2068:

- Review of available land within West Island subsequent of adaptation pathways adopted to date will need to be considered to confirm viable sites for GA assets.
- A protection pathway is recommended for the WWTP, Defence site and refuse station.
- The Bureau of Meteorology (BoM) and airport assets on the lagoon side of the runaway are assumed to be afforded protection via the proposed protection pathway as outlined in *Section 7.2.1 MU1 West Island Settlement* (West Island Settlement adaptation pathway).



Pathways and Actions

Undeveloped Areas		**Avoid –** AV / PMR5 Avoid further development, implement planning controls to prevent new development	
Developed Areas	Rumah Baru Fuel Station	**Protect –** P5b + P6 Seawall and Levees	
	WWTP Defence Operations Refuse Station	**Planned and managed retreat –** PMR3 - Services Relocation	**Protect –** P5b + P6 Seawall and Levees
	GA Site and Buildings	**Planned and managed retreat –** PMR3 - Services Relocation	**Planned and managed retreat**
All Scenarios		**No Regrets** – NR1, NR2, NR3 and NR4 Monitoring and Assess	

Figure 67: MU3 and MU4 West Island lagoon beaches and Rumah Baru adaptation pathway

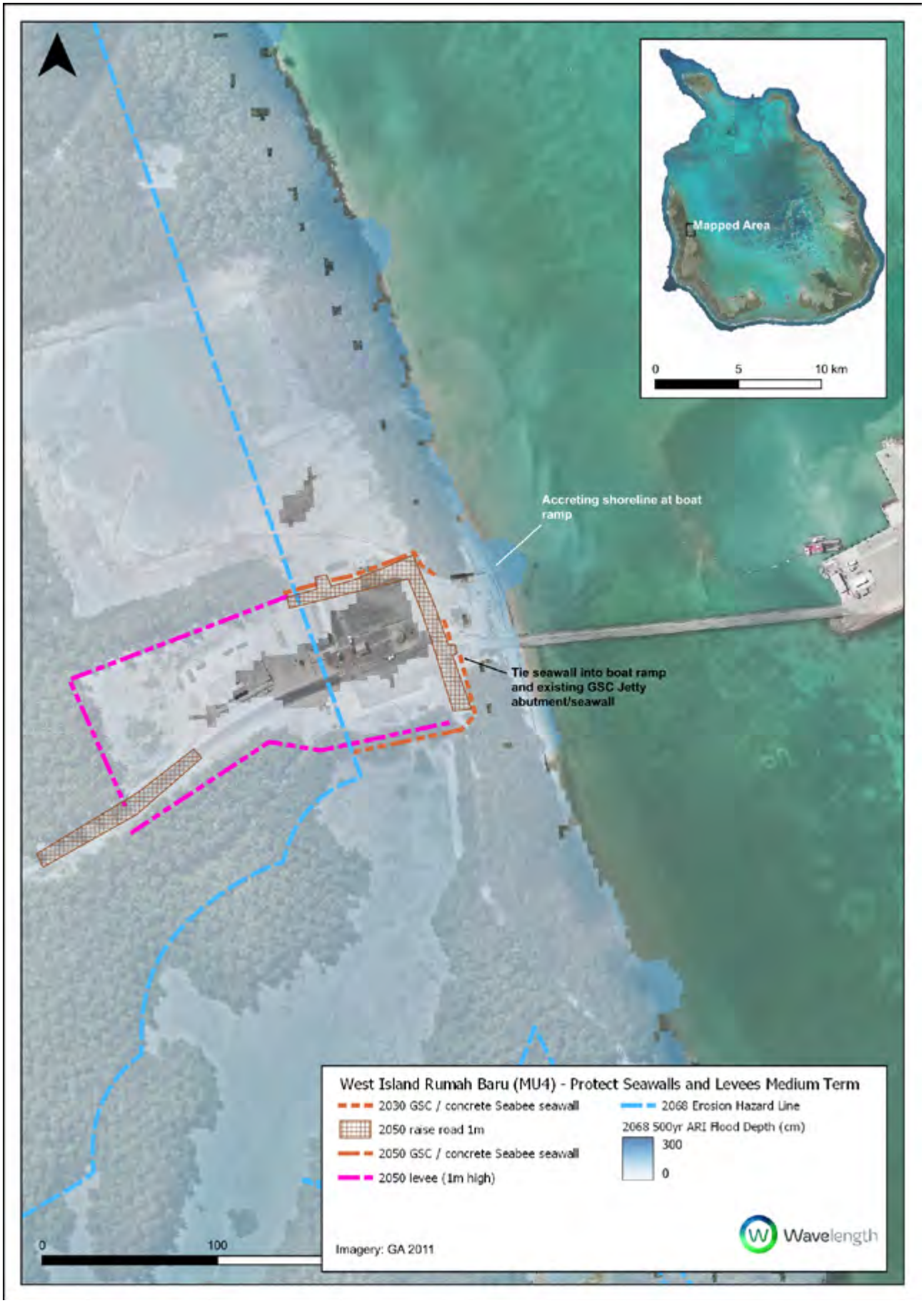


Figure 68: Example adaptation pathway for Rumah Baru (medium-term - 2068)

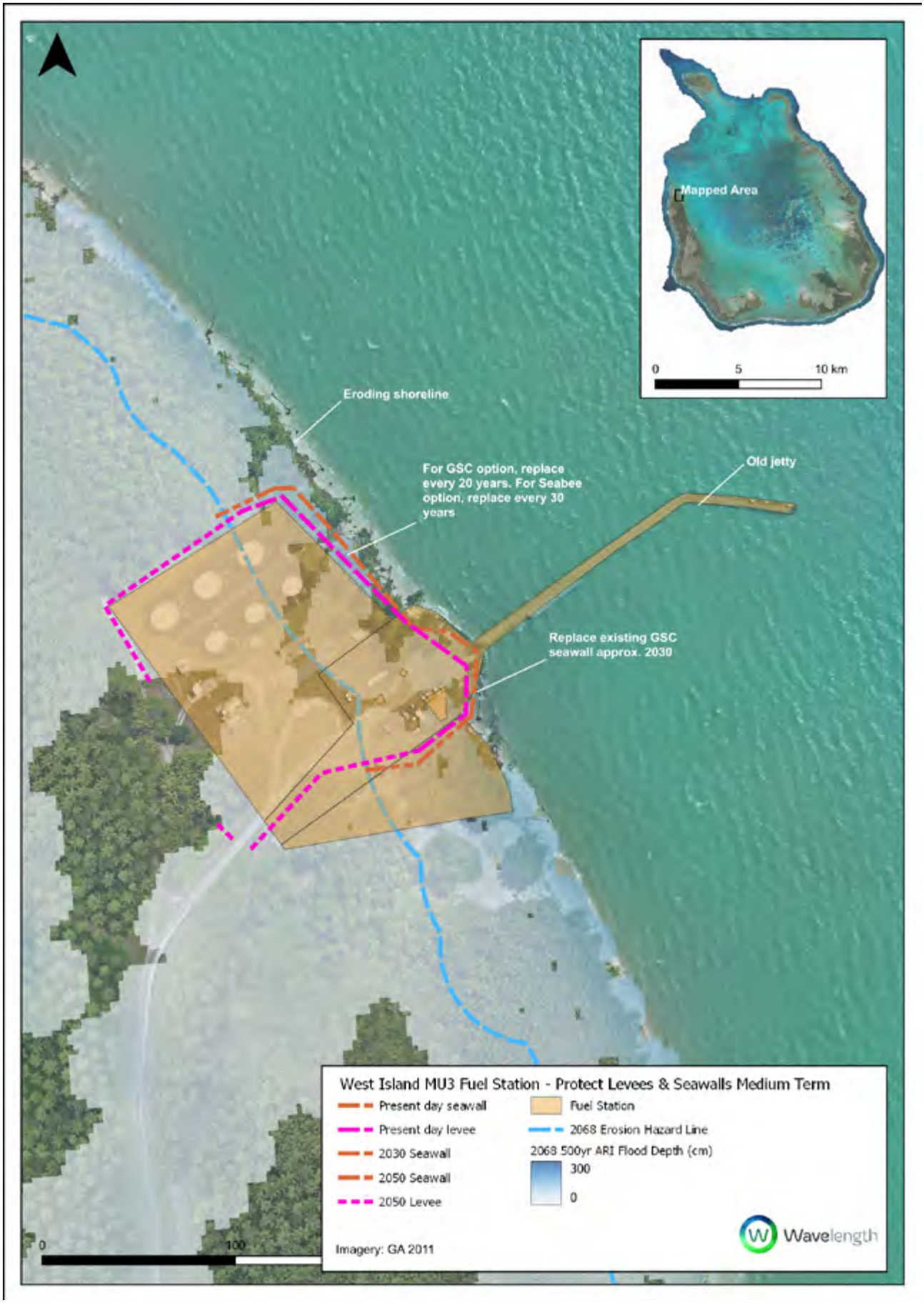


Figure 69: Example adaptation pathway for Fuel Station (medium-term - 2068)

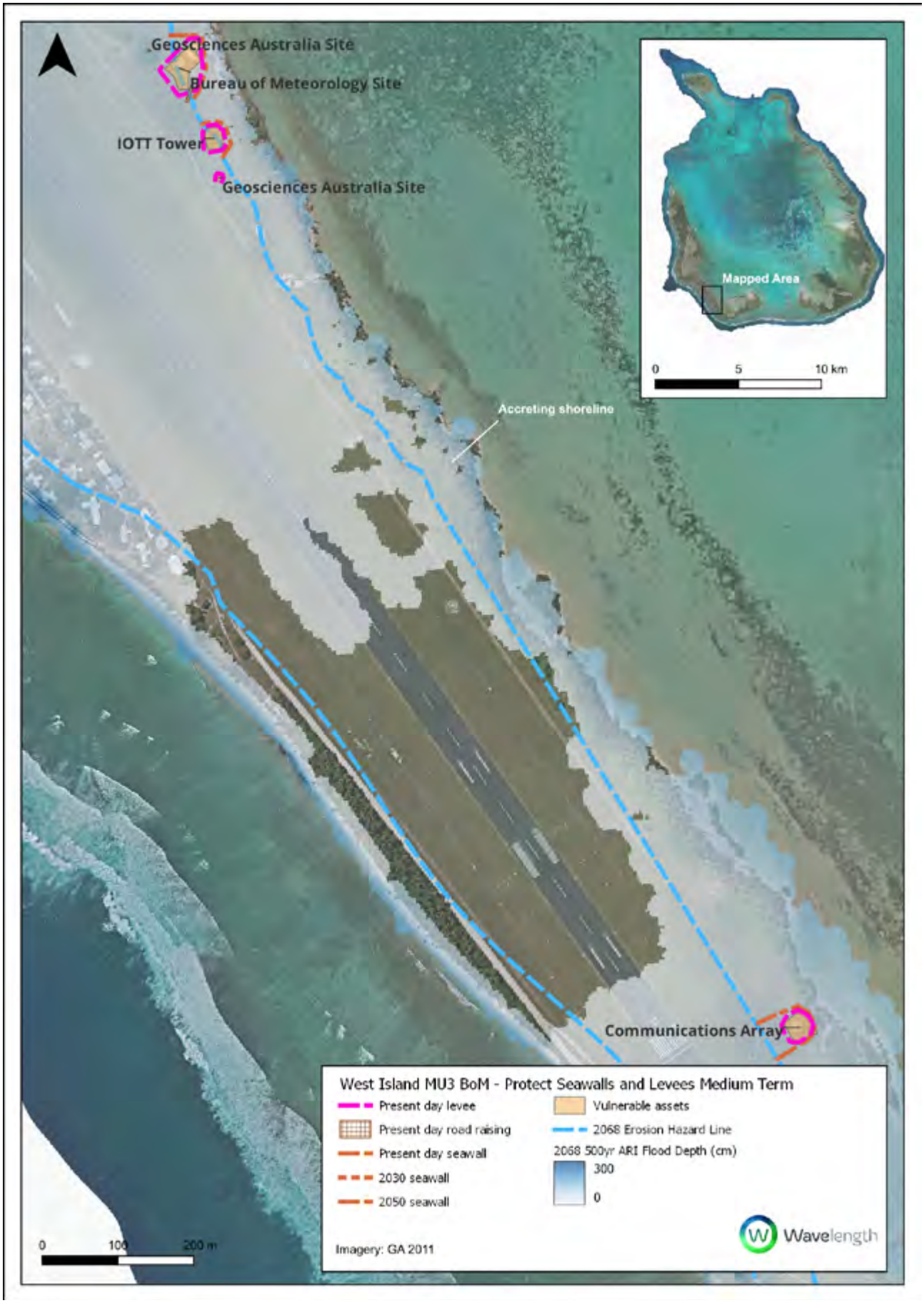


Figure 70: Example adaptation pathway for BoM sites (medium-term - 2068)

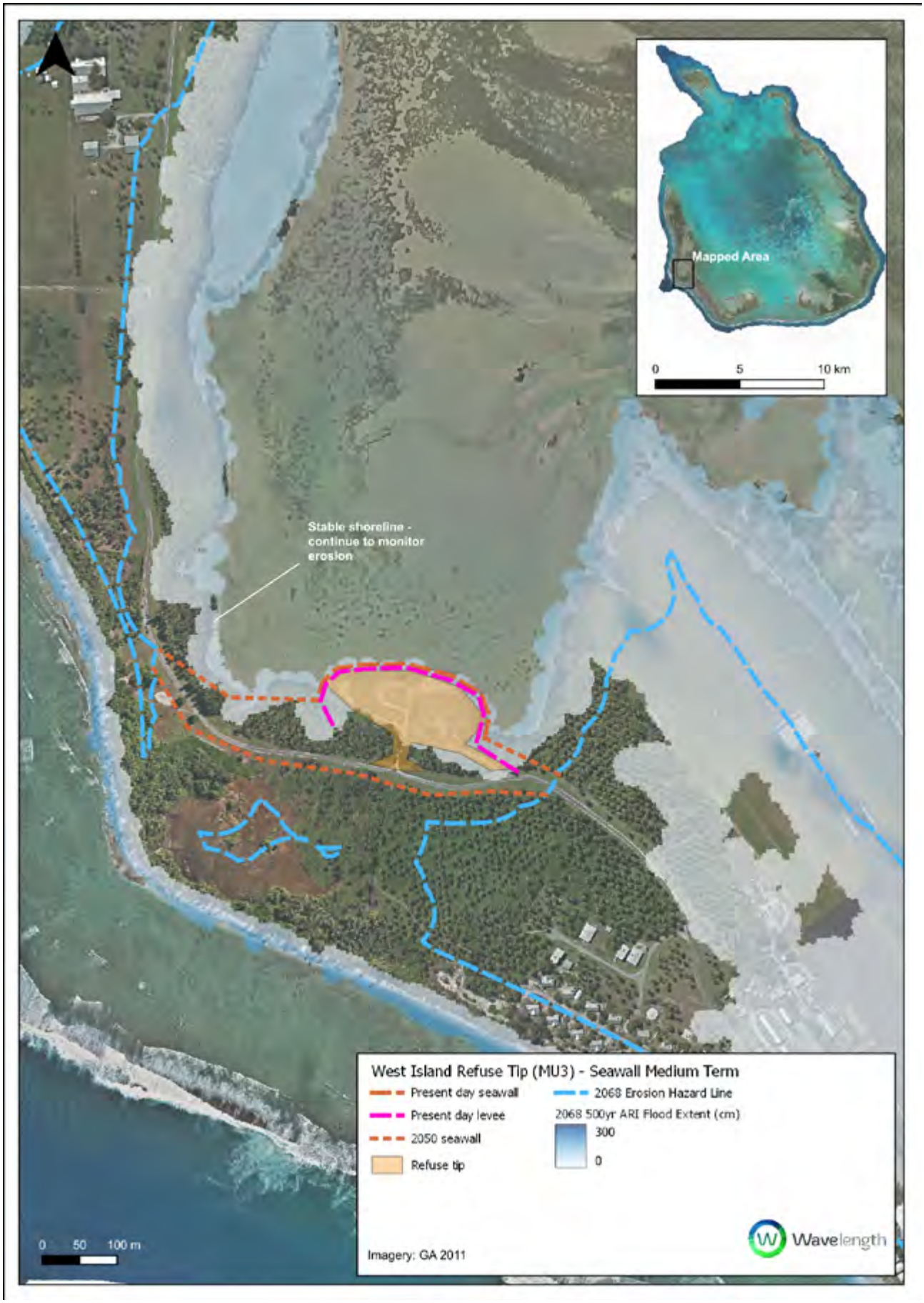


Figure 71: Example adaptation pathway for refuse station (medium-term - 2068)

7.2.4 MU5 and MU6 Scout Park/Kite Beach and West Island ocean beaches south

The recommended management actions for Scout Park/Kite Beach and West Island ocean beaches south to 2068 include:

- AV – Avoid further development
- AC1 – Structural - Design assets to withstand hazards
- P5b + P6 – Protect (concrete seawalls with levees)
- PMR2 – Minor Asset Relocation
- PMR3 – Services Relocation
- PMR5 – Planning Controls for Managed Retreat
- NR1 – Monitoring
- NR2 – Protection structure audit

The adaptation pathway for MU5 and MU6 is presented in *Figure 72*.

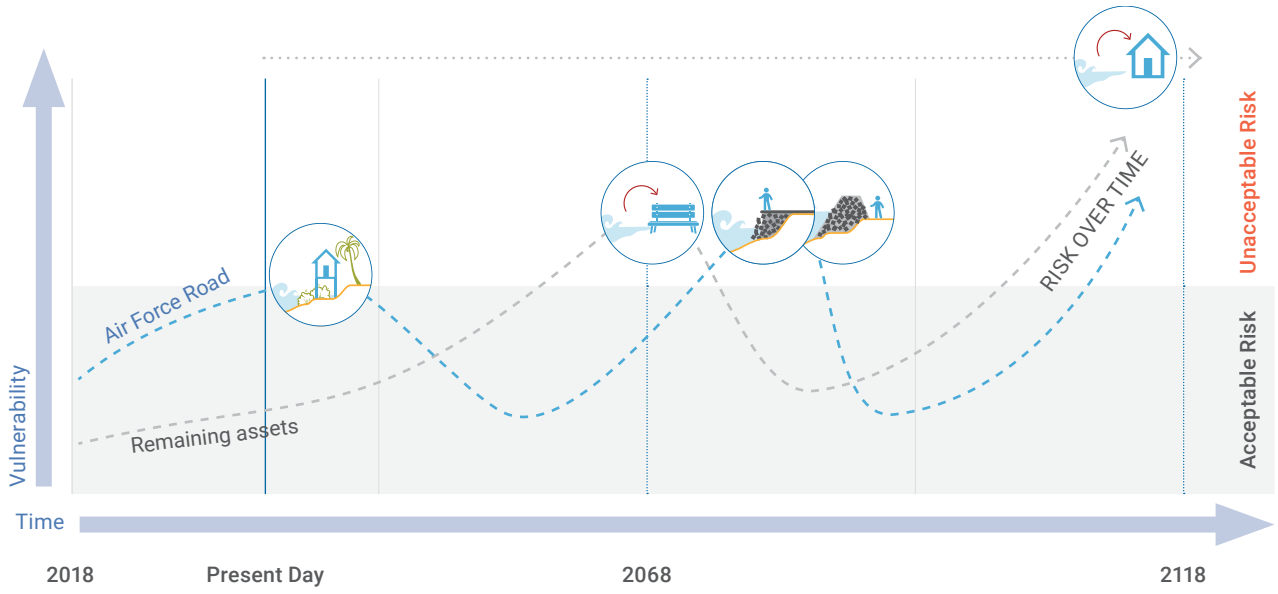
Raising Air Force Rd between the end of the runway and the Communications Facility is recommended as a priority to maintain access to the highly valued areas at Scout Park, Kite Beach and the Yacht Club.

Figure 73 provides an overview of the medium-term (2068) adaptation pathway for the recreation reserve areas.

Ongoing monitoring will be imperative to confirm the trigger to transition to a management retreat pathway for these reserve areas and assets within them (shelters, buildings etc.). Appropriate sites to relocate affected assets will be determined at the time when monitoring identifies these triggers have occurred.

As longer term access is assumed to be required for the Communications Facility, a protection pathway is recommended for Air Force Rd. The condition of the existing GSC seawall (NR2) and proposed protection design and extent for the runway upgrade will need to be considered in the seawall protection design and staging.

The protection pathway is assumed to be necessary to maintain access to the Defence site only, that is, a planned and managed retreat pathway is assumed for the portion of Air Force Rd north-east of the Defence site given a planned and managed retreat pathway is recommended for the recreational reserve areas.



Pathways and Actions

Undeveloped Areas		**Avoid –** AV / PMR5 Avoid further development, implement planning controls to prevent new development	
Developed Areas	Air Force Road	**Accommodate –** AC1 Raise road	**Protect –** P5b + P6 Seawall and Levees
	Remaining assets	**Monitoring –** NR1 Shoreline monitoring to determine PMR pathway	**Planned and managed retreat –** PMR2 - Minor Asset Relocation PMR3 - Services Relocation
All Scenarios		**No Regrets** – NR1, NR2, NR3 and NR4 Monitoring and Assess	

Figure 72: MU5 and West Island ocean beach south adaptation pathway

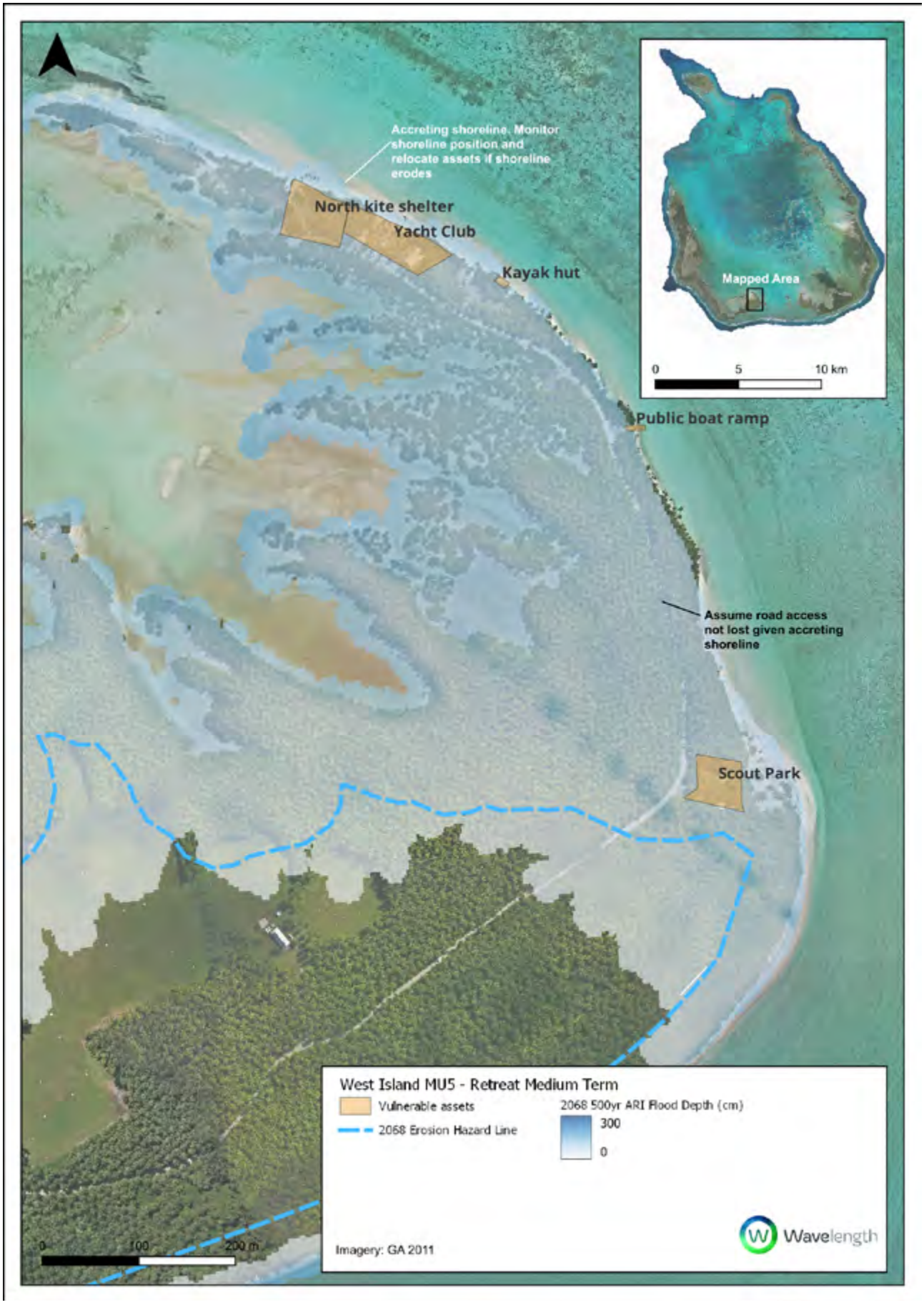


Figure 73: Example Medium-term Adaptation Pathway – West Island Management Unit 5 Recreation Reserves


Welcome to
The Yacht Club
COCOS ISLANDS
Swimming
Water Sports
BBQ
Toilet
No Fires
No Fishing
For more information:
Shire of Cocos (Keeling) Islands
+61 8 9162 6790
Maju Pulu Kita / Advance our Islands

7.2.5 MU7 Home Island Settlement

The recommended management actions for Home Island settlement are:

- AV – Avoid further development
- P5b + P6 – Protect (concrete seawalls with levees)
- PMR2 – Minor Asset Relocation
- PMR3 – Services Relocation
- PMR4 – Long-Term Settlement Planning
- Further investigation into stormwater and terrestrial flooding

The adaptation pathway for MU7 is presented in *Figure 74*.

The short-term adaptation pathway recommended for Home Island is Protect with a combination of seawalls and levees, as shown in *Figure 75*. The trigger to transition to the longer term pathway is largely driven by the public health and environmental health regulations associated with terrestrial flooding and drainage issues within the settlement.

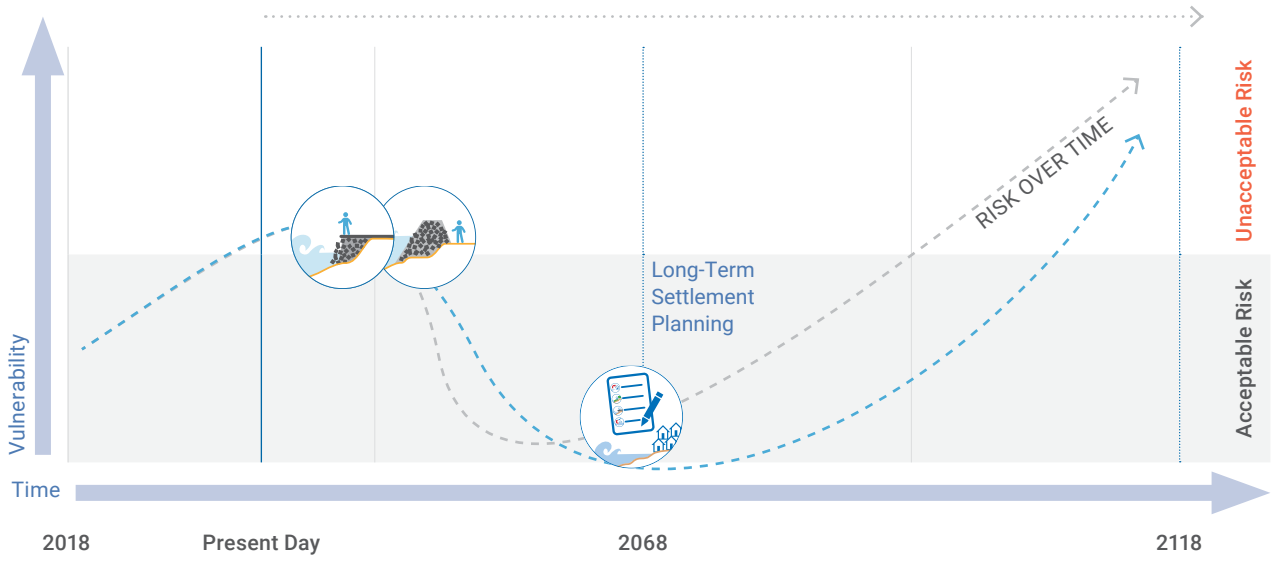
Community sentiment towards current impacts from terrestrial flooding and drainage has identified that this is approaching an unacceptable impact, however the potential future terrestrial flood risks are largely unknown.

Given the required planning and expense to implement a short-term protection pathway, a flood study and cost benefit analysis is recommended to provide clarity on the appropriate transition timeframe to a planned and managed retreat pathway, i.e. is it suitable to bring the transition period sooner.

The recommended pathway for the medium - longer term is planned and managed retreat.

As has been noted, a protect pathway over the medium to long-term becomes expensive and will result in a fundamental changed island experience. The island may no longer maintain its existing cultural and social value after such a significant change.

Notwithstanding, an alternative long-term protect pathway is illustrated in *Figure 76* and *Figure 77*.



Pathways and Actions

Undeveloped Areas	**Avoid –** AV / PMR4 Avoid further development, Long-Term Settlement Planning	
Developed Areas	**Protect –** P5b + P6 Seawall and Levees	**Planned and managed retreat –** PMR4 Relocate vulnerable assets in accordance with Long Term Settlement Planning)
	Planned and managed retreat – PMR2 - Minor Asset Relocation PMR3 - Services Relocation	
All Scenarios	**No Regrets** – NR1, NR2, NR3 and NR4 Monitoring and Assess	

Figure 74: MU7 Home Island Settlement adaptation pathway

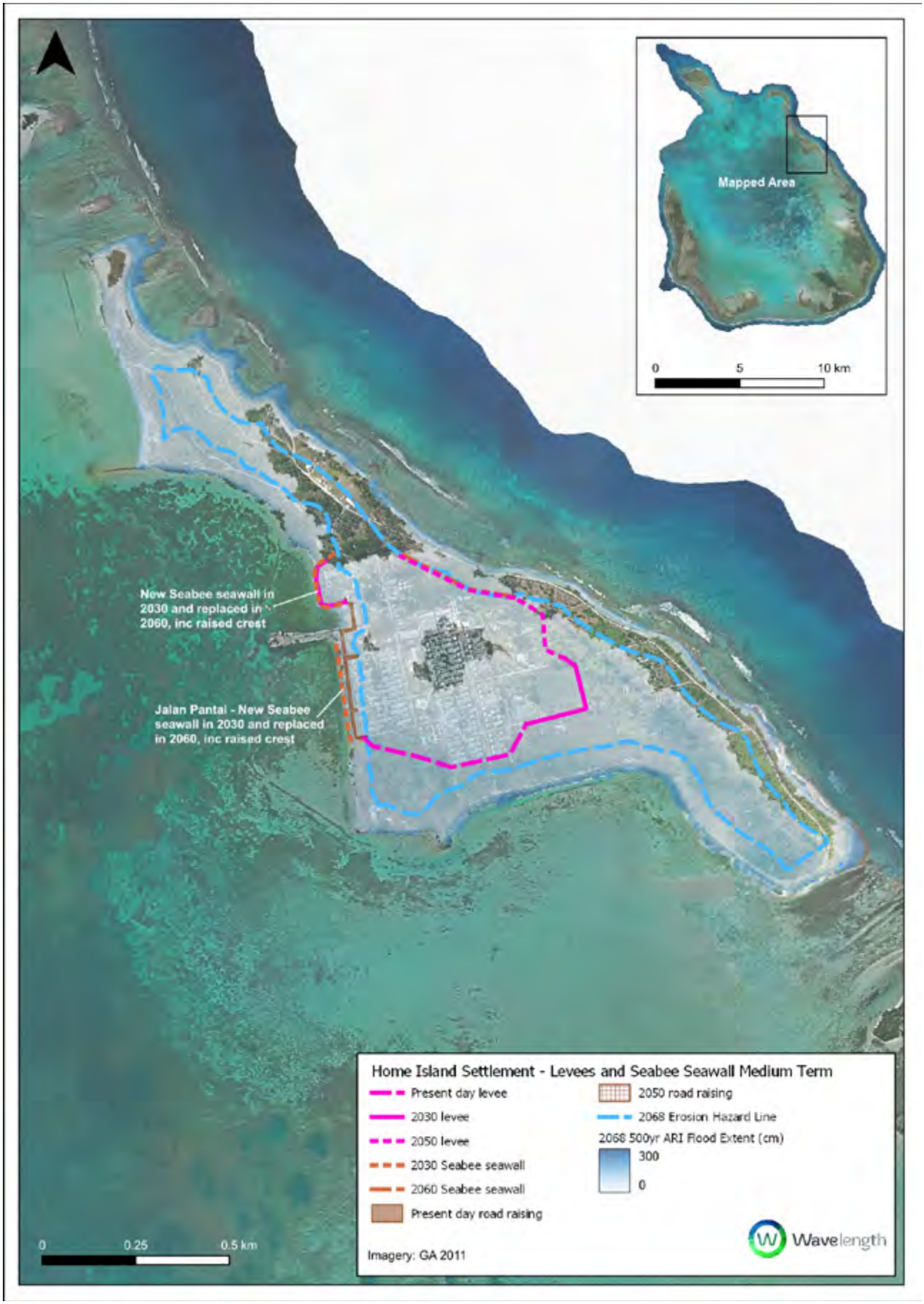


Figure 75: Medium-term Adaptation Pathway – Home Island Settlement Management Unit 7

Figure 76: Long-term Adaptation Pathway - Reclaim after Accommodate - Management Unit 7 Home Island Settlement

Figure 77: Long-term Adaptation Pathway - Reclaim after Protect - Management Unit 7 Home Island Settlement

7.2.6 MU8 and MU9 Home Island outside of settlement

The recommended management actions for Home Island outside of settlement are:

- AV – Avoid further development
- PMR2 – Minor Asset Relocation
- PMR3 – Services Relocation
- NR1 – Monitoring
- Cultural heritage assessment and culturally sensitive relocation program

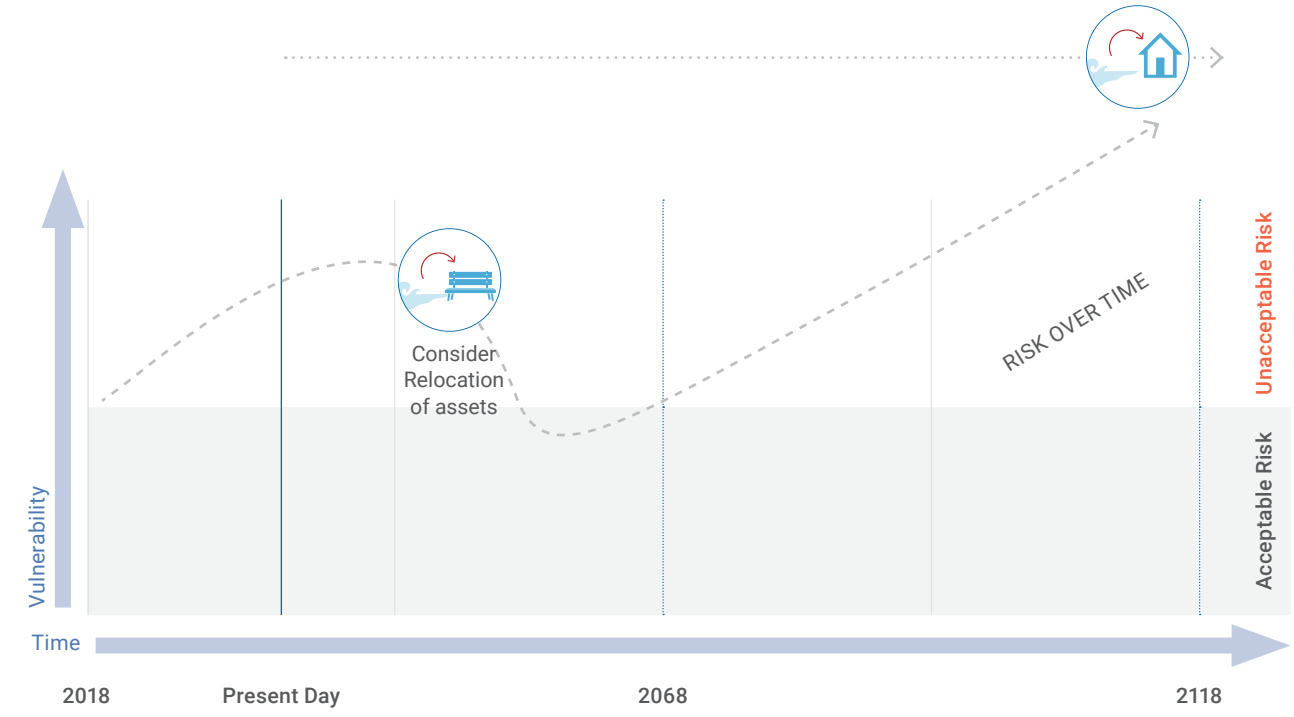
The adaptation pathway for MU8 andMU9 is presented in *Figure 78*.

Enough space is available to move assets and infrastructure from within the hazard area under a PMR5 approach. However, the appropriateness of shifting these assets, as opposed to decommissioning and removing them, will need to be considered on a case by case basis. This would likely depend on the agreed long-term settlement planning for Home Island.

For example, some assets could be moved within land parcels landward of the 2068 hazard area and structural changes applied to withstand 2068 inundation extents. However, if the Home Island settlement is/or has transitioned to a planned and managed retreat pathway, the cost benefit of undertaking significant construction works may not be appropriate.

The asset of exception to this is the cemetery due to its significant cultural significance and exposure to both erosion and inundation hazards. A protect pathway (seawall with levees) would require land reclamation (raising of the land levels) to mitigate the future groundwater and terrestrial flooding impacts. Given the potential cultural heritage impacts to adopting a land reclamation pathway, further engagement with the Elders and broader Home Island community via a cultural heritage assessment is recommended to inform actions.

Figure 79 to *Figure 81* depict examples of medium-term adaptation options for assets outside of settlements on Home Island – utilities, refuse stations and boat yard.



Pathways and Actions	
Undeveloped Areas	**Avoid –** AV / PMR5 Avoid further development, implement planning controls to prevent new development
Developed Areas	**Planned and managed retreat –** PMR2 - Minor Asset Relocation PMR3 - Services Relocation
All Scenarios	**No Regrets** – NR1 Monitoring and Assess

Figure 78: MU8 and MU9 Home Island outside of settlement adaptation pathway

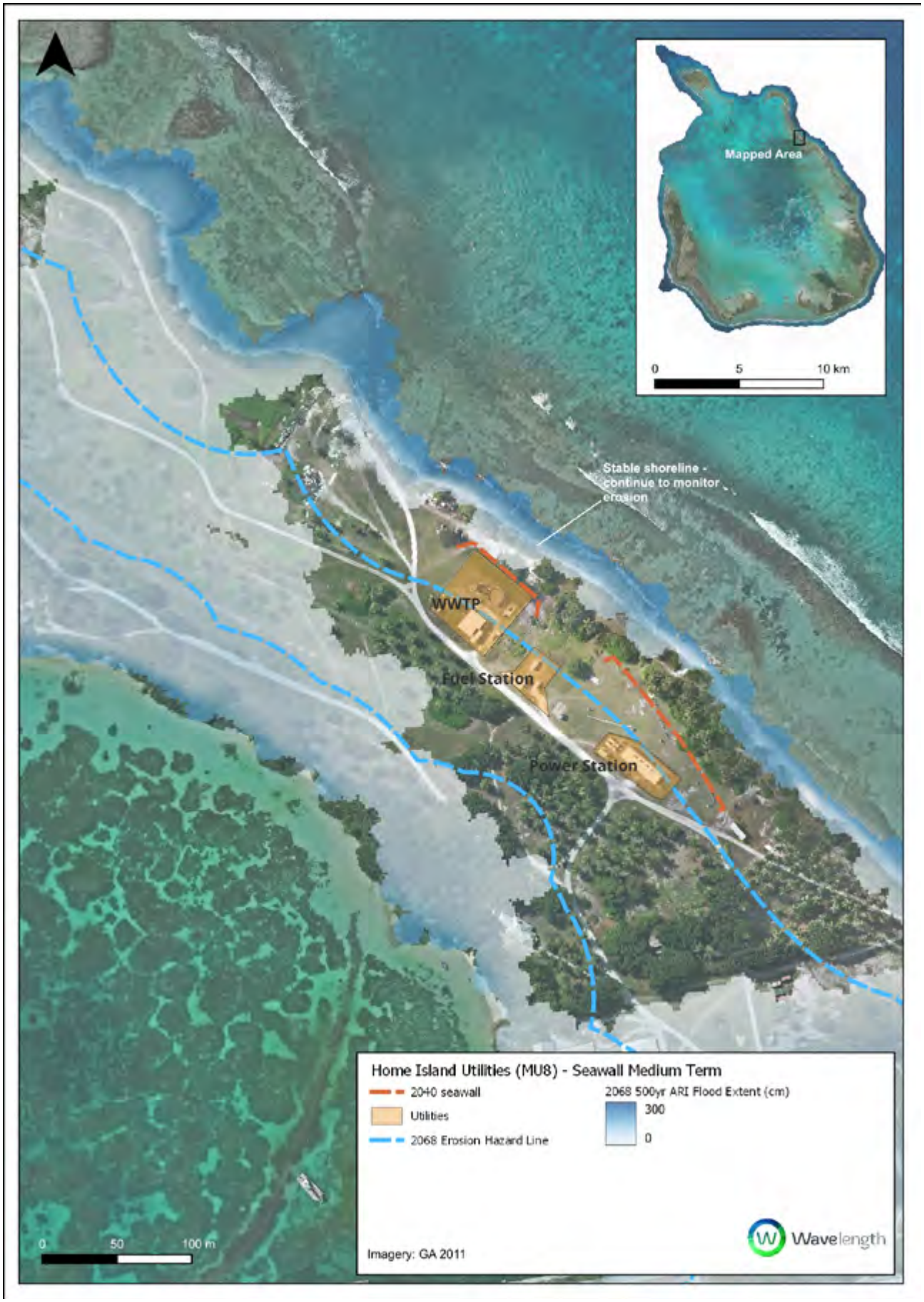


Figure 79: Example adaptation pathway for utilities infrastructure on Home Island (medium-term - 2068)

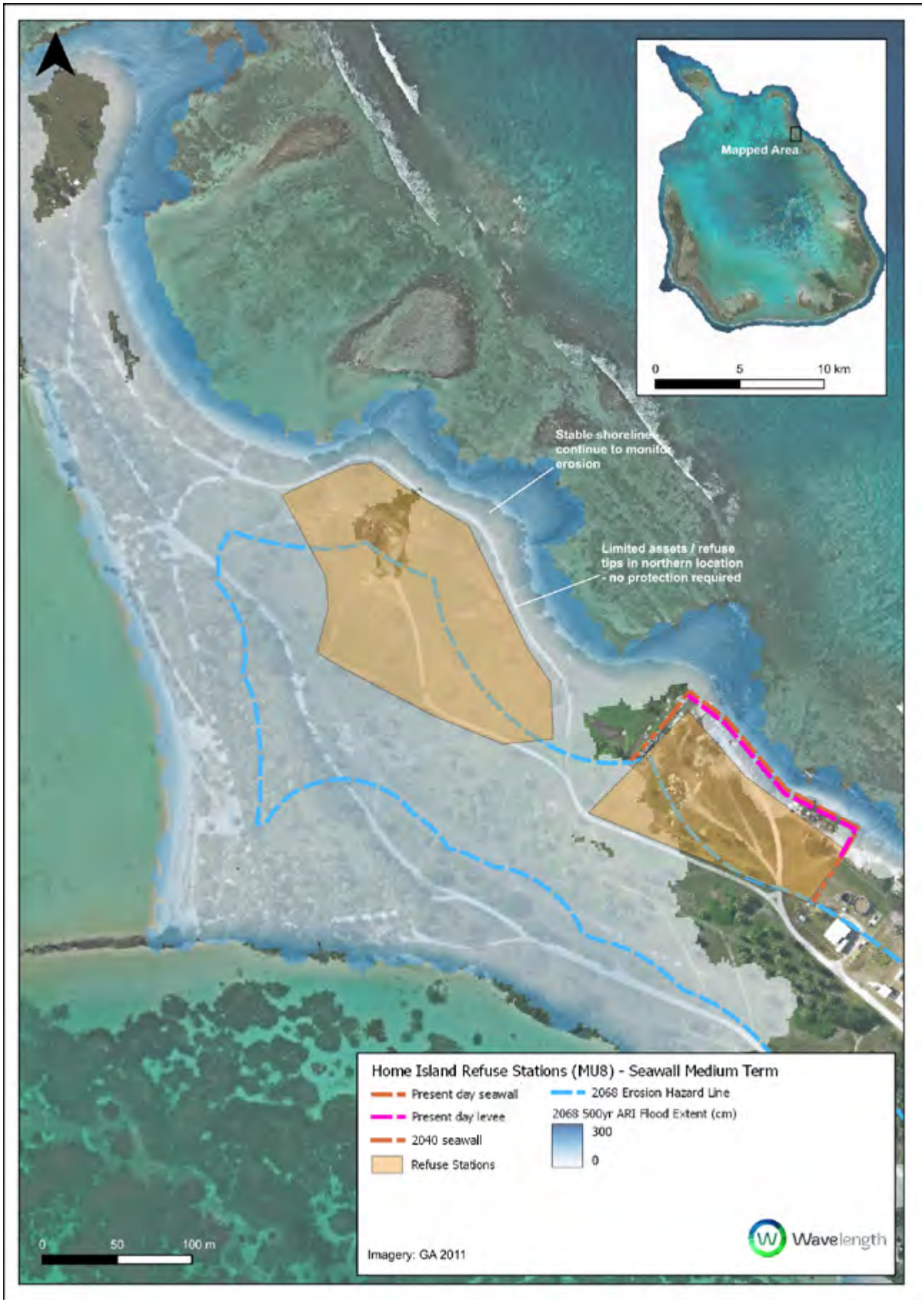


Figure 80: Example adaptation pathway for refuse tips on Home Island (medium-term - 2068)

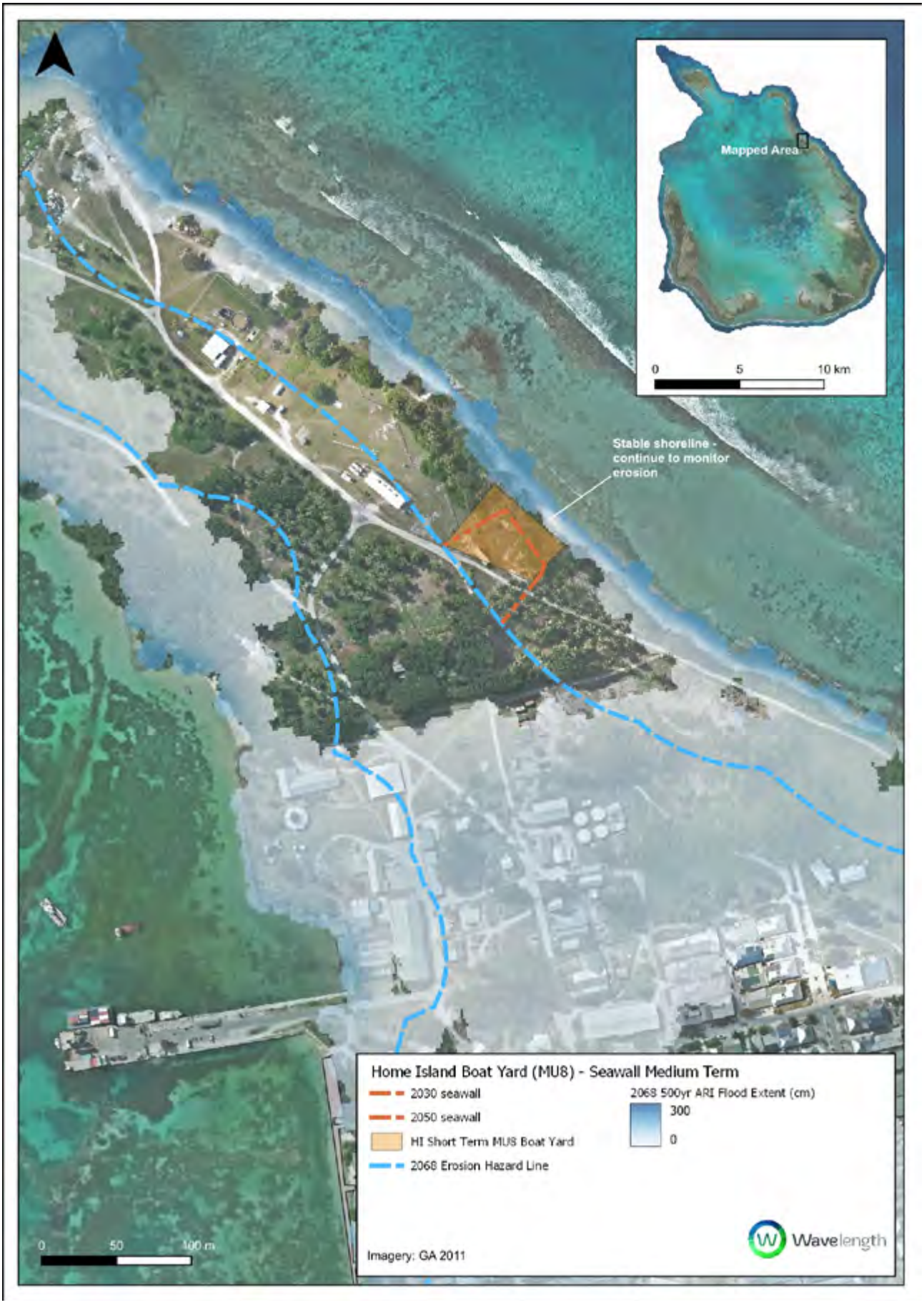
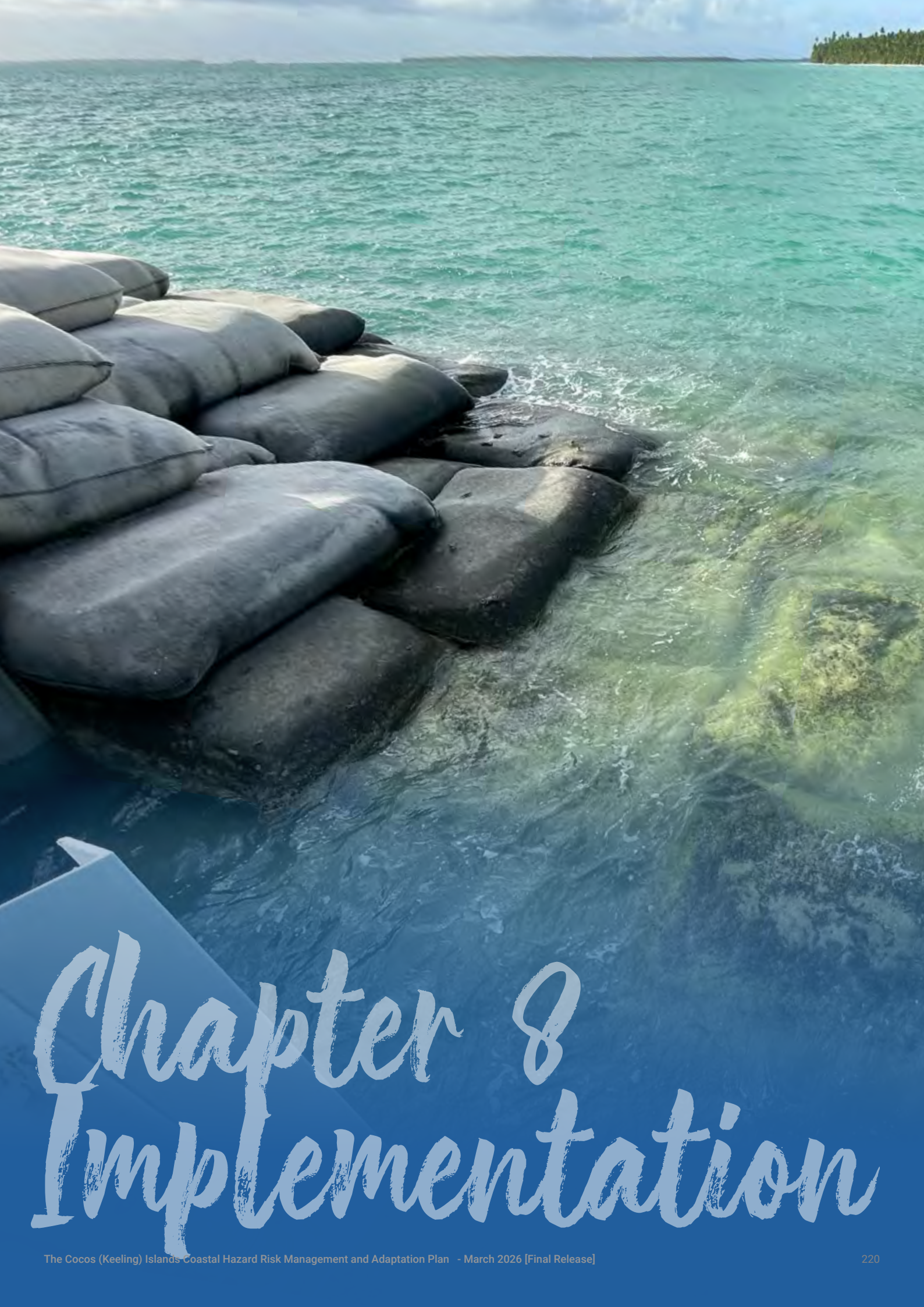


Figure 81: Example adaptation pathway for boat yard on Home Island (medium-term - 2068)



Chapter 8 Implementation

8 Implementation

The CHRMAP process recognises the difficult decisions that will need to be made in the near future.

To support these decisions, it is recommended that the CHRMAP be updated each five (5) years or as new information becomes available that may significantly affect the recommended adaptation pathways, such as the findings of the required further investigations (e.g. Home Island groundwater investigations and subsequent analysis).

The preceding chapters outline the recommended adaptation pathways to address the challenges of coastal erosion and inundation and their effects on the coastal zone over the 100-year CHRMAP timeframe. This section outlines the recommended actions to implement these pathways.

The implementation actions recommended within this document acknowledge the hierarchy of controls (Avoid, Planned and Managed Retreat, Accommodate and Protect) and the desire to maintain as much flexibility as possible for longer term planning.

However, as outlined in previous sections, given the severity of the coastal hazards, the number of assets at high or extreme risk now and the timing in which these risks become unacceptable, the number of viable, short-term adaptation pathways are limited. The recommended implementation actions have been guided by the outcomes of the MCA process in conjunction with robust and ongoing engagement with the community and broader stakeholder groups including State and Australian Government asset owners.

8.1 Key assumptions

The timeframes envisaged in the coastal adaptation pathways are not absolute. These timeframes are related to the current state of local land planning, coastal processes knowledge and climate projections, as outlined in the CHRMAP.

Therefore, the timeframes are typically not aligned on “worst-case” or “best-case” scenarios but often framed around adequate strategic planning for the worst in the hope that triggers are not met.

Other options may be envisaged over time, particularly if land planning practices, coastal processes knowledge or climate projections are changed. Therefore, the implementation pathway will evolve.

Options selected have been established through the CHRMAP project stages. Community and stakeholder inputs continue to be required as decisions are made over time. Detailed design and planning will be required to implement the listed options, and options should be optimised and modified following such additional investigations.

8.2 Short-term Implementation

For the short-term timeframe, some form of protect pathway has been recommended for both the Home and West Island settlements. Adequate planning, further investigations, and design are required to support this proposed pathway and is to be undertaken as soon as possible. More specifically, the below is required to be undertaken in parallel:

- Investigate and confirm funding mechanisms (options outlined below)
- West Island protection design and staging investigation
- Home Island groundwater/flooding investigation
- Cost Benefit Analysis (CBA) of Home Island adaptation options (subsequent to findings from groundwater/flooding investigation) to confirm short-term implementation pathway

For areas outside of the two settlement areas, a planned and managed retreat pathway is recommended, with the exception of the critical service infrastructure assets that can not be easily relocated, which require a protect or accommodate pathway. The planning and investigation required for protection structures for the West Island Fuel Station and Rumah Baru can be included in the protection design and staging investigation scope for the settlement.

Consideration should be given to raising Air Force Rd as soon as practicable, with consideration of the drainage design and potential runoff impacts to the surrounding assets and environments.

Where planned and managed retreat has been identified as an adaptation pathway, Long-Term Settlement Planning should commence as soon as possible, even if it is not acted upon immediately. This is prudent preparation given potential triggers through future unforeseen events.

8.3 Long-term Implementation

The recommended long-term adaptation pathways are summarised in *Section 6.2.4 Shortlisted Long-term Adaptation Options*. This section highlights that limited viable pathways exist for both West and Home Island. Longer term adaptation options may be required sooner (before 2068) if triggers are met sooner or if groundwater shoaling or terrestrial flood risks become unacceptable.

Further to this, a number of further investigations have been recommended which may influence the appropriateness of the long-term adaptation pathways, as set out in *Section 7.1 Overarching Actions*.

The recommended coastal management action to mitigate coastal hazards for Home Island is:

- Planned and managed retreat: Using planning instruments to progressively move assets with low adaptive capacity out of the hazard zone for all non critical assets.
- Long-term Settlement Planning: Partner with the community on long term settlement planning to determine a measured and considered approach that is flexible to the needs of the community and the need for adaptation over time.

The recommended coastal management actions to mitigate coastal hazards for West Island are:

- Continue a protect pathway for the settlement areas and critical service infrastructure assets outside of the Settlement Area that can't be easily relocated (Fuel Station, Rumah Baru, Airport).
- Transition from a planned and managed retreat to a protect pathway for relocatable, critical service infrastructure assets outside of the Settlement (Defence site, WWTP and Refuse Station).
- Planned and managed retreat: Using planning instruments to progressively move assets with low adaptive capacity out of the hazard zone for all non critical service infrastructure assets.

As monitoring is undertaken and data is reviewed, long-term pathways may change substantially, take longer to be triggered, or occur much sooner.

8.4 Funding

Section 6.2.5 Preliminary Cost Estimate presents a summary of financial and economic implications to inform decision-makers of the potential cost to implement the recommended treatment options over the planning timeframe.

The following section identifies all revenue-raising mechanisms available for obtaining funds to assist implementation. Given the current risks posed by coastal hazard and the subsequent imminent timeframes in which adaptation pathways are required to be pursued, investigation and confirmation of a viable funding mechanism will be an urgent priority. Funding mechanisms considered to include:

- Operating budget, general rates and coastal management fund
- Australian Government funding
- Beneficiary (user) Pays

8.4.1 Operating Budget, General Rates and Coastal Management Fund

Land managers or asset owners within the study area could consider establishing a coastal management fund that includes specific allowance for managing and adapting to the risk posed by coastal erosion and inundation. The purpose of this fund includes:

- To allocate a percentage of the organisation's operating budget for coastal management.
- To save funds routinely so that when triggers are met the established management actions can be implemented efficiently.
- Acknowledge coastal management costs are forecast to increase in line with sea level rise.

8.4.2 Australian Government Funding

CKI is a non-self-governing External Territory, for which the Australian Government has exclusive legislative responsibility. That is, not only does the Australian Government have the same role in CKI that it has elsewhere in Australia, but it also facilitates the delivery of services normally expected from a State government.

The Australian Government, through DITRDCSA, has responsibility for policy development, provision of services, and capital works on CKI. The underlying principle of this service delivery is to ensure that the CKI communities are provided with services and infrastructure comparable with those provided to equivalent WA mainland communities.

While the underlying principle of this service delivery is to ensure that the CKI communities are provided with services and infrastructure comparable with those provided to equivalent WA mainland communities, the unique circumstances of the Cocos (Keeling) Islands and the coastal hazards they face will require a unique response.

"State-type" services are predominantly delivered through Service Delivery Arrangements (SDAs) with Western Australian (WA) Government agencies.

A number of "state-type" services on CKI are delivered directly by the Australian Government through the Indian Ocean Territories Administration, including:

- health services;
- community infrastructure;
- employee and public housing maintenance and management; and
- Crown land management.

8.4.3 Government Grants

Owning to its status as a non-self-governing External Territory, CKI is generally not eligible to apply for Australian Government or State Government grant programs.

Government grants are variable and often unpredictable, but it is important for CKI's coastal managers to stay aware of any funding and grant programs available. Early planning and preparation will mean more-competitive applications can be prepared quickly when grant funding opportunities become available.

An example of Australian Government funding is the Disaster Ready Fund, which is funded by the *Disaster Ready Fund Act 2019* and administered by National Emergency Management Agency.

The Disaster Ready Fund supports projects that support Australians to manage the physical and social impacts of disasters caused by climate change and other natural hazards. For further information visit: https://nema.gov.au/disaster-ready-fund

It should be noted that Australian Government funding mechanisms may also require matching contributions. Such funding may still need to be sourced through one or more of the other available measures. Federal funding grants may restrict access to funding where funding would partially or predominantly benefit landowners or users.

Notwithstanding current eligibility requirements, it is worth noting the following relevant grants, which are managed by the State of Western Australia. Ongoing liaison with funding bodies will be required to understand any changes to eligibility requirements for these grants, or to investigate new funding avenues through these or other grant systems.

Local Government Financial Assistance Grants are administered by the Department of Local Government, Sport and Cultural Industries. They are grants funded by the Australian Government and are distributed among 137 local governments in WA each year. The grants allow councils to spend the funds according to local priorities, and could include relocation of community facilities outside of the hazard zone once triggers are reached. For further information visit: https://www.dlgsc.wa.gov.au/local-government/local-governments/financial-assistance-grants.

CoastWA aims to implement a strategic response to the growing impacts of coastal hazards to ensure sustainable land use and development on the coast for the long-term. For further information visit https://www.wa.gov.au/government/document-collections/coastwa-grants. It comprises the following grant programs:

- Coastal Adaptation and Protection grants
- Coastwest grants
- Coastal Management Plan Assistance Program

DTMI administers the Coastal Adaptation and Protection (CAP), which provide financial assistance for local projects that identify and manage coastal hazards. The program aims to build partnerships with local coastal managers to help coastal hazard adaptation. CAP Grants fund up to 50% of project costs (and must be matched by the applicant).

Coastwest grants support eligible coastal land managers and community organisations to undertake projects that manage and enhance WA's coastal environments through rehabilitation, restoration and preventative actions. Coastwest grants are administered by the Department of Planning, Lands and Heritage (DPLH).

Coastal Management Plan Assistance Program (CMPAP) grants support eligible coastal land managers to develop adaptation and management plans and strategies for coastal areas that are, or are projected to become, under pressure from a variety of challenges. CMPAP grants are also administered by the DPLH.

There are also two other grant programs relevant to coastal hazard risk management in WA:

- Royalties for Regions
- Local Government Financial Assistance Grants

Royalties for Regions is facilitated by Department of Primary Industries and Regional Development. For further information visit: https://www.wa.gov.au/organisation/department-of-primary-industries-and-regional-development/royalties-regions.

It should be noted that State funding mechanisms require matching cash or in-kind contributions from the land manager, and as such, funding will still need to be sourced through one or more of the other available measures. State funding grants may also restrict access to funding where public monies would partially or predominantly benefit private landowners or users.

8.4.4 Beneficiary (user) Pays

'User Pays' principles essentially dictate that the beneficiaries of adaptation options should pay for them, as they are the beneficiary.

Where adaptation options are designed to protect specific sections of coastal land and assets that is primarily to benefit private property or Government assets it is recommended that the decision maker allocate costs according to the Benefit Distribution Analysis (BDA) in *Appendix G* and *Section 6.5* to understand who should pay and how much. A BDA typically considers:

- Direct benefits - immediate impacts such as having the ocean frontage protected to maintain a home, or a road protected to enable access to private properties
- Indirect benefits - such as public spaces or commercial activities that many people enjoy
- Community benefits - including benefits to a locality such as tourism income and business activity

The rate applied to those beneficiaries may vary over the planning timeframe. The amount raised should consider the estimated 100-year cost for each option.

Chapter 9 Monitoring and Review

9 Monitoring and Review

Coastal monitoring will inform short-term implementation through tracking of changes to the coastline and observance of trigger points.

This will be paramount to the sections of coastline outside of the two settlement areas, where a transition to an alternate pathway is required over time based on the landward migration of the shoreline (i.e., erosion extent).

9.1 Structures

Given the current fair or poor condition of some structures within the study area, an annual condition inspection by consultant engineers is recommended. It is recommended that this be complemented by post storm event inspections by Shire officers.

As repairs/upgrades are undertaken and condition improves, monitoring frequency can be reduced accordingly. Annual condition inspections should identify the condition rating, remaining life, and replacement cost with information added to the Shire's asset database. This should be undertaken in context of the protection pathway design and staging investigation to inform staging of upgrades over time.

9.2 Storm events

In the event a significant storm event occurs, the following monitoring items are recommended:

- If there is sufficient time available undertake pre-storm beach profiles and beach photos for defined monitoring locations.
- Post storm beach profiles and beach photos.
- Post storm coastal structures inspection. This can be undertaken initially by a Shire officer, if any significant damage is evident a full condition inspection by a coastal engineer is recommended.

A coastal engineering consultant should work with the Shire to confirm the designated storm monitoring locations and priority structures to be inspected.

9.3 Beach Profiles

It is recommended beach profile surveys be undertaken annually, with the objective of capturing beach profiles pre- and post-winter. These are required to inform several short-term triggers. Consideration should be given to the use of drone surveys as they become more readily available. These can be a cost-effective option and can provide a more detailed coverage of both the dunes and beach.

Corresponding monitoring photos should be taken at the same time as beach surveys, particularly for inundation events, as it is often impractical to organise detailed survey at short notice. The community can be engaged to support such activities through citizen science monitoring programs.

9.4 Aerial Photography

Vertical aerial photography, captured by Landgate, and associated photogrammetry to plot shoreline change is recommended as an important tool for evaluating long-term changes in the position of the coast. It is recommended that the minimum collection frequency of 5 years be continued.

9.5 Flooding Impacts

Both West and Home Island experience impacts from terrestrial flooding. The associated pooling of water during terrestrial flood events is often confused with the impacts of ocean induced events (i.e. storm surge events). The frequency and intensity of rainfall events, particularly on Home Island, may be having a greater impact on assets and communities' way of living than ocean induced events (i.e. coastal inundation and erosion). The following monitoring tasks are proposed to further investigate the terrestrial flooding impacts:

- Shire to document rainfall data and duration (hours, days) of a given event, including the millimetres of rainfall received (supplement to data collected by the Bureau of Meteorology).
- Photos are to be taken through out the event at pre-defined locations and specific angles of view. Time lapse monitoring cameras could be set up in key locations to automate this process.
- Record maximum water depths reached at predetermined locations.
- Shire to record the time in which water takes to recede (i.e. total time pooling) at pre determined locations.
- Record if event has coincided with an ocean induced event and if storm erosion and/or inundation is experienced as a cumulative impact.

9.6 Data Management and Sharing

It is recommended that GIS metadata summaries of collected coastal zone data be created to ensure information is well-archived. There is also the opportunity for increased coordination with DTMI regarding the collection of coastal photography and hydrographic survey to seek synergies with DTMI and the Shire's spatial data team where data sets are shared. The GIS metadata summaries should be updated annually with any additional information collected.

9.7 Review

The CHRMAP should be updated at least every 5 years to maintain currency and should be a "living document". An earlier review should be considered if the following event occurs:

- Substantial storm events generating severe coastal hazards approaching or exceeding the CHRMAP projections (as confirmed via monitoring)
- Significant changes to land ownership, such as relocation of large populations.
- Changes to land ownership related to the Trust Land.
- Preparation of site specific CHRMAP become available from other stakeholders or potential developers.
- New information becomes available which substantially affects the summary of local community values and assets (natural or built)
- Updates in climate change science, specifically local sea level rise projections and improved understanding of atoll response to SLR
- Triggers are reached

Monitoring of CHRMAP outcomes, actions and future updates should always include consultation with stakeholders and the community to make sure any changes are communicated, and that the stakeholders' positions are reflected in the coastal management outcomes.

Chapter 10 Summary of Actions

10 Summary of Actions

This section provides a summary of the adaptation pathways proposed to respond to erosion and inundation for the Shire of CKI's two settlement islands, West and Home Island.

This section summarises the individual actions/ options, the area of interest, the action type, the relevant trigger and the required timeframe. The timeframes used are immediate (now), short-term (within 10 years), medium-term (10-50 years) and long-term (beyond 50 years). All timeframes for asset actions are approximate, as the trigger point is the key determinant of action.

With regard to cost, it should be noted that each individual option would require a detailed cost assessment based on final design and source material availability and cost.

Protection measures should not be implemented if maintenance schedules cannot be adhered to, as this places undue risk on future populations. Likewise, the identified triggers should be subject to ongoing monitoring and review.

In the first instance, monitoring should be in accordance with the monitoring recommendations outlined in *Chapter 9 Monitoring and Review*. However, regular review of the overarching hazard models should also occur. It is recommended that decision-makers continue to monitor changes in international scientific understanding of atoll response to sea level rise, and maintain a working relationship with the DPLH as well as the DTMI's coastal planning personnel in this regard.

A review of immediate actions recommended in the CHRMAP should be undertaken within three (3) years to confirm progress. A full review should be undertaken within five (5) years and in conjunction with ongoing reviews of the Shire's Local Planning Strategy and Local Planning Scheme.

Table 36: Summary of CHRMAP Actions

NO.	AREA OF INTEREST	ACTION TYPE	RECOMMENDATION	TRIGGER	TIMEFRAME
1	CKI	Investigation	Develop Community Engagement Plan and communications program to continue information sharing and gathering with the community regarding the CHRMAP and ongoing management	Following the release of the Final CHRMAP	Immediate
2	CKI	Planning	Prepare detailed implementation plan	Following the release of the Final CHRMAP	Immediate
3	CKI	Investigation	CBA of Home Island and West Island protect pathway versus planned and managed retreat to confirm short-term implementation pathway	As soon as scoped appropriately and funding obtained	Immediate
4	CKI	Investigation	Completion of a sand source and raw materials investigation to determine the capacity of local sand supply within the atoll and external options (i.e. importing of basic raw materials)	As soon as scoped appropriately and funding obtained	Immediate
5	Home Island	Investigation	Completion of groundwater/flooding to confirm timing for longer term planning	As soon as scoped appropriately and funding obtained	Immediate
6	West Island	Investigation	Assess Rumah Baru and the seawall currently protecting the fuel station to inform timing of the upgrade of critical service infrastructure assets at Rumah Baru and the fuel station	As soon as scoped appropriately and funding obtained	Immediate
7	West Island	Investigation	Boat ramp assessment to consider maintenance or design alterations in existing sites, or relocation to more appropriate sites	As soon as scoped appropriately and funding allocated by local government	Immediate
8	CKI	Planning	Local Planning Scheme – Establish a Special Control Area to control land use planning on land identified as being vulnerable	Local Planning Strategy and Scheme	Immediate
9	CKI	Planning	Develop Local Planning Strategy – in collaboration with the community, including detailed engagement on Long-Term Settlement Planning, and ensuring that the vulnerability of the study area is adequately identified in the strategic planning framework	Following the release of the Final CHRMAP	Immediate

Table 36: Summary of CHRMAP Actions (continued)

NO.	AREA OF INTEREST	ACTION TYPE	RECOMMENDATION	TRIGGER	TIMEFRAME
10	CKI	Planning	Shire Infrastructure Asset Planning to make sure that future assets are sensibly located to manage risk to assets	Ongoing	Immediate
11	CKI	Planning	Australian Government infrastructure asset planning to make sure that future assets are sensibly located to manage risk to assets	Ongoing	Immediate
12	CKI	Planning	Preparation of an emergency management plan to protect the safety of the community should a significant storm event occur	As soon as scoped appropriately and funding obtained	Immediate
13	CKI	Planning and Monitoring	Resilience Planning including monitoring (in some cases immediate) to support natural hazard management through dune vegetation. Monitoring plan development	As soon as scoped appropriately and funding obtained	Immediate
14	Home Island	Planning, design and physical works	Levee protection – south to south west point of Home Island	As soon as scoped appropriately and funding obtained	Immediate
15	Home Island	Planning, design and physical works	Road raising on the western side of Home Island	As soon as scoped appropriately and funding obtained	Immediate
16	West Island	Planning, design and physical works	Move Sydney Highway and underground services	As soon as scoped appropriately and funding obtained	Immediate
17	West Island	Planning, design and physical works	New seawalls on the sea side of West Island	As soon as scoped appropriately and funding obtained	Immediate
18	West Island	Planning, design and physical works	Levees and seawall on front of settlement (ocean side)	As soon as scoped appropriately and funding obtained.	Immediate
19	CKI	Planning, design and physical works	Protect pathway design and staging. Protection action including detailed design, confirmation of more accurate timing for staging of upgrades, detailed costing and a monitoring program Settlement Area and critical service infrastructure assets outside of settlement (Rumah Baru, Fuel station)	As soon as scoped appropriately and funding obtained	Short

Table 36: Summary of CHRMAP Actions (continued)

NO.	AREA OF INTEREST	ACTION TYPE	RECOMMENDATION	TRIGGER	TIMEFRAME
20	CKI	Investigation	Investigate options for the future of the settlement (in collaboration with the community)	Informed by community consultation and completion of CBA	Short
21	CKI	Planning	Notification on titles to advise property owners where land is identified as being at risk	Ongoing	Short
22	CKI	Planning	Preparation of a Local Planning Policy to work alongside the Special Control Areas	2025/26	Short
23	CKI	Investigation	Property Acquisition Investigation	2025/26	Short
24	CKI	Investigation	Preparation of a Local Heritage Survey and Cultural Heritage Management Plan to understand how to protect or manage loss of cultural heritage values	2026/27	Short
25	Home Island	Planning and design	Protect pathway design and staging following CBA	On completion of CBA	Short
26	West Island	Planning, design and physical works	Raise Airfield Road to ensure ongoing access to the Communications Facility west of Scout Park	2026/27	Short
27	CKI	Monitoring	Condition inspection of structures (complementary to avoiding further development in Hazard Zones)	Ongoing (Annually)	Short
28	CKI	Physical works	Strategic vegetation planting and dune care (out of settlement areas)	Ongoing	Short
29	CKI	Monitoring	Monitoring of storm events, ocean induced and terrestrial events as set out in Monitoring Plan.	Ongoing (As events occur)	Short
30	CKI	Monitoring	Aerial photo review	Ongoing (Every 5 years)	Short
31	CKI	Monitoring	Bi-annual beach profile surveys (pre- and post-winter)	Ongoing	Short
32	CKI	Review	Progress Review	Ongoing (<3 years)	Short
33	CKI	Review	CHRMAP to be updated every 5 years or as new information becomes available, to support decision-making	Every 5 years	Short
34	Home Island	Planning, design and physical works	Levee protection on the north-western side of the Home Island settlement	By 2030	Short

Table 36: Summary of CHRMAP Actions (continued)

NO.	AREA OF INTEREST	ACTION TYPE	RECOMMENDATION	TRIGGER	TIMEFRAME
35	Home Island	Planning, design and physical works	Seawall protection on the western side of the Home Island settlement	By 2030	Short
36	West Island	Planning, design and physical works	Replace existing sandbag seawalls adjacent William Keeling Crescent with a concrete seawall. All existing seawalls should also be assessed at this time	By 2030	Short
37	West Island	Planning, design and physical works	Seawall protection north and south of existing at settlement	By 2030	Short
38	West Island	Planning, design and physical works	Levee protection east side of runway	By 2030	Short
39	West Island	Planning, design and physical works	Levees on the lagoon side near the refuse station	By 2030	Short
40	CKI	Investigation	Condition assessment and monitoring of existing seawalls to determine timing of upgrade	Ongoing	Short
41	West Island	Monitoring	Ongoing monitoring of Kite Beach, Yacht Club and Scout Park, to confirm timing for relocation	Ongoing	Short
42	West Island	Planning, design and physical works	CKI Runway Upgrade – as it includes a Materials Offloading Facility located immediately north of the boat ramp and Rumah Baru access jetty, consideration will be required to tie-in seawalls appropriately	Ongoing	Short
43	West Island	Planning, design and physical works	Rumah Baru access road – raise road and pavement above flood level	By 2030	Short
44	Home Island	Planning, design and physical works	Move infrastructure into settlement area	As soon as scoped appropriately and funding obtained	Short
45	Home Island	Planning, design and physical works	Protect the cemetery with seawall and levees, including land reclamation	As soon as scoped appropriately and funding obtained	Short
46	West Island	Investigate	Investigate the management of existing vulnerable assets on the coastal side	As soon as scoped appropriately and funding obtained	Short

NO.	AREA OF INTEREST	ACTION TYPE	RECOMMENDATION	TRIGGER	TIMEFRAME
47	West Island	Principle	Transition from planned and managed retreat to a protect pathway for relocatable, critical service infrastructure assets outside of the settlement (Defence site, water treatment plant and refuse station)	As soon as scoped appropriately and funding obtained	Medium
48	West Island	Principle	Planned and managed retreat planning: using planning instruments to progressively move assets out of the hazard zone for all non-critical service infrastructure assets	As soon as scoped appropriately and funding obtained	Medium
49	West Island	Principle	Planned and managed retreat planning – short-medium-term to 2068 for management of existing vulnerable assets, including: • Transmitter site – immediately confirm building floor levels, raise if necessary to lift building higher than flood levels. • Sydney Highway • Assets at Trannies Beach, Big Barge Art Centre	By 2068	Medium
50	West Island	Planning, design and physical works	Relocate by 2068 – Lagoon side assets including two refuse stations, waste water treatment plant, Air Force site, Bureau of Meteorology, airport assets and Geoscience Australia building	By 2068	Medium
51	West Island	Planning, design and physical works	Move existing vulnerable assets including Kite Beach, Yacht Club and Scout Park	As soon as scoped appropriately and funding obtained	Medium
52	CKI	Planning and physical works	Planned and managed retreat Planning - Relocate assets within land parcels away from hazard zone (outside of settlement areas), and remove non-critical service infrastructure assets from site	Begin planning: Trigger 1 Begin physical works: Trigger 2	Medium
53	Home Island	Planning and physical works	Progress agreed option for the future of the settlement (in collaboration with the community through Long-term Settlement Planning)	2068	Medium
54	Home Island	Planning, design and physical works	Road raising	Where assessed as necessary	Medium

NO.	AREA OF INTEREST	ACTION TYPE	RECOMMENDATION	TRIGGER	TIMEFRAME
55	Home Island	Planning, design and physical works	Levee and Seawall protection	Where assessed as necessary	Medium
56	Home Island	Planning, design and physical works	Existing seawall and sandbags replace in 2050/60	By 2060	Medium
57	West Island	Planning, design and physical works	Levee protection	Where assessed as necessary	Medium
58	West Island	Planning, design and physical works	Replace all seabee seawalls, with crest increased 1 metre	By 2050-60	Medium
59	West Island	Monitor	Transmitter site – monitor shoreline, as retreat may be necessary in medium-term	Where assessed as necessary	Medium
60	West Island	Planning and design	Protection design requirements for Sydney Highway, Waste Water Treatment Plant, Refuse Station	Begin planning: Trigger 1 Begin physical works: Trigger 2	Long
61	West Island	Planning, design and physical works	Beyond 2068 – Protect – more levees and new seawalls needed for both lagoon and seaside, runway protection over long-term, medium to long-term seawall protection of moved Sydney Highway	As assessed beyond 2068	Long
62	CKI	Planning, design and physical works	Progress agreed option for the future of the settlement (in collaboration with the community through Long-term Settlement Planning)	As soon as scoped appropriately and funding obtained	Long

11 References

ABS. (2021). *6799, OT 2021 Census Community Profiles*. Australian Bureau of Statistics. Retrieved 3 August 2023 from https://www.abs.gov.au/census/find-census-data/community-profiles/2021/POA6799

Bluecoast Consulting Engineers. (2021). *Cocos (Keeling) Islands Coastal Vulnerability Assessment Addendum - 2031 Planning Period.* Department of Planning, Lands and Heritage.

Bureau of Meteorology, 2024. Southern Hemisphere Tropical Cyclone Data Portal, accessible from <http://www.bom.gov.au/cyclone/tropical-cyclone-knowledge-centre/history/tracks/>, accessed on 7 June 2024.

CoastAdapt. (2017). *CoastAdapt. Retrieved August 2021,* from https://coastadapt.com.au

CSIRO. (2020, March 31). *Causes of extreme sea levels*. Retrieved from CSIRO: https://research.csiro.au/slrwavescoast/extremes/causes-extreme-sea-levels/

DAL. (1999). *Investigations for the proposed freight and passenger facilities at Rumah Baru (Cocos Islands), DRAFT.* D.A. Lord & Associates Pty Ltd.

Department of Local Government (2013) *Risk Management Resources.* Prepared by Government of Western Australia and Department of Local Government. March 2013

DITRDCSA. (n.d.). *Cocos (Keeling) Islands environment and heritage.* Retrieved from Department of Infrastructure, Transport, Regional Development and Communications: https://www.infrastructure.gov.au/territories-regions-cities/territories/indian-ocean-territories/cocos-keeling-islands/environment-heritage

DoT. (2010). *Sea Level Change in Western Australia. Application to Coastal Planning.* Department of Transport .

GHD. (January 2017). *Patrick Ports Cocos Keeling Islands Coastal Management Plan.*

IPCC. (2014). *Climate Change 2014: Synethis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change.* Intergovernmental Panel on Climate Change.

IPCC. (2021). *Summary for Policymakers. In: Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change.*

Maunsell. (2009). *Climate Change Risk Assessment for the Australian Indian Ocean Territories, Cocos (Keeling) Islands and Christmas Island.* Canberra: Maunsell Australia Pty Ltd.

Office of Environment and Heritage (2011) *Guide to Climate Change Risk Assessment for NSW Local Government.* Prepared by the Government of New South Wales Office of Environment and Heritage. December 2011.

Pacific Region Infrastructure Facility (2017) *Guidance for coastal protection works in Pacific island countries*.

RHDHV, 2019. Cocos (Keeling) Islands Coastal Vulnerability Assessment Technical Note - Post-event report. Report prepared for Department of Planning, Lands and Heritage.

RHDHV, 2021a. Cocos (Keeling) Islands Coastal Vulnerability Study. Report prepared for Department of Planning, Lands and Heritage.

RHDHV, 2021b. Cocos (Keeling) Islands Coastal Vulnerability Assessment Technical Note – Site Visit Report. Report prepared for Department of Planning, Lands and Heritage.

Robb, A., Stocker, L., Payne M., & Middle, G., (2017). *Planning for coastal erosion and inundation in Western Australia: Practices and perceptions from the local level*, Environmental and Planning Law Journal, Volume 34.

Robb, A., Payne, M., Stocker, L., Middle G. & Trosic, A. (2018). *Development Control And Vulnerable Coastal Lands: Examples Of Australian Practice*, Urban Policy and Research, DOI:10.1080/08111146.2018.1489791

SEA. (2001). *Cocos (Keeling) Islands Storm Surge Study.* Gutteridge Haskins and Davey Pty Ltd on behalf of the Department of Transport and Regional Services.

Searle. (1994). *Late Quaternary morphology of the Cocos (Keeling) Islands* . Atoll Research Bulletin.

Standards Australia Limited (2013) *Australian Standard 5334-2013 Climate Change Adaptation for Settlements and Infrastructure – A Risk Based Approach*.

The Plan Journal. (2017). Interrupted Atolls: Risscapes and Edge Imaginaries in Tuvalu - Elizabeth Yarina, Shoko Takemoto. *The Plan Journal*, 2, 461-495.

WAPC. (2013a). *State Planning Policy 2.6 - State Coastal Planning Policy.*

WAPC. (2019). *Coastal Hazard Risk Management and Adapation Planning Guidelines.*

WAPC. (July 2019). *Coastal Hazard Risk Management and Adaptation Planning Guidelines.* Western Australian Planning Commission.

Western Australian Planning Commission. (2013). *State Planning Policy 2.6 - State Coastal Planning Policy.*

Appendices


BIAK SELAMAT