

Shire of Murray Coastal Hazard Risk Management Adaptation Plan Summary

June 2023



We acknowledge the Bindjareb people of the Noongar nation as traditional owners of the land on which the CHRMAP is being prepared. We acknowledge their connection to land, sea and country and pay respect to their elders, past, present and emerging.



A message from the Shire President

The Shire of Murray (SoM) considers the management of the estuarine and riverine areas and foreshore reserves throughout the region, and the mitigation of the coastal hazard risk posed to the community, as integral to the Shire's ongoing and future success.

Erosion and inundation are an increasing risk for the Shire of Murray, and to best protect our community we have developed a Coastal Hazard Risk Management Adaptation Plan (CHRMAP) to guide how we manage that risk.

Our community have been involved with this work at every stage in the process helping us develop a plan that is practical, easily understood and based on the latest science.

Looking after our waterways is crucial for our community. Consequently, responding to the likely challenges of a changing climate and probable sea-level rise is a priority for the Shire of Murray. Our aim throughout this process has been to provide our community with the maximum benefits of our unique natural environment for generations to come.

There are two focus areas in this work: public land and infrastructure, and private property.

For public areas, we aim to provide outcomes where environmental, lifestyle, access and economic services will still thrive in an era when sea-level rises and their impacts are likely.

For private property coastal risks will need to be considered in future planning decisions. This will ensure that growth areas are located and designed to minimise vulnerability to coastal risks. For established areas the CHRMAP includes a series of short term actions and longer term pathways designed to improve the resilience of these areas.

We will continue to work with landholders to ensure that they can continue to enjoy and use their properties in the face of the threat of climate change for as long as possible.

The Shire will facilitate this by:

Providing a framework for development that is adaptable to potential changes in coastal hazard risk

Advocating for funding for protection, adaptation and resilience measures

Planning community infrastructure that helps mitigate potential future erosion/inundation impacts

Making any changes to development rights contingent on physical trigger points being reached



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How vulnerable is our shoreline?

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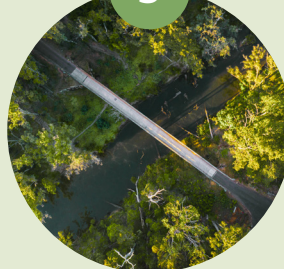
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Managing the Shire of Murray shoreline areas

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Abbreviations

BCR	Benefit Cost Ratio
CHRMAP	Coastal Hazard Risk Management and Adaptation Planning
CBA	Cost Benefit Analysis
CRG	Community Reference Group
DPLH	Department of Planning, Lands and Heritage
DoT	Department of Transport
HSD	Horizontal Shoreline Datum
LPP	Local Planning Policy
MCA	Multi-Criteria Analysis
NBS	Nature Based Solutions
NPV	Net Present Value
SoM	Shire of Murray
SCA	Special Control Area
SMU	Shoreline Management Unit
SPP2.6	State Coastal Planning Policy. State Planning Policy 2.6
TAG	Technical Advisory Group
WAPC	Western Australian Planning Commission

An aerial photograph of a coastal town, likely in the Shire of Murray. The image shows a mix of residential housing, some with solar panels, along a river or estuary. A large green circular graphic is overlaid on the center of the image, containing the number '1' and the title 'Introduction'. The background shows a lush green landscape with trees and a golf course in the distance.

1

Introduction

The Estuarine and Riverine coastline and shorelines of the Shire of Murray are an intrinsic part of life in the Murray region, supporting a range of residential and commercial development and a variety of recreational activities.

The Peel-Harvey Estuary was listed under the Ramsar Convention in 1990 as a wetland and ecosystem of international significance and is home to tens of thousands of water birds. The Peel-Harvey Estuary and the Murray and Serpentine Rivers provide a unique natural setting for the local community as well as the estimated 400,000 domestic and international visitors that come to the Shire each year.

However, our shoreline areas are vulnerable to both inundation and erosion. The dynamic nature of inland tidal waterways, coupled with man-made impacts including the opening of the Dawesville Channel, land use changes for agriculture and development, and the cumulative impacts of recreation and boating, all increase the vulnerability of our coastal areas.

These impacts are anticipated to continue as sea levels are predicted to rise at an increasing rate (Intergovernmental Panel on Climate Change, 2021). The management of the estuarine and riverine areas and foreshore reserves throughout the region, and the mitigation of the coastal hazard risk posed to the community, is therefore integral to the Shire's ongoing and future success.

This report provides a summary of the draft CHRMAP to assist with community consultation. This summary report should be read in conjunction with the CHRMAP.

What is a CHRMAP?

A Coastal Hazard Risk Management and Adaption Plan, also known as a CHRMAP, is a strategic, long-term plan that guides the response to the existing and potential future risk of impact from erosion and inundation along the coast. In the Shire of Murray these risks are most acute in the tidally influenced parts of the river and estuary system. The CHRMAP assesses risk levels at specific planning timeframes of 10, 30, 50 and 100 years into the future.

The CHRMAP outlines adaptation pathways to be pursued to minimise risk and vulnerability across these timeframes. CHRMAPs are prepared in Western Australia in accordance with the CHRMAP guidelines (WAPC, 2019) and State Planning Policy No. 2.6 – State Coastal Planning Policy (WAPC, 2020).

Purposes and objectives

The Shire has completed a CHRMAP for its tidally influenced estuarine and riverine areas to support its future management and planning decisions. The CHRMAP project has been developed in consultation with the local community and a range of stakeholders, and has been delivered in accordance with local and national guidelines and standards (WAPC 2019, AS5334-2013).

The key objectives of the CHRMAP are to:

Improve understanding of the Peel-Harvey estuarine coastal and Murray and Serpentine riverine features, processes, as well as erosion and inundation hazards in the study area.

Gain an understanding of asset vulnerability in the Peel-Harvey estuarine coastal and Murray and Serpentine riverine zones that includes the areas of water and land that are predominately influenced by coastal processes.

Identify significant asset vulnerability trigger points and respective timeframes to mark the need for implementation of immediate or medium-term risk management action.

Identify assets (natural and man-made) and the services and functions they provide situated in the Peel-Harvey estuarine coastal and Murray and Serpentine riverine zones.

Identify the value of the assets that are vulnerable to adverse impacts from erosion and inundation hazards.

Determine the likelihood and consequence of the adverse impacts of erosion and inundation hazards on the assets and to assign a level of risk.

Identify risk management measures and actions and how these shall be incorporated into short and long-term decision-making.

Engage stakeholders and the community in the planning and decision-making process.



Study area

The study area for the CHRMAP includes the eastern shoreline of the Peel-Harvey estuary and the tidally influenced sections of the Murray and Serpentine Rivers.

The **study area** includes approximately 50km of largely natural shoreline including various nature reserves. A range of residential and commercial developments are sited in the north of the study area including the localities of Furnissdale, North Yunderup and South Yunderup. South of Point Grey, the locality of Birchmont and the campground at Herron Point are adjacent to the Harvey Estuary.



Project staging

The CHRMAP project has been undertaken in seven stages:

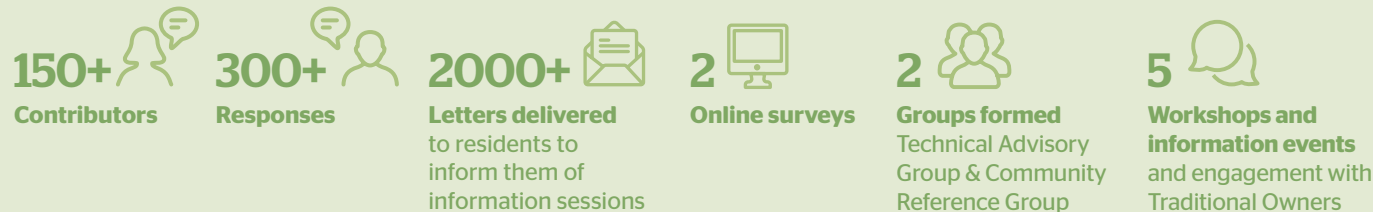


Community and stakeholder engagement

A range of community engagement activities were undertaken to support the project. These have helped improve the understanding of the project within the community and fostered local input to the CHRMAP process.

A Stakeholder and Community Engagement Strategy was prepared to guide the engagement process and ensure that the community and stakeholders were effectively and actively involved throughout each of the key project stages during the CHRMAP preparation process. Their involvement has guided the determination of the final outcomes.

Engagement



Respondents included residents of nearby locations adjacent to the Shire of Murray, including Mandurah, Waroona, Warnbro and Rockingham

Coastal assets and values

Top 3 reasons people interact with the estuary



Fishing/Crabbing, horse riding and boating

Highest value amongst the community



Environmental values and land/water-based recreation opportunities

Top 3 social assets identified



Walking paths, fishing areas and crabbing areas

Top 3 environmental assets identified



Foreshore area, river system and the Murray Delta Islands

Assets and management



The environment was identified by the community as the most important asset.



Erosion was perceived to be the greatest immediate concern of participants.



Houses & properties had the highest priority ranking.



Protect & accommodate were the preferred adaptation strategies.



Nature-based solutions were the most popular adaptation options (i.e. brushwall and revegetation).

Success criteria

Based on the coastal values identified in the community engagement the following success criteria were defined:

Conserve, enhance and maintain the natural environmental and character of the river regions and Peel-Harvey estuary areas.

Protect and restore estuary river shorelines and their wetlands and manage coastal processes.

Manage impacts to the existing residential areas from erosion and inundation.

Maintain critical infrastructure supporting the community (roads, utilities).

Manage and maintain coastal infrastructure that provides access to the water and supports the lifestyle enjoyed by people in the region.

Maintain the ecological values of the rivers, estuary and associated wetlands (e.g. birds, fishing and crabbing).

Preserve the key heritage sites of significance (e.g. Coopers Mill).

Facilitate and promote public usage and enjoyment of the estuary and river by the community – swimming, kayaks/canoeing, horse riding, bird watching, camping, fishing, crabbing.

An aerial photograph of a coastal town, likely in Australia, showing a river flowing through the center. The town is densely packed with houses and trees. A large, semi-transparent green circle is overlaid on the center of the image, containing the number '2' and the title 'Coastal hazards'.

2

Coastal hazards

Coastal hazards are associated with the natural variability of the ocean and processes that have the ability to impact coastal areas and assets. Coastal hazards have always existed along coastlines and associated shorelines and are not solely influenced by climate change.

Coastal hazards

The impact of sea-level rises has been factored into future coastal planning in this CHRMAP based on the projection of a +0.9m sea-level rise over the next 100 years. The projected sea-level rise in the coming century is expected to increase the vulnerability of assets and foreshore areas to hazards such as inundation and erosion.



Erosion

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. This can be rapid (e.g. due to a storm event) or over a longer period time (e.g. the shoreline gradually retreats due to sea-level rises or variability in local coastal processes). Erosion coupled with assets often results in permanent damage.



Inundation

The flow of water onto previously dry land. It may either be permanent (e.g. due to sea-level rise) or a temporary occurrence during a storm event. This leads to the flooding of low-lying areas, and where assets exist in these areas, they may be impacted temporarily, which often leads to permanent damage.

Coastal hazard assessment

A coastal hazard assessment was undertaken for the Shire of Murray in accordance with the State Coastal Planning Policy (SPP2.6, WAPC 2020), which examined projected coastal erosion and inundation processes over the next 100 years (Seashore 2021).

S1 Erosion Allowance for extreme storm impact (e.g. large storm event)

S2 Erosion Allowance for shoreline movement based on previously measured trends

S3 Erosion Allowance for erosion caused by future sea-level rise

S4 Inundation Allowance for the risk of storm-surge inundation in an extreme event

The sum of each of the components for erosion (S1, S2 & S3) and inundation (S4) were used to derive hazard lines for 2020, 2030, 2050, 2070 and 2120 timeframes. Hazard lines depict the active limit for each coastal hazard at a given timeframe and are used to identify at-risk areas and assets along the Shire's shorelines.

Based on the findings of the coastal hazard report, the current and future extent of coastal hazard over a range of planning periods was determined across the study area. Mapping of the inundation areas (depth of flooding) and the coastal processes allowances (erosion setback distances) along estuarine and river shorelines have been used to inform the impacts to coastal assets in the CHRMAP.



Loss to erosion over 4 years
Cooleenup island



2019



2020



2021



2022



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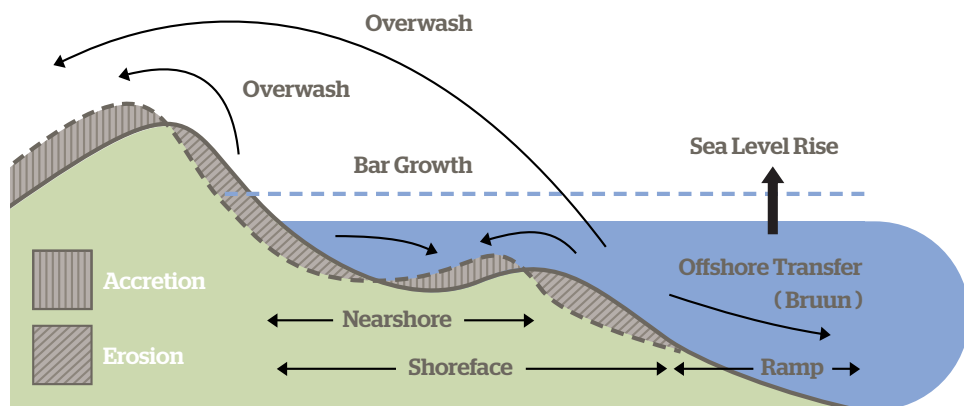
How
vulnerable is
our shoreline?

Coastal hazard study

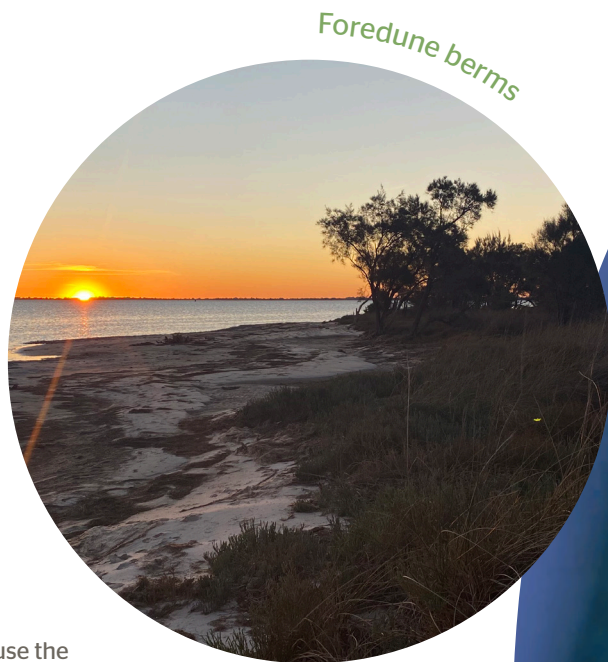
The potential response of the shoreline to future sea-level rise is strongly linked to the height and stability of the berms.

For shoreline areas, sea-level rises will cause the coast to rise and roll landward over low-lying areas (Davidson-Arnott model). For the Harvey Estuary shorelines the erosion response is small due to the relatively high foreshore area. For the Murray Delta Islands the erosion response is large due to the low-lying topography around the foreshore berm. Critical to the long-term foreshore dynamics for the Yunderup area is that foredune berms keep pace with any increase in sea-level.

Onshore Transfer (Davidson-Arnott)



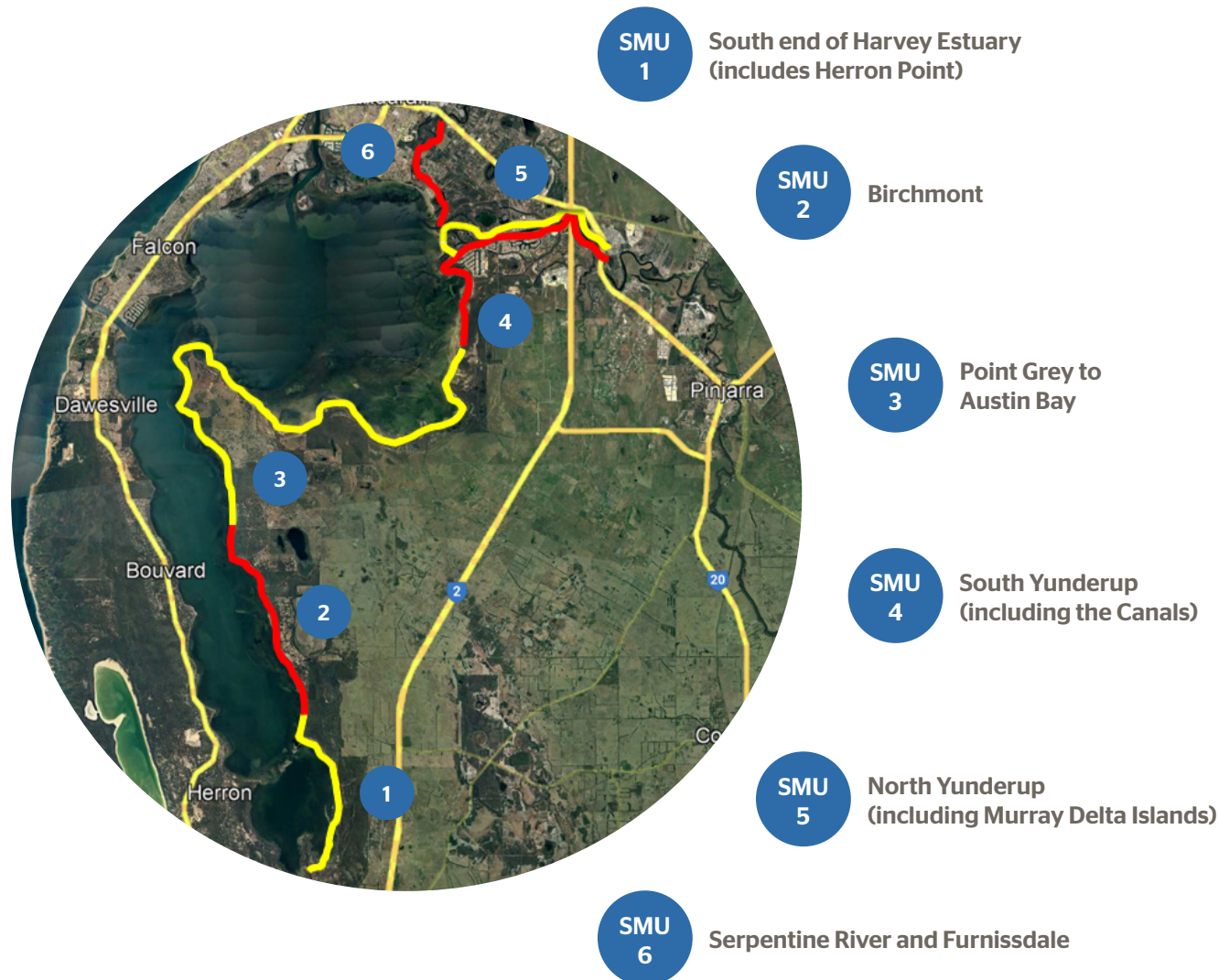
Cross-shore response to sea-level rise (diagram adapted from Dubois 1992).



Analysis of shoreline transects in Coastal Processes Study (Seashore 2021)

Approach to analysis

The study area was broken down into six sections of shoreline. Coastal assets in the shoreline areas were identified in each of the six respective shoreline management units (SMUs) for the CHRMAP as summarised here:



The CHRMAP vulnerability assessment first considers the potential impact to coastal assets as a combination of the likelihood and the consequence of that hazard occurring. The vulnerability assessment then considers the adaptive capacity of coastal assets; that is, the ability of a coastal asset to accommodate coastal hazard impact. The vulnerability analysis was 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) adapted to an estuarine environment.

In risk management terms, 'likelihood' is the chance of something happening, and is similar to the concept of probability. Alternatively, 'consequence' is used to describe the impact to assets when coastal hazard is realised. The assessment of potential impact to coastal assets uses the likelihood and consequence to determine a level of risk.

Likelihood was assigned using the results of coastal processes and coastal hazard inundation. Consequence of coastal hazards are considered across a range of categories representing severity, with risk rating designated to one of four categories adopted from WAPC (2019). Risk ratings were then combined with an asset's adaptive capacity to assign assets with a rating for vulnerability over each planning horizon.



Key outcomes

- Many of the river foreshore areas and associated Shire infrastructure are rated as highly vulnerable to erosion over the planning timeframes, these include minor roads, jetties, drainage features and other associated infrastructure
- Coopers Mill is highly impacted from both erosion and inundation in the short-term timeframe without management
- The majority of private lots across the Shire are only at risk from minor inundation, and this only occurs in the long-term planning timeframe under projected sea-level rises
- There are a number of private lots, particularly in the North Yunderup and Murray Delta Island areas that are vulnerable in the current and short-term timeframes from inundation and erosion without further management
- Regular, programmed and consistent monitoring and maintenance of the foredune berms in the Yunderup area is critical.





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**What are the
management
options?**

Whose responsibility is it to manage the shoreline?

There is no legal obligation for Local or State Governments to protect public or private assets within coastal hazard areas, or to compensate for any losses caused by coastal hazards. SPP2.6 however, requires local governments to prepare a CHRMAP to identify areas at risk, outline possible adaptation pathways and share this information with the community.

Given the likely expensive nature of the adaptation works, it is recommended that the Shire determines funding pathways for coastal adaptation to ensure works can be undertaken as they become necessary. The cost of adaptation works can be supported by State and Federal funding programs including the Western Australian-based Coastal Management Plan Assistance Program, Coastal Adaptation and Protection grants and Coastwest grants.

It is also noted that many of the impacted shorelines are highly valued by the community as public assets, with stakeholders ranging from property owners, traditional owners, all levels of government, industry, community and environmental groups, ratepayers and users from within and outside the jurisdictional boundaries. It is crucial that planning and management of these areas is as transparent and equitable as possible, giving the utmost importance to ensuring equity is a central concept of the CHRMAP process.

Responsibility for coastal planning lies with both Local and State Governments, with a requirement to ensure decision making in risk management is undertaken considering the following:



Potential benefits

Effectiveness in reducing losses or maximising opportunities

Cost of implementation and ongoing maintenance

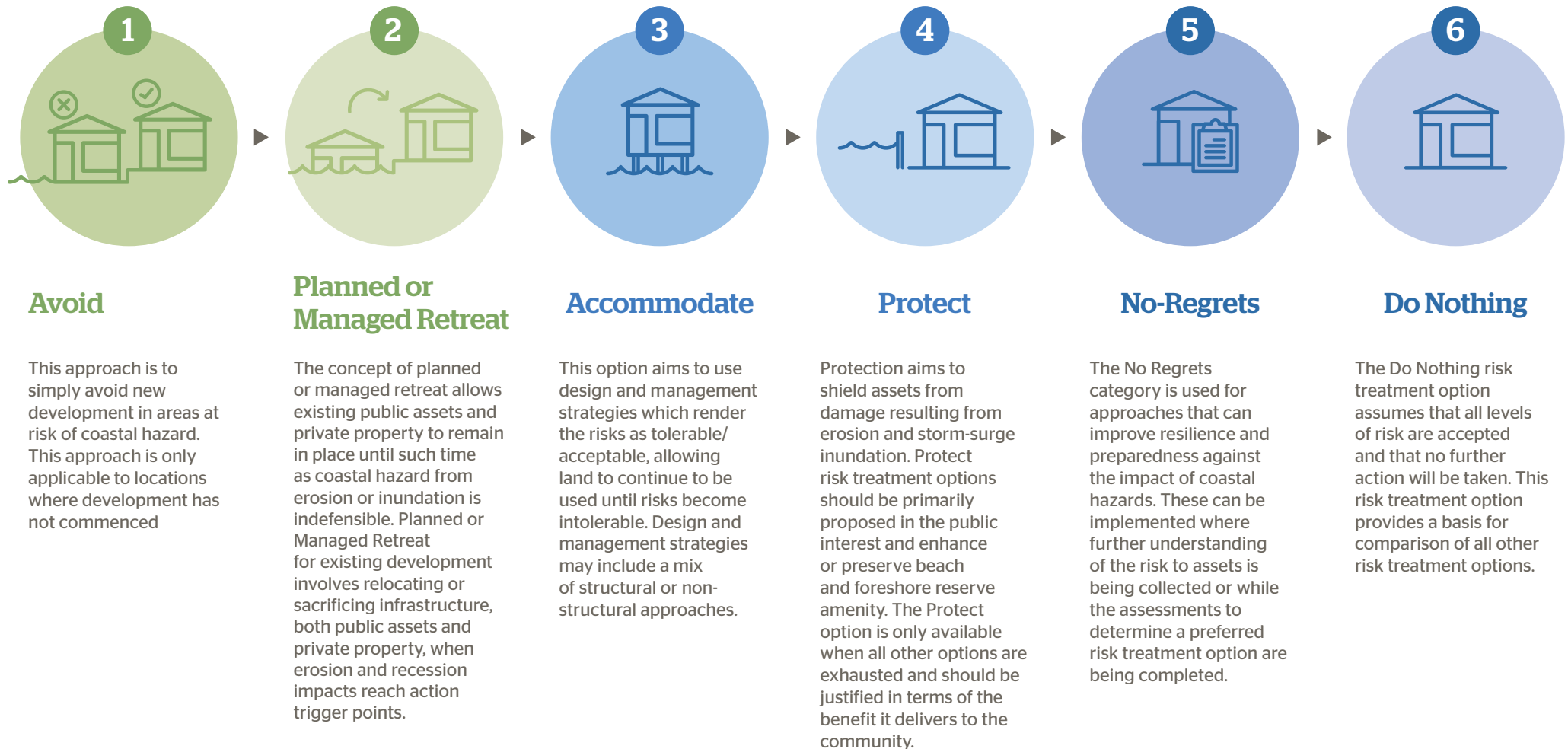
Equity implications
(i.e. who pays?; are the costs/benefits shifted between stakeholders? is this fair and acceptable?; whose values are being protected/negatively impacted?)

Impact of the treatment option on other objectives, including the introduction of new risks or issues

Intergenerational equity

Adaptation hierarchy

Effective adaptation planning involves identifying and evaluating a range of suitable options to help manage the risk of coastal hazards. Potential options have been identified from the CHRMAP guidelines (WAPC, 2019) which describe the general risk treatment categories in a risk treatment and adaptation hierarchy under the categories: Avoid, Planned or Managed Retreat, Accommodate and Protect. Protection is the least-preferred management option.



Management options



Avoid

Adaption Type

Code

Applicable

Measures

Locating assets in areas that are not vulnerable to coastal hazards

AV.1

Can be applied to all asset types. Applicable to undeveloped residential and commercial land

Amend local planning scheme to include Special Control Area which encompasses all areas affected by either erosion of inundation hazard over the 100-year planning period.

Establish planning-based controls that only allow development in the SCA that can address coastal hazard.



Planned or Managed Retreat

Leaving assets unprotected

MR.1

Low cost, temporary and easily relocatable recreation amenities.

Amend local planning scheme to include Special Control Area.
Determine assets that are deemed sacrificial.
Monitoring (NR1) to identify when trigger is reached.

Demolition, removal or relocation of assets from inside the hazard area

MR.2

Assets of low value where it is impractical both technically and financially to design the asset to withstand the impact of the coastal hazards instead of relocating it.

Amend local planning scheme to include Special Control Area.
Determine assets that are deemed sacrificial or relocatable, and update Council's Asset register to reflect likely timeframe for impact to assist in prioritising asset relocation.
Monitoring (NR1) to identify when trigger is reached.

Event limited development approval/prohibit expansion of existing use rights

MR.3

Generally applicable where protection of assets is not viable. All assets where it is impractical to ultimately implement protection.

Amend local planning scheme to include Special Control Area.

Voluntary acquisition

MR.4

All private property where it is impractical to ultimately implement protection.

This risk treatment option would require the acquisition of affected properties, on a voluntary basis.

Ensures land in the coastal zone is continuously provided for coastal foreshore management, public access, recreation and conservation.

Investigate/put in place funding for acquisition of priority properties.
Offer voluntary acquisitions reflecting asset value in light of hazard.

Limit further subdivision

MR.5

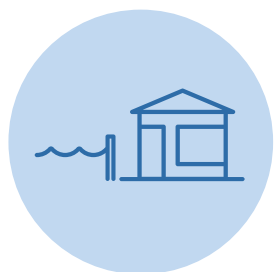
Limit further subdivision of existing lots identified in the hazard area.

Amend local planning scheme to include Special Control Area.



Accommodate

Building design - Relocatable structures	AC.1	Design assets to be relocatable. Structures can be moved in future as risk increases and becomes intolerable.	Amend local planning scheme to include Special Control Area. Prepare local planning policy containing relevant inundation and wave overtopping development controls.
Building design - Design assets to withstand impacts	AC.2	Where avoiding or relocating an asset is not an option, design of assets to withstand the impact of inundation.	Approval of local planning policy by Council. Implement local planning policy development controls to all properties within the special control area for coastal hazards within the local government area.
Building design - Appropriate finished floor levels	AC.3	Roads, car parks, residential property, hospitals, aged care facilities, schools, childcare facilities.	
Filling land	AC.4		



Protect

Beach management/ sand management	PR.1	Shorelines of the Peel Inlet where maintenance of the berm is expected to play a key role in preventing significant erosion impacts under future sea level rise scenarios.	Rehabilitate the berm, investigate field approaches that can be used to reshape the upper beach profile. Investigate and secure suitable sand sources for nourishment, planning approvals and to determine funding mechanisms.
Erosion control - nature-based solutions	PR.2	This approach refers to 'soft engineering' methods that are in keeping with nature. Protection of the Murray Delta Islands shoreline areas, the Murray and Serpentine River and Peel-Harvey shorelines	Shire to issue guideline on river erosion edge treatments that will provide a framework for acceptable standard of approaches by the landowner.
Coastal revegetation	PR.3	Revegetation of the shoreline areas with plant species that can stabilise and bind together the sediment in the shoreline and provide natural resilience	Shire to issue guideline on coastal revegetation in its shorelines that will provide information of key plant species for Shire areas.
Seawalls	PR.4	Involves construction of a seawall usually along an entire section of shoreline. The seawall could be applied to protect important built assets from erosion.	Undertake NR2, to investigate viability of existing seawalls on beaches. Consider in accordance with Council's Asset Management Plan. Undertake investigation of rock and sand sources for detailed costings, design of seawall and nourishment, planning approvals and funding mechanisms. Continued monitoring (NR1) for trigger.
Flood mitigation structure	PR.5	Involves construction of a flood control which is either permanent or temporary along an entire section of shoreline. Format could be a large-scale permanent flood control structure at the Dawesville Cut or local scale small dike structure on the island shorelines.	Undertake investigations of rock and sand sources for detailed costings, design of flood structures and nourishment, planning approvals and developing business case for funding. Continued monitoring (NR1) for trigger.



No Regrets

Monitoring	NR.1	Applicable to all areas. Long-term baseline monitoring and event-based monitoring following storm-erosion events.	Set up a baseline monitoring programme for long-term trends and conditions following major events. Review results for particular asset triggers regularly. Re-run risk assessment based on monitoring results and revise risk management measures if risk level changes (i.e. increase or decrease in level of risk).
Protection structure audit	NR.2	All existing coastal protection structures. This risk treatment option involves undertaking an audit of existing protection structures, to determine their current condition, effectiveness and future protection potential.	Conduct audit of existing protection structures. Update hazard lines where relevant to account for existing protection structures. Update CHRMAP proposed actions to account for condition (life) of existing protection structures.
Notification on title (also relevant to, planned/managed retreat, accommodate and protect options)	NR.3	All assets located within an area vulnerable to coastal hazards within the planning timeframe. Indicated 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 decision 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.	Implement in accordance with the planning framework, and as conditions of approval for subdivision and development.
Emergency evacuation plans (also relevant to accommodate options)	NR.4	Roads (with regard to managing traffic flows during an event), car parks, residential property, hospitals, aged care facilities, schools, childcare facilities.	Development of evacuation plans for locations without existing inundation mapping as a priority. Update evacuation plans with latest inundation mapping available or include coastal inundation area into existing evacuation plans.
Reduce vessel speeds in the waterways	NR.5	Review the speed limits for vessels travelling through the lower Murray River.	Complete studies to examine erosion impacts to the riverbanks from vessels and or vessel activities. Implement revised speed limits through the Shire's waterways (signage, etc).
Do nothing	DN.1	Low value assets and assets that must be located in the shoreline areas for their function/purpose,	Take no action and accept risk.



Do Nothing

Planning response

Recommended planning actions include the preparation of a Special Control Area (SCA) and local planning policy to cover all the areas projected to be impacted by erosion and inundation over the next 100 years.

Key provisions of the SCA include:

- a trigger for development approval for most development within the SCA, except where exempt under a local planning policy
- a requirement to consider coastal risks when deciding on applications
- provision for potential notices to be issued to remove development upon defined trigger events occurring.

Planning changes are developed in order to:

Ensure land in the shoreline areas is continuously available for foreshore management, public access, recreation and conservation

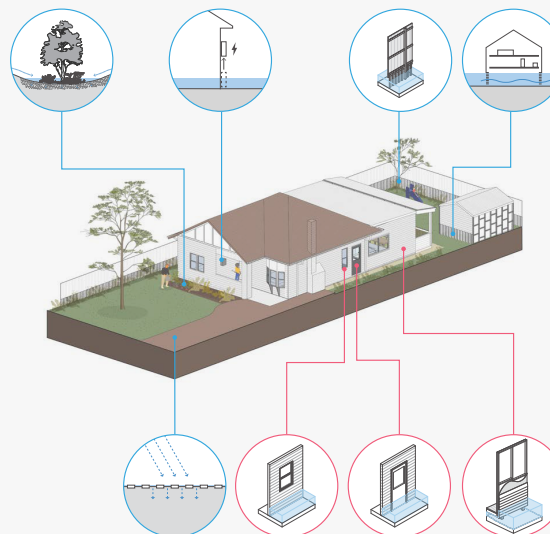
Ensure public safety and reduce risk associated with erosion and inundation

Avoid inappropriate land use and development of land at risk of erosion and inundation

Ensure land use and development does not accelerate erosion or inundation risk or have a detrimental impact on the functions of public reserves

Protect new developments from the impacts of erosion and inundation

Provide for implementation of the Shire of Murray CHRMAP



Examples of relocatable homes and new design guides that can support planning response

What does the policy mean for my house?

The policy does not apply to existing development.

Rather it provides guidance on how the Shire will consider proposals within the SCA 1 area to better accommodate and respond to the risk of coastal hazard. Areas of exemption are also proposed including for:

- Minor habitable development, less than 10m²
- Non habitable structures such as outbuildings
- Other development outside the 2120 erosion line that meets the policy design guidelines

If you wish to undertake new development within the area, the following may apply

Where land lies on the water side of the 2120 erosion line:

- land subdivision will not generally be allowed
- permanent development will be precluded, unless exempt
- non-permanent development may be approved provided the lifespan of the development is less than the applicable erosion line (2030, 2050, 2070, 2120); the design is relocatable, and subject to minimum habitable floor levels; conditions limiting the time of approval, removal upon defined trigger events occurring; a notification being placed on the land title; and suitable building controls such as structural sufficiency, utility service design levels, design of fill/retaining walls to maintain amenity and water flows.

Where land lies on the land side of the 2120 erosion line but is within the area subject to inundation:

development will generally be approved subject to minimum habitable floor levels; suitable building controls such as structural sufficiency, utility service design levels, design of fill/retaining walls to maintain amenity and water flows; and, where appropriate, notifications on the land title.



Triggers to respond

The concept of a trigger is to have 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'. The ongoing process of monitoring and evaluation of SoM's shoreline areas will be used to determine at which point further action is required. This is one of the important features in the CHRMAP risk management pathways approach in that triggers for the decision points are associated with the observation of key events on the ground rather than being time-based.

Triggers	Code	Decision	Measures	Identification
 The Horizontal Shoreline Datum (HSD) is within the S1 distance of an asset's most seaward extent (this will generally be between 3 and 11 depending on the specific location)	T1	Ongoing monitoring to define changes to the HSD line (NR1). Refinement to the S1 value based on field data collected following extreme events. Updated modelling information.	Provide interim protection for major infrastructure (roads, car parks), residential and commercial buildings. Remove major infrastructure (roads, car parks), residential and commercial buildings, transfer land to public realm. Prepare response plans for minor infrastructure that could be impacted.	Assessment of the shoreline position will be a task included in the annual monitoring program.
 A public road is no longer available or able to provide legal access to a property	T2	Liaison with/notification by relevant level of government.	Remove residential and commercial buildings and transfer land to public realm.	Task included in the annual monitoring program.
 Water, sewer or electricity to a lot is no longer available as they have been removed or decommissioned by the relevant authority due to coastal hazards	T3	Liaison with/notification by utility providers.	Remove residential and commercial buildings, and transfer land to public realm.	Task included in the annual monitoring program.
 Residential or commercial property lies seaward of the 100-year coastal erosion hazard line or coastal inundation hazard extent	T4	Definition of hazard extents through CHRMAP using recently updated information regarding sea-level rise predictions and changes in environmental conditions (e.g. tidal planes, mean sea level).	Include all affected land in a SCA and ensure the hazard information is incorporated in structure planning. Provide notification of potential hazards on certificates of title where reasonably practicable and by direct contact with affected landholders.	This is defined in the SCA1 as an outcome of the CHRMAP.



An asset is damaged, destroyed or becomes unsafe due to coastal erosion

T5

Inspection of coastal assets following storm events or during times of increased longshore erosion.

Shire asset management includes inspection and reporting on structure conditions.

Notification by the public.

Remove assets and relocate to less hazardous area is possible/appropriate.

Informed by the Asset Management and Structure Condition Assessments undertaken by Shire. Also captured in Annual Monitoring Program.



Assets are predicted to become highly or very highly vulnerable within the planning timeframe or the next 10 years

T6

Definition of hazard extents through CHRMAP using recently updated information regarding sea-level rise predictions and changes in environmental conditions (e.g. tidal planes, mean sea level).

Undertake cost-benefit analysis and assessment of community acceptance of interim protection vs. managed retreat of the affected asset.

Identify sources and begin to allocate funding for risk management measures.

As part of future CHRMAP review this can be reassessed periodically (every 5-10 years).



The overall community and stakeholders are no longer supportive of a specific risk management technique or approach

T7

Ongoing community engagement; Cost-benefit analysis.

Investigate, identify and implement a change in the risk management pathway, if appropriate.

As part of future CHRMAP review this can be reassessed periodically (every 5-10 years).



A specific risk management technique is forecast to no longer be economically or physically feasible within 10 years

T8

Ongoing shoreline and coastal asset monitoring Budget expenditure and forecasts cost-benefit analysis.

Investigate, identify and implement a change in the risk management pathway, if appropriate.

As part of future CHRMAP review this can be reassessed periodically (every 5-10 years).



The beach and coastal foreshore reserve is significantly diminished with respect to its original state and function

T9

Long-term coastal monitoring program. Assessment of aerial imagery. Feedback through ongoing community consultation.

Investigate, identify and implement a change in the risk management pathway, if appropriate.

Assessment of the shoreline position will be a task included in the annual monitoring program.



Undeveloped land is identified as lying within the hazard extents

T10

Definition of hazard extents through CHRMAP using recently updated information regarding sea-level rise predictions and changes in environmental conditions (e.g. tidal planes, mean sea level).

Implement planning controls to avoid inappropriate development of the land.

This is defined in the SCA1.
As part of future CHRMAP review this can be reassessed periodically (every 5-10 years).

An aerial photograph of a dense forest with a mix of green and yellow foliage. A large, semi-transparent light green circle is centered over the image. Inside this circle, at the top, is a smaller dark green circle containing the number '5'. Below this, the text 'Area summaries based on Shoreline Management Unit (SMU)' is written in a green, sans-serif font. The background shows a winding road or path through the trees and a body of water in the lower left corner.

5

**Area summaries
based on Shoreline
Management Unit
(SMU)**



SMU
1

South end of Harvey Estuary (inc Herron Point)

SMU1 extends along the shoreline of the Kooljerrenup Nature Reserve, across approximately 8km of the lower Harvey Estuary.

SMU1 – South end of Harvey Estuary (includes Herron Point)

Due to the natural state of the foreshore areas, it is considered the majority of the SMU provides adequate area landward of the present-day shoreline for coastal processes in future planning periods. The shoreline areas are low lying and inundation extents associated with extreme events and sea level rise scenarios show the hazard region extending up to 400m inland through the Kooljerrenup Nature Reserve in the region south of Herron Point. The shoreline is considered to have high adaptive capacity and the risk and vulnerability of the shoreline area through the nature reserve is rated low to medium.

A summary of the key findings for SMU1 are:

The vulnerability rating for the Kooljerrenup Nature Reserve is high in 2030 and 2050 rising to very high in 2070 and beyond. For inundation the vulnerability rating is moderate in 2030, high in 2050 and 2070, rising to very high in 2120.

For Herron Point, there are a range of assets that are at risk of erosion and inundation including the Herron Point access road, Herron Point boat ramp, campground and car park.



Erosion of the Kooljerrenup Nature Reserve was assessed against the adaption strategy of purchasing land on the eastern side of the reserve, to mitigate the loss of land due to erosion on the shoreline side. Loss of land area is projected to increase markedly after the 2050 period due to shoreline erosion driven by projected sea level rise. Monitoring of the shoreline areas and their response to sea-level rises in the next 20 years will inform the future adaptation strategy with further consideration of the need for potential acquisition of land recommended in the 2040 to 2050 planning period.



Erosion

The erosion vulnerability assessment showed:

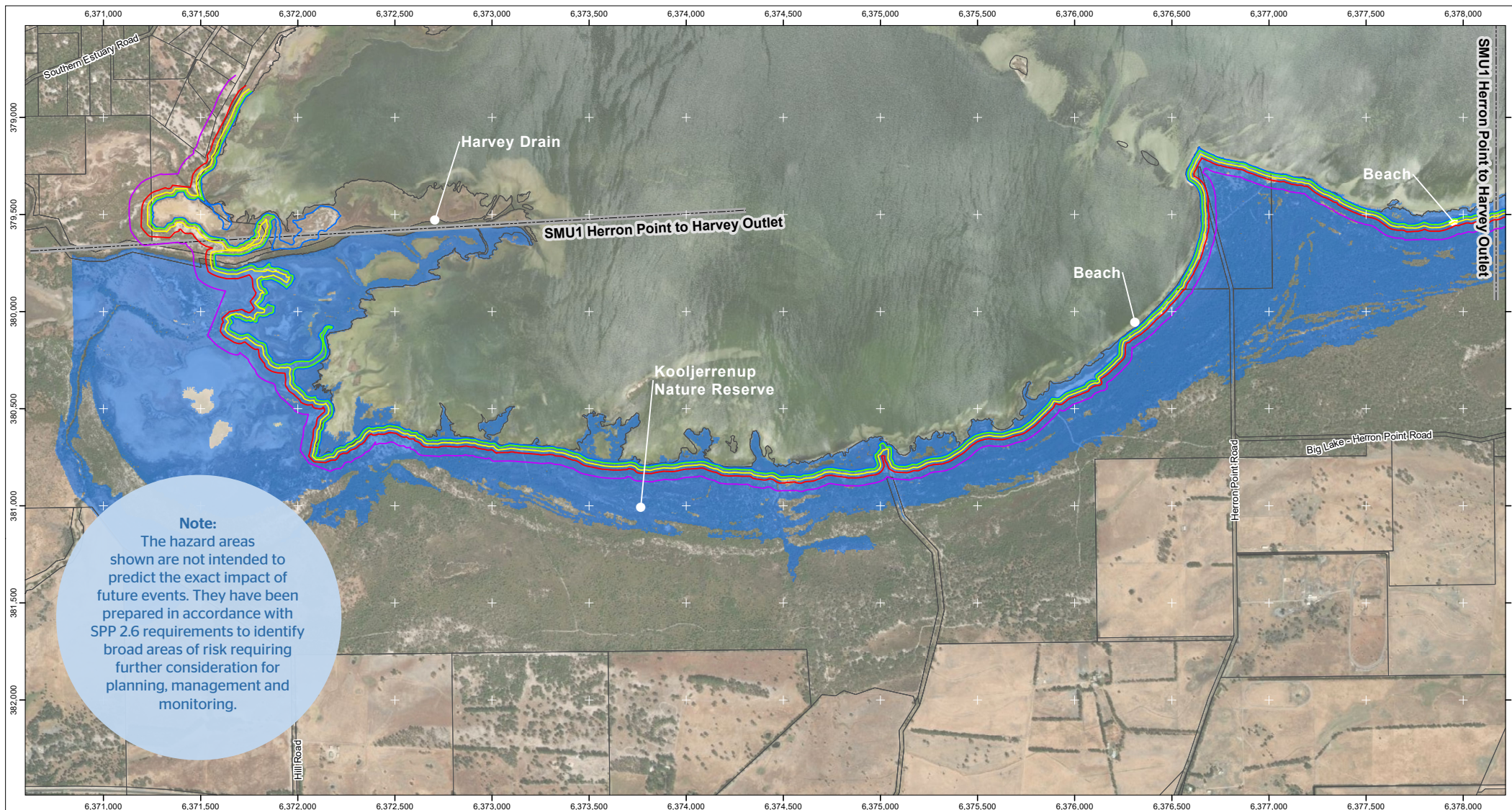
The beach around Herron Point, the carpark and boat ramp are all rated highly vulnerable by 2030 with increasing vulnerability (increasing to very high rating) in future planning periods. In planning timeframes from 2050 onward, assets that reach high vulnerability ratings include the foreshore reserve, coastal pathways and roads and toilets of the camping ground.



Inundation

The findings of the inundation assessment were:

The vulnerability is rated low to moderate for most assets, with the roads in the campground and the Herron Point access road rated highly vulnerable from the 2070 period onward



Legend

- Inundation
- Coastal Processes Setbacks**
- 2020
- 2030
- 2050
- 2070
- 2120



0 200 metres

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray. Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site. Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Disclaimer

The hazard areas depicted in this map are presented as potential inundation and coastal processes areas of impact based on SPP2.6 requirements. These future scenarios are based on work presented in Seashore 2021 and used to inform areas requiring further consideration for planning, management and monitoring in CHRMAP.

SMU 1 - Herron Point to Harvey Outlet

Shire of Murray Coastal Hazard Flood Mapping

500yr ARI Design Storm in Planning year 2120

**Inundation Depth Based on Peak Water level
of 2.34m AHD (includes 0.9m Sea Level Rise)**



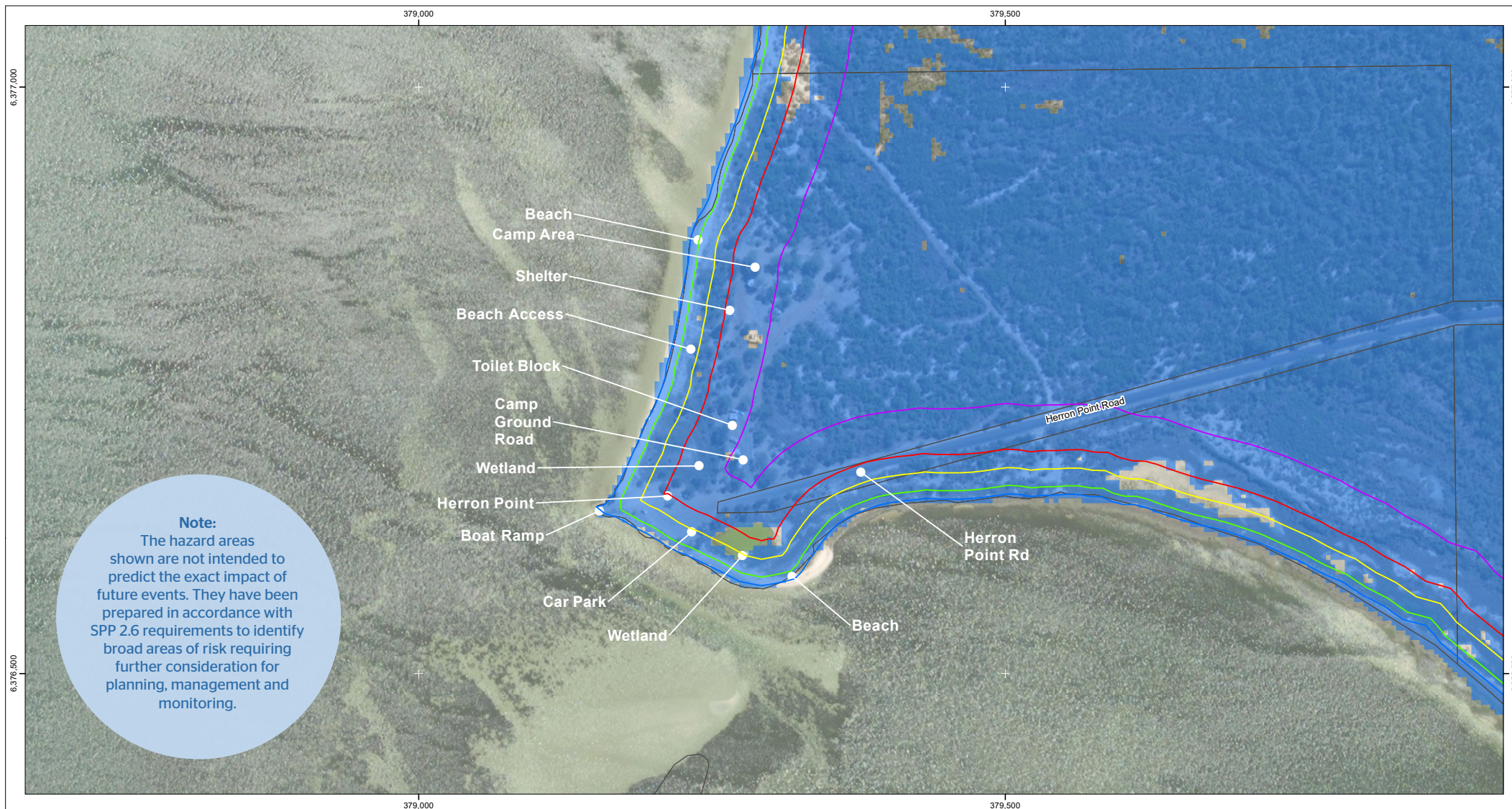
1915 Pinjarra Rd
Pinjarra WA 6208

<https://www.murray.wa.gov.au/>

Mapping prepared by **Baird.**

Map Published: 15 Sep. 2022





Legend

- Inundation
- Coastal Processes**
- Setbacks**
- 2020
- 2030
- 2050
- 2070
- 2120



0 200 metres

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray. Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site. Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

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SMU 1 – Herron Point Shire of Murray Coastal Hazard Flood Mapping

**500yr ARI Design Storm
in Planning year 2120**

**Inundation Depth Based on Peak Water level
of 2.34m AHD (includes 0.9m Sea Level Rise)**

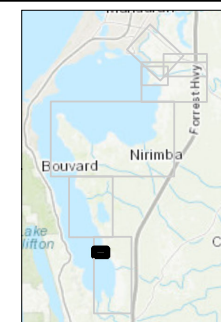


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Mapping prepared by **Baird.**

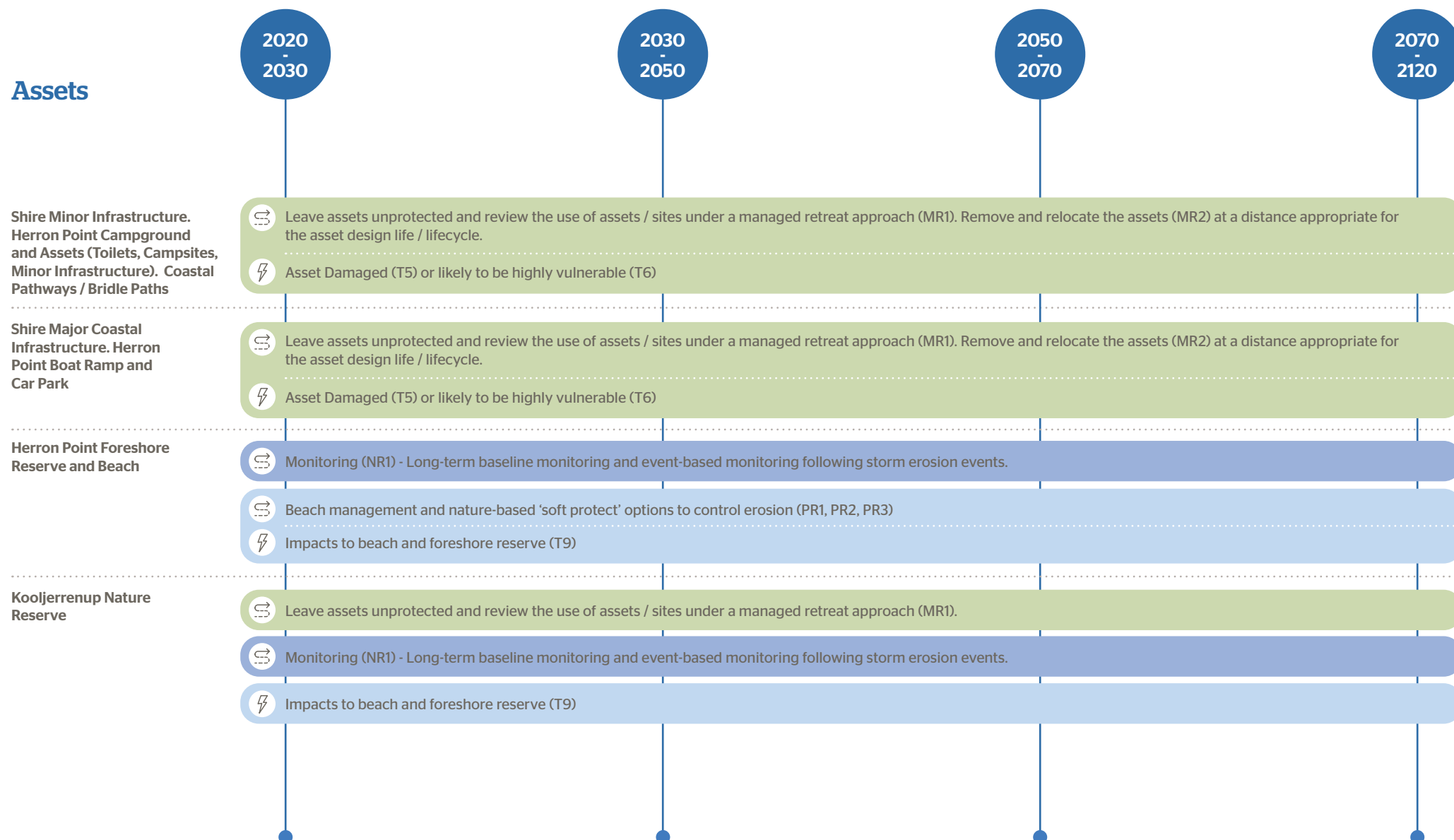
Map Published: 15 Sep. 2022





Risk management and adaptation pathways

Assets





Erosion

Vulnerability ratings

	2030	2050	2070	2120
1 Beach areas	●	●	●	●
2 Foreshore Nature Reserve	●	●	●	●
3 Harvey Drain	●	●	●	●
4 Kooljerrenup Nature Reserve	●	●	●	●
5 Herron Point Camping Ground	●	●	●	●
6 Herron Point Foreshore	●	●	●	●
7 Coastal Pathways / Bridle Paths	●	●	●	●
8 Carpark at Herron Boat Ramp	●	●	●	●
9 Herron Point Boat Ramp	●	●	●	●



Inundation

Vulnerability ratings

	2030	2050	2070	2120
1 Beach areas	●	●	●	●
2 Foreshore Nature Reserve	●	●	●	●
3 Harvey Drain	●	●	●	●
4 Kooljerrenup Nature Reserve	●	●	●	●
5 Herron Point Camping Ground	●	●	●	●
6 Herron Point Foreshore	●	●	●	●
7 Coastal Pathways / Bridle Paths	●	●	●	●
8 Carpark at Herron Boat Ramp	●	●	●	●
9 Herron Point Boat Ramp	●	●	●	●





SMU
2

Birchmont

SMU2 extends along approximately 7km of the Harvey estuary and includes the Birchmont section of coast through to Mealup Point.

SMU 2 – Birchmont

The shoreline is largely undeveloped with foreshore reserve in front of the Birchmont developed lots and the Mealup Point nature reserve providing a buffer between the Harvey Estuary and areas landward. The Birchmont boat ramp and carpark are sited in close proximity to the estuary within the coastal hazard region for inundation and erosion. Development north and south of the boat ramp in the form of large rural lots is generally behind the coastal hazard areas with some encroachment of the hazard on the lower western edge of the lots in future planning periods. There is natural elevation in the shoreline areas inland which means there is a narrower section of the coast susceptible to flooding during extreme design flooding scenarios compared with SMU1.

In total around 50 residential properties are within the mapped at-risk areas. The majority of the impacts are in the 2070 to 2120 period with sea-level rises causing minor flooding.



Erosion

The erosion vulnerability assessment showed:

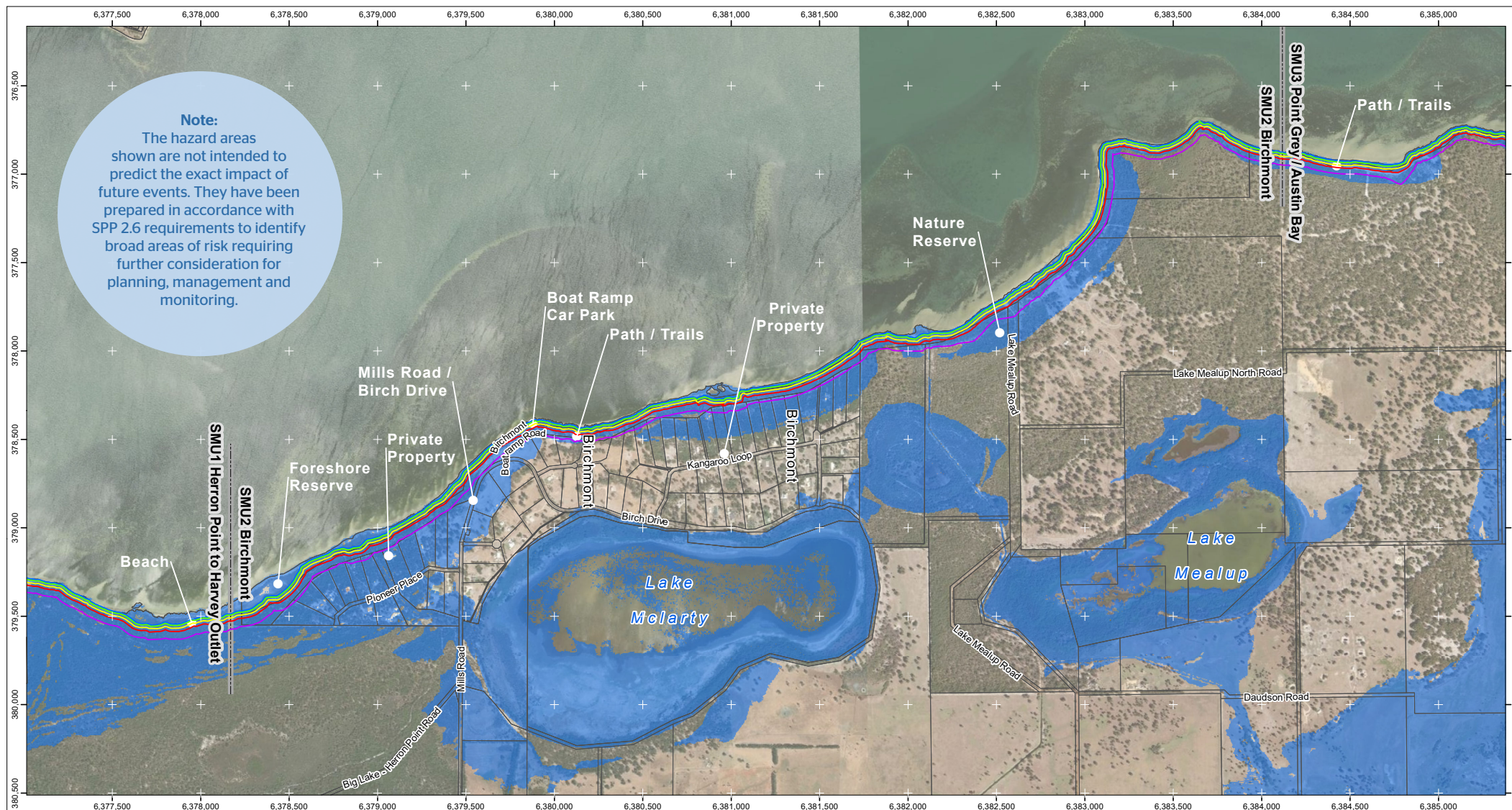
- A high rating for beaches from 2030 onwards. There are several assets that reach a high rating by the year 2050 including nature reserve, coastal pathways, the boat ramp and car park. By planning year 2070, the residential lots (western edge) as well as the access road to the boat ramp and Birch Drive are rated highly vulnerable.



Inundation

The findings of the inundation assessment were:

- That the vulnerability is moderate to low for most coastal assets. For residential properties the rating is moderate at 2030 and 2050 and then high in the planning year from 2070 reflecting the influence of projected sea-level rises.
- For Lake McLarty and Lake Mealup the vulnerability is moderate in 2030, high in 2050 and 2070 and extreme in 2120 reflecting the sensitivity of the Lake systems should salt-water intrusion from the Estuary in large events under sea-level rise projections become commonplace. It is noted the flood control weir at Lake Mealup is not considered in this assessment - this is discussed further in Chapter Report 4 - controls.



Legend

Inundation

Coastal Processes

Setbacks

— 2020

— 2030

— 2050

— 2070

— 2120



0 200
metres

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray. Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site. Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

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SMU 2 – Birchmont

Shire of Murray

Coastal Hazard Flood Mapping

500yr ARI Design Storm
in Planning year 2120

Inundation Depth Based on Peak Water level
of 2.34m AHD (includes 0.9m Sea Level Rise)



1915 Pinjarra Rd
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Mapping prepared by **Baird.**

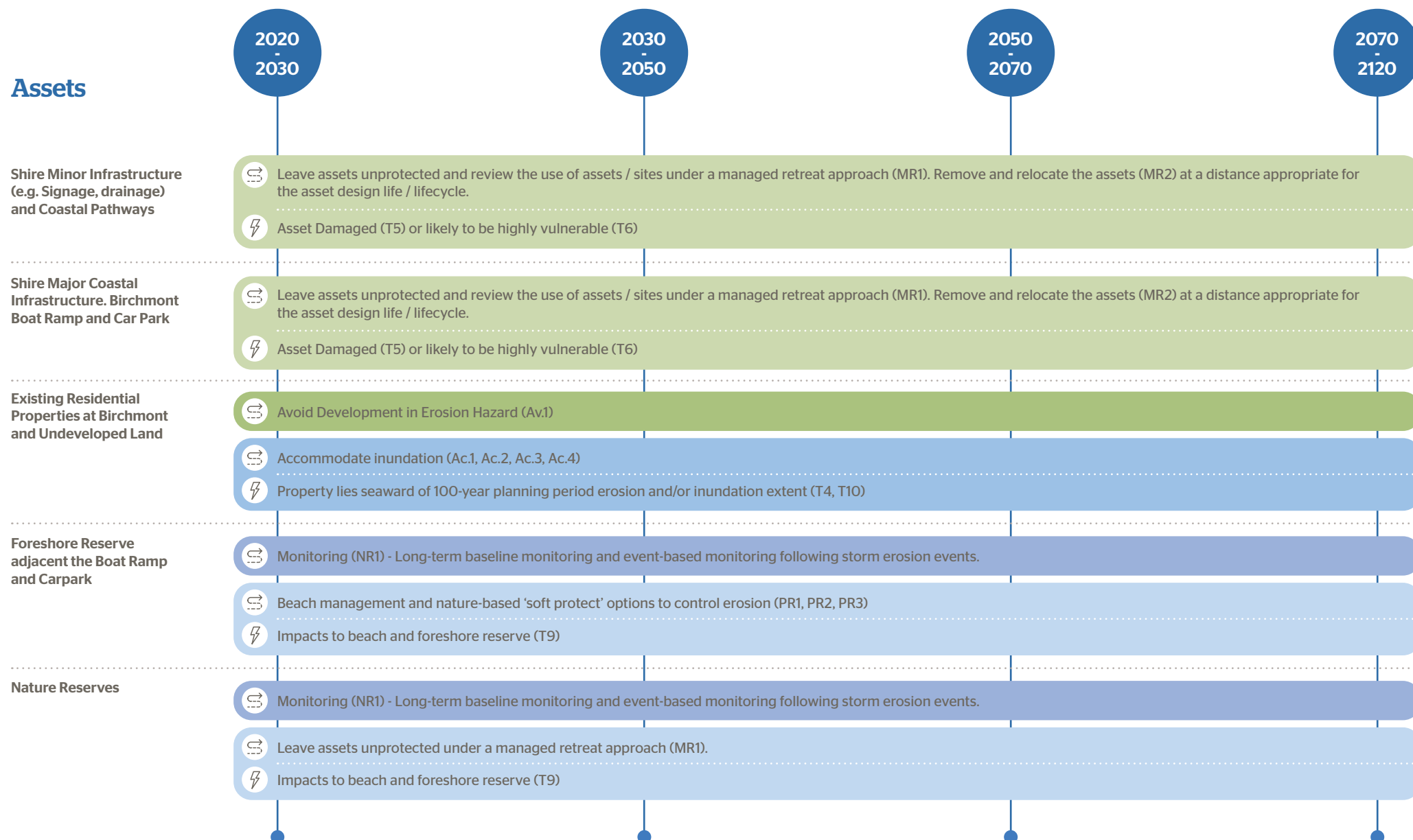
Map Published: 15 Sep. 2022





Risk management and adaptation pathways

Assets





Erosion

Vulnerability ratings

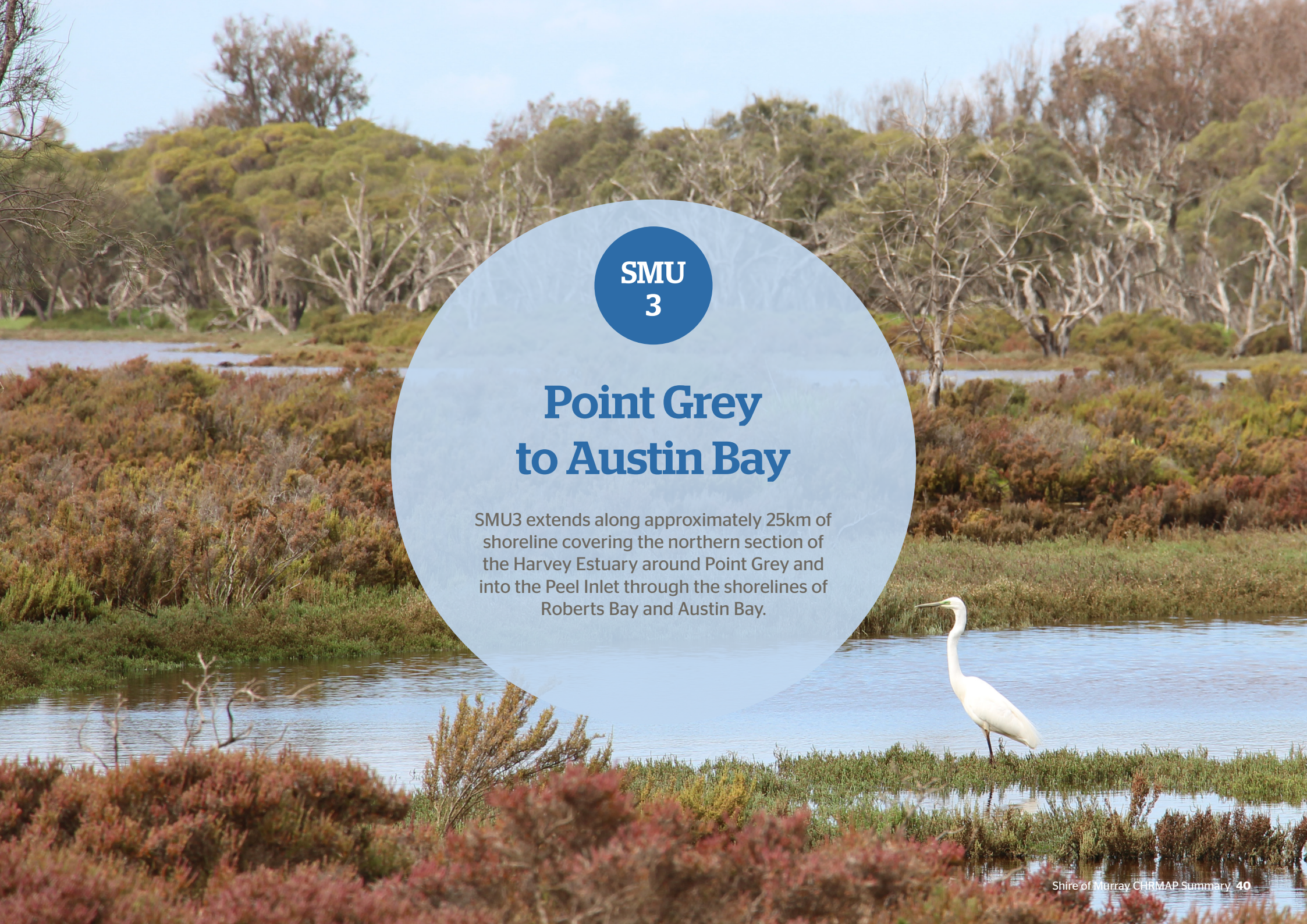
	2030	2050	2070	2120
1 Beach areas	●	●	●	●
2 Foreshore Nature Reserve	●	●	●	●
3 Lake McLarty and McLarty Nature Reserve	●	●	●	●
4 Lake Mealup / Mealup Point Nature Reserve	●	●	●	●
5 Foreshore Reserve at Birchmont Boat Ramp	●	●	●	●
6 Coastal Pathways / Bridle Paths	●	●	●	●
7 Residential Properties	●	●	●	●
8 Carpark at Birchmont Boat Ramp	●	●	●	●
9 Birchmont Boat Ramp	●	●	●	●
10 Minor Infrastructure (signage, fencing)	●	●	●	●
11 Roads	●	●	●	●



Inundation

Vulnerability ratings

	2030	2050	2070	2120
1 Beach areas	●	●	●	●
2 Foreshore Nature Reserve	●	●	●	●
3 Lake McLarty and McLarty Nature Reserve	●	●	●	●
4 Lake Mealup / Mealup Point Nature Reserve	●	●	●	●
5 Foreshore Reserve at Birchmont Boat Ramp	●	●	●	●
6 Coastal Pathways / Bridle Paths	●	●	●	●
7 Residential Properties	●	●	●	●
8 Carpark at Birchmont Boat Ramp	●	●	●	●
9 Birchmont Boat Ramp	●	●	●	●
10 Infrastructure (signage, fencing, bus shelter)	●	●	●	●
11 Drainage features	●	●	●	●
12 Roads	●	●	●	●



**SMU
3**

Point Grey to Austin Bay

SMU3 extends along approximately 25km of shoreline covering the northern section of the Harvey Estuary around Point Grey and into the Peel Inlet through the shorelines of Roberts Bay and Austin Bay.

SMU 3 – Point Grey to Austin Bay

The shoreline through this SMU is undeveloped with foreshore reserve and nature reserve providing a buffer between the Peel-Harvey shorelines and areas landward. Around Point Grey, the natural topography rises sharply directly inland of the shoreline, reducing the inundation hazard extent to a minimum. The shoreline areas are much flatter through the Peel sections of Roberts Bay and Austin Bay and inundation hazard reaches further inland compared with Point Grey. In future planning periods extreme flooding scenarios impact agricultural land on the edge of the nature reserve of Austin Bay.

In total there are around 20 properties within the mapped at-risk areas and the majority of the impacts are in the 2070 to 2120 period with sea-level rises and are due to minor flooding.



Erosion

The erosion vulnerability assessment showed:

- A high rating for Carrabungup Road in 2030 and very high from 2050 onwards. For the beach areas and drainage features these are also rated highly vulnerable to erosion from 2030 onwards.
- Foreshore reserve, coastal pathways and agricultural land are rated moderate in 2030 and highly vulnerable by planning year 2050. For residential lots on Point Grey, small sections of the land area adjacent the Peel-Harvey estuary are rated highly vulnerable from planning year 2070.

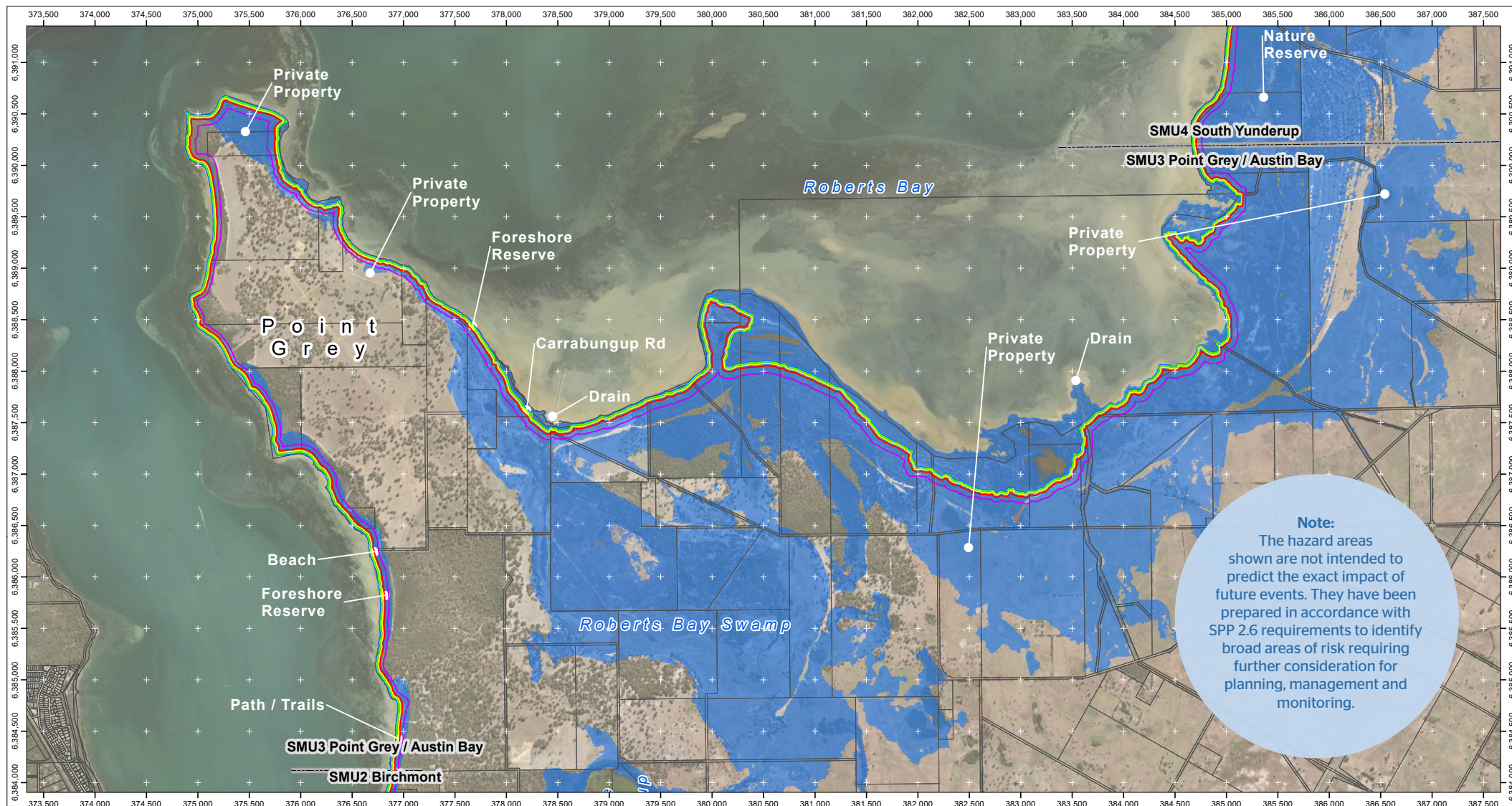


Inundation

The findings of the inundation assessment were:

Most of the coast assets were rated low to moderate, with the exception of:

- Carrabungup Rd which is rated highly vulnerable through all planning periods. The Carrabungup Rd section along Roberts Bay approaching Point Grey is low lying and close to the Peel Estuary shoreline.
- Roberts Bay swamp which is rated highly vulnerable at 2030 and then very highly vulnerable thereafter under projected sea-level rise. This is primarily based on the understanding that increasing salt-water intrusion is a major threat to the ecological character of Roberts Bay swamp.



Legend

 Inundation

Coastal Processes

Setbacks

— 2020
— 2030
— 2050
— 2070
— 2120



0 200
metres

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray. Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site. Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Disclaimer

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SMU 3 – Point Grey / Austin Bay

Shire of Murray Coastal Hazard Flood Mapping

500yr ARI Design Storm in Planning year 2120

**Inundation Depth Based on Peak Water level
of 2.34m AHD (includes 0.9m Sea Level Rise)**



1915 Pinjarra Rd
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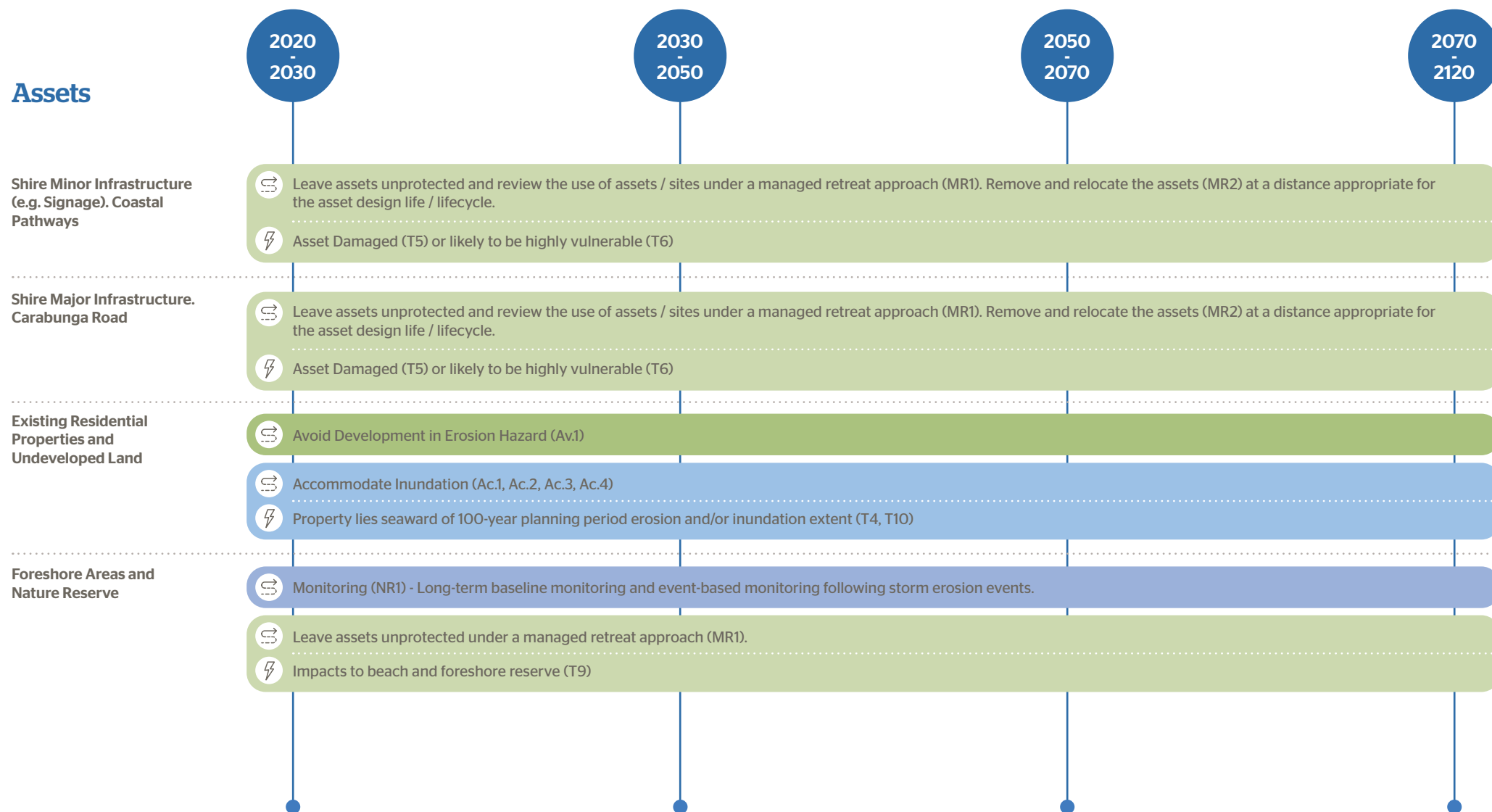
Mapping prepared by **Baird.**

Map Published: 15 Sep. 2022



Risk management and adaptation pathways

Assets





Erosion

Vulnerability ratings

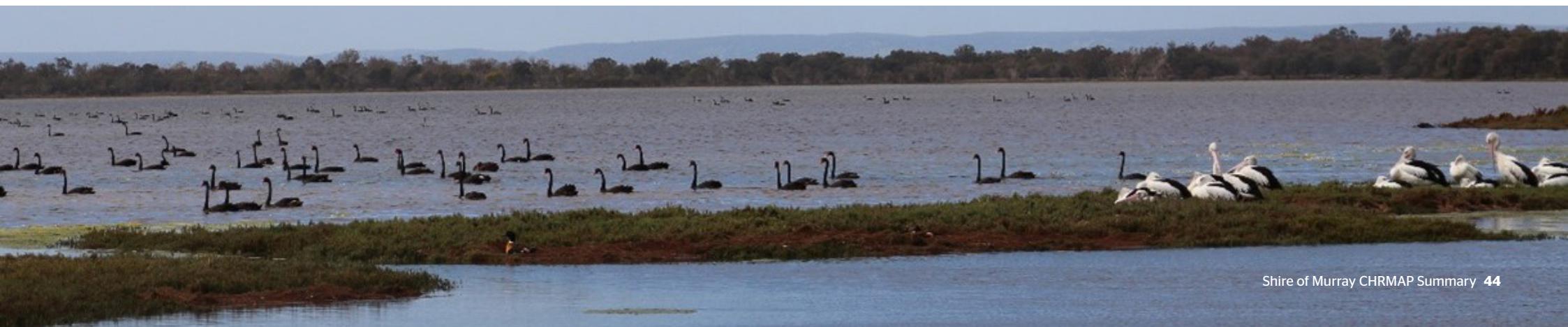
	2030	2050	2070	2120
1 Beach areas	●	●	●	●
2 Foreshore Nature Reserve	●	●	●	●
3 Austin Bay Nature Reserve	●	●	●	●
4 Foreshore Reserve	●	●	●	●
5 Coastal Pathways / Bridle Paths	●	●	●	●
6 Residential Properties	●	●	●	●
7 Agricultural Properties	●	●	●	●
8 Minor Infrastructure (signage, fencing)	●	●	●	●
9 Drainage features	●	●	●	●
10 Roads (Carabunga Road)	●	●	●	●



Inundation

Vulnerability ratings

	2030	2050	2070	2120
1 Beach areas	●	●	●	●
2 Foreshore Nature Reserve	●	●	●	●
3 Austin Bay Nature Reserve	●	●	●	●
4 Robert Bay Swamp	●	●	●	●
5 Coastal Pathways / Bridle Paths	●	●	●	●
6 Residential Properties	●	●	●	●
7 Agricultural Properties	●	●	●	●
8 Minor Infrastructure (signage, fencing)	●	●	●	●
9 Drainage features	●	●	●	●
10 Roads (Carabunga Road)	●	●	●	●





SMU
4

South Yunderup

SMU4 describes South Yunderup, including the 4km section of the Peel Estuary shoreline south of the Murray River entrance as well as the southern side of the Murray River from the entrance to Pinjarra Road (~7.5km). The South Yunderup canals and the Austin Lakes development are included in the SMU.

SMU 4 – South Yunderup

In South Yunderup there are around 1500 private lots within the mapped at-risk areas, however the majority are impacted in the 2070 to 2120 period with sea-level rises and are due to minor flooding. There are significant implications for the dredge spoil site at Batavia Quay should the revetment fail; therefore, specific monitoring and maintenance needs to be built in to specific site management.



Erosion

The erosion vulnerability assessment showed:

- Beaches of the Peel and the riverbank areas were rated highly vulnerable in the 2030 period increasing to very high later in the planning timeframe.
- At Batavia Quay the revetment on the Peel shoreline has been established to protect the area inland, which was the site of the dredge spoil for the original canals of South Yunderup. Acid Sulphate Soils are located on the site which if disturbed and released into the Murray River would cause environmental damage.
- Residential properties located in the section of shoreline between Young Rd to Strain Glen and from Pelican Road to Banksia Terrace are rated highly vulnerable in 2030 and very high from 2050 onwards.
- The bund in front of the South Yunderup canals is rated high to very highly vulnerable in the 2070 to 2120 planning periods.
- Coastal pathways, car parks and toilets adjacent the River Murray are all rated highly vulnerable over the planning timeframe. Jetties, boat launch areas and foreshore reserve are rated highly vulnerable.
- Drainage features (culverts/ pipework etc) and Watercorp infrastructure is rated high to very highly vulnerable through the planning periods due to its close proximity to the coastal erosion hazard area.



Inundation

The findings of the inundation assessment were:

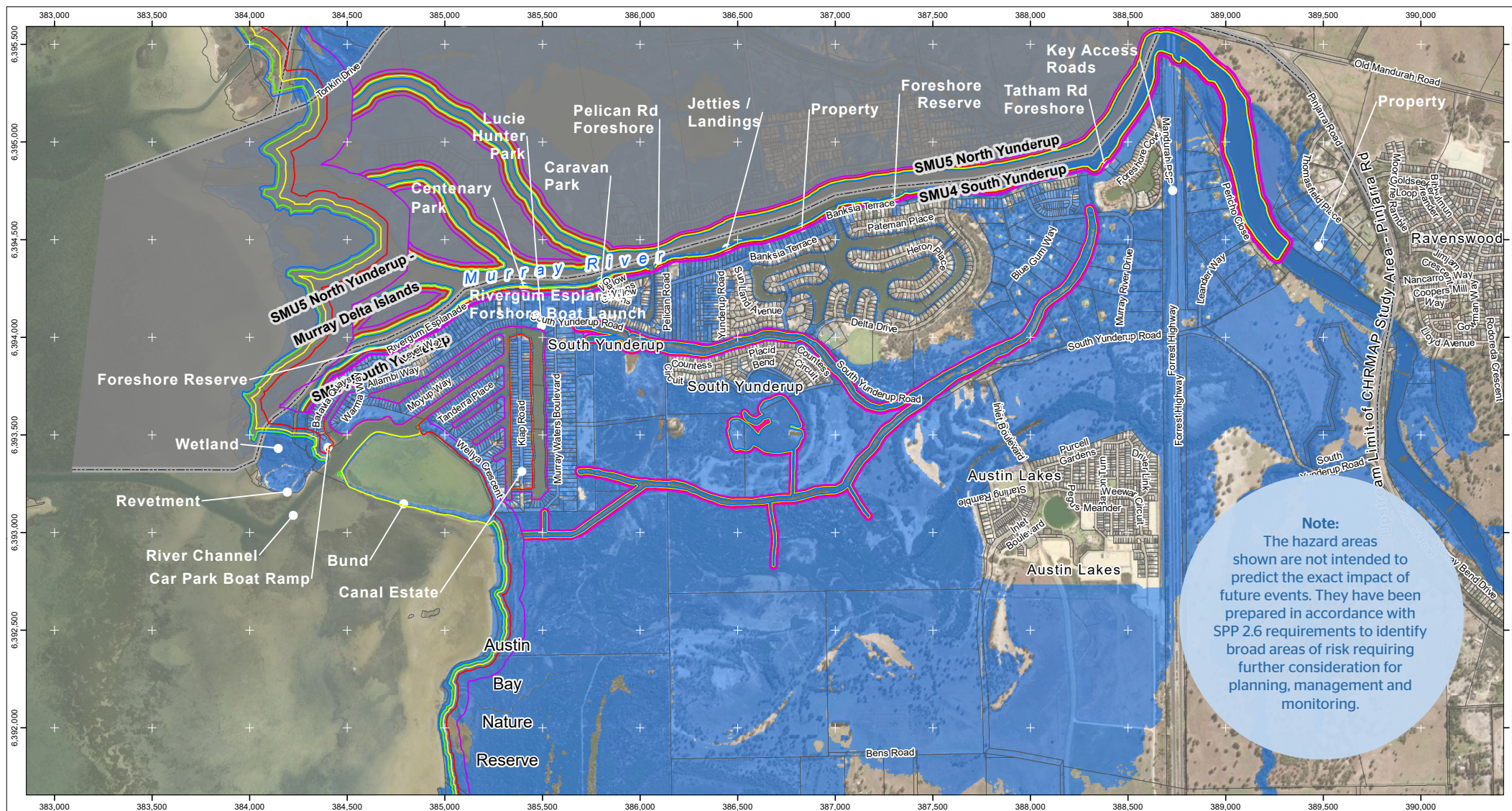
- The lower Peel shoreline and the Austin Bay nature reserve are very low lying and susceptible to flooding. Inland development is minimal through this section of the coast with agricultural land around Beacham Rd experiencing coastal inundation hazard in extreme events in future planning periods. The planning levels for the recently established Austin Cove development are safely above the coastal inundation hazard over the 100-year planning timeframe.
- For the south Yunderup canal developments, the floor level of properties is set high enough that vulnerability inundation is rated low until the year 2120 at which point it is rated moderate.
- The recent canal developments and landside areas around the Sandy Cove Tavern and South Yunderup sports club are all sited above the inundation hazard.
- The bund feature that is constructed on the Peel shoreline in front of the canal development to control water quality is rated as highly vulnerable to inundation in 2030 and 2050 and then very highly vulnerable in future planning years.
- The revetment on the Peel shoreline at the Murray entrance adjacent to Batavia Quay protects the site of the dredge spoil sediments (Acid Sulphate Soils) which if released into the Murray River would be harmful. The level of the revetment is expected to protect the region from inundation in all coastal inundation scenarios. It is imperative this revetment be maintained in its current form or higher in future planning periods.
- For residential areas along the Murray there are two key areas which are rated highly vulnerable to inundation by planning year 2120. These are for properties located in the section between Young Rd to Strain Glen and from Pelican Road to Banksia Terrace. The finished floor level of the properties was determined by assessing the ground level of the LiDAR with the addition of 0.3m assumed for freeboard (e.g. pad height of developed properties).
- Other assets that are rated highly vulnerable in the 2030 period include drainage features and WaterCorp infrastructure due to being located close to the shoreline areas

Flooding over jetty



Bowser underwater during flood





- Legend**
- Inundation
 - Coastal and River Processes Setbacks



0 200 metres

Source Data
Inundation areas defined from LIDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray. Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site. Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Disclaimer
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SMU 4 – South Yunderup

Shire of Murray Coastal Hazard Flood Mapping

**500yr ARI Design Storm
in Planning year 2120**

**Inundation Depth Based on Peak Water level
of 2.34m AHD (includes 0.9m Sea Level Rise)**



1915 Pinjarra Rd
Pinjarra WA 6208
<https://www.murray.wa.gov.au/>

Mapping prepared by **Baird.**

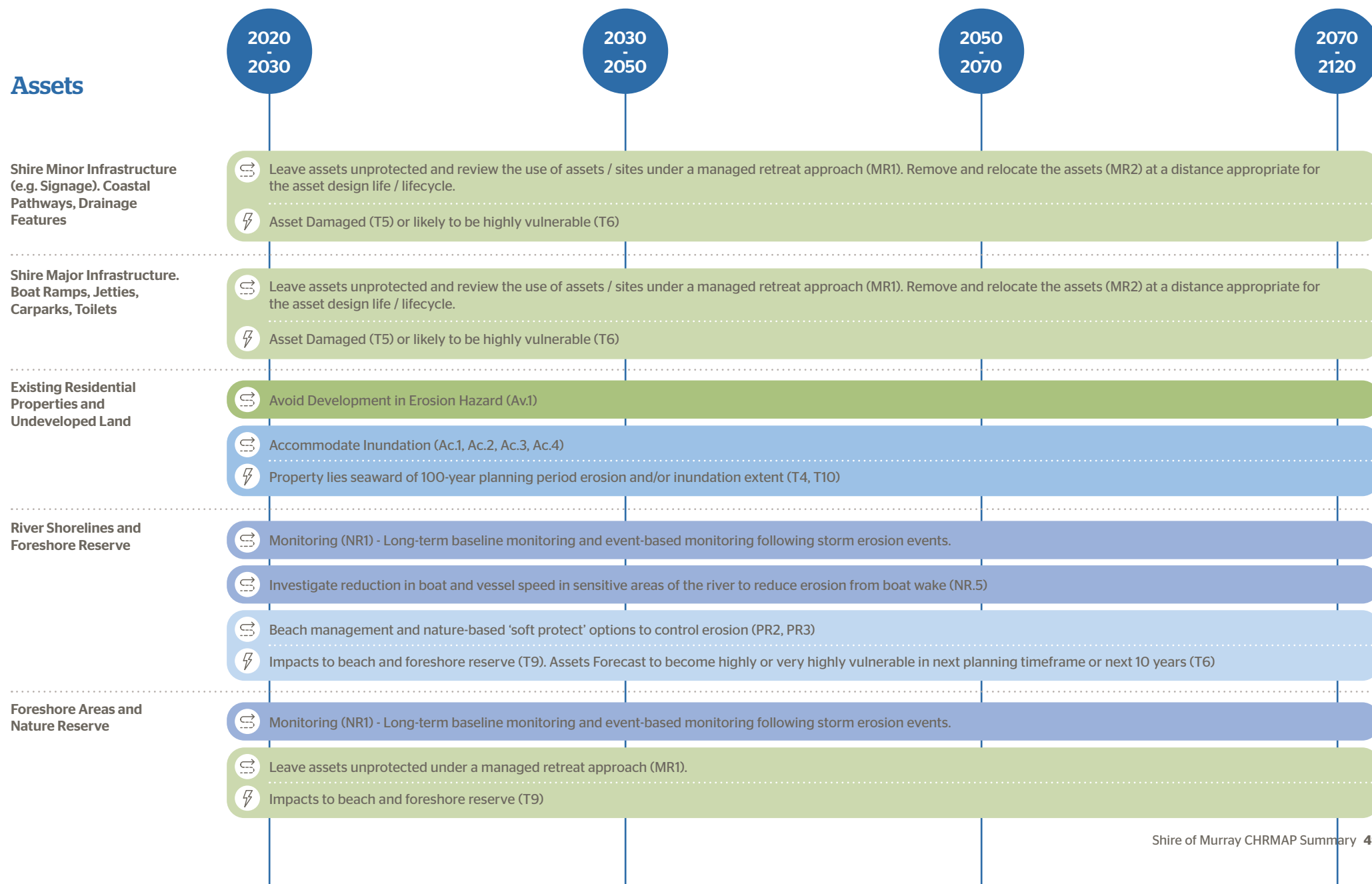
Map Published: 30 Sep. 2022





Risk management and adaptation pathways

Assets



	2020 - 2030	2030 - 2050	2050 - 2070	2070 - 2120
Protection Structures and Seawalls - Batavia Quays, South Yunderup Bund, Canals	Monitoring (NR1) - Long term baseline monitoring and event-based monitoring following storm erosion events and inundation events.			
	Berm management, planting and nature based 'soft protect' options to control erosion (PR1, PR2, PR3)			
	Impacts to beach and river shorelines (T9)			
Key Access Roads	Develop Emergency evacuation plan for key routes such as South Yunderup Road (NR.4)			

Avoid

Planned/Managed Retreat

Accommodate

Protect

No Regrets

Do Nothing



Pathways



Trigger





Erosion

Vulnerability ratings

		2030	2050	2070	2120
1	Beach areas - Peel Inlet facing beach Batavia	●	●	●	●
2	Riverbanks - Murray River	●	●	●	●
3	Austin Bay Nature Reserve	●	●	●	●
4	Batavia Quays Wetland	●	●	●	●
5	Batavia Quays Dredge Spoil Site ^{4.1}	●	●	●	●
6	S.Y. Canal Bund - Water Quality ^{4.2}	●	●	●	●
7	Coastal Pathway - Bund, S.Y. canals ^{4.2}	●	●	●	●
8	Coastal Pathway - Wellya Crescent Park ^{4.2}	●	●	●	●
9	Foreshore Reserve (Tatham Rd, Rivergum Esplanade, Centenary Park)	●	●	●	●
10	Coastal Pathways Murray River (Tatham Rd, Rivergum Esplanade) ^{4.5a}	●	●	●	●
11	Coastal Pathway, Batavia Quay Headland ^{4.1}	●	●	●	●
12	Res. Properties S.Y Canal Estate ^{4.2 4.3}	●	●	●	●
13	Res. Properties Placid Bend, Chipper Way, Countess Circuit	●	●	●	●
14	Res. Properties Batavia Quay ^{4.1 4.3}	●	●	●	●
15	Res. Properties Warma Wy to Young Rd	●	●	●	●
16	Res. Properties Young Rd to Strain Glen	●	●	●	●
17	Res. Properties Pelican Rd, Banksia Terrace	●	●	●	●
18	Tathams, Murray River Caravan Park	●	●	●	●
19	Jetties and Moorings Privately Held	●	●	●	●
20	Minor Roads (Rivergum Esplanade, Young Rd, Strain Glen, Pelican Rd, Banksia Tce)	●	●	●	●

		2030	2050	2070	2120
21	Shire Jetties - Tatham Rd, Pelican Rd, Centenary Park	●	●	●	●
22	Boat Launch - Rivergum Esplanade	●	●	●	●
23	Boat Launch - Batavia Quays Launch Facility	●	●	●	●
24	Batavia Quays Club Shed	●	●	●	●
25	Toilets - Batavia Quays	●	●	●	●
26	Toilets - Pelican Road ^{4.5c}	●	●	●	●
27	Car Park - Batavia Quays	●	●	●	●
28	Car Park - Rivergum Esplanade Foreshore	●	●	●	●
29	Car Park - Centenary Park	●	●	●	●
30	Car Park - Pelican Road ^{4.5c}	●	●	●	●
31	Park Furniture - Centenary Park	●	●	●	●
32	Playground Equipment - Centenary Park	●	●	●	●
33	Park Furniture - Wellya Crescent Park ^{4.2}	●	●	●	●
34	Playground Equipment - Wellya Crescent ^{4.2}	●	●	●	●
35	Park Furniture - Pelican Rd Park ^{4.5c}	●	●	●	●
36	Playground Equipment - Pelican Rd Park ^{4.5c}	●	●	●	●
37	Park Furniture - South Yunderup Foreshore	●	●	●	●
38	Footpaths	●	●	●	●
39	Minor Infrastructure (Signage, fencing etc)	●	●	●	●
40	Drainage features (pits, pipes, culverts)	●	●	●	●
41	Water Corp Infrastructure	●	●	●	●



Inundation Vulnerability ratings

		2030	2050	2070	2120
1	Beach areas - Peel Inlet facing beach Batavia	●	●	●	●
2	Riverbanks - Murray River	●	●	●	●
3	Austin Bay Nature Reserve	●	●	●	●
4	Batavia Quays Wetland	●	●	●	●
5	Batavia Quays Dredge Spoil Site ^{4.1}	●	●	●	●
6	S.Y. Canal Bund - Water Quality ^{4.2}	●	●	●	●
7	Coastal Pathway - Bund, S.Y. canals	●	●	●	●
8	Coastal Pathway - Wellya Crescent Park	●	●	●	●
9	Foreshore Reserve (Tatham Rd, Rivergum Esplanade, Centenary Park)	●	●	●	●
10	Coastal Pathways Murray River (Tatham Rd, Rivergum Esplanade)	●	●	●	●
11	Coastal Pathway, Batavia Quay Headland ^{4.1}	●	●	●	●
12	Res. Properties South Yunderup Canal	●	●	●	●
13	Res. Properties Placid Bend, Chipper Way, Countess Circuit	●	●	●	●
14	Res. Properties Batavia Quay	●	●	●	●
15	Res. Properties Warma Wy to Young Rd	●	●	●	●
16	Res. Properties Young Rd to Strain Glen	●	●	●	●
17	Res. Properties Pelican Rd, Banksia Terrace	●	●	●	●
18	Tathams, Murray River Caravan Park	●	●	●	●
19	Jetties and Moorings Privately Held	●	●	●	●
20	Minor Roads (Rivergum Esplanade, Young Rd, Strain Glen, Pelican Rd, Banksia Tce)	●	●	●	●
21	Shire Jetties - Tatham Rd, Pelican Rd, Centenary Park	●	●	●	●

Vulnerability rating ● Low ● Medium ● High ● Very High

		2030	2050	2070	2120
22	Boat Launch - Rivergum Esplanade	●	●	●	●
23	Boat Launch - Batavia Quays Launch Facility	●	●	●	●
24	Batavia Quays Club Shed	●	●	●	●
25	Toilets - Batavia Quays	●	●	●	●
26	Toilets - Pelican Road	●	●	●	●
27	Car Park - Batavia Quays	●	●	●	●
28	Car Park - Rivergum Esplanade Foreshore	●	●	●	●
29	Car Park - Centenary Park	●	●	●	●
30	Car Park - Pelican Road	●	●	●	●
31	Park Furniture - Centenary Park	●	●	●	●
32	Playground Equipment - Centenary Park	●	●	●	●
33	Park Furniture - Wellya Crescent Park ^{4.2}	●	●	●	●
34	Playground Equipment - Wellya Crescent	●	●	●	●
35	Park Furniture - Pelican Rd Park	●	●	●	●
36	Playground Equipment - Pelican Rd Park	●	●	●	●
37	Park Furniture - South Yunderup Foreshore	●	●	●	●
38	Footpaths	●	●	●	●
39	Minor Infrastructure (Signage, fencing etc)	●	●	●	●
40	Drainage features (pits, pipes, culverts)	●	●	●	●
41	Water Corp Infrastructure	●	●	●	●
42	Residential Properties Murray River Drive, Leander Way, Pericho Close ^{4.4}	●	●	●	●
43	Agricultural / Vacant Land - Beacham Rd to Austin Cove ^{4.4}	●	●	●	●
44	Major Roads (South Yunderup Road, Forrest Highway)	●	●	●	●
45	South Yunderup Fire Station	●	●	●	●
46	Toilets - Centenary Park	●	●	●	●
47	Car Park - Willow Gardens	●	●	●	●
48	Car Park - Fire Station	●	●	●	●
49	Park Furniture - Lucie Hunter Park	●	●	●	●



**SMU
5**

North Yunderup & Murray Delta Islands

SMU5 describes the areas on the northern bank of the Murray River at North Yunderup, and also includes the Murray Delta Islands.

Storm surge in
North Yunderup

SMU 5 – North Yunderup and Murray Delta Islands

The projected erosion along the banks of the Murray River is the driver for vulnerability of residential areas in SMU5. The Murray Delta islands are generally low-lying. Whilst they are generally set above the present-day extreme water levels, they are susceptible to flooding in extreme events in future planning periods under adopted sea level rise.

In this SMU there are around 300 lots impacted by erosion and inundation scenario mapping, this includes 89 private lots on the Murray Delta Islands. A number of these lots are impacted at present by minor flooding and the impacts can potentially rise in the short term.



Erosion

The erosion vulnerability assessment showed:

- The developed areas on Yunderup Island, Ballee Island and Cooleenup are all rated very highly vulnerable by planning year 2070. For the residential properties on Culeenup Road along the river, these are rated very highly vulnerable from 2030.
- The site of Coopers Mill and the caretakers house are rated highly vulnerable in planning year 2030 and beyond.
- The beaches on the Peel Estuary and the riverbank areas of the Murray and Delta Islands are all rated high to very highly vulnerable through the planning timeframe.
- The car park at the boat launch and the toilets adjacent to Coopers Mill are both rated highly to very highly vulnerable over the planning timeframe.
- Jetties, boat launch areas, coastal pathways and foreshore reserve are rated highly vulnerable.
- Drainage features (culverts/ pipework etc) and Watercorp infrastructure is rated high to very highly vulnerable through the planning periods due to its close proximity to the coastal erosion hazard area.



Inundation

The findings of the inundation assessment were:

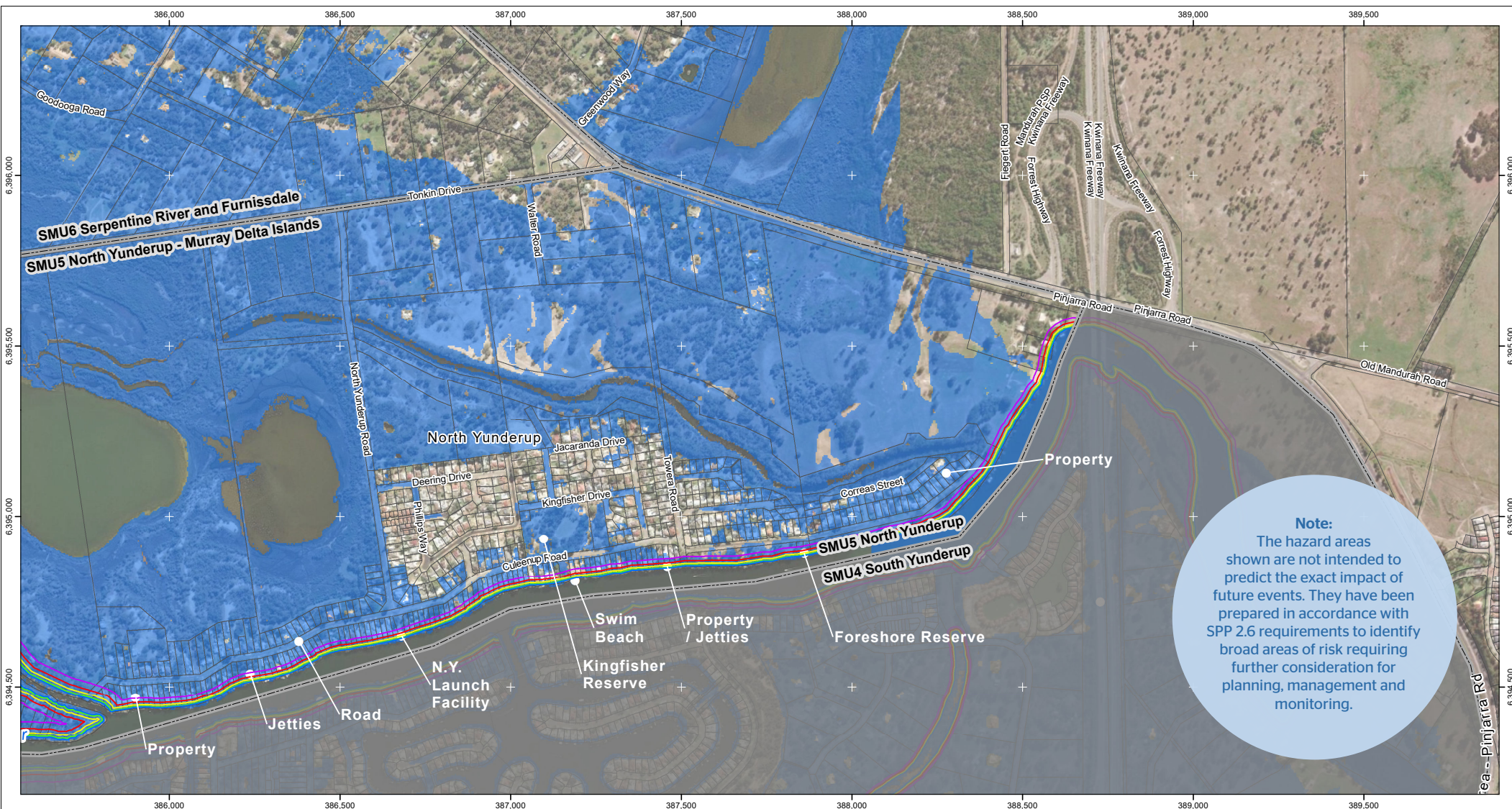
- The vulnerability rating for residential properties on the Murray Delta Islands increased through future planning periods and was rated high in 2050 and 2070 and very high in 2120, due to the increased exposure risk to flooding as a result of projected sea-level rises. The floor level of the properties was determined by assessing the ground level of the LiDAR around established structures with an addition of +0.3m assumed for freeboard (e.g. pad height of developed properties). It is noted that the land area around the house is generally at a lower elevation.
- It is assumed all island properties are on septic systems. These are rated as highly vulnerable from 2030 onward on all islands. The level of the septic system is considered to be just above the highest astronomical tide (0.6m to 0.7m AHD). The risk of flooding is rated extreme, with the septic system considered to have good adaptive capacity. The resulting vulnerability rating is high for all planning periods.
- Coopers Mill is rated highly vulnerable in all planning periods. The site is low lying and close to the rivers edge and there is evidence of previous flooding from recent large storms events.
- Drainage features (culverts/ pipework etc) and Watercorp infrastructure is rated highly vulnerable through the planning periods due to its close proximity to the coastal erosion hazard area.



Cooleenup
Island is also
the location of the
heritage-listed Coopers
Mill which is unique in
Western Australia and
currently impacted by
storm surge and
inundation.



Cooper's Mill 1910, published in
the Western Mail by E.L. Mitchell



Legend

-  Inundation
- Coastal and River Processes Setbacks**
-  2020
-  2030
-  2050
-  2070
-  2120



0 200 metres

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray. Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site. Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Disclaimer

The hazard areas depicted in this map are presented as potential inundation and coastal processes areas of impact based on SPP2.6 requirements. These future scenarios are based on work presented in Seashore 2021 and used to inform areas requiring further consideration for planning, management and monitoring in CHRMAP.

SMU 5 – North Yunderup

Shire of Murray

Coastal Hazard Flood Mapping

500yr ARI Design Storm
in Planning year 2120

Inundation Depth Based on Peak Water level
of 2.34m AHD (includes 0.9m Sea Level Rise)



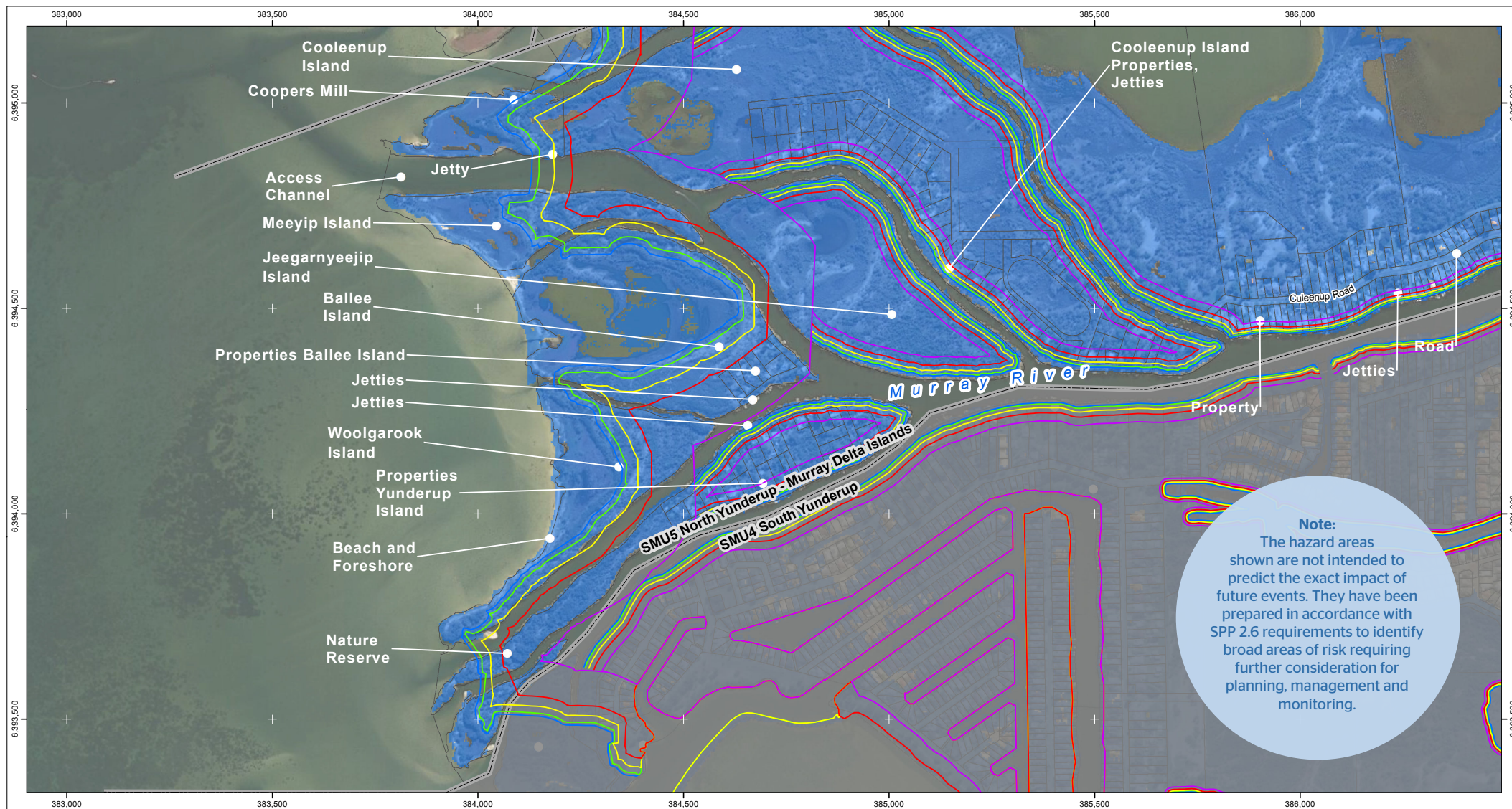
1915 Pinjarra Rd
Pinjarra WA 6208

<https://www.murray.wa.gov.au/>

Mapping prepared by **Baird.**

Map Published: 28 Sep. 2022





Legend

Inundation

Coastal and River Processes Setbacks

— 2020
— 2030
— 2050
— 2070
— 2120



0 200 metres

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray. Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site. Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

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The hazard areas depicted in this map are presented as potential inundation and coastal processes areas of impact based on SPP2.6 requirements. These future scenarios are based on work presented in Seashore 2021 and used to inform areas requiring further consideration for planning, management and monitoring in CHRMAP.

SMU 5 – North Yunderup – Murray Delta Islands

Shire of Murray
Coastal Hazard Flood Mapping

500yr ARI Design Storm
in Planning year 2120

Inundation Depth Based on Peak Water level
of 2.34m AHD (includes 0.9m Sea Level Rise)



1915 Pinjarra Rd
Pinjarra WA 6208

<https://www.murray.wa.gov.au/>

Mapping prepared by **Baird.**

Map Published: 30 Sep. 2022





Flooding at Coopers Mill during Tropical Cyclone Seroja storm event in May 2021 as a result of storm surge.



Risk management and adaptation pathways

Assets

Shire Minor Infrastructure
(e.g. Signage). Coastal
Pathways, Drainage
Features

2020
-
2030



Leave assets unprotected and review the use of assets / sites under a managed retreat approach (MR1). Remove and relocate the assets (MR2) at a distance appropriate for the asset design life / lifecycle.



Asset Damaged (T5) or likely to be highly vulnerable (T6)

Shire Major Infrastructure.
Boat Ramps, Jetties,
Carparks, Toilets



Leave assets unprotected and review the use of assets / sites under a managed retreat approach (MR1). Remove and relocate the assets (MR2) at a distance appropriate for the asset design life / lifecycle.



Asset Damaged (T5) or likely to be highly vulnerable (T6)

**Berm along the western
shoreline of the Murray
Delta Islands in Peel Inlet**



Monitoring (NR1) - Long-term baseline monitoring and event-based monitoring following storm erosion events.



Berm management, planting and nature-based 'soft protect' options to control erosion (PR1, PR2, PR3)



Impacts to beach and foreshore (T9)

**Existing Residential
Properties and
Undeveloped Land
- North Yunderup
Culeenup Rd**



Avoid Development in Erosion Hazard (Av.1)

- Amend local planning scheme to include Special Control Area which encompasses all areas affected by either erosion or inundation hazard over the 100-year planning period.
- Establish planning-based controls that only allow development in the SCA that can address coastal hazard.



Accommodate Inundation (Ac.1, Ac.2, Ac.3, Ac.4)



Property lies seaward of future planning period erosion and/or inundation extent (T4, T10)

**River Shoreline section of
Culeenup Road Properties
with River Frontage**



Monitoring (NR1) - Long-term baseline monitoring and event-based monitoring following storm erosion events.



Residential or commercial property lies seaward of the most up to date 100-year coastal erosion hazard line or coastal inundation hazard extent (T4)



Engineering edge treatments to protect against erosion and inundation (PR.4)



Assets predicted to become highly/very highly vulnerable within next planning timeframe or within 10 yrs (T6)

	2020 - 2030	2030 - 2050	2050 - 2070	2070 - 2120
River Shorelines, Peel Inlet Shorelines and Foreshore Reserve	 Investigate reduction in boat and vessel speed in sensitive areas of the river to reduce erosion from boat wake (NR.5)			
	 Berm management, planting and nature-based 'soft protect' options to control erosion (PR1, PR2, PR3)			
	 Impacts to beach and foreshore reserve (T9)			
Murray Delta Islands - Residential Properties	 Avoid Development in Erosion Hazard (Av.1) • Amend local planning scheme to include Special Control Area which encompasses all areas affected by either erosion or inundation hazard over the 100-year planning period. • Establish planning-based controls that only allow development in the SCA that can address coastal hazard.		 Removal or relocation of Asset (MR2)	
	 Accommodate inundation (Ac.1, Ac.2, Ac.3, Ac.4)			
	 Monitoring (NR1) - Long-term baseline monitoring and event-based monitoring following storm erosion events.			
	 Property lies seaward of 100-year planning period erosion and/or inundation extent (T4, T10)		 HSD is within the S1 distance, asset becomes highly vulnerable or damaged due to erosion (T1, T5, T6).	
Murray Delta Islands - Shorelines Ballec Island, Yunderup Island, Cooleenup Island Adjacent Residential Properties	 Monitoring (NR1) - Long-term baseline monitoring and event-based monitoring following storm erosion events.			
	 Berm management, planting and nature-based 'soft protect' options to control erosion (PR1, PR2, PR3)			
	 Impacts to beach and river shorelines (T9)			
Coopers Mill	 Monitoring (NR1) - Long-term baseline monitoring and event-based monitoring following storm erosion events and inundation events.			
	 Berm management, planting and nature-based 'soft protect' options to control erosion (PR1, PR2, PR3)			
	 Impacts to beach and river shorelines (T9)			
	 Do Nothing (DN1) - For inundation : Take no action and accept the risk			
General River Shorelines and Nature Reserve	 Monitoring (NR1) - Long-term baseline monitoring and event-based monitoring following storm erosion events.			
	 Investigate reduction in boat and vessel speed in sensitive areas of the river to reduce erosion from boat wake (NR.5)			
	 Do Nothing (DN1)			

Shire of Murray CHRMAP Summary 60

	2020 - 2030	2030 - 2050	2050 - 2070	2070 - 2120
Key Access Roads	- Pathways Develop Emergency evacuation plan for key routes such as North Yunderup Road (NR.4) - Trigger Assets predicted to become highly or very highly vulnerable within next 10 years (T6)	- Pathways Design Assets to withstand Coastal Hazard Impacts (AC2, AC3, AC4) - Pathways Leave assets unprotected and review the use of assets / sites under a managed retreat approach (MR1). Remove and relocate the assets (MR2) at a distance appropriate for the asset design life / lifecycle. - Trigger Asset is damaged or unsafe (T5)		
Coopers Mill	- Pathways Monitoring (NR1) - Long-term baseline monitoring and event-based monitoring following storm erosion events and inundation events. - Pathways Berm management, planting and nature-based 'soft protect' options to control erosion (PR1, PR2, PR3) - Trigger Impacts to beach and river shorelines (T9) - Pathways Do Nothing (DN1) - For inundation : Take no action and accept the risk			
Avoid Planned/Managed Retreat Accommodate Protect No Regrets Do Nothing Pathways Trigger				





Erosion

Vulnerability ratings

		2030	2050	2070	2120
1	Beaches, Peel Inlet Murray Delta Islands	●	●	●	●
2	Riverbank - Delta Islands and Murray River	●	●	●	●
3	Nature Reserve, West end Yunderup Island	●	●	●	●
4	Ballee Island Wetland	●	●	●	●
5	Pathway - Culeenup Rd east of Towerup St	●	●	●	●
6	Foreshore Reserve - Culeenup Rd	●	●	●	●
7	Foreshore Reserve - Yunderup Island, Ballee Island, Cooleenup Island	●	●	●	●
8	Residential Properties North Yunderup, Culeenup Rd	●	●	●	●
9	Residential Properties Thomasfield Pl, Ravenswood	●	●	●	●
10	Residential Properties Yunderup Island	●	●	●	●
11	Residential Properties Ballee Island	●	●	●	●
12	Residential Properties Cooleenup Island	●	●	●	●
13	Jetties and Moorings - Privately Held	●	●	●	●
14	Minor Roads Culeenup Rd West ^{5.3b}	●	●	●	●
15	Shire Jetties - Culeenup Rd, Coopers Mill Precinct, North Yunderup Launch Facility.	●	●	●	●
16	Boat Launch - North Yunderup Launch	●	●	●	●
17	Toilets - Coopers Mill Precinct	●	●	●	●
18	Car Park - North Yunderup Launch Facility	●	●	●	●
19	Park Furniture - North Yunderup Foreshore	●	●	●	●
20	Park Furniture- North Yunderup Launch	●	●	●	●

Nature-based solutions



		2030	2050	2070	2120
21	Park Furniture - Coopers Mill Precinct	●	●	●	●
22	Playground Equipment - Coopers Mill	●	●	●	●
23	Footpaths	●	●	●	●
24	Minor Infrastructure (Signage, fencing etc)	●	●	●	●
25	Drainage features (pits, pipes, culverts)	●	●	●	●
26	WaterCorp Infrastructure	●	●	●	●
27	Coopers Mill	●	●	●	●
28	Coopers Mill Caretakers House	●	●	●	●



Inundation Vulnerability ratings

		2030	2050	2070	2120
1	Beaches, Peel Inlet Murray Delta Islands	●	●	●	●
2	Riverbank - Delta Islands and Murray River	●	●	●	●
3	Nature Reserve, West end Yunderup Island	●	●	●	●
4	Ballee Island Wetland	●	●	●	●
5	Foreshore Reserve - Culeenup Rd Towerup	●	●	●	●
6	Foreshore Reserve - Yunderup Island, Ballee Island, Cooleenup Island	●	●	●	●
7	Residential Properties North Yunderup, Culeenup Rd	●	●	●	●
8	Residential Properties Thomasfield Pl, Ravenswood ^{5.1}	●	●	●	●
9	Rural Properties Pinjarra Rd, Tonkin Drv, Walter Rd ^{5.1}	●	●	●	●
10	Residential Properties Thomasfield Pl, Ravenswood ^{5.1}	●	●	●	●
11	Residential Properties Yunderup Island	●	●	●	●
12	Residential Properties Ballee Island	●	●	●	●
13	Residential Properties Cooleenup Island	●	●	●	●
14	Septic Systems Yunderup Island	●	●	●	●
15	Septic Systems Ballee Island	●	●	●	●
16	Septic Systems Cooleenup Island	●	●	●	●
17	Jetties and Moorings along River Privately	●	●	●	●
18	Minor Roads (Culeenup Rd - Western end)	●	●	●	●
19	Major Roads (Pinjarra Rd, Forrest Hwy)	●	●	●	●
20	Shire Jetties - Culeenup Rd, Coopers Mill Precinct, North Yunderup Launch Facility.	●	●	●	●



		2030	2050	2070	2120
21	Boat Launch - N.Y Launch Facility	●	●	●	●
22	Toilets - Kingfisher Park	●	●	●	●
23	Toilets - Coopers Mill Precinct	●	●	●	●
24	Toilets - North Yunderup Launch Facility	●	●	●	●
25	Car Park - North Yunderup Launch Facility	●	●	●	●
26	Park Furniture - North Yunderup Foreshore	●	●	●	●
27	Park Furniture - North Yunderup Launch	●	●	●	●
28	Park Furniture - Coopers Mill Precinct	●	●	●	●

The background image shows a black boat with a canopy on a river. A man in a striped shirt and blue shorts is standing on a wooden dock, leaning over the side. The water is calm with some ripples. In the background, there are trees and a house.

**SMU
6**

Serpentine River and Furnissdale

SMU6 describes the approximate 5km section of the Serpentine River from the entrance to Pinjarra Road and includes the suburb of Furnissdale.

SMU 6 – Serpentine River and Furnissdale

The SMU is a mix of residential and large rural and semi-rural blocks. The inland area in the region bounded by Tonkin Rd, Goodooga Rd and Furnissdale Rd is low-lying and largely undeveloped and is susceptible to flooding. The developed areas along the river at Riverside Drive are susceptible to inundation risk in future planning periods. In total there are around 500 properties within the mapped at-risk areas and the majority of the impacts are in the 2070 to 2120 period with sea-level rises causing minor flooding.



Erosion

The erosion vulnerability assessment showed:

- The riverbank areas are high to very highly vulnerable to erosion over the planning periods.
- The foreshore reserve at Furnissdale, the jetties and boat ramp are all rated highly vulnerable.
- Car parks are rated high to very highly vulnerable over the planning period
- Residential properties along Riverside Drive near Smith Street and in the larger properties north of Paull Street were rated high to very highly vulnerable over the planning timeframe. Several residential properties on the banks of the Serpentine River in the section between Furnissdale Road and the Serpentine entrance were rated high to very highly vulnerable.
- A small section of Riverside Drive near Smith Street which is in close proximity to the foreshore is rated as high to very highly vulnerable.
- Drainage features (culverts/ pipework etc.) and Watercorp infrastructure is rated high to very highly vulnerable through the planning periods due to its close proximity to the coastal erosion hazard area.

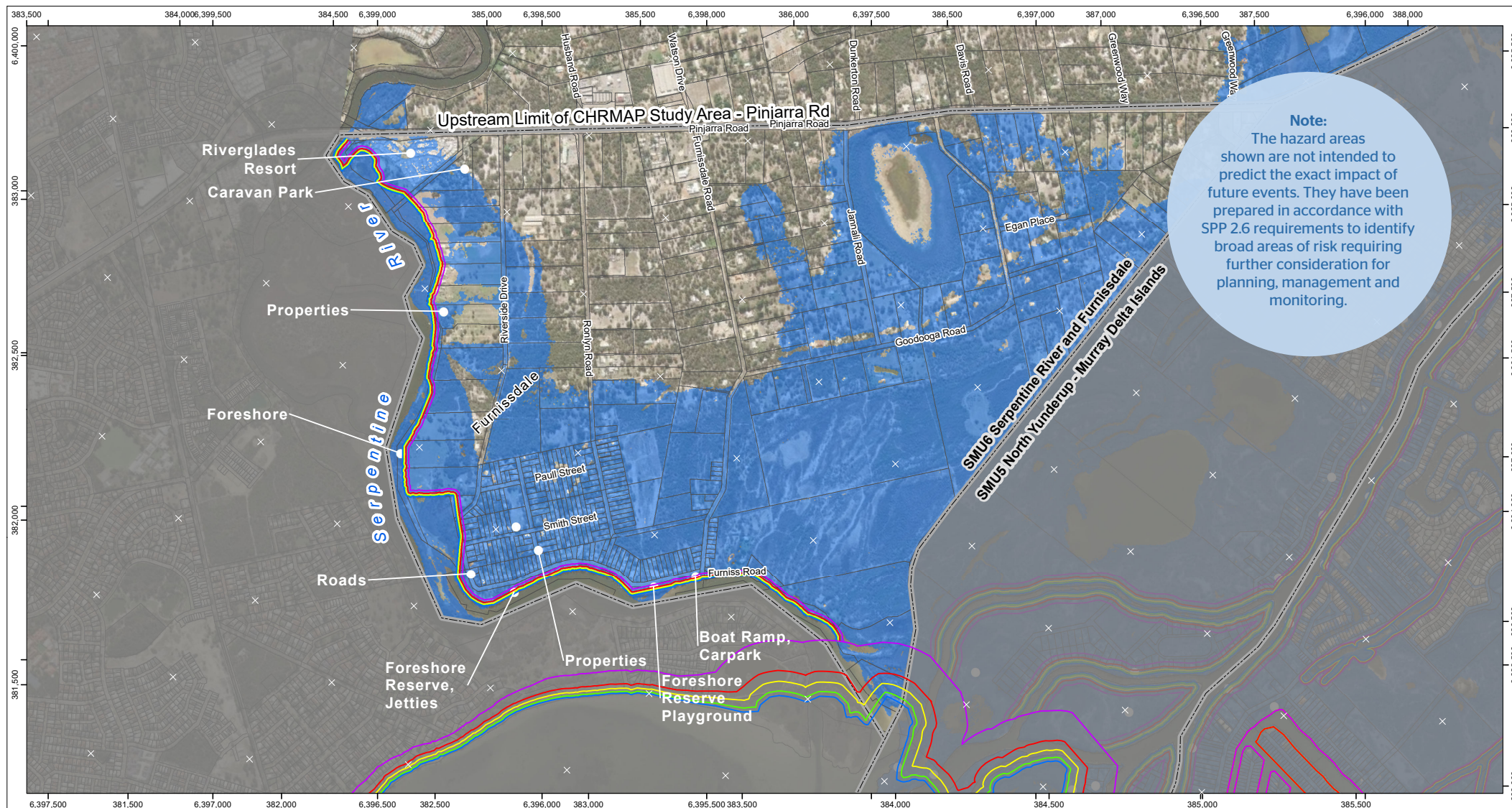


Inundation

The findings of the inundation assessment were:

- The foreshore reserve, jetties and carparks are rated at low to moderate vulnerability over the planning period.
- The residential properties along Riverside Drive are rated highly vulnerable in the planning year 2120
- Sections of Riverside drive, Ronlyn Rd and Furnissdale Rd are rated highly vulnerable by 2070 under adopted sea level rise.
- Drainage features (culverts/ pipework etc.) and Watercorp infrastructure is rated highly vulnerable through the planning periods due to its close proximity to the coastal erosion hazard area.





Legend

-  Inundation
- Coastal and River Processes Setbacks**
-  2020
-  2030
-  2050
-  2070
-  2120



0 200
metres

Source Data

Inundation areas defined from LiDAR datasets collected in 2008 (DWER) and 2016 (Landgate) through the Shire of Murray. Levels across Austin Lakes development based on construction drawings (2009) with minimum 2.9m AHD level across site. Cadastral data supplied by Landgate. This product is for information purposes only and is not guaranteed. The information may be out of date and should not be relied upon without further verification from the original documents. Where the information is being used for legal purposes then the original documents must be searched for all legal requirements.

Disclaimer

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SMU 6 – Serpentine River and Furnissdale

Shire of Murray Coastal Hazard Flood Mapping

500yr ARI Design Storm in Planning year 2120

**Inundation Depth Based on Peak Water level
of 2.34m AHD (includes 0.9m Sea Level Rise)**



1915 Pinjarra Rd
Pinjarra WA 6208

<https://www.murray.wa.gov.au/>

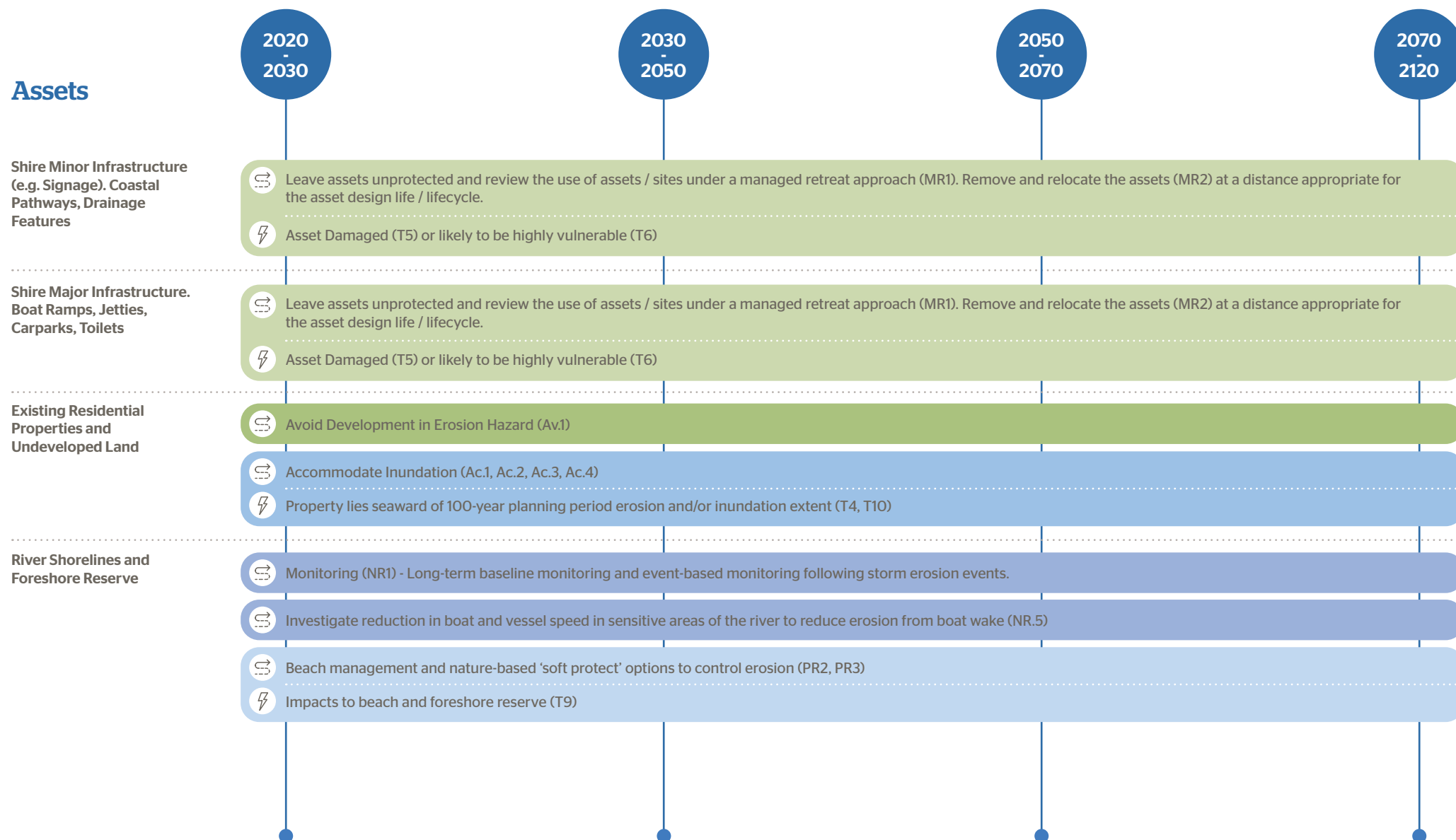
Mapping prepared by **Baird.**

Map Published: 28 Sep. 2022



Risk management and adaptation pathways

Assets





Erosion

Vulnerability ratings

		2030	2050	2070	2120
1	Riverbank - Serpentine River	●	●	●	●
2	Foreshore Reserve - Furnissdale Foreshore	●	●	●	●
3	Residential Properties Riverside Drive along	●	●	●	●
4	Residential Properties along Serpentine	●	●	●	●
5	Residential Properties Riverside Drive Smith	●	●	●	●
6	Residential Properties Riverside Drive NE of Paull St	●	●	●	●
7	River Glades Resort	●	●	●	●
8	Jetties and Moorings along River - Private	●	●	●	●
9	Minor Roads (Riverside Drive Near Smith St)	●	●	●	●
10	Shire Jetties - Furnissdale Launch Facility, Floating Jetty	●	●	●	●
11	Shire Jetties - Furnissdale Launch Facility, Timber Jetty	●	●	●	●
12	Shire Jetties - Tonkin Drive Foreshore, Timber Jetty	●	●	●	●
13	Boat Ramp - Furnissdale Launch Facility	●	●	●	●
14	Car Park - Furnissdale Launch Facility	●	●	●	●
15	Car Park - Riverside Drive	●	●	●	●
17	Car Park - Tonkin Drive Foreshore	●	●	●	●
18	Car Park - Furnissdale Bridge Foreshore ^{6.3a}	●	●	●	●
19	Park Furniture - Furnissdale Launch Facility Foreshore Reserve	●	●	●	●
20	Playground Equipment - Furnissdale Foreshore	●	●	●	●



		2030	2050	2070	2120
21	Footpaths	●	●	●	●
22	Minor Infrastructure (Signage, fencing etc)	●	●	●	●
23	Drainage features (pits, pipes, culverts)	●	●	●	●
24	WaterCorp Infrastructure	●	●	●	●



Inundation Vulnerability ratings

		2030	2050	2070	2120
1	Riverbank - Serpentine River	●	●	●	●
2	Foreshore Reserve - Furnissdale Foreshore	●	●	●	●
3	Residential Properties Riverside Drive along Furnissdale Foreshore	●	●	●	●
4	Residential Properties along Serpentine River, Tonkin Drive to Furnissdale Road	●	●	●	●
5	Residential Properties Riverside Drive Smith St to Paull St	●	●	●	●
6	Residential Properties Riverside Drive NE of Paull St ^{6.1}	●	●	●	●
7	Rural Properties Pinjarra to Goodooga Rd ^{6.1}	●	●	●	●
8	Caravan Park	●	●	●	●
9	Riverglades Resort	●	●	●	●
10	Jetties and Moorings along River - Privately	●	●	●	●
11	Minor Roads (Riverside Drive Near Smith St)	●	●	●	●
12	Minor Roads (Riverside Drive foreshore, Furnissdale Rd, Ronlyn Rd)	●	●	●	●
13	Major Roads (Pinjarra Rd)	●	●	●	●
14	Shire Jetties - Furnissdale Launch Facility, Floating Jetty	●	●	●	●
15	Shire Jetties - Furnissdale Launch Facility, Timber Jetty	●	●	●	●
16	Shire Jetties - Tonkin Drive Foreshore, Timber Jetty	●	●	●	●
17	Boat Ramp - Furnissdale Launch Facility	●	●	●	●
18	Toilets - York Road	●	●	●	●
19	Car Park - Furnissdale Launch Facility	●	●	●	●



		2030	2050	2070	2120
20	Car Park - Riverside Drive	●	●	●	●
21	Car Park - Tonkin Drive Foreshore	●	●	●	●
22	Car Park - Furnissdale Bridge Foreshore	●	●	●	●
23	Park Furniture - Furnissdale Launch Facility	●	●	●	●
24	Playground Equipment - Furnissdale	●	●	●	●
25	Park Furniture - York Road Park	●	●	●	●
26	Playground Equipment - York Road Park	●	●	●	●
27	Footpaths	●	●	●	●
28	Minor Infrastructure (Signage, fencing etc)	●	●	●	●
29	Drainage features (pits, pipes, culverts)	●	●	●	●
30	WaterCorp Infrastructure	●	●	●	●
31	York Road Clubrooms and Sports Courts	●	●	●	●

An aerial photograph of a river winding through a dense forest. On the left, a pontoon boat with a red canopy is moored. In the foreground, a houseboat with a white roof and red trim is moving downstream, leaving a white wake. Two people are visible on the deck of the houseboat. The water is calm, reflecting the surrounding trees.

6

Managing the Shire of Murray shoreline areas

Community and stakeholder preferences

Multi-criteria assessment

A multi-criteria analysis (MCA) to contrast and compare adaptation options was completed for four key focus areas highlighted in the risk assessment. An MCA is a tool to compare various alternatives or options. It provides a structured way to compare and contrast options and uses a number of criteria, and scoring of those criteria, to compare options.

Criteria were assigned a “score” based on the expected performance against three key categories:

Technical | Social | Environmental

Cost was also considered but as a standalone category.



The key focus areas that were identified for the MCA application were:

Erosion/inundation of nature reserves
Kooljerrenup

Inundation of low-lying properties
Murray Delta Islands, South / North Yunderup and Furnissdale

Erosion of riverbanks
North and South Yunderup, including Murray Delta Islands

Septic tanks

Highest ranked

A nature-based solutions approach

Planning-based approaches for housing design

Nature-based solutions (soft-edge treatments)

Upgrade to Centralised ATU was the highest ranked

Second highest-scoring

Managed Retreat with purchase of land areas followed by the Do-Nothing option

Managed-Retreat followed by the option to examine housing design using fill

Managed Retreat

Connecting to Mains Sewage

An MCA workshop was completed in November 2021. For each of the focus locations, the range of risk-mitigation approaches were discussed. Outcomes agreed in the sessions can be seen here.

Economic assessment - Cost benefit analysis

The Cost Benefit Analysis (CBA) followed on from the MCA process by examining the short-listed and highest-ranking options in detail. The CBA refines the evaluation by quantifying the economic value of the various adaptation options considered to mitigate hazards associated with coastal erosion and inundation.

The economic CBA assesses various scenarios against a “base case” scenario. In this case, a “do-minimum” scenario was adopted for the base case condition. Under this scenario, no mitigation is undertaken to protect foreshore areas or property, and erosion and inundation will continue to worsen and impact the study area. Mitigation options are then compared with the base case scenario, to determine the overall economic viability of implementing these mitigation measures.

Key mitigation measures that were assessed:



Hard-engineering option

which would include typical foreshore treatments like revetments



Nature-based solutions

which include a combination of vegetation and softer engineering solutions to provide protection

The benefits for the mitigation options were considered in terms of the protection provided for both erosion and inundation of properties. Economic values were estimated for the base case condition, as well as the mitigation option, to determine an overall net benefit. These were compared against the estimated costs for the project.

The key findings from the CBA in terms of supporting CHRMAP recommendations for adaptation options in the CMU's is summarised as follows:

Murray Delta Islands

Nature-based approaches would become viable in the next 10 years (based on low-cost to mid-range projections). It is recommended under the CHRMAP that natural approaches to protect the shoreline areas on the three islands commence now.



The Murray River shoreline of North Yunderup

Nature-based solutions perform well due to the density of properties, however there may be practical challenges due to the available space in this area. It is recommended that a technical study is undertaken in the next five years (by 2027) to examine an engineered hard structure (river wall) along the North Yunderup section of shoreline.



The shoreline along the Murray River at South Yunderup

Performs well with nature-based solutions indicating these options are supported for implementation today. These solutions suit the shoreline areas with generally greater land buffer in this location compared with the northern side of the Murray River.



Monitoring of the shoreline areas and their response to sea-level rise in the coming years will inform the future adaptation strategy for the shoreline areas.

Benefit distribution analysis

A benefit-distribution analysis was completed to examine the beneficiaries of the recommended adaptation options. This has shown that the private landholders are the key beneficiaries of many of the adaptation options recommended:

80% Murray Delta Islands

For nature-based options there is estimated to be an 80%/20% distribution of the benefit between the private landholders and the public.

50% South Yunderup shorelines

Nature-based options are estimated to deliver 50% private and 50% public benefit.

It is recommended the Shire seek funding contribution from private landholders who will directly benefit from the adaptation approaches. For the proportion of the public benefit for each respective adaptation option these would be funded by the Shire.

There are several funding mechanisms at State and Federal level available to the Shire to support the adaptation approaches which can provide public benefit. These are generally based on a co-funded approach whereby the Shire contributes 50% of the funding which is matched.

Monitoring

To further understanding of the coastal processes in the Shire and support the aims of the CHRMAP, a structured monitoring process will be developed to target key locations to improve understanding of coastal erosion and inundation impacts in the coming years. It will also provide the mechanism to assess where established triggers are being approached, to provide early indication where a change in management pathway may be required.

The monitoring and review process will ensure that the management and adaptation actions remain relevant. In conjunction with annual monitoring activities, a general review of the CHRMAP, approximately every five years, would be used to implement the findings from the monitoring program and address updates to the CHRMAP recommendations where required.

A key feature of the monitoring is the capture of aerial survey data using a drone (UAV). The capture of survey using UAV across the Murray Islands and shorelines of North Yunderup is expected to offer an efficient and cost-effective means of capturing this data when compared to traditional methods of capture by a surveyor along fixed transects.



Priority recommendations for action

Implementation Actions

The short-term implementation actions over the period 2022 to 2040 include recommendations for:

- a. Planning Actions
- b. Annual Monitoring Program
- c. Additional Technical Studies
- d. Additional Planning Based Studies and Adaptation Studies
- e. Adaptation Actions in Shoreline Areas

An overview of the actions is presented along with a summary of projected timing and estimated cost.

Planning Implementation

There are a number of planning recommendations in the short-term which involve updates to existing planning instruments and development of new policies. The key items and indicative timeframe are as follows:

- Initiate amendment to LPS4 to introduce a Special Control Area (immediately)
- Prepare a LPP (immediately)
- Prepare an Emergency Evacuation Plan (next 5-years)
- Prepare a Foreshore Management Plan (next 5-years)
- Prepare a Managed Retreat Policy (6 - 10 years)



Management of shoreline areas over the next 10 years

The use of nature based erosion protection to protect against erosion of shorelines is recommended for:

- South Yunderup Foreshore
- Yunderup Island
- Ballee Island
- Coopers Mill
- Cooleenup Island

Approx. cost **\$460k - \$1.34m**

Potential co-funding through Grants (e.g., Dept of Transport, Coastwest)



Foreshore Management at South Yunderup and Murray Delta Islands

- recommended approaches, indicative cost and timing

SMU
5

Ballee Island

Where Shoreline adjacent developed properties

What Application of nature-based revegetation and foreshore stabilisation techniques

\$50k - \$130k

2023 to 2027

SMU
4

South Yunderup

Where Shoreline Young Street Carpark to Banksia Terrace

What Application of nature-based revegetation and foreshore stabilisation techniques

\$320k - \$870k

2023 to 2027

SMU
5

Cooleenup Island

Where Shoreline adjacent developed properties

What Application of nature-based revegetation and foreshore stabilisation techniques

\$340k - \$930k

2023 to 2027

SMU
5

Yunderup Island

Where Shoreline adjacent developed properties

What Application of nature-based revegetation and foreshore stabilisation techniques

\$240k - \$670k

2023 to 2027

SMU
5

Coopers Mill Shoreline (Cooleenup Island)

Where Shoreline adjacent developed properties

What Application of nature-based revegetation and foreshore stabilisation techniques

\$140k - \$400k

2028 to 2032



Further studies

Additional studies by the Shire over the next five years to inform the next review of the CHRMAP and improve understanding of the coastal hazard risk are as follows:

Capture the elevation across the Murray Delta Islands using either traditional LiDAR or UAV

Data would be used to assess changes to the islands and to review flood risk and update mapping if/as required.

Surveyor to determine the floor level of each property for existing properties on Ballee, Yunderup and Culleenup Islands

This would give a more precise understanding of the risk of inundation in extreme events at property level.

Surveyor to determine elevation and approximate location of septic system on existing properties on Ballee, Yunderup and Culleenup Islands

This would give a more precise understanding of the risk of inundation in extreme events at property level.

Study of erosion from vessel wakes on the river shorelines in the Murray and Serpentine

The study should examine current and projected boat usage and vessel types.

Feasibility study for North Yunderup river shoreline protection options

Appoint a working group with local representatives and undertake a study to examine the requirements for foreshore protection along the section of river fronting the 100 properties on Culleenup Road.

over 5 years



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