City of Albany

Foreshore Management Plan

Emu Beach

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Contents

Tables
(contained within report text)

Plates

(contained within report text)

Figures

(contained within report text)

(compiled at rear of report)

Appendices

CERTIFICATION

This Foreshore Management Plan has been prepared to accord with State Planning Policy 2.6: State Coastal Planning Policy.

IT IS CERTIFIED THAT THIS FORESHORE MANAGEMENT PLAN WAS ENDORSED BY RESOLUTION OF THE WESTERN AUSTRALIAN PLANNING COMMISSION ON:

Signed for and on behalf of the Western Australian Planning Commission:

_____

an officer of the Commission duly authorised by the Commission pursuant to Section 16 of the *Planning and Development Act 2005* for that purpose, in the presence of:

_____

Witness signature

_____

Print name

_____

Date

ACKNOWLEDGEMENTS

This Foreshore Management Plan has been prepared in collaboration with the City of Albany and has been informed by the following key studies:

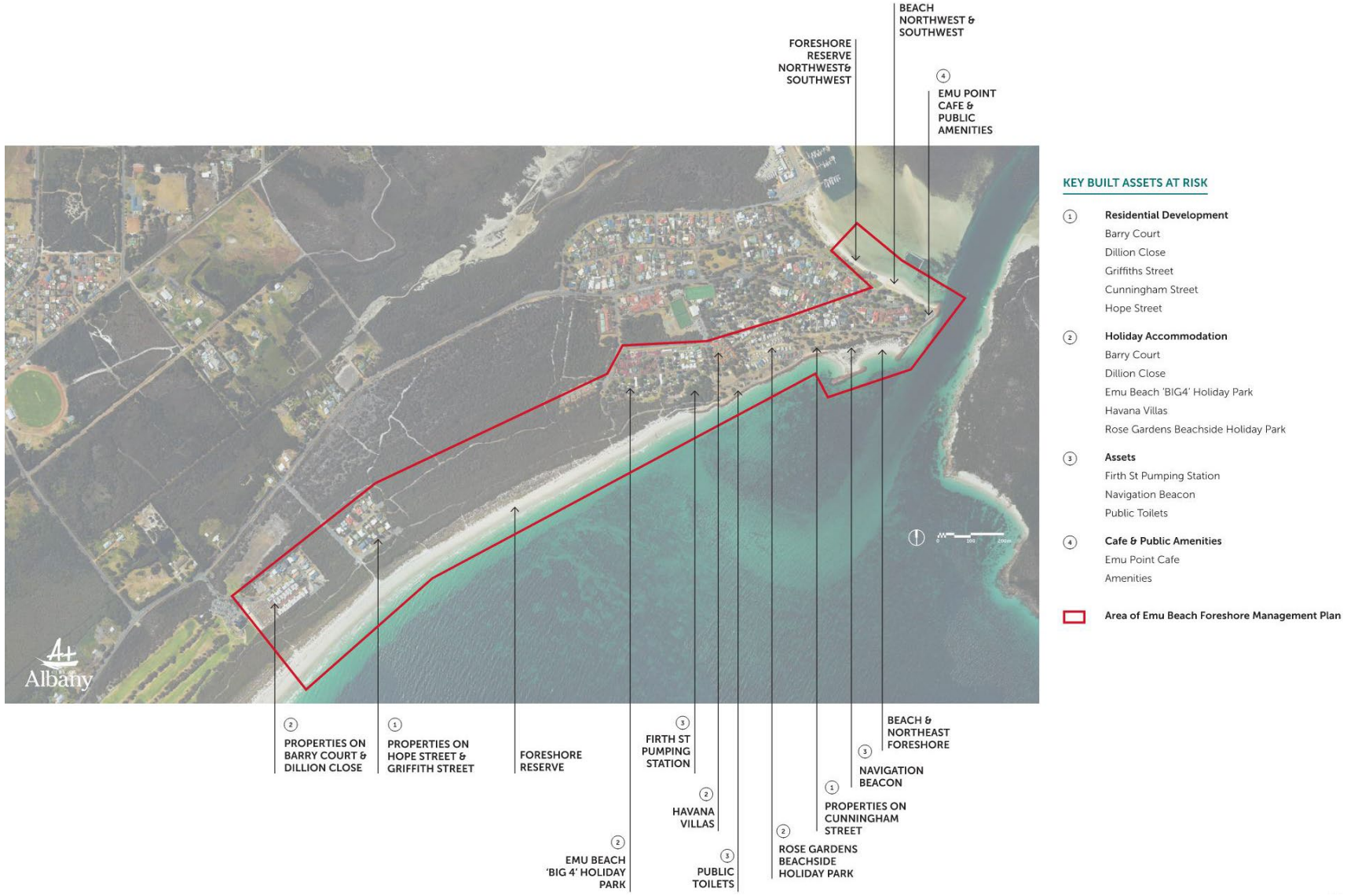
1. Landscape Master Plan prepared by SeeDesign Studio
2. Technical coastal engineering studies including the preliminary Basis of Design of coastal adaptation options prepared by Bluecoast Consulting Engineers.

SUMMARY

Background

This Emu Beach Foreshore Management Plan (FMP) is an important guiding document for the management of coastal erosion and hazards between the Albany Golf Club and Emu Point. The FMP area is a significant tourism attraction and previous stakeholder engagement has repeatedly shown that the local community strongly values its social and recreational amenity.

This FMP represents the logical next step from the completion of the endorsed Emu Point to Middleton Beach Coastal Hazard Risk Management and Adaptation Plan (CHRMAP), which recognises the ongoing coastal erosion impacts on community assets, the natural environment, properties and the future tourism economy. The key assets within the FMP area are presented in Figure 1.



Source: City of Albany

Figure 1: Emu Beach FMP key assets

The FMP area continues to experience storm events and subsequent erosion, hence the need for the City of Albany (CoA) to act has become increasingly urgent.

Emu Beach foreshore management plan

This FMP is consistent with State Planning Policy 2.6 - State Coastal Planning Policy and the endorsed CHRMAP. Whilst the CHRMAP makes broad recommendations about what to do to manage the coast over the long-term, this FMP essentially details the how – identifying a series of key management actions.

To support the FMP implementation, a Landscape Master Plan (SeeDesign Studio 2021; Appendix A) has been prepared to provide the foreshore vision and proposed infrastructure for the Emu Beach and Emu Point localities and includes a range of practical management requirements. The FMP also includes a basis of design for the identified coastal adaptation options (Bluecoast Consulting Engineers 2021; Appendix B) and a life cycle costing of foreshore assets (Appendix C), including key maintenance.

The FMP was prepared in conjunction with several key government, cultural, community and natural resource management stakeholders, and can now be used as the basis for well-informed, evidence-based decision making to deliver a positive outcome for the community, a more secure tourism economy and a more sustainable coastline.

Key management actions

This FMP details key infrastructure and governance management actions to be implemented over the short term (zero to five years) and medium term (five to ten years) planning horizons (Table 1).

Table 1: Emu Beach FMP key management actions

FMP management action	Planning horizon
Infrastructure	
1. Undertake the capital works for the Landscape Master Plan and granite boulder groyne field establishment	Short term[1]
2. Undertake sand nourishment in Emu Beach and Oyster Harbour	Short term[2]
3. Undertake the capital works for the upgrades to the existing coastal protection structures, including the Emu Point rock revetment	Medium term[12]
Governance	
1. Approve the advertisement of the Emu Beach FMP for the purpose of advertising / public consultation	Short term
2. Complete the CoA's LPS No.1 review, which is currently being progressed, to include the vulnerable zone (the modelled hazard area to 2120) in a Special Control Area	Short term
3. Updated lease arrangement for the southern portion of the Emu Beach 'BIG4' Holiday Park	Medium term
4. Investigate the opportunity to acquire at risk land as it becomes available on the public market	Medium term[2]

Budget considerations

To deliver on the FMP's key management actions, the CoA requires approximately $11.5 million (ex. GST), which is a considerable amount in the context of the City's overall annual budget. This includes approximately $6 million for landscape elements and approximately $5.5 million for coastal protection works.

This budget commitment will provide significant social and recreational benefits to the Albany community, and substantial support to its tourism industry and, in turn, local jobs and economic growth of the region.

[1] Implementation of capital works will be dependent upon when the external government funding is realised.

[2] Action will be commenced when the trigger value is reached.

1 INTRODUCTION

1.1 Background

The Emu Beach Foreshore Management Plan project area (FMP area) is located approximately 8.5 kilometres (km) from the Albany town site, within the City of Albany's (CoA) local government area (Figure A).

Historically, the Emu Beach shoreline has been subject to coastal erosion. The endorsed Emu Point to Middleton Beach Coastal Hazard Risk Management and Adaptation Plan (CHRMAP; Aurora Environmental 2019a) identified Emu Beach as being at risk of future erosion and inundation due to storm events and predicted sea level rise in the short term. This is important context as the FMP area is a highly valued residential and tourist destination, particularly during the summer months. Stakeholder engagement has shown that the local community strongly values the social and recreational amenity of the FMP area. This includes the retention of the character of the coastal zone between Emu Point and Middleton Beach as primarily residential, natural and recreational. As a result, the FMP area requires a considered management approach to protect and maintain its important social, environmental and economic values.

1.1.1 Emu Point to Middleton Beach coastal hazard risk management and adaptation plan

The CHRMAP considers the impacts of the coastal hazards of erosion and ocean flooding (inundation) in the Emu Point to Middleton Beach study area over a 100-year time frame and provides strategic guidance on coordinated, integrated and sustainable planning and management for the area's key coastal assets.

The CHRMAP study area is divided into five discrete management units (Figure B):

1. MU1. Ellen Cove
2. MU2. Surfers and Golf Course
3. MU3. Emu Point Beach
4. MU4. Emu Point
5. MU5. Oyster Harbour Southeast Beach.

The FMP area comprises the MU3. Emu Point Beach, MU4. Emu Point and a portion of MU5. Oyster Harbour Southeast Beach management units (Figure B). A brief overview of these management units has been provided in Sections 1.1.1.1, 1.1.1.2 and 1.1.1.3 is based on the information provided in the CHRMAP and CHRMAP Implementation Plan (Aurora Environmental 2019b).

The recommended coastal hazard adaptation options for the MU3. Emu Point Beach, MU4. Emu Point and a portion of MU5. Oyster Harbour Southeast Beach management units (i.e. Recommendations 14–20 in the CHRMAP) underpin the coastal engineering and landscaping responses within the FMP area.

1.1.1.1 MU3. Emu Point Beach

Key coastal features, risks and recommendations of the MU3. Emu Point Beach area include:

- Transitions from a stable accreting shoreline to the eroded area adjacent to the Emu Point revetment. Shoreline is relatively sheltered from normal storm events. However, it can be subject to significant erosion during less frequent storms with a more south-easterly aspect
- Existing assets include residential properties, Emu Beach 'BIG4' Holiday Park, foreshore reserve and beach. The foreshore reserve has been identified as a part of an ecological corridor providing habitat for western ringtail possum, orchids and other flora and fauna species
- Existing coastal protection structures are trial geotextile sand container (GSC) groynes and GSC revetment
- High to extreme coastal vulnerability in the short term, with vulnerable assets identified as the foreshore reserve and residential properties
- Recommended coastal hazard adaptation options are:

- Managed retreat and relocation of residential properties on Griffiths Street (Recommendation 14 in the CHRMAP)
- Managed retreat of assets in the southern portion of the Emu Beach 'BIG4' Holiday Park (Recommendation 15 in the CHRMAP)
- Renovation /expansion of GSC groynes (Recommendation 16 in the CHRMAP)
- Upgrade to existing protection structures (Recommendation 17 in the CHRMAP).

1.1.1.2 MU4. Emu Point

Key coastal features, risks and recommendations of the MU4. Emu Point area include:

- Shoreline is defined by the existing coastal protection structures and extends through the mouth into Oyster Harbour. Shoreline is controlled by the structures and the risk to assets is dependent on the structures' integrity
- Existing assets include residential properties, Rose Gardens Beachside Holiday Park, a pumping station, toilets, navigational beacon, foreshore reserve and beach
- Existing coastal protection structures include rock revetment, detached breakwater, southern groyne and training wall
- Extreme coastal vulnerability short term, with the foreshore reserve identified as the asset at risk
- Recommended coastal hazard adaptation options are:
  - Seagrass replenishment program to be continued and enhanced (Recommendation 18 in the CHRMAP)
  - Revetment to be upgraded along with the redevelopment of the foreshore park and removal of sandbag revetment (Recommendation 19 in the CHRMAP).

1.1.1.3 MU5. Oyster Harbour Southeast Beach

Key coastal features, risks and recommendations of the MU5. Oyster Harbour Southeast Beach area include:

- Shoreline is sheltered from the ocean storms and is a low energy environment. Shoreline is controlled by locally generated waves. The presence of the swimming facility causes wave sheltering resulting in a bulge in the shoreline and adjacent erosion requiring periodic sand management to maintain a stable beach profile. The beach is backed by a grouted rock wall
- Existing assets include Emu Point café, toilets, foreshore reserve and beach
- Existing coastal protection structures include training wall and northern groyne
- Extreme coastal vulnerability short term, with the beach identified as the asset at risk
- Recommended coastal hazard adaptation options are:
  - Sand nourishment (Recommendation 20 in the CHRMAP).

1.2 FMP area

1.2.1 Location, site description and tenure

The FMP area is an approximately 59.25 hectare (ha) parcel of coastal land and includes the existing coastal foreshore reserve to the east of the Albany Golf Club stretching north to Emu Point (Figure A).

The existing coastal reserve is comprised of Reserves 14789 and 22698. These reserves are managed by the CoA for the purpose of "Recreation" and "Business Areas / Recreation", respectively (CoA 2010).

The FMP area also includes the following key built assets:

- Residential development along Barry Court and Dillion Close (Figure B, Asset ID 20), Griffiths Street (Figure B, Asset ID 21) and Cunningham Street (Figure B, Asset ID 27)
- Holiday accommodation including
  - Along Barry Court and Dillion Close (Figure B, Asset ID 20)
  - Emu Beach 'BIG4' Holiday Park (Figure B, Asset ID 17)
  - Havana Villas (Figure B, Asset ID 25)
  - Rose Gardens Beachside Holiday Park (Figure B, Asset ID 28)
- Firth St pumping station (Figure B, Asset ID 29), navigation beacon (Figure B, Asset ID 26) and toilets (Figure B, Asset ID 30)
- Emu Point Café (Figure B, Asset ID 31) and toilets (Figure B, Asset ID 31).

The location of the FMP area's natural features (e.g. Emu Point Beach Foreshore, Asset ID 18; Emu Point Foreshore, Asset ID 23) is also identified in Figure B.

DevelopmentWA's Emu Point residential estate is also proposed to be located on Lots 1523 and 3000 Emu Point Drive (Figure A; Figures H and I). The Emu Point residential estate's development footprint is zoned "Future Urban" under the CoA's Local Planning Scheme (LPS) No. 1 (Figure C).

1.3 Purpose

This FMP has been prepared to provide the management framework for the implementation of the coastal adaption responses in the Emu Point Beach and Emu Point localities, consistent with State Planning Policy (SPP) 2.6: State Coastal Planning Policy (Western Australian Planning Commission 2013) and the endorsed CHRMAP.

This FMP also includes:

- Landscape master plan (Appendix A; SeeDesign Studio 2021) provides the CoA and local communities long-term vision and proposed infrastructure for the Emu Point Beach and Emu Point localities, details of the key structural elements of the foreshore design and has been developed having regard for the foreshore's local and regional context, social and environmental characteristics, and a range of practical management requirements (e.g. access, vegetation retention)
- Basis of design (Appendix B; Bluecoast Consulting Engineers 2021) outlines the future requirements for the management of the coast within the FMP area and provides the preliminary basis of design for the identified coastal adaptation options
- Long-term management plan (Appendix C) provides life cycle and cost of foreshore assets framework, inclusive of key maintenance milestones and costings, which commits to implementation of coastal hazard reduction actions over the next 100 years on a staged basis.

1.4 Aims

The overall aims of this FMP are to retain and enhance the key recreational and amenity values of the Emu Point Beach and Emu Point foreshore environments and provide the detailed implementation framework for the key recommendations of the endorsed CHRMAP in these localities.

1.5 Objectives

Aligned with the identified aim, the following key objectives have been established by the CoA:

- FMP is consistent with the endorsed CHRMAP and that coastal adaptation requirements are met for at least 50 years (noting the implementation of coastal adaption measures may be staged)
- Guidance is provided for the future development and management of the foreshore reserve
- High quality community / tourist amenity will be provided that improves on the dilapidated and increasingly unsafe foreshore

- Developed in conjunction with the community and key stakeholders
- Acceptable uses, facilities, structures and land management practices within the foreshore reserve are defined
- Preliminary level of design for adaptation strategies is provided
- Overall landscape master plan including perspectives, levels, transitions and materials provided
- Order of cost/opinion of probable cost is defined for future implementation concepts
- Comprehensive, consolidated document able to be used for potential future external funding applications for detailed design and implementation purposes is delivered
- Key stakeholders and local community are meaningfully engaged and kept informed throughout the process.

1.6 Key issues

This FMP guides management actions and outlines the proposed design response to address the following key issues within the Emu Point Beach and Emu Point foreshore environments:

- Coastal inundation and erosion hazards
- Pedestrian access to beach environments and facilitating beach recreational uses
- Vegetation retention and environmental rehabilitation.

1.7 Structure

The FMP in addressing the above issues has been set out in the following sections:

- Statutory planning and policy context (Section 2)
- FMP area context (Section 3)
- Existing environment (Section 4)
- Foreshore design and function (Section 5)
- Coastal hazard risk management and adaptation (Section 6)
- Foreshore rehabilitation (Section 7)
- Implementation and responsibility (Section 8).

2 STATUTORY PLANNING AND POLICY CONTEXT

A range of plans, strategies and policies provide the context for the future conservation, development and use of the FMP area. This section provides a summary of those statutory and policy mechanisms applicable to this FMP.

2.1 Local Planning Scheme No. 1

The CoA's LPS No.1 sets out the way land is to be used and developed, classifies areas for land use and include provisions to coordinate infrastructure and development within the City's local government area. The CoA's LPS No.1 zonings and reservations for the FMP area are shown in Figure C.

Land use and future development within the FMP area will be subject to the controlling provisions set out in the CoA's LPS No. 1.

2.2 Local Planning Strategy

The CoA's Local Planning Strategy (CoA 2019) provides strategic direction which, over the long-term, will deliver a more compact city where residents will live closer to local shops, services and employment with easy access to public transport and greater ability to walk or cycle.

The objectives of the CoA's Local Planning Strategy are to:

- Contain urban development and rural living within the existing supply of land zoned and planned for settlement growth.
- Promote urban consolidation by making better use of existing zoned land and infrastructure through urban renewal and infill residential and rural living development.
- Facilitate the growth of sustainable rural villages to support agriculture and hinterland communities.
- Plan for a variety of housing types in close proximity to services and facilities, in particular affordable housing and one and two bedroom units that meet the needs of young people, retirees and the elderly.
- Provide an appropriate level of community facilities and services in existing and planned settlement areas.
- Enable people to make healthy choices through effective planning and urban design.
- Conserve places and areas of aboriginal and historic heritage significance.
- Incorporate recognition of native title rights and interests in planning determinations.
- Facilitate accessibility to services and facilities through integrated public transport linkages and cycle and pedestrian-friendly environments.

The CoA's Local Planning Strategy provides the high-level strategy for the future development of the FMP area. Relevant considerations specific to the Emu Point locality addressed by the CoA's Local Planning Strategy include activity centre, coastal planning and management and investigation areas.

2.2.1 Activity centre

Emu Point is designated as a Local Centre in the CoA's Activity Centre network hierarchy. The function of local centres is to provide for some daily and weekly household shopping, community facilities and a small range of other convenience services. Local centres typically comprise of convenience retail, personal services, local offices and community purpose land uses (CoA 2019).

2.2.2 Coastal planning and management

To ensure that planning proposals on the coast will not be impacted by coastal processes the following key management actions are identified by CoA (2019):

1. Require that coastal planning strategies or foreshore management plans are carried out as early as possible in the planning processes. Foreshore management plans are to determine suitable setbacks and land required to be ceded for public foreshore reserves by an assessment of coastal processes in accordance with SPP 2.6
2. Pursue funding and progressively undertake Coastal Hazard Risk Management Adaptation Plans for priority areas, including Princess Royal Harbour, Oyster Harbour, Goode Beach and the Whaling Station area
3. Implement the recommendations of the CHRMAP for the Emu Point to Middleton Beach area.

2.3 Albany Regional Vegetation Survey

The Albany Regional Vegetation Survey (ARVS) (Sandiford and Barrett 2010) provides a local and regional overview of the native vegetation of the greater Albany area to assist land use and conservation planning in the region by describing mapping and assessing the conservation status of the vegetation.

Assessments of the extent, rarity, diversity and reservation status of vegetation units, their status as wetland/ streamline/estuarine or coastal dune vegetation and threats to vegetation units are provided to assist in determining the local and regional conservation significance of the vegetation (Environmental Protection Authority 2010).

The ARVS identified the FMP area is comprised of the following vegetation associations:

- Beach Herbland / Grassland
- Peppermint Low Forest mosaic
- Limestone Coastal Heath.

The ARVS has been referenced in Section 4.5 to provide an overview of the vegetation associations within the FMP area.

2.4 Council Management Plan, Middleton Beach

The Council Management Plan, Middleton Beach (including Emu Point Foreshore) (CoA 2010) outlines the background and issues relevant to the Middleton Beach and Emu Point Reserves and provides the framework for sustainability and environmental protection outcomes for the foreshore area from Ellen Cove, continuing east long Middleton Beach and Emu Point to the boat marina at the end of Swarbrick Street.

Threats to conservation values are listed with proposed management strategies to address them. Key identified threatening processes include:

- Physical disturbances including trampling and track creation
- Environmental weeds.

Recommendations for management include constructing a formal pathway and conducting weed control programs in conjunction with rehabilitation programs.

The foreshore rehabilitation program identified in Section 7 addresses the key identified threatening processes within the FMP area.

2.5 State planning policy 2.6: State coastal planning policy

The purpose of SPP 2.6 is to provide guidance for decision-making within the coastal zone including managing development and land use change; establishment of foreshore reserves; and to protect, conserve and enhance coastal values. Specifically, SPP 2.6:

- Informs and guides decision making by WAPC and its committees
- Integrates and coordinates the activities of state agencies that influence the use and development of land in the coastal zone
- Guides local government, state government agencies, State Administrative Tribunal and the state government in aspects of state planning policy concerning the coastal zone that should be taken into account in planning and decision making.

The objectives of SPP 2.6 are to:

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

SPP 2.6 provides guidance for the assessment of coastal processes through consideration of the following key components over a 100-year planning time frame:

- S1 Erosion: Allowance for the current risk of storm erosion
- S2 Erosion: Allowance for historic shoreline movement trends
- S3 Erosion: Allowance for erosion caused by future sea level rise
- S4 Inundation: Allowance for the current risk of storm surge inundation.

The Coastal Vulnerability Study and Hazard Mapping (Royal Haskoning DHV 2017) provides coastal hazard mapping across a 100-year time frame, using interim planning horizons of 2017, 2030, 2050, 2070, and 2120 consistent with the SPP 2.6 requirements. The coastal hazard mapping presented in Royal Haskoning DHV (2017) underpinned the potential erosion and inundation extents identified in the endorsed CHRMAP.

This FMP has been prepared to provide the management framework for the implementation of the coastal adaption responses in the Emu Point Beach and Emu Point localities, consistent with SPP 2.6 and the endorsed CHRMAP.

2.6 Coastal Parks Enhancement Plan

The Coastal Parks Enhancement Plan (Syrinx Environmental and Place Laboratory 2014) provides strategic guidance and direction for the staged improvements of Emu Point, Surfers Beach, Middleton Beach and Ellen Cove and Eyre Park localities from 2014 until the end of 2023–2024 financial year.

With specific reference to the Emu Point foreshore environment, the Coastal Parks Enhancement Plan identifies:

- Existing condition and key issues
- Design principles
- Recommendations for improvement.

The Coastal Parks Enhancement Plan Emu Point foreshore environment context has been incorporated into the Landscape Master Plan (Appendix A; SeeDesign Studio 2021).

2.7 FMP approval process

It is anticipated that the approvals process for this FMP would generally include:

1. Draft FMP prepared by CoA for the purpose of advertising / public consultation
2. Commencement of the advertising / public consultation period
3. Review and respond to any submissions received by the CoA
4. FMP to be updated (this stage would be undertaken on an ‘as required’ basis)
5. Final adoption of the FMP by CoA
6. Submission of FMP to WAPC for approval.

2.8 Future planning and environmental approvals

Development works within the FMP area will be subject to the following planning and environmental controls:

- Development application (CoA)
- Engineering / landscape construction design drawings (CoA)
- Agreement between tenant and Minister of Lands for changes to lease agreements. Surveyed plan for any changes to lease agreements to be provided to Landgate
- Purpose Permit clearing application approval (DWER) for removal terrestrial vegetation and marine seagrass.

3 FMP AREA CONTEXT

Emu Point is one of Albany's most popular swimming and recreational areas. The surrounding Emu Point suburb comprises a mixture of primary residences as well as including an assortment of holiday accommodation, ranging from caravan parks to motels and independent 'bed and breakfasts' and private holiday houses. The Emu Point foreshore serves as a popular destination for Albany's local and broader communities, whilst functioning as a tourism destination for visitors to the Great Southern region.

The social, environmental, personal and economic value of the Emu Point Beach to Emu Point coastline has been considered by the CoA's Study of Coastal Values and Character Emu Point to Middleton Beach (Greenskills 2013) and more recently by the CHRMAP. These documents identify that the Emu Point Beach to Emu Point coastal environment is highly valued by the local community for walking, swimming, visiting the commercial area, sitting and reading.

Plate 1: Emu Point beach

The planned upgrades to the FMP area will maintain and enhance the existing social and environmental values and deliver a contemporary foreshore precinct for Albany's local and broader communities.

3.1 Stakeholder consultation

3.1.1 Key stakeholders

The key stakeholders in the FMP include CoA; Department of Transport (DoT); Department of Planning, Lands and Heritage (DPLH); Southern Ports Authority; Department of Biodiversity Conservation and Attractions (DBCA); Department of Water and Environmental Regulation; Department of Primary Industry and Regional Development; South Coast Natural Resource Management; Minang-Noongar Elder; and Emu Point and Middleton Beach Friends groups.

The FMP Steering Group has been formed to provide strategic advice and guidance to the CoA in relation to developing the marine and foreshore environments within the Emu Beach and Emu Point localities. The development of this FMP has occurred across four distinct stages, with distinct hold points established at 30%, 50% and 90% complete stages to allow for review and comment by the CoA, FMP Steering Group and engagement with the local community.

There are numerous other stakeholders that have be considered in communicating the FMP including:

- Government departments
- Marine recreational groups including recreational fishers
- Environmental groups
- Educational institutions
- Disability groups
- Local organisations and business within the FMP area
- Hospitality businesses
- Interested community members
- Local residents.

3.1.2 Stakeholder engagement

As part of developing this FMP the following stakeholder engagement activities were undertaken to ensure that all relevant issues were identified and addressed:

- Delivery of presentation to FMP Steering Group on 26 February 2020 of draft FMP (30% complete) outcomes, including site walk over. Draft FMP (30% complete) was reviewed by FMP Steering Group members with opportunity for comment provided by the CoA
- Meeting with owners of Emu Beach ‘BIG4’ Holiday Park to review current and future lease arrangements was undertaken by the CoA on 10 March 2020
- Meeting with DoT and DPLH to review the coastal adaptation options for the MU3. Emu Point Beach area on 22 July 2020
- Public consultation was undertaken by the CoA from July through to October 2020 which included:
  - Publication of on the CoA’s website and Facebook page, including:
    - Community update
    - Project information
    - Electronic copies of the information boards
    - Video overview
    - Feedback form
  - Advertisement in local newspaper
  - Targeted printed letters to local residents and electronic mail to:
    - Relevant user/community groups
    - People previously involved in CHRMAP feedback
    - Key stakeholders / FMP Steering Group
  - Placement of information boards at the Emu Point barbecue enclosure (opposite the café) and the CoA’s North Road office
  - Community consultation session held at Emu Point Sporting Club on 23 September 2020 and was attended by approximately 85 people.

4 EXISTING ENVIRONMENT

4.1 Topography

The FMP area primarily consists of a sandy beach with a series of parabolic and nested parabolic dunes, belonging to the Quindalup dune system, located directly to the north of the beach.

The beach is generally flat with limited variation, ranging in elevation from a maximum height of approximately 4.0 metres Australian Height Datum (m AHD) to 0 m AHD along the shoreline. The natural topography of vegetated dunes is slightly more undulating ranging from a maximum height of approximately 10 m AHD, between Griffiths Street in the west and the Emu Beach 'BIG4' Holiday Park in the east, through to 4.0 m AHD adjacent to the beach (Figure D).

4.2 Geology

4.2.1 Terrestrial geology

The 1:50,000 Environmental Geology Series identified the FMP area consists predominantly of S13 (SAND) – white, medium-grained rounded quartz and shell debris, with S2 (SAND) - white, medium to coarse-grained, moderately well sorted, quartz and shell debris primarily underlying the beach and adjacent foreshore area of MU3. Emu Point Beach (Figure E).

4.2.1.1 Acid sulfate soils

DWER's acid sulfate soil (ASS) risk mapping indicates that the FMP area is primarily not at risk of ASS occurring within 3.0 metres of the natural soil surface. However, a small portion of project area's eastern marine extent is mapped as high to moderate risk of ASS occurring within 3.0 metres of the natural soil surface (Figure F).

4.2.2 Marine sediments

The marine sediments and water movement adjacent to the FMP area have been subject to detailed studies including:

- Sediment sampling from Emu Point to Middleton Beach, including Emu Point channel and Lockyer Shoal
- Sediment and water movement around the permanently open mouth of an estuary: Emu Point, on the south coast of Western Australia (University of Western Australia 2015).

These studies generally found that the physical processes which influence marine sediment movement proximate to the FMP area are shear, tidal overflows, wave formation, wave progression, counter currents and reflection from the rock walls (University of Western Australia 2015).

4.3 Surface water

There are no major surface watercourses or water bodies, including wetlands, located within the FMP area. The FMP area is not within the catchment of any ground or surface water supply areas.

A flood plain, which drains in a north-eastly direction into Oyster Harbour, is situated approximately 500 m to the north-west of the FMP area within Lot 555 Swarbrick Street / Reserve 15879. Lake Seppings, a south-coast significant wetland, is located approximately 1 km to the south-west of the FMP area.

The dominant hydrological process for the FMP area is rainfall infiltration, with run-off accumulating in the inter-dunal swales and infiltrating into the highly permeable sand aquifer. Any run-off adjacent to existing roads (e.g. Barry Court and Dillion Close, Griffiths and Hope streets, and Cunningham Street) would likely be intercepted by the CoA's stormwater system.

4.4 Groundwater

Groundwater level and quality monitoring undertaken for the Emu Point residential estate indicates that groundwater underlying the FMP area is likely to:

- Flow in a south-easterly direction towards the coast (Strategen 2007)
- Be relatively shallow. Depths varied from approximately two to six metres below ground level for the Emu Point residential estate in 2006 (GHD 2010)
- Be mostly fresh, with salinity increasing with proximity to the coast (Strategen 2007).

4.5 Flora and vegetation

4.5.1 Regional vegetation mapping

4.5.1.1 Interim Biogeographical Regionalisation of Australia

The Interim Biogeographic Regionalisation for Australia (IBRA) divides Australia into bioregions based on major biological and geographical/geological attributes (Thackway and Cresswell 1995). The IBRA currently recognises 89 bioregions and 419 biological subregions in Australia. The FMP area is situated within the IBRA region of Jarrah Forest and the subregion of Southern Jarrah Forest (Environment Australia 2000).

The Southern Jarrah Forest subregion is broadly described as:

> Duricrusted plateau of Yilgarn Craton characterised by Jarrah-Marri forest on laterite gravels and, in the eastern part, by Wandoo – Marri woodlands on clayey soils with eluvial and alluvial deposits supporting Agonis shrublands
>
> (Hearn et al. 2002)

4.5.1.2 South Coast Macro Corridor Network

The 5.4 million ha South Coast Macro Corridor Network project area lies on the central south coast of Western Australia and includes the catchments of all southerly flowing rivers from Walpole in the west to Cape Arid National Park, approximately 700 km to the east (Wilkins et al. 2006). Twenty-one potential vegetation corridors of regional nature conservation significance and strategic spatial significance within the South Coast region were broadly identified within the project area.

The FMP area is included within the coastal corridor, which spans approximately 500 km of coastal land from Walpole to Cape Arid. The coastal corridor is generally protected to some degree either as DBCA managed estate, local government reserve or unallocated Crown land (Wilkins et al. 2006). The coastal corridor is a very high priority linkage as it links two high nature conservation value protected areas (Two Peoples Bay Nature Reserve and the Fitzgerald River National Park) and numerous other protected areas (Waychinicup National Park/Mt. Manypeaks Nature Reserve, Stokes National Park, Cape Le Grand National Park and Cape Arid National Park) (Wilkins et al. 2006).

4.5.1.3 Shepherd vegetation association mapping

Most of the FMP area is mapped as Shepherd's vegetation association 423 – Shrublands; Acacia scrub-heath (unknown spp.) (Figure G). Vegetation association 423 is widespread and well reserved in the Southern Jarrah Forest subregion with approximately 62.6% of its pre-European extent remaining, of which 45.2% is present in secure tenure (Shepherd et al. 2002).

A minor eastern portion of the FMP area is mapped as Shepherd's vegetation association 51 – Sedgeland; reed swamps, occasionally with heath (Figure G). Vegetation association 51 is widespread and well reserved in the Southern Jarrah Forest subregion with approximately 51.7% of its pre-European extent remaining, of which 69.4% is present in secure tenure (Shepherd et al. 2002).

4.5.1.4 Albany Regional Vegetation Survey

The ARVS identified the FMP area is comprised of the following vegetation associations:

- Beach Herbland/Grassland vegetation association
  - A colonising unit that occurs on beaches above the high-water mark and on some foredunes. This unit is transitional, subject to erosion by storm wave action or invasion by secondary successional species and changing to Coastal Limestone Heath. The unit varies from an open herbland to a closed grassland with most species present introduced. Common species include *Spinifex hirsutus*, *Lepidosperma gladiatum*, **Spinifex sericeus*, **Ammophila arenaria*, **Lagurus ovatus*, *Ficinia nodosa*, **Cakile maritima*, **Arctotheca calendula*, *Carpobrotus* sp., **Pelargonium capitatum* and **Euphorbia paralias*. Occasional, shrubs may be present. Species present are salt tolerant and many were only recorded in this unit (Sandiford and Barrett 2010)
  - The ARVS notes that this vegetation association has high numbers of introduced species and is widespread along beaches in south-west Western Australia (Sandiford and Barrett 2010).
- Peppermint Low Forest mosaic
  - Is restricted to the coastal dune system where it commonly occurs in swales and flats. A dense canopy of *Agonis flexuosa* (peppermint) is characteristic of this unit with the structure varying from a closed heath on exposed coastal slopes to a low closed forest in swales with shrub species often sub or codominant in exposed areas. A tall shrubland of *Spyridium globulosum*, *Adenanthos sericeus*, *Bossiaea linophylla* and *Leucopogon obovatus* is usually present over an open or closed sedgeland with *Rhagodia baccata, Hardenbergia comptoniana* and *Clematis pubescens* common (Sandiford and Barrett 2010)
  - The ARVS notes that this vegetation association has many infestations of **Acacia longifolia* and is generally common along the south-west coastline, though in instances where *Adenanthos sericeus* comprises the understorey are restricted to areas around Albany as this species only occurs from the Nullaki Peninsula to Waychinicup with an outlying population at Warriup (Sandiford and Barrett 2010).
- Limestone Coastal Heath
  - Is a heterogeneous group that is restricted to yellow-grey and light grey alkaline sands and limestone soils of the coastal fringe. Several sub-units are described with exposure, soil depth, rock cover and time since fire factors influencing the structure and floristic composition of these sub-units. *Scaevola striata* and *Acacia littorea are* often very prominent in the first few years after fire. (Sandiford and Barrett 2010)
  - The ARVS notes that this vegetation association is naturally restricted to the coastal fringe with most occurrences on the Meerup landform unit (Sandiford and Barrett 2010). Heaths occurring on coastal limestone and alkaline sands are common along the southern Western Australian coast however two species sometimes dominant in this unit: *Adenanthos sericeus* and *Banksia praemorsa* are largely restricted to the ARVS context area (Sandiford and Barrett 2010).

4.5.2 Flora and vegetation review

A flora and vegetation survey (Hickman 2005) was previously undertaken for the Emu Point residential estate and includes a portion of the FMP area (i.e. portion of Lots 3000 and 1523 north-east of Griffiths and Hope streets) within its survey extent (Figure H). An orchid survey of the development site was undertaken by local orchid expert, Keith Smith, in 2006 to inform the environmental scoping document (as reported in Strategen 2007). GHD undertook a further reconnaissance field Vegetation and Flora Assessment to review the vegetation condition assessment undertaken by Hickman (2005) and noted the presence of any species not identified in the Hickman (2005) survey, as part of the Public Environmental Review of the development site (GHD 2010). Additionally, the flora and vegetation and fauna review undertaken for the Middleton Beach Activity Centre (RPS 2015), included the FMP area within its database search area.

These desktop resources have been reviewed to provide a high-level overview of the FMP area's flora and vegetation context. A site walk over of the FMP area was undertaken by RPS on 26 February 2020 to confirm the vegetation association mapping and validate the findings of the desktop review.

4.5.2.1 Vegetation association mapping

Of the four vegetation associations identified by Hickman (2005), the peppermint Thicket and Littoral Zone vegetation associations closely aligns with the FMP area. A minor extent of the peppermint heath vegetation association also intersects the FMP area (Figure H).

The peppermint Thicket vegetation association is comprised of two subcategories that run parallel to each other and to the beach:

1. Thicket of *Agonis flexuosa* over tall open scrub of *Acacia littorea* and *Spyridium globulosum* over shrubland of *Acacia cochlearis*, *Hibbertia cuneformis* and *Leucopogon parviflorus* over sedgeland of *Desmocladus flexuosus* and *Lepidosperma costale*
2. Thicket of *Agonis flexuosa* over tall open scrub of *Acacia littorea* and *Spyridium globulosum* over shrubland of *Hibbertia cuneformis*, *Leucopogon parviflorus* and *Phyllanthus calycina* over sedgeland of *Lepidosperma gladiatum*.

The Littoral Zone vegetation association runs in a thin strip along the beach. It is classified as closed low heath of **Euphorbia paralias* and **Pelargonium capitatum* over very open grassland of *Spinifex hirsutus* and *Ammophila arenaria*.

The peppermint heath vegetation association is a mosaic of four sub-categories:

1. Tall shrubland of *Agonis flexuosa* and *Banksia ilicifolia* over shrubland of *Bossiaea linophylla*, *Jacksonia horrida* and *Melaleuca striata* over open low heath of *Dasypogon bromeliifolius*, *Leucopogon* spp. and *Pimelea rosea* over very open mixed herbland
2. Very open tall shrubland of *Agonis flexuosa* over open heath of *Jacksonia horrida*, *Leucopogon revolutus* and *Melaleuca thymoides* over open low heath of *Dasypogon bromeliifolius*
3. Tall shrubland of *Agonis flexuosa* and *Banksia attenutata* over tall open shrubland of *Adenanthos cuneatus*, *Hakea oleifolia* and *Spyridium globulosum* over open heath *Acacia cochlearis*, *Jacksonia horrida* and *Leucopogon revolutus* over low open shrubland of *Adenanthos cuneatus* and *Pimelea rosea* over very open mixed herbs over open sedgeland *Desmocladus flexuosus*, *Lepidosperma squamata* and *Lyginia barbata*
4. Very open tall shrubland of *Agonis flexuosa* over open shrubland of *Melaleuca thymoides* over open low heath of *Lysinema cilataum* and *Dasypogon bromeliifolius* over sedgeland of *Lepidosperma squamata* and *Lyginia barbata*.

The vegetation condition within the portion of the FMP area assessed by Hickman (2005) and GHD (2010) was primarily “Excellent”. Figure H presents the Hickman (2005) vegetation association mapping in relation to the FMP area.

These vegetation associations extend beyond the Hickman (2005) survey area running parallel with the coast in both directions where they have not been cleared for development (Strategen 2007). This finding is supported by the fauna habitat assessment undertaken for the Emu Point residential estate by ATA Environmental in 2006, which primarily mapped the native vegetations extents to the south and north of the Hickman (2005) survey area as ‘Closed peppermint (*Agonis flexuosa*) thicket over sedgeland.’

4.5.2.1.1 Key outcomes of site walk over

The site walk over confirmed the findings of Strategen (2007), and ATA Environmental (2006), that the peppermint thicket vegetation extends to the southern border of the FMP area (Plate 2) and to the north of the Hickman (2005) survey area to Firth Street (Figure H). The Littoral zone vegetation was also found to extend to the southern border of the FMP area (Plate 2) and approximately 150 m to the north of the Hickman (2005) survey area (Figure H).

Plate 2: Peppermint Thicket and Littoral zone vegetation associations in the south of the FMP area

The foreshore area north of Firth Street was found to be characterised by a 'parkland' cleared environment characterised by remnant peppermint (*Agonis flexuosa*) trees over an understorey primarily comprised of introduced grass and weed species (Figure H). Consolidated understorey patches mostly comprised of remnant sedges (*Lepidosperma* sp) are also scattered throughout the foreshore area to the north of Firth Street.

The Littoral Zone vegetation at Emu Point Beach and the fringing peppermint trees to the north of the beach have been subject to rehabilitation efforts (Plate 3; Figure H). Ongoing weed management is required to control introduced species, including sea spurge (**Euphorbia paralias*), within the rehabilitation areas. Section 7 identifies the approach to be implemented in rehabilitating Emu Point Beach foreshore environment.

Plate 3: Rehabilitation of Littoral zone vegetation association at Emu Point beach

4.5.2.2 Threatened and Priority flora

No threated flora species were recorded by Hickman (2005), Strategen (2007) or GHD (2010) within the FMP area. None of the DBCA-listed Priority species recorded by Hickman (2005) and GHD (2010) were situated within the FMP area.

Five DBCA-listed *Adenanthos x cunninghamii* (Priority 4)[3] plants were recorded in the peppermint Thicket (two plants), Sheoak Woodland (two plants) and Open peppermint Heath (one plant) vegetation associations by Hickman (2005) outside of the FMP area.

DBCA-listed *Andersonia depressa* (Priority 3) was recorded by GHD (2010) within the Sheoak Woodland and Open peppermint heath vegetation associations immediately north of the FMP area.

DBCA-listed *Poa billardierei* (Priority 3) was recorded within the Middleton Beach foreshore reserve, whilst *Stylidium articulatum* (Priority 2) was recorded in the Albany Golf Course by RPS (2015). These records are approximately 1.6 km to the south-west of the FMP area.

4.5.2.3 Threatened and Priority ecological communities

No threatened ecological communities (TECs) or Priority ecological communities (PECs) were recorded by Hickman (2005). The following two TECs, listed under the EPBC Act, were recorded within 5 km of the FMP area by RPS (2015):

1. Proteaceae Dominated Kwongan Shrublands of the Southeast Coastal Floristic Province of Western Australia
2. Subtroprical and temperate Coastal Saltmarsh.

[3] *Adenanthos x cunninghamii* was removed from the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) list of threatened species on 18 August 2006.

The key diagnostic characteristics of these TECs are not representative of the peppermint Thicket or Littoral zone vegetation associations described by Hickman (2005).

4.5.2.4 Weed species

No Declared plant species were identified by Hickman (2005). Common non-aggressive weed species present within the survey area included ursinia (*Ursinia anthemoides*) and flatweed (*Hypochaeris glabra*). Regarding the FMP area, Hickman (2005) notes the presence of garden escape species, particularly kikuyu (*Pennisetum clandestinum*), around the boundary of the Griffiths and Hope streets residential development.

4.5.2.5 Phytophthora dieback

A small pocket of Phytophthora dieback was detected by Hickman (2005) within Sheoak Woodland vegetation association adjacent to Emu Point Drive. Additional Phytophthora dieback mapping of the development site was undertaken by GHD (2010), which identified the peppermint Thicket vegetation association as uninterpretable due to an absence of susceptible species.

4.6 Terrestrial fauna

4.6.1 Terrestrial fauna review

A fauna habitat assessment, inclusive of a western ringtail possum survey and an assessment of adjacent areas to assess the available fauna habitats, (ATA Environmental 2006) was previously undertaken for the Emu Point residential estate to inform the environmental scoping document (as reported in Strategen 2007). Opportunistic fauna observations were also recorded by Hickman (2005). A further targeted western ringtail possum survey was undertaken by Green Iguana in 2007 and Coffey undertook a desktop and field vertebrate fauna assessment for the development site and two comparison sites in the Albany area in 2009 to inform the Public Environmental Review (as reported in GHD 2010). Additionally, the flora and vegetation and fauna review undertaken for the Middleton Beach Activity Centre (RPS 2015), included the FMP area within its database search area.

These desktop resources have been reviewed to provide a high-level overview of FMP area's fauna context. A site walk over of the FMP area was undertaken by RPS on 26 February 2020 to validate the findings of the desktop review.

4.6.2 Fauna habitat mapping

The findings of the ATA Environmental (2006) fauna habitat assessment were generally consistent with the vegetation assessment conducted by Hickman (2005). With respect to the FMP area, the key fauna habitat types identified were:

- Closed peppermint (*Agonis flexuosa*) thicket over sedgeland
- Open Heathland and Grassland within the swales of dunes
- Open peppermint (*Agonis flexuosa*) / *Banksia attenuata* woodland over *Adenanthos* sp./ *Spyridium globulosum* shrubland over closed heathland.

Figure I presents the ATA Environmental (2006) fauna habitat mapping in relation to the FMP area.

4.6.2.1 Threatened and Priority fauna

The key threatened and priority fauna species reported within the Emu Point residential estate by the various surveys were:

- Western ringtail possum
- White-tailed black cockatoos (Carnaby's black cockatoo and Baudin's black cockatoo)
- Southern brown bandicoot.

4.6.2.1.1 Western ringtail possum

Western ringtail possum (*Pseudocheirus occidentalis*), as listed under the *Biodiversity Conservation Act 2016* (BC Act) and EPBC Act, occurrence within the Emu Point residential estate was recorded as follows:

- Thirty-two dreys and 13 western ringtail possums were identified by ATA Environmental in 2006, which included one possum and two dreys that were identified outside of the survey area (Strategen 2007).
- Ninety-two dreys, of which 78 were considered to be potentially active, and 23 western ringtail possums were identified by Green Iguana in 2007 (GHD 2010)
- Twenty-nine dreys and 23 western ringtail possums were identified by Coffey in 2009 (GHD 2010).

The key western ringtail possum habitat type within the development site is the closed peppermint (*Agonis flexuosa*) thicket over sedgeland (Plate 4), which dominates the FMP area (Figure I). The site walk over confirmed the extent of the key western ringtail possum habitat (i.e. peppermint Thicket vegetation) is consistent with the ATA Environmental (2006) fauna habitat mapping (Figure I).

Plate 4: Closed peppermint (*Agonis flexuosa*) thicket over sedgeland habitat

4.6.2.1.2 White-tailed black cockatoos

A flock of 30 white-tailed black cockatoos (Carnaby's or Baudin's), as listed under the BC and EPBC Acts, were recorded in 2006 by ATA Environmental feeding on *Banksia* sp. within the open peppermint (*Agonis flexuosa*) / *Banksia attenuata* woodland over *Adenanthos* sp./ *Spyridium globulosum* shrubland over closed heathland (Strategen 2007). The Open peppermint (*Agonis flexuosa*) / *Banksia attenuata* woodland over *Adenanthos* sp./ *Spyridium globulosum* shrubland over closed heathland habitat type, which provides foraging habitat for these species, comprises only a minor portion of the FMP area (Figure I).

4.6.2.1.3 Southern brown bandicoot

One DBCA-listed southern brown bandicoot (*Isoodon obesulus* subsp. *Fusciventer*; Priority 5) was identified within the Open peppermint (*Agonis flexuosa)* / *Banksia attenuata* woodland over *Adenanthos* sp./ *Spyridium globulosum* shrubland over closed heathland habitat type by Coffey, however this species is likely to occur

throughout the development site particularly in the Closed peppermint (*Agonis flexuosa*) thicket over sedgeland (GHD 2010). Hickman (2005) observed bandicoots in the peppermint Thicket and reported diggings across the survey area.

4.6.2.2 Migratory and marine fauna

Various migratory and marine shorebird species listed under the EPBC Act were recorded proximate to the FMP area by RPS (2015), including common sandpiper (*Actitis hypoleucos*), sharp-tailed sandpiper (*Caldris acuminata*), red-necked stint (*Calidris ruficollos*), red knot (*Calidris canutus*), great knot (*Calidris tenuirostris),* bar-tailed godwit (*Limos lapponica*), grey plover (*Pluvialis squatarola*), common greenshank (*Tringa nebularia*) and marsh sandpiper (*Tringa stagnatilis*). These species are generally recorded in coastal habitats, such as large intertidal sand flats, banks, mudflats, estuaries, inlets, harbours, coastal lagoons and bays, and are likely to be infrequent visitors to the Emu Point Beach coastal and Oyster Harbour estuary environments (RPS 2015).

The EPBC Act-listed, white-bellied sea eagle (*Haliaeetus leucogaster*) and BC Act-listed peregrine falcon (*Falco peregrinus*) may be infrequently observed flying over the FMP area (RPS 2015). EPBC and BC Act-listed sea-lion, seal and marine turtle species could also be infrequently sighted in the ocean proximate to FMP area (RPS 2015).

4.7 Coastal processes

The potential future vulnerability of the coastline and the subsequent risk to the community, economy and the environment, needs to be considered for the FMP area. Temporal changes to the risk profile need to be understood to ensure that appropriate decisions can be made, and steps taken, to respond to this changing risk – particularly in response to potential climate induced change.

Effective management of coastal processes requires assessment of the asset specific risk exposure, identification of risks that require management and development of suitable management practices and adaptation techniques that the management authority considers to be acceptable in response to the present and future risks.

4.7.1 Coastal hazard risk management and adaptation plan

The CHRMAP assesses the coastal processes potentially affecting the MU3. Emu Point Beach, MU4. Emu Point and MU5. Oyster Harbour Southeast Beach management units over a 100-year planning period in accordance with SPP 2.6 requirements.

This work has identified the coastal processes hazard lines using interim planning horizons of 2017, 2030, 2050, 2070, 2090 and 2120, to provide an understanding of potential coastal hazard risk over the 100 year planning period. The detailed outcomes of the CHRMAP coastal processes assessment are presented in Table 2 for the MU3. Emu Point Beach management unit; in Table 3 for MU4. Emu Point; and in Table 4 for MU5. Oyster Harbour Southeast Beach.

The erosion extent at each of the time frames identified in Tables 2, 3 and 4 is estimated as the sum of the following factors:

- Allowance for the current risk of storm erosion (S1)
- Allowance for historic shoreline movement trends (S2)
- Allowance for erosion caused by future sea level rise (S3).

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

- Allowance for the current risk of storm surge inundation (S4)
- Future sea level rise.

Table 2: Coastal processes summary for MU3. Emu Point Beach

Planning horizon	S1 – severe storm erosion (m)	S2 - historic shoreline movement (m)	S3 – climate change (m)	Safety factor	Total coastal processes allowance
2017	40	0	0	0	40
2030	40	0	6	3	49
2050	40	0	19	7	66
2070	40	0	38	11	89
2090	40	0	61	15	116
2120	40	0	97	21	158

(Source: Royal Haskoning DHV 2017)

Table 3: Coastal processes summary for MU4. Emu Point

Planning horizon	S1 – severe storm erosion (m)		S2 - historic shoreline movement (m)		S3 – climate change (m)		Safety factor		Total coastal processes allowance	
	With hard structures	Without hard structures	With hard structures	Without hard structures	With hard structures	Without hard structures	With hard structures	Without hard structures	With hard structures	Without hard structures
2017	0	20	0	0	0	0	0	0	0	20
2030	0	20	0	0	0	6	0	3	0	29
2050	0	20	0	0	0	19	0	7	0	46
2070	0	20	0	0	0	38	0	11	0	69
2090	0	20	0	0	0	61	0	15	0	96
2120	0	20	0	0	0	97	0	21	0	138

(Source: Royal Haskoning DHV 2017)

Table 4: Coastal processes summary for MU5. Oyster Harbour Southeast Beach

Planning horizon	S1 – severe storm erosion (m)	S2 - historic shoreline movement (m)	S3 – climate change (m)	Safety factor	Total coastal processes allowance
2017	5	0	0	0	5
2030	5	3	6	3	17
2050	5	7	19	7	38
2070	5	11	38	11	65
2090	5	15	61	15	96
2120	5	21	97	21	144

(Source: Royal Haskoning DHV 2017)

The CHRMAP identifies that coastal erosion presents as the key risk to the existing foreshore reserves and key built assets within the FMP area over the next 50 years. The risk of coastal inundation impacting the existing foreshore reserves over the 100 year time frame was assessed to be low by the CHRMAP.

The CHRMAP identifies that it is possible for the Emu Point Beach and Emu Point foreshores, properties on Griffiths Street and toilets in front of the Rose Gardens Beachside Holiday Park to be at risk from coastal processes by 2030 (Figure 2).

Further the properties on Barry Court and Dillion Close, the Firth Street pumping station, toilets and properties on Cunningham Street are all at risk from coastal processes by 2070, should no prior management action(s) be implemented to mitigate this risk (Figure 2). Coastal processes can be successfully mitigated in the MU4. Emu Point management unit (i.e. the developed eastern portion of the FMP area) through the implementation of coastal protection structures (Figure 3).

The coastal hazard adaption recommendations identified by the CHRMAP for the FMP area were:

1. Managed retreat and relocation of residential properties on Griffiths Street (Recommendation 14 in the CHRMAP)
2. Managed retreat of assets in the southern portion of the Emu Beach 'BIG4' Holiday Park (Recommendation 15 in the CHRMAP)
3. Renovation /expansion of GSC groynes (Recommendation 16 in the CHRMAP)
4. Upgrade to existing protection structures (Recommendation 17 in the CHRMAP)
5. Seagrass replenishment program to be continued and enhanced (Recommendation 18 in the CHRMAP)
6. Revetment to be upgraded along with the redevelopment of the foreshore park and removal of sandbag revetment (Recommendation 19 in the CHRMAP)
7. Sand nourishment (Recommendation 20 in the CHRMAP).

The long-term coastal processes and implementation of the CHRMAP recommendations are considered further in Section 6.0 of this FMP, having regard for existing and proposed community infrastructure and the risk management approach to be employed.

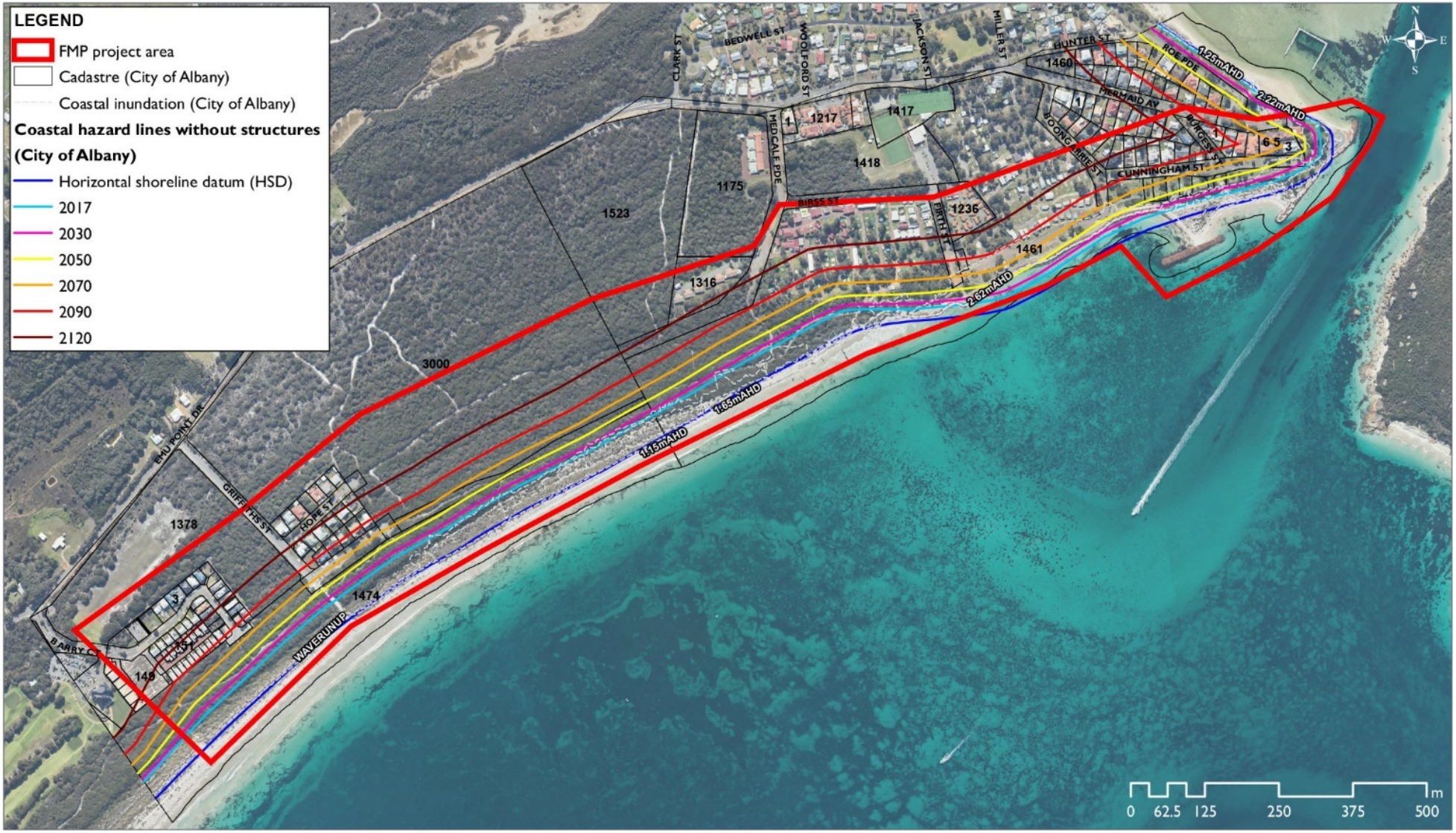


Figure 2: Coastal hazard risk for the FMP area over the 100 year planning period without coastal structures

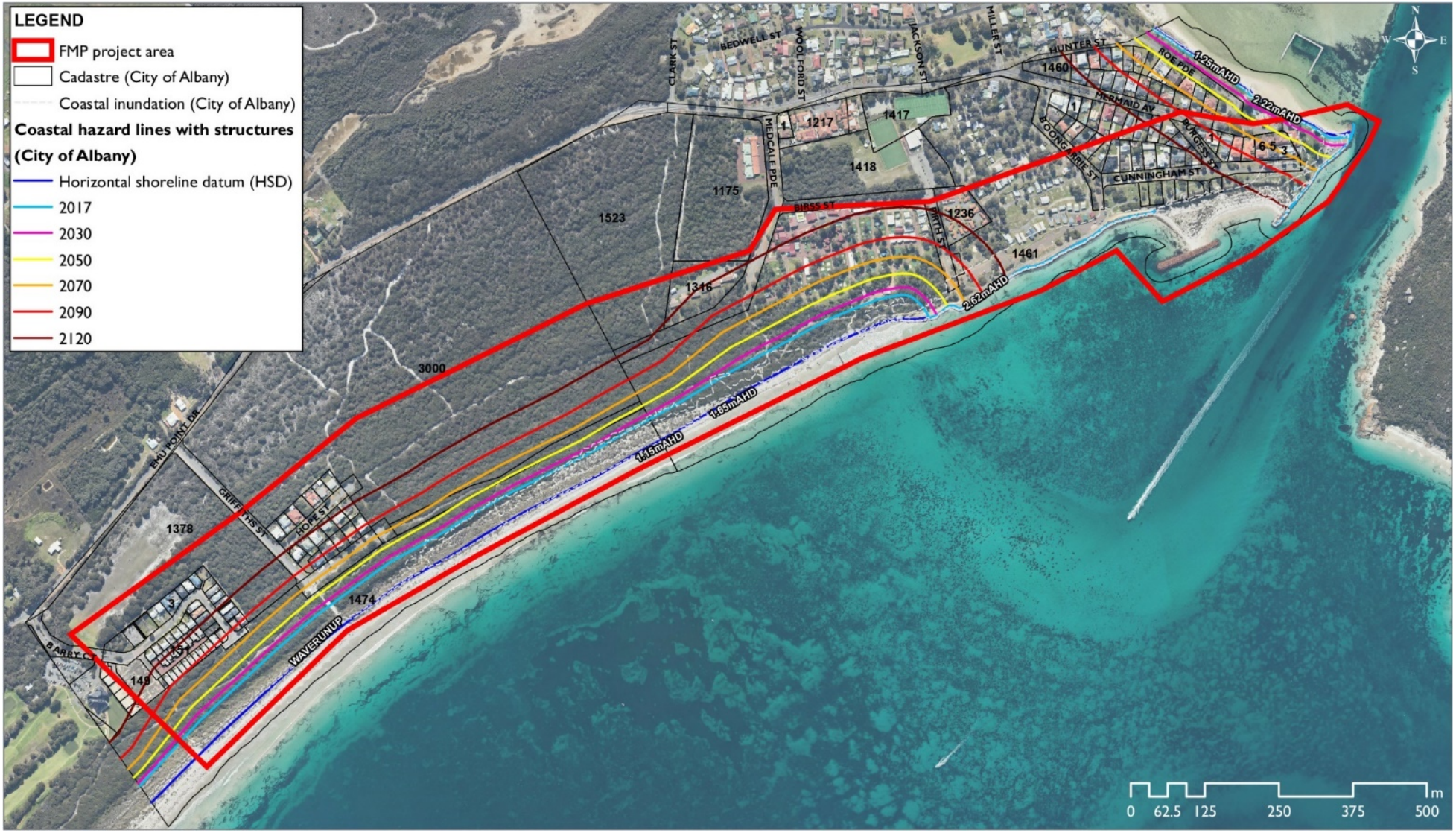


Figure 3: Coastal hazard risk for the FMP area over the 100 year planning period with coastal structures

4.8 Land use

A review of the historical aerial images reveals that the FMP area has remained relatively consistent in its land use since at least 1954. The early development of Emu Point is visible from 1954 with the construction of the present-day alignment of Cunningham Street, Griffiths Street and the Rose Garden Beachside Holiday Park occurring prior to 1961. The Emu Beach 'BIG4' Holiday Park along with the existing Emu Point development footprint was largely constructed prior to 1977, with the Barry Court and Dillion Close development under construction in 2001.

4.8.1 Existing leases

The CoA holds long-term lease agreements with operators of holiday accommodation for use of land within the coastal foreshore area including:

- Emu Beach 'BIG4' Holiday Park
- Havana Villas
- Rose Gardens Beachside Holiday Park.

The spatial extent of the existing leases is presented in Figure 4. An overview of the potential impacts to these lease areas from coastal processes over the 100 year time frame and proposed mitigation actions are discussed further in Section 6. A more detailed review is provided by the preliminary Basis of Design (Appendix B; Bluecoast Consulting Engineers 2021) report.

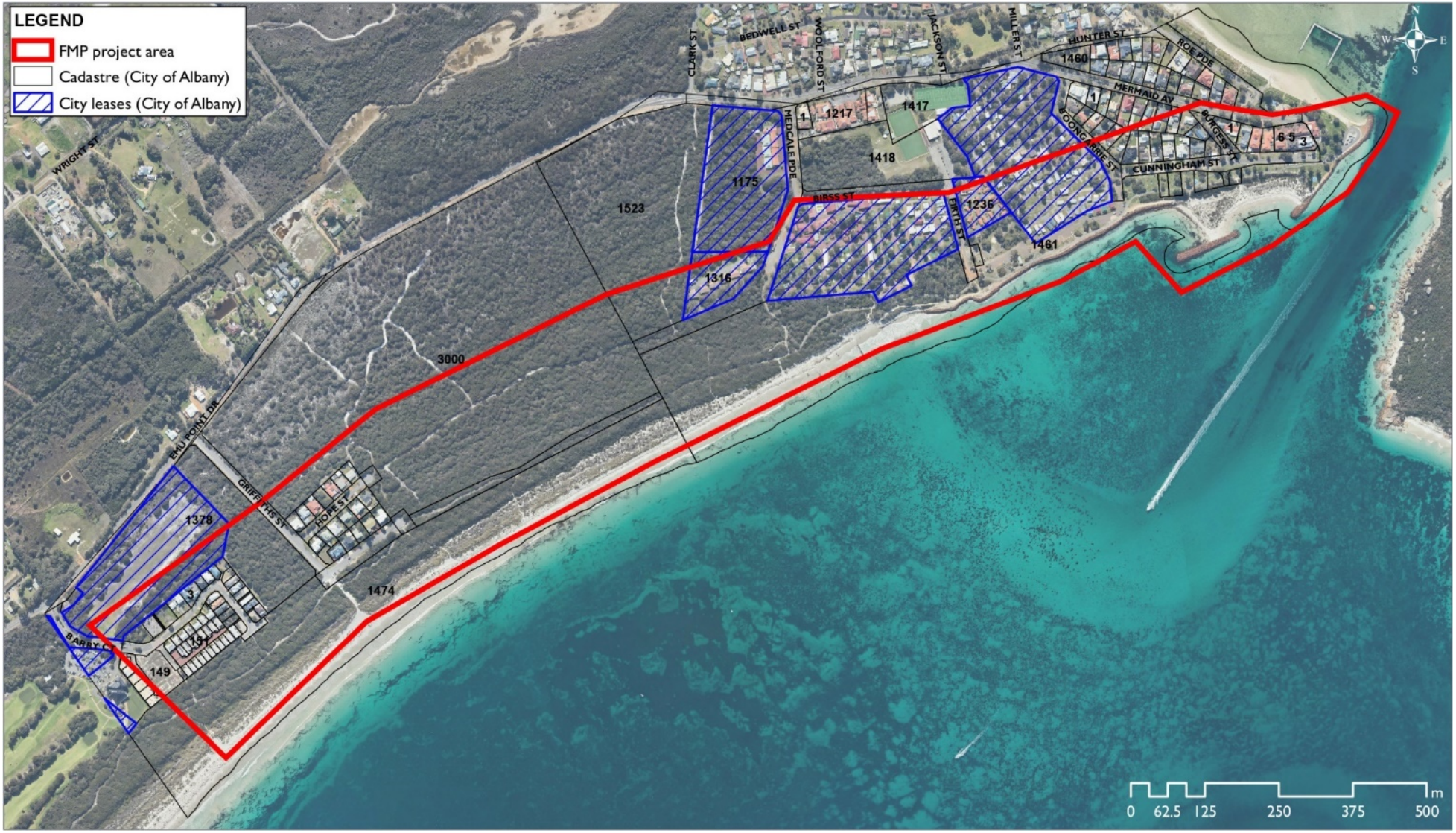


Figure 4: Existing CoA leases

4.8.2 Heritage

4.8.2.1 Aboriginal heritage and culture

The DPLH's Aboriginal Heritage Inquiry System identified that no Registered Heritage Sites or additional Other Heritage Places are located within the FMP area.

4.8.2.2 Natural and historic heritage

A search of the State Heritage Office's inHerit database undertaken on 11 February 2020 identified that no state registered heritage places are located within the FMP area.

4.8.3 Potential contamination

A search of DWER's Contaminated Sites Database undertaken on 11 February 2020 identified no known contaminated sites are located within the FMP area.

Due to the timing of development commencement at Emu Point (i.e. circa 1954) asbestos containing materials could have been used as a building material. This is of relevance in situations where the original buildings have been demolished and the land use change has occurred. For instance, the site of an original building which has previously been demolished has subsequently been included in the foreshore reserve.

A preliminary site investigation will be undertaken by the CoA if areas previously or presently containing original buildings in the foreshore reserve are proposed to be developed as part of the implementation of the Landscape Master Plan (Appendix A; SeeDesign Studio 2021).

4.9 Bushfire

A search of the Department of Fire and Emergency Services' Map of Bushfire Prone Areas identified that most of the FMP area is mapped as a Bushfire Prone Area, with only the more developed portion of the FMP area to the east of the Rose Gardens Beachside Holiday Park not mapped as being bushfire prone (Figure J).

The reconfiguration of land uses within Reserve 22698 will result in the loss of existing vehicular access between Firth and Cunningham streets. The existing trafficable surface between Firth and Cunningham streets, known as Boongarrie Street, forms part of Reserve 22698 (i.e. Boongarrie Street is not a formally gazetted Local Road in LPS No. 1). The Landscape Master Plan (Appendix A; SeeDesign Studio 2021) maintains access for fire / emergency vehicles through realignment of the dual use path to connect to the new Firth and Boongarrie street car parks.

Additional bushfire management provisions incorporated into the Landscape Master Plan (Appendix A; SeeDesign Studio 2021) include realigning the dual use foreshore path to accord with existing firebreaks and providing access to a cleared area of parkland via the Boongarrie Street car park.

5 FORESHORE DESIGN AND FUNCTION

The Landscape Master Plan (Appendix A; SeeDesign Studio 2021) has been completed to ensure the Emu Beach foreshore provides the required level of amenity for Albany's local and broader communities. In particular, the Landscape Master Plan has also sought to address existing issues that are currently experienced with the foreshore through improving pedestrian access to the foreshore and beach environments, restricting pedestrian access to the existing costal protection structures, addressing bushfire management and providing relief from sun, rain and prevailing winds.

The overall aim of the Landscape Master Plan is to retain and enhance the key recreational and amenity values of the Emu Point Beach and Emu Point foreshore environments, whilst ensuring its ongoing protection from coastal hazards.

The CoA will be responsible for the implementation of the Landscape Master Plan which is expected to cost at least $5.91 million (ex. GST) excluding civil/roads and earthwork costs.

5.1 Design principles

Six strategic values critical to the enhancement of the CoA's coastal parks, including Emu Beach and Emu Point, were identified in the Coastal Parks Enhancement Plan (Syrinx Environmental and Place Laboratory 2014):

1. Coastal identity
2. Environmental quality
3. Destination development
4. Connections
5. Facilities and amenities
6. A place for everyone.

These core values have provided thematic context to the landscape design principles embedded in the Landscape Master Plan.

5.1.1 Landscape design principles

- Accessibility – Ensuring that the landscape is accessible to people of all abilities will result in repeat patronage and ensure an inviting place for all.
- Local – Emu Point should look and feel like a place that is itself. By using local materials and leaning on local vernacular to retain the landscape character across the FMP area.
- Amenity – Establish varied and numerous amenities for public use to allow year round activation. Upgrading or extending the play and exercise spaces will attract families and non-beachgoers to ensure an activated, vibrant foreshore.
- Comfort – Providing protection from both sun, rain and prevailing winds through the precinct with both vegetation and structures ensures people can utilise and activate the space at all times of days in comfort.
- Destination – Strengthen and enhance the existing qualities of Emu Beach landscape and create a hierarchy of various activities.
- Connectivity – Enhance existing connections to the pedestrian/cycle network with the creation of nodes along the length of the waterfront with wayfinding, interpretation and shelter to provide linkage across the FMP area.
- Enhanced environment - Through the protection and rehabilitation of remnant vegetation key wildlife corridors can be maintained to support various endemic species. Whilst assisting in mitigating coastal erosion and increasing shade.

- Robust – The use of robust, well-engineered materials within the coastal conditions allows the creation of a landscape that remains viable for many years to come.
- Vehicle management – Prioritise pedestrians where possible and formalise parking to increase capacity and improve use of recreational spaces.

5.2 Landscape Master Plan

The overall Landscape Master Plan divides the FMP area into two distinct parts, Barry Court to Medcalf Parade and Medcalf Parade to Emu Point, with detailed plans prepared for Emu Point, Boongarrie Street and Firth Street localities to provide additional site context.

The overall Landscape Master Plan and detailed locality plans are provided in the Landscape Master Plan (Appendix A; SeeDesign Studio 2021).

6 COASTAL HAZARD RISK MANAGEMENT AND ADAPTATION PLAN IMPLEMENTATION

6.1 Coastal hazard risk

The CHRMAP assesses the coastal processes potentially affecting the MU3. Emu Point Beach, MU4. Emu Point and MU5. Oyster Harbour Southeast Beach management units over a 100 year planning period in accordance with SPP 2.6 requirements.

This work has identified the coastal processes hazard lines using interim planning horizons of 2017, 2030, 2050, 2070, 2090 and 2120, to provide an understanding of potential coastal hazard risk over the 100 year planning period. The detailed outcomes of the CHRMAP coastal processes assessment for the three management units is summarised in Table 5.

Table 5: Coastal processes summary for the MU3. Emu Point Beach, MU4. Emu Point and MU5. Oyster Harbour Southeast Beach management units

Planning horizon	Total coastal processes allowance			
	MU3. Emu Point Beach	MU4. Emu Point		MU5. Oyster Harbour Southeast Beach
		With hard structures	Without hard structures	
2017	40	0	20	5
2030	49	0	29	17
2050	66	0	46	38
2070	89	0	69	65
2090	116	0	96	96
2120	158	0	138	144

(Source: Royal Haskoning DHV 2017)

The projected long-term coastal hazard, at each planning horizon, is illustrated with respect to the FMP area in Figure 2 (without coastal structures) and Figure 3 (with coastal structures).

6.1.1 Consideration of State Planning Policy 2.6: State Coastal Planning Policy

SPP 2.6 incorporates a justifiably conservative methodology to ensure that the siting of future development or assets is cognisant of potential future hazards, even those with a very low likelihood of occurrence. As a result, it is important to understand that the coastal hazard lines provided in Royal Haskoning DHV (2017) are not predictions of the future shoreline location. In this regard, the full requirements for maintaining the coastal reserve will need to be informed by ongoing coastal monitoring.

This coastal monitoring will inform both the requirements for the maintenance of the existing Emu Point and Oyster Harbour beaches and the requirements of the ongoing protection of the landscaped foreshore area behind the existing coastal protection structures.

6.2 Management and adaptation planning

SPP 2.6 outlines a hierarchy of risk management measures and adaptation options available in the coastal planning process. There are four broad categories of management/adaptation approaches, generally described as follows:

- Avoid – locating development to avoid coastal hazards and risks. Planned or Managed Retreat – locating low-cost / sacrificial public infrastructure within the physical processes allowance area, which can be removed/demolished as they become at risk of coastal hazards over time.
- Retreat – the relocation or removal of assets within an area identified likely to be subject to intolerable risk of damage from coastal hazards.

- Accommodate – the use of regulatory tools (notifications, easements on title), evacuation plans and/or a variety of physical measures to best accommodate physical processes on privately owned properties.
- Protect – the use of hard infrastructure/physical works (e.g. sea walls, groynes) to defend and protect public/private land from physical processes.

6.3 Coastal hazard risk management and adaptation plan implementation framework

In consideration of the identified coastal hazard risk, the CoA, as the authority responsible for the current and future management of the foreshore reserves, has undertaken an assessment of the future requirements for the FMP area. This assessment highlighted that the foreshore reserves within the FMP area represents a significant community asset within an important coastal precinct within the greater Albany area. In recognition of these above key factors, the CoA has determined that the significant recreational and amenity values of the foreshore reserves require a comprehensive planning response to address the identified coastal hazard risk.

This FMP provides the detailed implementation framework for the key recommendations of the endorsed CHRMAP within the FMP area:

1. Managed retreat and relocation of residential properties on Griffiths Street (Recommendation 14 in the CHRMAP)
2. Managed retreat of assets in the southern portion of the Emu Beach 'BIG4' Holiday Park (Recommendation 15 in the CHRMAP)
3. Renovation /expansion of GSC groynes (Recommendation 16 in the CHRMAP)
4. Upgrade to existing protection structures (Recommendation 17 in the CHRMAP)
5. Seagrass replenishment program to be continued and enhanced (Recommendation 18 in the CHRMAP)
6. Revetment to be upgraded along with the redevelopment of the foreshore park and removal of sandbag revetment (Recommendation 19 in the CHRMAP)
7. Sand nourishment (Recommendation 20 in the CHRMAP).

6.3.1 Consultation with Department of Transport and Department of Planning, Lands and Heritage

The preliminary Basis of Design (Appendix B; Bluecoast Consulting Engineers 2021) report was provided to the DoT and DPLH in June 2020 at 50% complete stage for review.

The DoT's key concern was that the design life for the proposed upgrade the trial GSC groynes was not consistent with the FMP objective of meeting coastal adaptation requires for at least 50 years. A teleconference was held between the CoA, DoT and DPLH on 22 July 2020 to discuss the proposed approach for the GSC groynes. The following outcomes were agreed from the teleconference:

- FMP to be a consolidated document integrating the coastal adaptation recommendations from the CHRMAP with landscape upgrade and environmental considerations
- Coastal protection strategies to meet a 50 year planning horizon, noting that the GSC groynes form only part of the coastal protection framework proposed within the MU4. Emu Point management unit
- Order of magnitude cost estimates for the coastal protection structures to be provided
- Approach to staging of the implementation of coastal protection structures works, construction and monitoring to be included.

The preliminary Basis of Design (Appendix B; Bluecoast Consulting Engineers 2021) report was updated for the 90% complete stage to address the agreed teleconference outcomes and additional comments from the DoT and CoA. The 90% complete document was subsequently provided to the DoT in January 2021. In March 2021 the DoT advised that the updated 90% complete document contained sufficient context on the proposed coastal adaptation options to inform the FMP. The DoT also noted that the CoA has agreed to undertake more detailed coastal engineering investigations to define the specific engineering requirements for the groynes and proposed Emu Beach sand nourishment.

6.4 Coastal hazard risk management actions

This section provides a summary of the CoA's approach to addressing the key recommendations of the endorsed CHRMAP. A more detailed review is provided by the preliminary Basis of Design (Appendix B; Bluecoast Consulting Engineers 2021) report.

6.4.1 MU3. Emu Point Beach

6.4.1.1 Managed retreat and relocation of residential properties on Griffiths Street

The CHRMAP identifies that it is possible for front row of properties on Griffiths Street to be at risk from coastal processes by 2030. This is due to the access road itself being at risk[4] due to proximity to the ocean and an absence of any hard coastal protection structures.

The front row of properties on Griffiths Street are slightly more at risk than adjacent properties on Barry Court and Dillion Close. Although these properties have longer term access and short term alternatives available the same managed retreat framework proposed for the Griffiths Street properties will also be applied to the Barry Court and Dillion Close properties.

The preferred options for the Griffiths Street properties identified by the CHRMAP are:

- Short term: Sand nourishment and continued monitoring
- Medium term: Managed retreat, to be initiated by a coastal response trigger value.

In this location, the trigger value for the implementation of managed retreat is when the Horizontal Shoreline Datum (HSD) is less than 40 m from Griffiths Street. Monitoring should be undertaken every two years in spring and after any significant storm erosion event to understand increased likelihood of risk and determine if more expeditious relocation is required. Consideration for the Barry Court and Dillion Close properties will be included as part of the monitoring framework.

A recent topographic survey (March 2019) established the 40 m trigger line landward of the foredune and at an approximate distance of 70m to HSD (Figure 5). Signs of long-term beach accretion in this location have been documented in Royal Haskoning DHV (2017). The trigger point is considered unlikely to be activated in a 1 in 100 year event (Bluecoast Consulting Engineers 2021). However should this occur, sand nourishment will be undertaken and monitored to ensure the long-term accretionary trend continues along this part of the beach (Bluecoast Consulting Engineers 2021).

[4] When the road and services are damaged, legal access to the lots will be affected and the properties will be impacted (Aurora Environmental 2019b)

(Source: Bluecoast Consulting Engineers 2021)

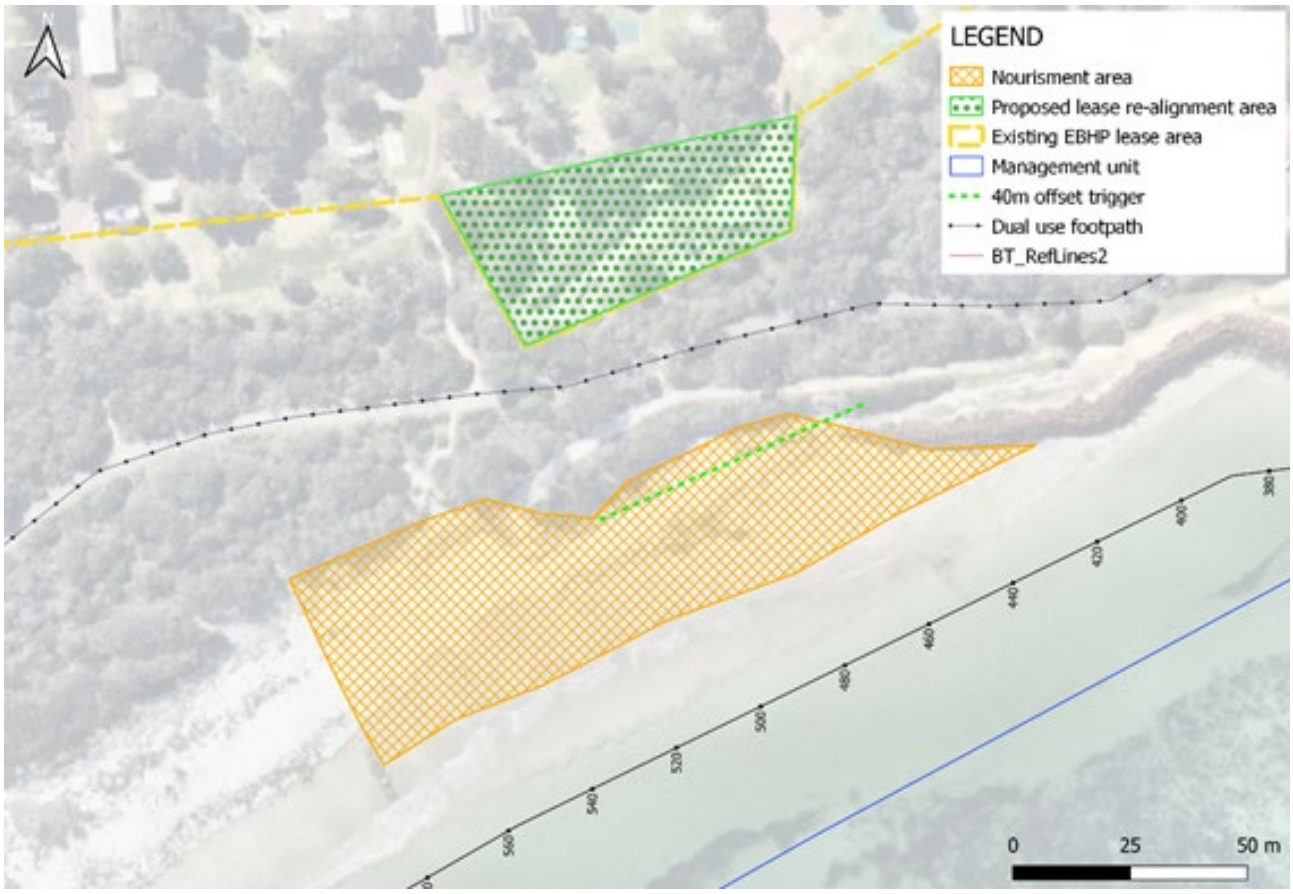
Figure 5: Topographic survey (March 2019) of the Griffiths Street foreshore and 40 m trigger value

The CoA's Local Planning Strategy (CoA 2019) recognises the implementation CHRMAP as Investigation Area 12. This outcome addresses Recommendation 1 in the CHRMAP (Aurora Environmental 2019a). The following overarching recommendations of the CHRMAP will be actioned by the CoA to facilitate managed retreat:

- LPS Special Control Area (Recommendation 2 in the CHRMAP)
  - Complete the CoA's LPS No.1 review, which is currently being progressed, to include the vulnerable zone (the modelled hazard area to 2120) in a Special Control Area. It is proposed that the Special Control Area will alert existing and future landowners to seek information from the CoA and enable notification to landowners if they seek a development approval.
- Purchase of Property Investigation (Recommendation 8 in the CHRMAP). The CoA to investigate the opportunity to acquire at risk land as it becomes available on the public market.

6.4.1.2 Managed retreat of assets in the southern portion of the Emu Beach 'BIG4' Holiday Park

Like the planned managed retreat for the Griffith Street properties (Section 6.4.1.1), managed retreat of assets in the southern portion of the Emu Beach 'BIG4' Holiday Park has also been recommended by the CHRMAP. Consistent with the Griffith Street properties, the trigger value for the implementation of managed retreat is when the HSD is less than 40 m from the Emu Beach 'BIG4' Holiday Park lease area (Figure 6). The trigger value is close to being initiated, with approximately 25 m between the HSD and the 40 m trigger line (Bluecoast Consulting Engineers 2021). Resultantly, the CoA has been working closely with the leaseholder to plan for staged retreat of assets within the southern portion of the Emu Beach 'BIG4' Holiday Park and has commenced discussions around the realignment of the current lease boundary.



(Source: Bluecoast Consulting Engineers 2021)

Figure 6: Emu Beach 'BIG4' Holiday Park southern lease area and 40 m trigger value

Based on the implementation of the remaining CHRMAP recommendations in the MU3. Emu Point Beach management area (Section 6.4.1.3), it is anticipated that the managed retreat trigger value is unlikely to be initiated for some time (Bluecoast Consulting Engineers 2021).

It is also anticipated that the proposed upgrade works will provide a beach with a greater appeal to users. With a widened and a greater protected foreshore, there exists an opportunity to continue to allow accommodation within the southern portion of the current Emu Beach 'BIG4' Holiday Park lease area through the provision of less permanent assets/uses such as unpowered camp sites and parklands on the foreshore area, provided there is an appropriate emergency management plan for responding to extreme storm activity.

The CoA and the leaseholder should continue to work toward an agreed level of risk for the southern portion of the Emu Beach 'BIG4' Holiday Park, steering the discussions around future lease agreements, to further reduce the risk to assets presented by coastal hazards.

6.4.1.3 Renovation/expansion of GSC groynes and upgrade to existing protection structures

The GSC groynes were installed in 2014 as a trial to assess protection of Emu Point Beach (Figure 7). The GSC groynes have shown to be of benefit in the retention of sand, however due to their exposure to cyclic wave action and UV the condition of the groynes has deteriorated and now present as a risk to public safety (Bluecoast Consulting Engineers 2021).

(Source: Bluecoast Consulting Engineers 2021)

Figure 7: As-constructed drawings of the GSC groynes

The original design intention of the GSC groynes as a trial has now passed, with the impact on the coastline being understood from the CoA's ongoing coastal monitoring program. To ensure that the coastal adaptation requirements are met for at least the next 50 years a groyne field comprising granite boulders will be established in the current location of the GSC groynes. A third granite boulder groyne is also proposed to be established to the west of the two existing GSC groynes as part of the groyne field.

The CoA will be responsible for the implementation of the upgrades to the GSC groynes, including the establishment of a third granite boulder groyne, and the sand nourishment (Section 6.4.1.3.1), which is expected to cost at least $2.03 million (ex. GST) excluding monitoring and maintenance.

Preliminary information on groyne design, permeability, length, spacing orientation, crest level / width and scour level for the proposed upgrades is provided in the preliminary Basis of Design (Appendix B; Bluecoast Consulting Engineers 2021) report. This context has informed a detailed study currently being undertaken by the CoA to assess the most suitable layout (size and orientation) and number of structures required to facilitate the upgrade of the GSCs to suitably sized and locally sourced granite boulders.

The proposed upgrades to the rock revetment are addressed in Section 6.4.1.2.

6.4.1.3.1 Sand nourishment

A large erosion scarp has formed on the beach immediately to the west of the Emu Beach 'BIG4' Holiday Park between the Emu Point rock revetment and GSC groynes. A GSC revetment has been established in this location and subsequently damaged, primarily due to cyclic wave action (Plate 5).

(Source: Bluecoast Consulting Engineers 2021)

Plate 5: Large erosion scarp and GSC revetment

Sand nourishment in this location will be undertaken following the construction of the granite boulder groyne field to re-establish the beach. The indicative location of the sand nourishment area is shown in Figure 6.

Preliminary information on nourishment design, sediment source, overfill ratio, machinery and delivery method for the proposed sand nourishment in the preliminary Basis of Design (Appendix B; Bluecoast Consulting Engineers 2021) report identifies that:

- Opportunistic sand nourishment could be implemented should coastal or dredging works be commenced along the beaches or upper dunes from Ellen Cove to Oyster Harbour within King George Sound, Oyster and Royal Princess harbours, and any excess sediment generated be assessed suitable for sand nourishment. Excess sediment could also be used for sand nourishment in the western lee of the detached breakwater in the MU4. Emu Point management unit.
- Appropriate reinstatement actions (e.g. sand nourishment or scraping) should be undertaken if beach access becomes dangerous due to high (>1 m) vertical dune scarps.

This context will be used by the CoA to inform the implementation of the sand nourishment works.

6.4.2 MU4. Emu Point

6.4.2.1 Seagrass replenishment program be continued and enhanced

Preliminary shoreline modelling undertaken for the CHRMAP by Royal Haskoning DHV (2017) identified the formation of a circulation cell in the lee of Lockyer Shoal that feeds the ebb current jetting out of Oyster Harbour. Sediment transported within the easterly current would be deposited at the edge of the Oyster Harbour stream, feeding the Lockyer Shoal. During flood currents this sediment would be deposited within Oyster Harbour or within the channel, to be redistributed to the shoal on the subsequent outgoing tide due to the ebb-dominated asymmetry in tidal current velocities (Bluecoast Consulting Engineers 2021).

This finding implies that any additional sediment placed on the erosion-affected Emu Beach shoreline as part of the sand nourishment works (Section 6.4.1.3.1) has the propensity to travel east into the circulation cell to feed the growth of Lockyer Shoal thereby assisting to meet the intent of this recommendation.

6.4.2.2 Revetment to be upgraded along with redevelopment of Foreshore Park and removal of sandbag revetment

The condition of the existing coastal protection structures (i.e. rock revetment and detached breakwater) immediately adjacent to and east of the Emu Beach 'BIG4' Holiday Park within the MU4. Emu Point management unit was assessed as part of the preliminary Basis of Design (Appendix B; Bluecoast Consulting Engineers 2021) report. The condition assessment identified that:

- The rock revetment and detached breakwater range from "Good" to "Poor" condition.
- They are meeting their functional objective of protecting the coastal assets in their lee and preventing overtopping and inundation.
- The rock revetment and detached breakwater present as a safety hazard, should public access be permitted[5].

Bluecoast Consulting Engineers (2021) identifies that the trigger value for the implementation of upgrades to the existing coastal protection structures to be either of the following:

- Condition assessment rating of "Very Poor" for any section of rock revetment. Condition assessments should be undertaken every three years using a standardised assessment methodology
- Greater than three overtopping events of rock revetment within a 12-month period, where the overtopping event is determined to reach the overtopping limit for damage to grass covered areas.

The CHRMAP identifies that the rock revetment requires detailed redesign. Preliminary information on the rock revetment alignment, rock type, crest height, rock size, grading, filtration and revetment slope for the proposed upgrades is provided in the preliminary Basis of Design (Appendix B; Bluecoast Consulting Engineers 2021) report. This context will be used by the CoA to inform the detailed design of the future rock revetment upgrades.

The CoA will be responsible for the implementation of the required upgrades to the rock revetment, which are anticipated cost at least $3.5 million (ex. GST) excluding monitoring and maintenance.

The foreshore park is proposed to be significantly redeveloped in accordance with the Landscape Master Plan (Appendix A; SeeDesign Studio 2021) concurrently with rock revetment upgrades. The damaged GSC revetment is proposed to be removed (Section 6.4.1.3.1).

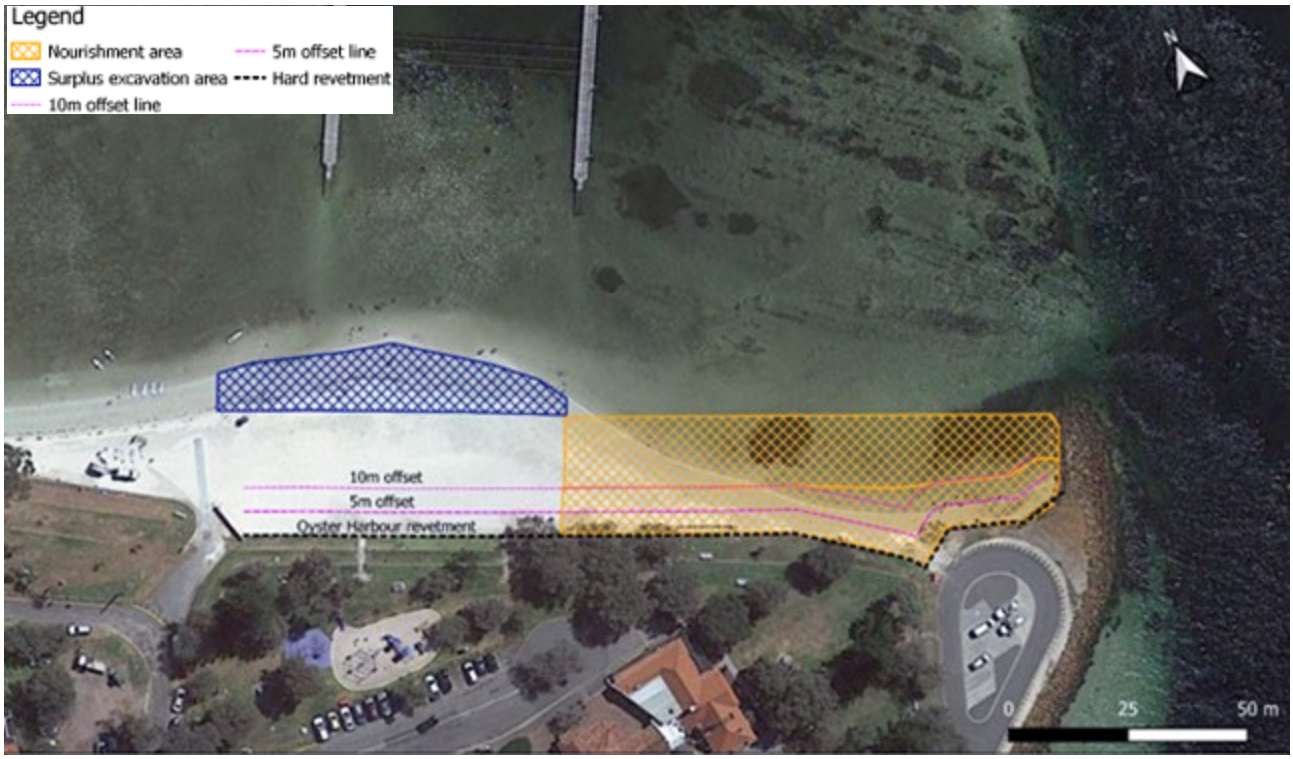
6.4.3 MU5. Oyster Harbour Southeast Beach

6.4.3.1 Sand nourishment

The MU5. Oyster Harbour Southeast Beach management unit is markedly different from the MU3. Emu Point Beach and MU4. Emu Point management units as it is a low energy estuarine environment with shallow water depths and different coastal processes. The shoreline is already managed by a grouted rock wall and the swimming structure also behaves somewhat like an offshore breakwater without the same effectiveness (Aurora Environmental 2019b). The eastern corner of the Oyster Harbour Beach, adjacent to the northern groyne, is most prone to seasonal erosion reducing recreational amenity.

The preferred option identified by the CHRMAP to manage erosion at Oyster Harbour Beach is sand nourishment. Sand is generally able to be sourced within Oyster Harbour due to the seasonal sand movement along the beach. Alternatively, clean beach sand is also able to be sourced from Middleton Beach and Ellen Cove.

[5] The Landscape Master Plan (Appendix A; SeeDesign Studio 2021) addresses public access to the existing coastal protection structures.



(Source: Bluecoast Consulting Engineers 2021)

Figure 8: Oyster Harbour beach sand nourishment

The trigger for sand nourishment to be implemented in the eastern corner of the Oyster Harbour Beach is when there is less than 5 m between the HSD and the northern groyne/ grouted rock wall. Sand is proposed to be placed at a height of +1. 5 m AHD from the northern groyne / grouted rock wall to an offshore distance of 10 m (Figure 8). The placed sand will then be graded down to 0 m AHD to the length of the northern groyne / grouted rock wall (Bluecoast Consulting Engineers 2021).

The CoA will be responsible for the implementation of the Oyster Harbour Beach sand nourishment works, which is expected cost at least $10, 000 (ex. GST) excluding any contingencies and maintenance.

7 FORSHORE REHABILITATION

7.1 Revegetation strategy

The revegetation strategy has been based on the Albany Regional Vegetation Survey (Sandiford and Barrett 2010) and will be implemented by the CoA. The indicative Emu Point Beach Rehabilitation Area is identified in Figure H and is shown as 'Dune revegetation' in the SeeDesign Studio Concept Plan (within the Landscape Master Plan – Appendix A).

7.1.1 Weed management

Weed management is an important component for the establishment of native vegetation. However in some locations, weeds are also providing stabilisation functions, and selective management will be required to balance site stability with revegetation. In other sections, weed control will be achieved through herbicide application. Herbicides will be selected for the target species, considering the surrounding environment and the constraints this may present. Amongst remnant native vegetation, selective herbicides (i.e. grass or broadleaf-specific) will be favoured over general knockdown herbicides, to keep off-target damage to a minimum. To ensure that off-target damage is minimised, herbicide spraying operators will only be engaged if they:

- Are appropriately qualified and licensed in herbicide application
- Have demonstrated experience in the ability to identify, and distinguish between, native and weed species
- Are familiar with the most appropriate control measures, timing, herbicides, and application rates for the target species.

The approach to controlling the weed species which may be encountered in the Emu Point Beach Rehabilitation Area is provided in Appendix D.

7.1.2 Revegetation

7.1.2.1 Species selection

Seedling planting will be the primary revegetation method employed within the Emu Point Beach Rehabilitation Area. Selection of appropriate species is the key to reaching a successful outcome for the revegetation works. Revegetation species have been carefully selected based on the existing floristic community type, topography and hydrology to ensure species are located in the areas in which they are most likely to survive in both short and long-term.

The revegetation species proposed for the Emu Point Beach Rehabilitation Area are primarily beach herbland/ grassland species, which have been classified into the following categories:

a. Beach grasses and herbaceous species adopted for the most exposed locations
b. Semi-stable dune colonisers adapted to partially protected areas
c. Set back / less-exposed dune situations and swales.

The revegetation species proposed for the Emu Point Beach Rehabilitation Area are listed in Appendix E.

7.1.2.2 Planting method

Seedlings will be directly planted using planting tubes, which negates the need for repeated bending for excavation of planting holes. Seedlings will be watered before delivery to site on the day of planting to reduce the potential for transplant shock, and provided the soil is moist no other watering is considered necessary.

7.1.3 Scheduling

Planting will be carried out from May–July when the soil moisture content is high enough for optimum seedling growth, without irrigation, and after the existing weeds have germinated and have been sprayed. Tube stock will be planted with a plastic guard to prevent rabbits feeding on plant stock and to protect from strong winds (as required). Tube stock planting density will be in accordance with the Landscape Master Plan (Appendix A; SeeDesign Studio 2021).

7.1.4 Site and plant protection

Brushing and/or matting will be installed over the surface of any eroded areas (as required) to stabilise the Emu Point Beach Rehabilitation Area prior to planting. All planted seedlings will be initially protected with corflute tree guards held in place with hardwood stakes. Once the plants are large enough to survive without the guards, they will be removed.

7.1.5 Post-instalment management

7.1.5.1 Completion criteria and success targets

The key actions / target completion criteria to monitor the success of the revegetation efforts are specified in Table 6. Revegetation efforts will be undertaken and monitored for a period of two years from the commencement of the revegetation plantings. If the completion criteria are not met, further action will be undertaken to improve the condition to the required standards.

Table 6: Revegetation and weed management key actions

Year after planting	Year 1	Year 2
Survival of planted seedlings	75%	90%
Minimum plant diversity (% of original number of planted species in project area that have survived)	70%	70%
Plant coverage (% area of visual ground cover measured by a botanist/revegetation consultant)	25%	50%
Weeds coverage	20% cover	10% cover

7.1.5.2 Vegetation monitoring and performance criteria

The Emu Point Beach Rehabilitation Area will be formally monitored biannually (includes weed monitoring) each spring and autumn, for a two year period after installation by the CoA. The season has been nominated rather than a specific month, as the timing of these assessments should be related to plant growth cycles, which in turn is influenced by the weather conditions at the time.

One monitoring plot of 5 m × 5 m will be established per revegetation area as well as one permanent photograph reference point at each monitoring plot. Photographic records will be captured prior to construction and annually to qualitatively assess density, diversity and weed cover. The first assessment in spring will assess the developing threats, the stabilisation of each area and the short term survival of the seedlings and weed cover. Any problems will be identified early so that comprehensive treatment(s) of the issue can be undertaken and additional seedlings propagated if required. The second assessment in the following autumn will determine if there are any losses over the dry summer period, and this will form the basis for the maintenance winter program. The first summer is the expected period of greatest mortality, and plants that survive this period are generally hardy and more likely to survive in the longer term. The emergence of summer weeds will also be assessed, so that control can be scheduled as required.

After the third and subsequent assessments, the long-term success of the revegetation operation will be indicated. This will determine whether any further remedial works are required. This may include:

- Additional revegetation works
- Weed management
- Other general maintenance activities
- Additional monitoring requirements.

Informal assessments will also be undertaken between formal assessments. The purpose of these assessments is to visually monitor progress, and to identify and counter emerging issues before they have a chance to become significant. Timing of the assessments will be adjusted to the appropriate stages of plant growth, which are influenced by annual weather conditions. The results of each monitoring assessment will be compared to determine germination and establishment rates and provide a quantitative measure of progress. The final monitoring inspection will be held to certify that the completion criteria have been met.

7.1.6 Site maintenance

If planting success falls below 90% of original numbers in two consecutive monitoring events, contingency measures will be implemented to increase the success of the revegetation program. The monitoring program will identify issues to any plant success rates so they can be dealt with in an appropriate and timely manner.

Maintenance activities may include:

- Brushing and/or matting over the surface of any eroded areas (as required)
- Ongoing weed management
- Replanting in areas
- Tree guard repair / replacement
- Undertake fence, sign and pathway maintenance (as required).

All the contingency measures listed in Table 7 will be reviewed if the target completion criteria fall below 90% in two consecutive events.

Table 7: Revegetation and weed management contingency measures

Plants	Plant death, storm/wind damage, vandalism	Plant additional tube stock in subsequent plantings
Weeds	Excessive weeds in revegetation areas	Undertake weed control measures. e.g. weed spraying.
Erosion	Erosion, storm damage	Apply brushing and/or matting over the surface of any eroded areas.
Revegetation success	Plant survival does not meet completion criteria	Replant seedlings and replace plant guards.

8 IMPLEMENTATION AND RESPONSIBILITY

Life cycle/asset management indicative cost estimate for the works proposed in this FMP have been provided in Appendix C, whilst Appendix A indicates the spatial extent of the various maintenance elements.

8.1 Implementation

The implementation of the Landscape Master Plan and coastal hazard risk management actions will be undertaken across short term (zero to five years) and medium term (five to ten years) planning horizons:

- Short term actions (zero to five years):
  - CoA to approve the advertisement of the Emu Beach FMP for the purpose of advertising / public consultation
  - CoA to implement sand nourishment in the eastern corner of the Oyster Harbour Beach when there is less than 5 m between the HSD and the northern groyne / grouted rock wall[6]
  - Complete the CoA's LPS No.1 review, which is currently being progressed, to include the vulnerable zone (the modelled hazard area to 2120) in a Special Control Area within five years
  - CoA to seek state and federal funds to undertake the capital works for the Landscape Master Plan and granite boulder groyne field establishment within five years[7]
  - CoA to commence Emu Beach sand nourishment:
    - Opportunistically
    - If beach access becomes dangerous due to high (>1 m) vertical dune scarps
    - After establishment of the groyne field.
- Medium term actions (five to ten years):
  - CoA and the Emu Beach 'BIG4' Holiday Park leaseholder to agree on updated lease arrangement for the southern portion of the park
  - CoA to investigate the opportunity to acquire at risk land as it becomes available on the public market when the HSD is less than 40 m from Griffiths Street[6]
  - CoA to seek state and federal funds to undertake the capital works for the upgrades to the existing coastal protection structures, including the Emu Point rock revetment[67], when:
    - Any section of rock revetment is assessed to be in "Very Poor" condition; or
    - More than three overtopping events of a rock revetment structure are recorded within a 12-month period.

An implementation schedule, which includes pre-, during and post-construction actions, is provided in Table 8.

8.2 Responsibility

The CoA will be responsible for the implementation of this FMP, including the Landscape Master Plan (Appendix A; SeeDesign Studio 2021) and coastal protection works identified by the preliminary Basis of Design (Appendix B; Bluecoast Consulting Engineers 2021) report.

The FMP budget (approximately $11.45 million (ex. GST)), which is comprised of the Landscape Master Plan (approximately $5.91 million (ex. GST) civil/roads and earthwork costs) and coastal protection works (approximately $5.54 million (ex. GST) excluding monitoring and maintenance requirements), is planned to be sourced by the CoA from state and Commonwealth governments.

[6] Action will be commenced when the trigger value is reached.

[7] Implementation of capital works will be dependent upon when the external government funding is realised.

Table 8: Implementation schedule

Objective / Parameter	Description	Pre-construction implementation	Construction implementation	Post-construction implementation
Statutory planning and policy context				
Comply with the purpose of the reserve under the LPS No. 1		• Preparation of a detailed FMP that reflects the objectives of the "Parks and Recreation" reservation under the LPS No. 1. • Development Applications to demonstrate design life of the Landscape Master Plan's key assets.	Installation approved Landscape Master Plan key assets in accordance with approved Development Applications.	• Monitoring and reporting on Revegetation Strategy. • Review integrity of the Landscape Master Plan key assets as per the Development Application approval. • Implement coastal hazard risk management actions including: – Complete the CoA's LPS No.1 review, which is currently being progressed, to include the vulnerable zone in a Special Control Area – Updated lease arrangement for the southern portion of the Emu Beach 'BIG4' Holiday Park – Investigate the opportunity to acquire at risk land as it becomes available on the public market – Undertake granite boulder groyne field establishment, Emu Beach sand nourishment, upgrades to the Emu Point rock revetment and Oyster Harbour Beach sand nourishment.
Comply with the objectives and requirements of SPP 2.6		• Preparation of a detailed FMP that reflects the CHRMAP and requirements of the requirements of the State Coastal Policy, SPP 2.6. • Development Applications to demonstrate design life of the Landscape Master Plan's key assets.	• Installation approved Landscape Master Plan key assets in accordance with approved Development Applications. • Implement Revegetation Strategy.	• Monitoring and reporting on Revegetation Strategy. • Review integrity of Landscape Master Plan key assets as per the Development Application approval. • Implement coastal hazard risk management actions including: – Complete the CoA's LPS No.1 review, which is currently being progressed, to include the vulnerable zone in a Special Control Area – Updated lease arrangement for the southern portion of the Emu Beach 'BIG4' Holiday Park – Investigate the opportunity to acquire at risk land as it becomes available on the public market – Undertake granite boulder groyne field establishment, Emu Beach sand nourishment, upgrades to the Emu Point rock revetment and Oyster Harbour Beach sand nourishment. • CoA to continue with the current Emu Beach and Oyster Harbour Beach monitoring programs and undertake any additional FMP monitoring requirements to assess managed retreat and sand nourishment trigger values. • CoA to monitor and maintain all coastal protection structures.
Foreshore design and function				
Support public recreational uses of the foreshore	• Improve public facilities and recreational amenity. • Provide facilities to support public recreational uses for all ages. • Provide for safe visitor experiences.	• Master planning and detailed design stages will ensure design for a range of recreational activities including zones for active sports and play, event spaces, beach vistas and lookouts, picnic and barbecue areas, and facilities for beach users. • Development Applications to demonstrate design life of the Landscape Master Plan's key assets. • Civil engineer to implement Construction Management Measures to the satisfaction of the CoA. • Construction fencing of the foreshore subject to the engineering works areas. • Signage to ensure pedestrians are warned not to enter the construction areas.	Installation approved Landscape Master Plan key assets in accordance with approved Development Applications.	Ensure that construction fencing and signs are removed.
Access management	• Provide safe, user friendly and controlled access to and across the foreshore. • Provide appropriate signage in accordance with CoA requirements.	• Establish safe beach access pathways to the beach for the duration of the construction period. The access pathways are to be focused on using existing cleared tracks. • Development Applications to demonstrate design life of the Landscape Master Plan's key assets. • Civil engineer to implement Construction Management Measures to the satisfaction of the CoA. • Construction fencing around the area subject to the engineering works. • Signage to ensure pedestrians are warned not to enter the construction area.	• Installation approved Landscape Master Plan key assets in accordance with approved Development Applications. • Regularly inspect signage. Replace signage if vandalised or removed. • Place appropriate signs at key beach access points.	Ensure that construction fencing and signs are removed.

Objective / Parameter	Description	Pre-construction implementation	Construction implementation	Post-construction implementation
Coastal hazard risk management				
Coastal hazards	Design foreshore redevelopment so assets are not at risk of coastal hazards over their design life.	The CHRMAP assesses the risks to coastal assets from coastal hazards and proposes suitable management responses. This FMP has been developed in accordance with the CHRMAP.	Installation approved Landscape Master Plan key assets in accordance with approved Development Applications.	• Implement coastal hazard risk management actions including: – Complete the CoA's LPS No.1 review, which is currently being progressed, to include the vulnerable zone in a Special Control Area – Updated lease arrangement for the southern portion of the Emu Beach 'BIG4' Holiday Park – Investigate the opportunity to acquire at risk land as it becomes available on the public market – Undertake granite boulder groyne field establishment, Emu Beach sand nourishment, upgrades to the Emu Point rock revetment and Oyster Harbour Beach sand nourishment. • CoA to continue with the current Emu Beach and Oyster Harbour Beach monitoring programs and undertake any additional FMP monitoring requirements to assess managed retreat and sand nourishment trigger values. • CoA to monitor and maintain all coastal protection structures.
Stabilisation and erosion control	Stabilisation of foreshore areas requiring restoration to limit wind-blown sand and degradation of the foreshore area.	• Establish rehabilitation and weed management areas in the FMP area to inform the preparation of the Revegetation Strategy. • Establish safe beach access pathways to the beach for the duration of the construction period. The access pathways are to be focused on using existing cleared tracks.	• Installation Landscape Master Plan key assets in accordance with approved Development Applications. • Revegetation will be undertaken as detailed in the Revegetation Strategy.	• CoA to continue with the current Emu Beach and Oyster Harbour Beach monitoring programs and undertake any additional FMP monitoring requirements to assess managed retreat and sand nourishment trigger values. • CoA to monitor and maintain all coastal protection structures. • Revegetation and monitoring will be undertaken as detailed in the Revegetation Strategy.
Foreshore rehabilitation				
Revegetation	Restore vegetation condition in defined areas of foreshore.	Map the revegetation and weed management areas.	Revegetation will be undertaken as detailed in the Revegetation Strategy.	Revegetation and monitoring will be undertaken as detailed in the Revegetation Strategy.
Weed management	Manage the introduction, spread and concentration of weed species.	Weed management will be undertaken as part of revegetation activities.	Weed management will be detailed in the Revegetation Strategy.	Revegetation and weed monitoring will be undertaken as detailed in the Revegetation Strategy.

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Figures

Figure A

Site location

GDA 1994 MGA Zone 50

0 125 250 500 m

Job Number:L19265-001
Doc Number: 001
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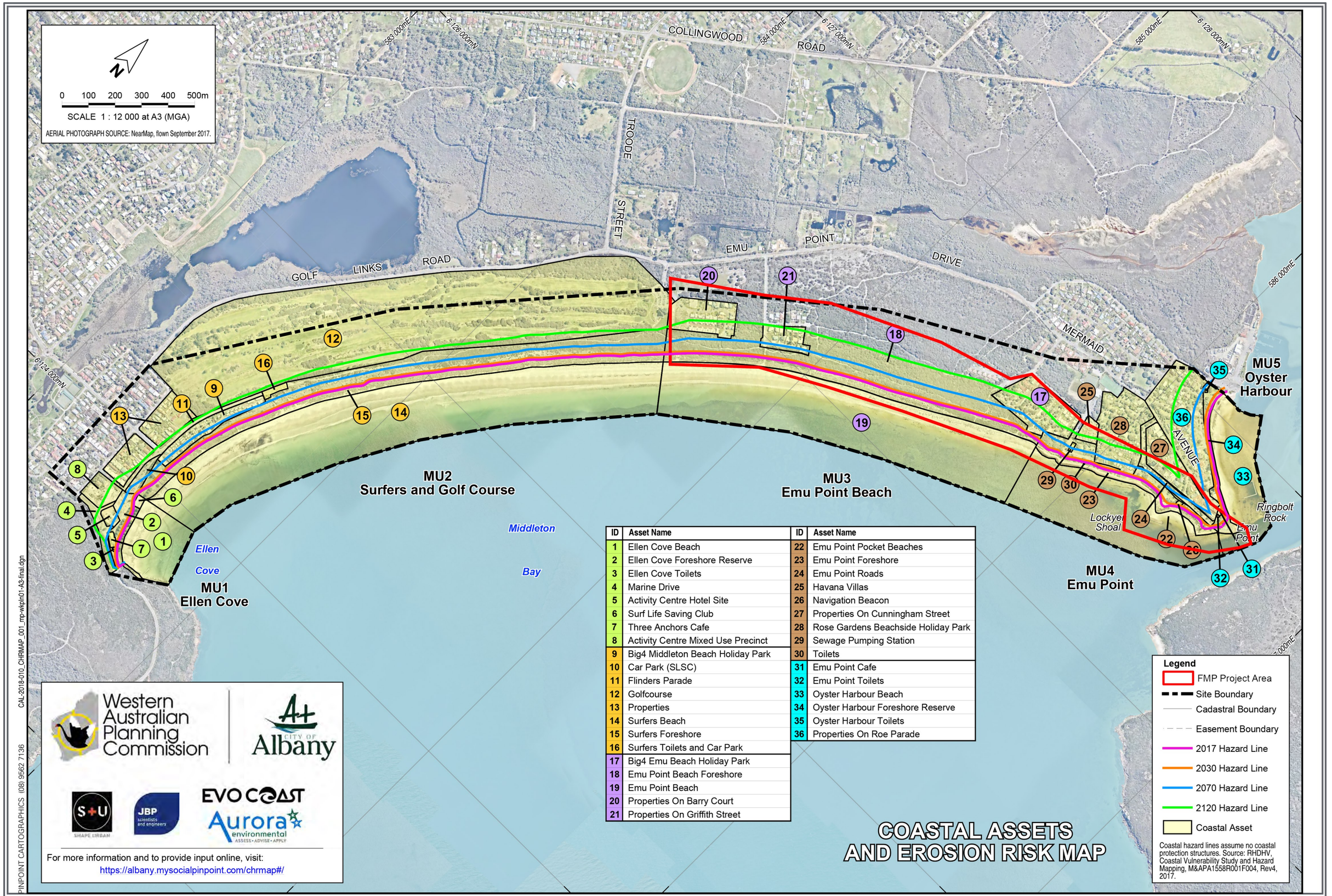
Created by: MA
Source: Imagery - Landgate 2019



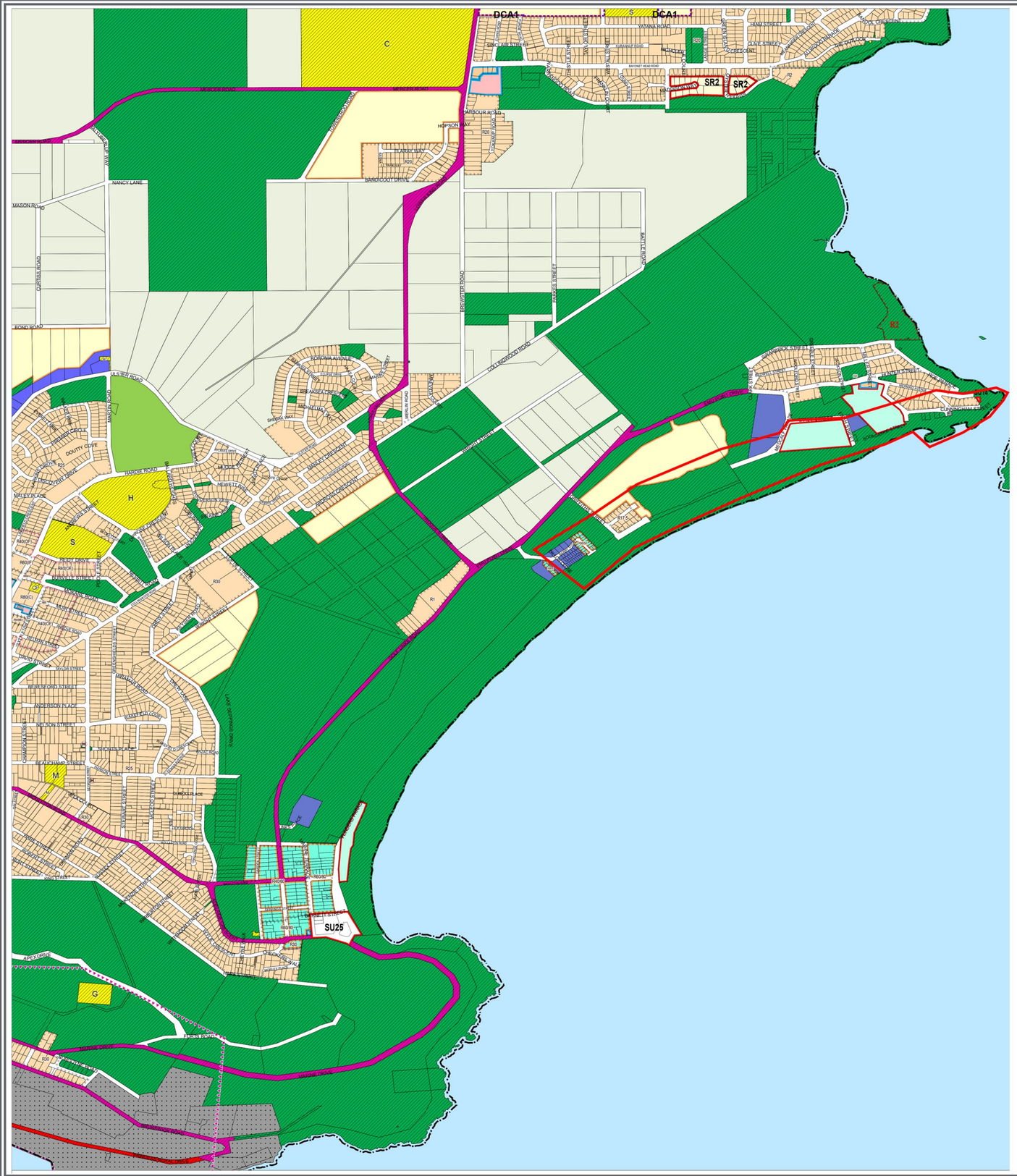
ID	Asset Name
1	Ellen Cove Beach
2	Ellen Cove Foreshore Reserve
3	Ellen Cove Toilets
4	Marine Drive
5	Activity Centre Hotel Site
6	Surf Life Saving Club
7	Three Anchors Cafe
8	Activity Centre Mixed Use Precinct
9	Big4 Middleton Beach Holiday Park
10	Car Park (SLSC)
11	Flinders Parade
12	Golfcourse
13	Properties
14	Surfers Beach
15	Surfers Foreshore
16	Surfers Toilets and Car Park
17	Big4 Emu Beach Holiday Park
18	Emu Point Beach Foreshore
19	Emu Point Beach
20	Properties On Barry Court
21	Properties On Griffith Street

ID	Asset Name
22	Emu Point Pocket Beaches
23	Emu Point Foreshore
24	Emu Point Roads
25	Havana Villas
26	Navigation Beacon
27	Properties On Cunningham Street
28	Rose Gardens Beachside Holiday Park
29	Sewage Pumping Station
30	Toilets
31	Emu Point Cafe
32	Emu Point Toilets
33	Oyster Harbour Beach
34	Oyster Harbour Foreshore Reserve
35	Oyster Harbour Toilets
36	Properties On Roe Parade

Figure B

CHRMAP management units

Job Number: L19265-001
Doc Number: 002
Date: 13.05.20
Scale: NTS @ A3
Created by: MA
Source: RPS, 2020



LEGEND

FMP Project Area

LOCAL SCHEME RESERVES

- Local Road
- Major Road
- Parks and Recreation
- Priority Road
- Public Use
- A — Public Use : Airport
- C — Public Use : Cemetery
- CI — Public Use : Communication
- CP — Public Use : Community Purpose
- CFF — Public Use : Conservation of Flora and Fauna
- G — Public Use : Government
- H — Public Use : Hospital
- M — Public Use : Museum
- PU — Public Use : Public Utility
- R — Public Use : Refuse
- S — Public Use : School
- T — Public Use : Technical College
- WC — Public Use : Water Corporation
- Rail

LOCAL SCHEME ZONES

- Caravan and Camping
- Clubs and Institutions
- Conservation
- Future Urban
- General Agriculture
- General Industry
- Highway Commercial
- Hotel / Motel
- Light Industry
- Local Centre
- Neighbourhood Centre
- Port Industry
- Priority Agriculture
- Regional Centre
- Regional Centre Mixed Business
- Regional Centre Mixed Use
- Residential
- Rural Residential
- Rural Small Lot Holdings
- Rural Village
- Special Residential
- Special Use
- Tourist Residential
- Yakamia Creek

OTHER CATEGORIES

(see scheme text for additional information)

- Scheme Area Boundary
- Local Government Boundary
- R20 R Codes
- A1 Additional Uses
- R1 Restricted Uses
- **RR1** Rural Residential Area
- **RSH** Rural Small Lot Holdings
- **SR1** Special Residential Area
- **RV1** Rural Village
- **SU1** Special Use Area
- Albany Airport Special Control Area (see c.6.2)
- Albany Port Special Control Area (see c.6.4)
- Albany Speedway Noise Special Control Area (see c.6.5)
- **CZ1** Conservation Zone Area
- **DCA1** Development Contribution Area
- **IA2** Industrial Area
- **IA4BA** Industrial Buffer Area
- Public Drinking Water Sources Special Control Areas (see c.6.3)
- Spencer Park Improvement Special Control Area (see c.6.7)
- Water Corporation Waste Water Treatment Plant Odour Buffer Special Control Area (see c.6.6)
- H Places of Heritage Value - Buildings

- No Zone
- Waterbodies

Figure C
City of Albany
Local Planning Scheme No. 1 mapping

Job Number: L19265-001
Doc Number: 003
Date: 20.01.20
Scale: NTS @ A3
Created by: MA
Source: RPS, 2020

Figure D

Topography

GDA 1994 MGA Zone 50

0 75 150 300 m

Source: Cadastre - Landgate, 2019 Orthophoto - Landgate, 2019 Contours derived from SRTM DEM.

Job Number: L19265-001
Doc Number: 004
Date: 13.05.20
Scale: 1:6,000 @ A3
Created by: MA

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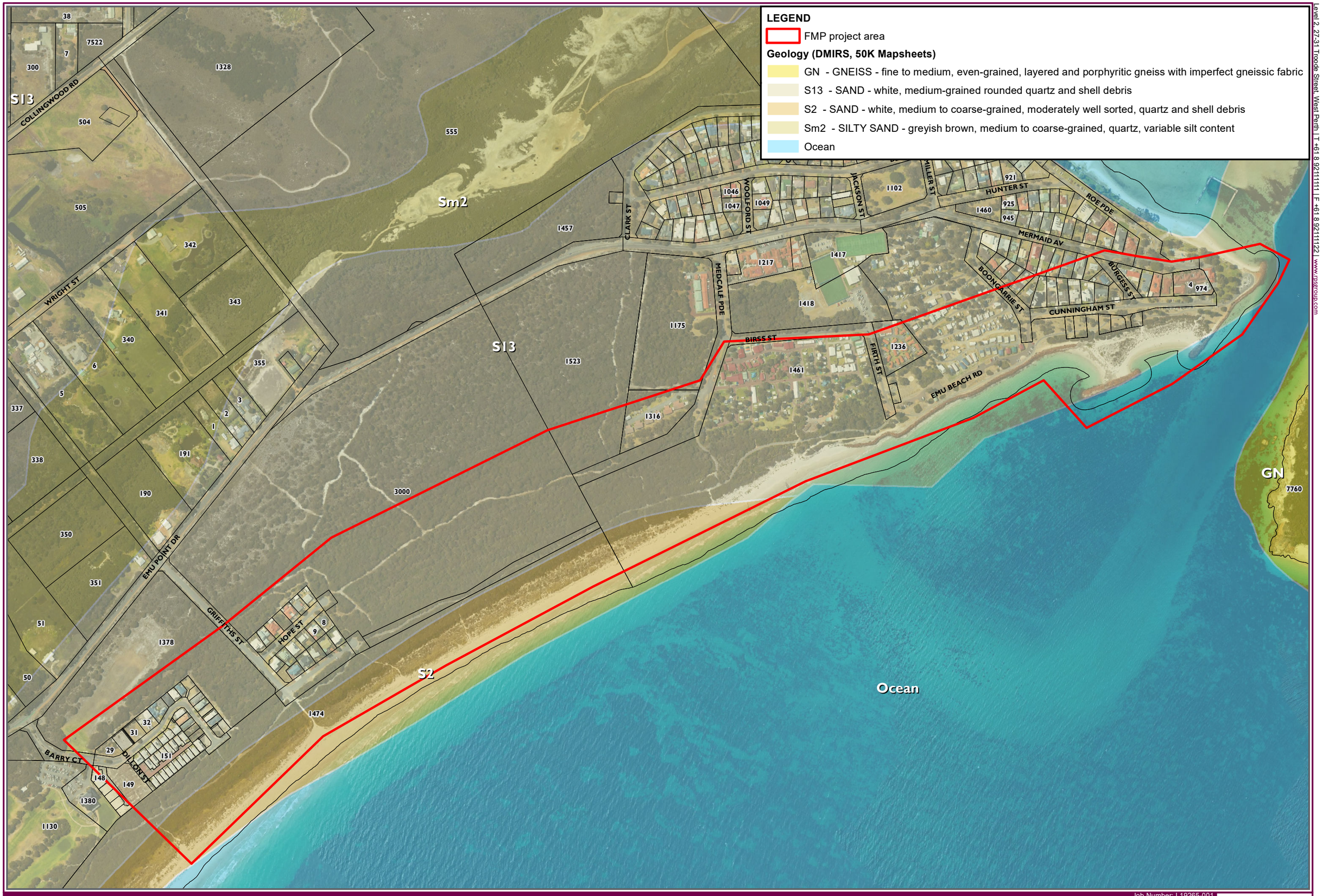

Figure E

Geology

GDA 1994 MGA Zone 50

0 75 150 300 m

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Doc Number: 005
Date: 13.05.20
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Created by: MA

Source: Cadastre - Landgate, 2019 Orthophoto - Landgate, 2019

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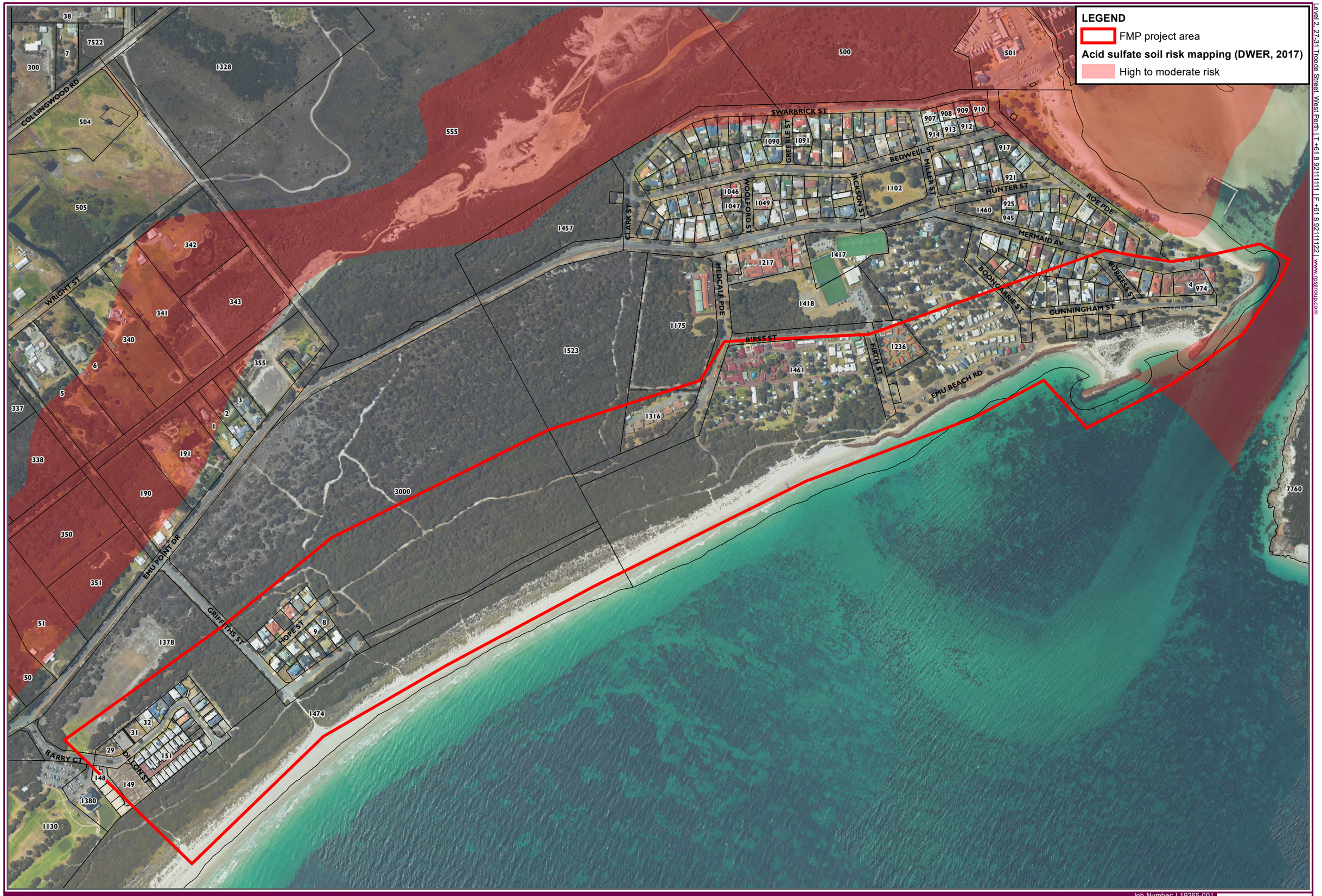

Figure F

Acid sulfate soil risk mapping

GDA 1994 MGA Zone 50

0 75 150 300 m

Job Number: L19265-001
Doc Number: 006
Date: 13.05.20
Scale: 1:6,000 @ A3
Created by: MA

Source: Cadastre - Landgate, 2019 Orthophoto - Landgate, 2019

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51

423

PARKES RD
COLLINGWOOD RD
WRIGHT ST
SWARBRICK ST
GREEBLE ST
BEDWELL ST
MILLER ST
HUNTER ST
ROE PDE
CLARK ST
WOOLFORD ST
JACKSON ST
MERMAID AV
BURGESS ST
BOONGARRIE ST
CUNNINGHAM ST
MEDCALF PDE
BIRSS ST
FIRTH ST
EMU BEACH RD
EMU POINT DR
GRIFFITHS ST
HOPE ST
BARRY CT
DILLON ST

LEGEND

- FMP project area
- Cadastre
- 51 - Sedgeland; reed swamps, occasionally with heath
- 423 - Shrublands; Acacia scrub-heath (unknown spp.)

Figure G

Shepherd vegetation association mapping

GDA 1994 MGA Zone 50

0 75 150 300 m

Job Number: L19265-001
Doc Number: 007
Date: 13.05.20
Scale: 1:6,500 @ A3
Created by: RL

Source: Cadastre - Landgate, 2019 Orthophoto - Landgate, 2019

Document Path: G:\Jobs\L_Jobs\L19265 - CoA Emu Beach FMP\Figures L19265-001\L19265-001_G_007_FigG_Shepherd vegetation association_200513.mxd

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WRIGHT ST
EMU POINT DR
GRIFFITHS ST
HOPE ST
BARRY CT
DILLON ST
CLARK ST
SWARBRICK ST
GREEBLE ST
WOOLFORD ST
JACKSON ST
BEDWELL ST
MILLER ST
HUNTER ST
ROE PDE
MERMAID AV
MEDCALF PDE
BOONGARRIE ST
BURGESS ST
CUNNINGHAM ST
BIRSS ST
FIRTH ST
EMU BEACH RD

LEGEND

- FMP project area
- Hickman (2005) survey area

Vegetation association - Hickman (2005)

- Open peppermint heath
- Peppermint thicket
- Sheoak woodland
- Littoral zone

Vegetation association - RPS inferred (2020)

- Open peppermint heath
- Peppermint thicket
- Littoral zone
- Parkland cleared
- Rehabilitation

Figure H

Flora and vegetation survey for the Emu Point residential estate

GDA 1994 MGA Zone 50

0 70 140 280 m

Job Number: L19265-001
Doc Number: 008
Date: 13.05.20
Scale: 1:6,000 @ A3
Created by: RL

Source: Cadastre & Orthophoto - Landgate, 2019 Veg Association - Landcorp, Oct 2005 and RPS indicative 2020.

Document Path: G:\Jobs\L_Jobs\L19265 - CoA Emu Beach FMP\Figures L19265-001\L19265-001_G_008_FigH_Flora and vegetation survey_200513.mxd

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WRIGHT ST
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BARRY CT
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CLARK ST
WOOLFORD ST
GREEBLE ST
SWARBRICK ST
JACKSON ST
MILLER ST
BEDWELL ST
HUNTER ST
ROE PDE
MERMAID AV
BOONGARRIE ST
BURGESS ST
CUNNINGHAM ST
MEDCALF PDE
BIRSS ST
FIRTH ST
EMU BEACH RD

SH
MSAFW
AFT
AFH
AFW
OH

LEGEND

- FMP project area
- Cadastre

Fauna habitat mapping

- AfH - Open Peppermint (*Agonis flexuosa*)/ *Banksia attenuata* Woodland over *Adenanthos sp./ Spyridium globulosum* Shrubland over Closed Heathland
- AfT - Closed Peppermint (*Agonis flexuosa*) Thicket over Sedgeland
- AfW - Open Sheoak (*Allocasuarina fraseriana*) / *Banksia attenuata* Woodland with occasional Peppermints (*Agonis flexuosa*) over Open Heathland
- MsAfW - Peppermint (*Agnonis flexuosa*)/ *Melaleuca sp.* Woodland over Heathland and Sedgeland
- OH - Open Heathland and Grassland
- SH - Sedgeland with isolated patches of Heathland

Figure I

Fauna habitat mapping for the Emu Point residential estate

GDA 1994 MGA Zone 50

0 75 150 300 m

Source: Cadastre & Orthophoto - Landgate, 2019 Fauna habitat mapping - ATA Environmental - Fauna Habitat Assessment Fig 7, 05.12.06

Job Number: L19265-001
Doc Number: 009
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Created by: RL

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Figure J

Bushfire prone area mapping

GDA 1994 MGA Zone 50

0 75 150 300 m

Job Number: L19265-001
Doc Number: 012
Date: 13.05.20
Scale: 1:8,000 @ A3
Created by: RL

Source: Cadastre & Orthophoto - Landgate, 2019 Fauna habitat mapping - ATA Environmental - Fauna Habitat Assessment Fig 7, 05.12.06

Document Path: G:\Jobs\L_Jobs\L19265 - CoA Emu Beach FMP\Figures L19265-001\L19265-001_G_012_FigJ_Bushfire prone areas_200513.mxd

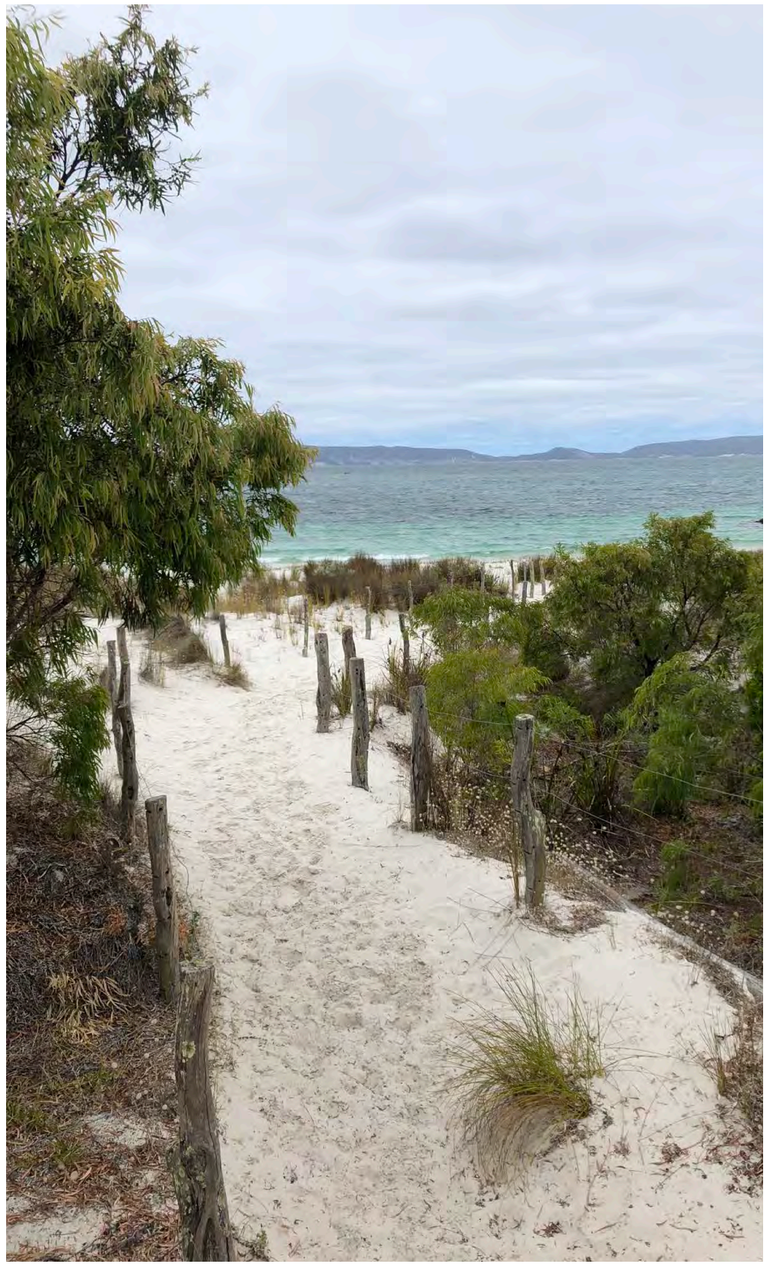
Appendix A
Landscape master plan

EMU BEACH FORESHORE MANAGEMENT PLAN LANDSCAPE MASTER PLAN

Final Landscape Architecture Report

SEE DESIGN

WWW.SEEDESIGNSTUDIO.COM.AU



Contents

01. Introduction

The Emu Beach Foreshore Management plan and accompanying Landscape Master Plan has been initiated by the City of Albany for the implementation of the coastal adaption responses in Emu Point Beach and Emu Point localities, consistent with State Planning Policy (SPP) 2.6: State Coastal Planning Policy (WAPC 2013a) and the endorsed Emu Point to Middleton Beach Coastal Hazard Risk Management and Adaptation Plan (CHRMAP; Aurora Environmental 2019a).

PURPOSE

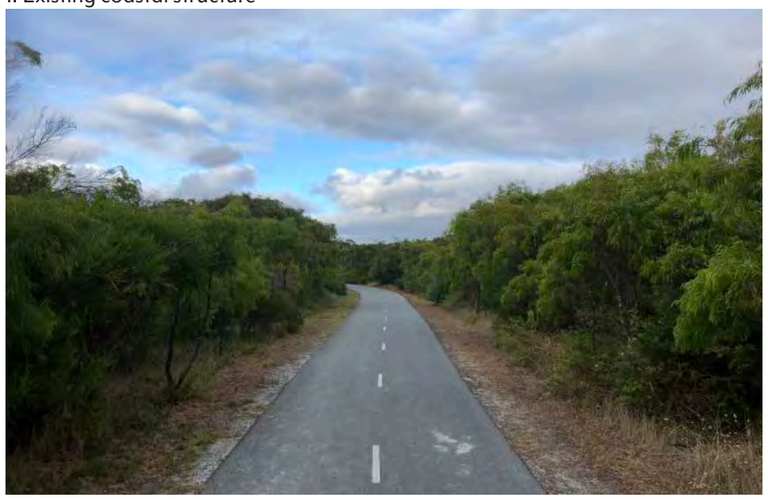
The Landscape Master Plan provides the CoA's long term vision and proposed infrastructure for the Emu Point Beach and Emu Point localities, details of the key structural elements of the foreshore design and has been developed having regard for the foreshore's local and regional context, social and environmental characteristics, and a range of practical management requirements (e.g. access, vegetation retention).

OBJECTIVES

The overall aim of the Landscape Master Plan is to retain and enhance the key recreational and amenity values of the Emu Point Beach and Emu Point foreshore environments, whilst ensuring its ongoing protection from coastal hazards.

1. Existing coastal structure

2. Site walk with key stakeholders



3. Dual use coastal path

4. Emu Beach park and adjacent cafe

02. Site Context

Emu Beach sits within the coastal suburb of Emu Point, Albany, approximately 6 kilometers north east of the city center. The site sits between Oyster Harbour to the north and faces onto scenic King George Sound. Emu Point and beach sits north of Middleton Beach, Albany's central town beach. It is a popular destination for locals and tourist as it offers a range of activities along the beautiful coast line and it is easily accessible from town. The site is primarily accessed by car and the dual use pedestrian and cycle path from Middleton Beach.

The site extends from the northern edge of the Middleton Beach golf course in the south to Emu Point Cafe and surrounding parkland in the north. It is characterised by an expansive white sandy beach which backs onto native coastal vegetation with coastal structures on the northern end of the beach. There are pockets of residential housing around Griffiths Street, Bayside Links Estate and the suburb of Emu Point connected by road and footpath into the town.

Dual use cycle and pedestrian path

Major roads to Emu Beach

03. Design Principles

The City of Albany has previously conducted community surveys as part of the Emu Point to Middleton Beach Coastal Adaptation and Protection Strategy (2013) along with the Coastal Parks Enhancement Plan (2014) to determine key principles and values which includes the Emu beach site.

Several significant values determined throughout the work shops included;

"The naturalness of the environment with areas of wilderness, large setback/ foreshore reserves, wide active beaches and shady quiet beaches were seen as in character. The safety, cleanliness, vistas across the ocean and the beach were highly valued."

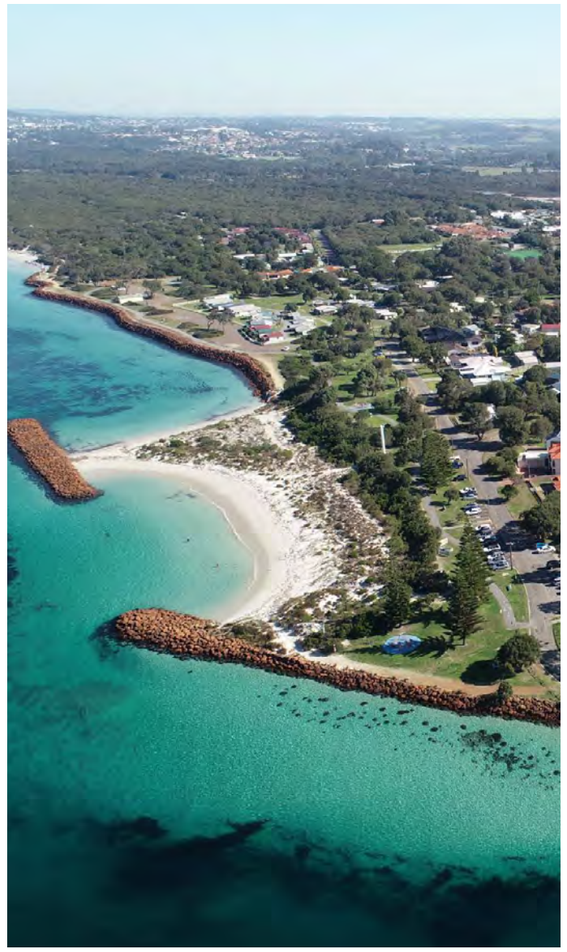
"The scenic quality, sense of place, and natural ecosystem. The open, wide expanse of the beaches, their natural, pristine state, sense of peace, relaxation and natural vistas are noted as key to the identity."

As part of the Parks Enhancement plan further workshops and consultation was undertaken to determine key values for the various coastal parkland's and to consider how to enhance and meet the community needs.

Six strategic values critical to the enhancement of the Coastal Parks including Emu Beach and its surrounds were determined. These identified themes and values will form the key principles to the landscape design outcome for Emu Beach.

Design Outcome

Retain and enhance the key recreational, landscape and amenity values of the Emu Point Beach and Emu Point foreshore environments.



Design Principles

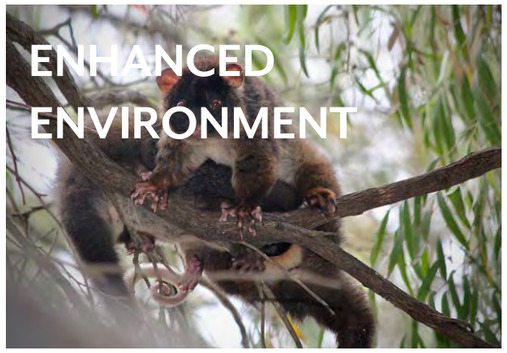
_Coastal Identity
_Environmental Quality
_Destination Development
_Connections
_Facilities and Amenities
_A place for Everyone

LANDSCAPE DESIGN PRINCIPLES

The following enhance and align to the key design principles including previous studies undertaken by the CoA, Coastal Park Enhancement Plan (2014)

Ensuring that the landscape is accessible to people of all abilities will result in repeated patronage. Ensuring an inviting place for all.

Providing protection from both sun, rain and prevailing winds throughout the precinct with both vegetation and structures ensures people can utilise and activate the space at all times of days in comfort.



Through the protection and rehabilitation of remnant vegetation key wildlife corridors can be maintained to support various endemic species. Whilst assisting in mitigating coastal erosion and increasing shade.

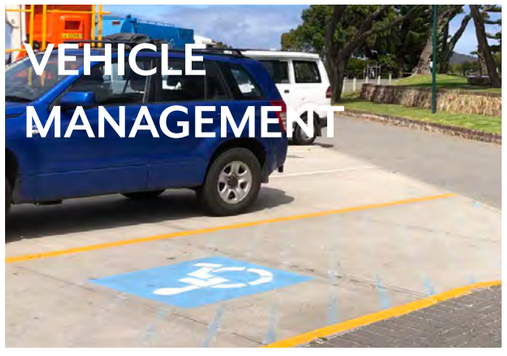
Emu point should look and feel like a place that is itself. By using local materials and leaning on local vernacular to retain the landscape character across the site.

Strengthen and enhance the existing qualities of Emu Beach landscape and create a hierarchy of various of activities.

The use of robust, well engineered materials within the coastal conditions allows the creation of a landscape that remains viable for many years to come.

Establish varied and numerous amenities for public use to allow year round activation. Upgrading or extending the play and exercise spaces will attract families and non beach goers to ensure an activated, vibrant foreshore.

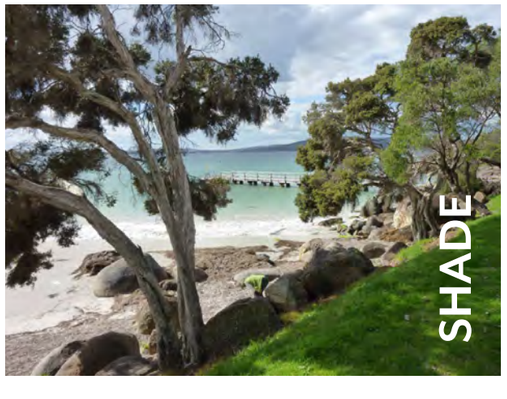
Enhance existing connections to the pedestrian/cycle network with the creation of nodes along the length of the waterfront with wayfinding, interpretation and shelter from the weather to provide linkage across the site.

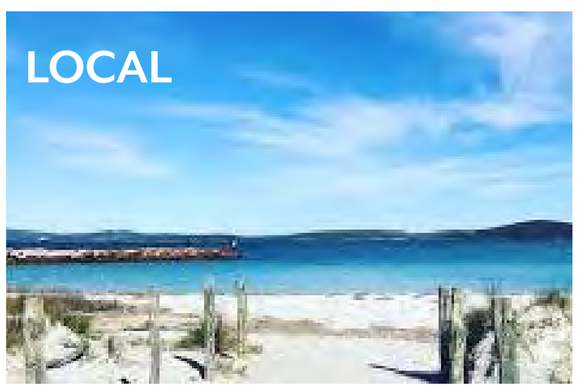


Prioritising pedestrians where possible and formalising parking nodes to improve the use of recreational spaces and movement through them.

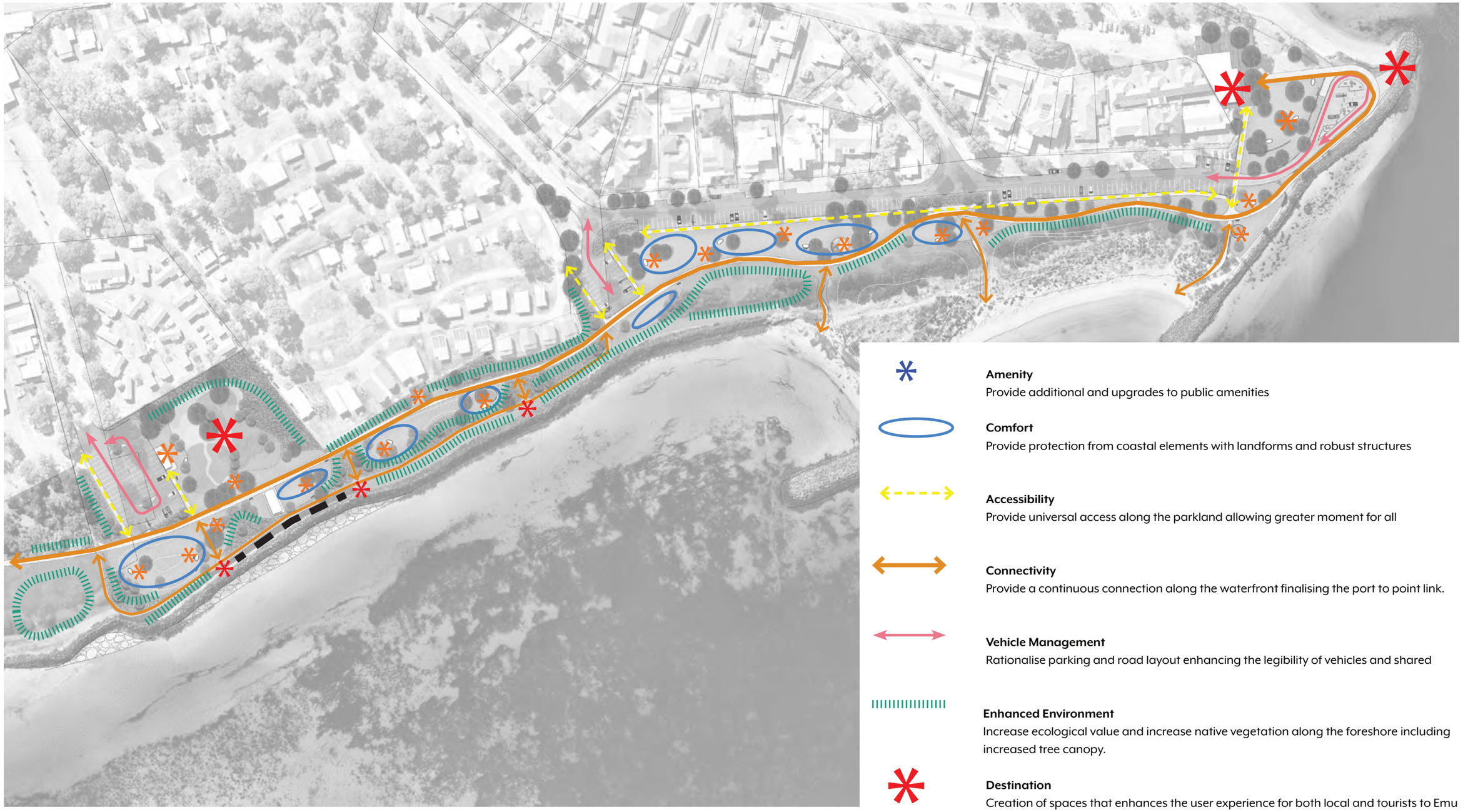
DESIGN CONSIDERATION

The following design considerations align with the overall design principles indicating a possible direction for the Emu Beach landscape.
Imagery focuses on both activation and potential direction of materiality.





LANDSCAPE DESIGN PRINCIPLES PLAN



Amenity
Provide additional and upgrades to public amenities

Comfort
Provide protection from coastal elements with landforms and robust structures

Accessibility
Provide universal access along the parkland allowing greater moment for all

Connectivity
Provide a continuous connection along the waterfront finalising the port to point link.

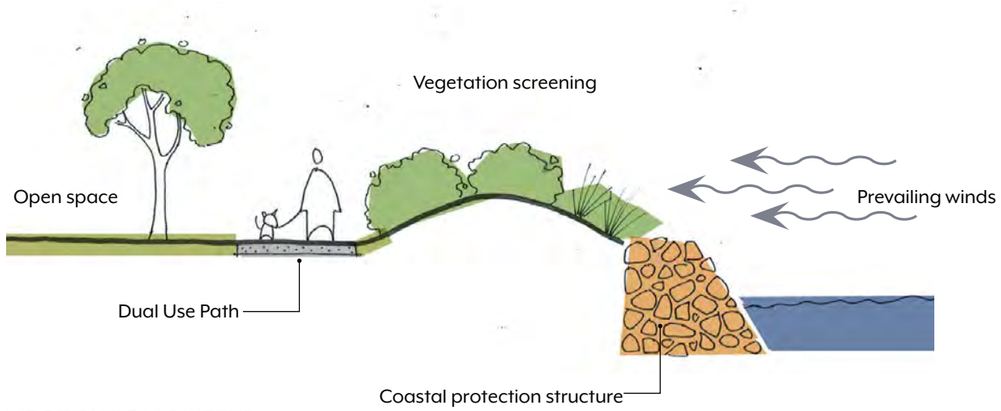
Vehicle Management
Rationalise parking and road layout enhancing the legibility of vehicles and shared

Enhanced Environment
Increase ecological value and increase native vegetation along the foreshore including increased tree canopy.

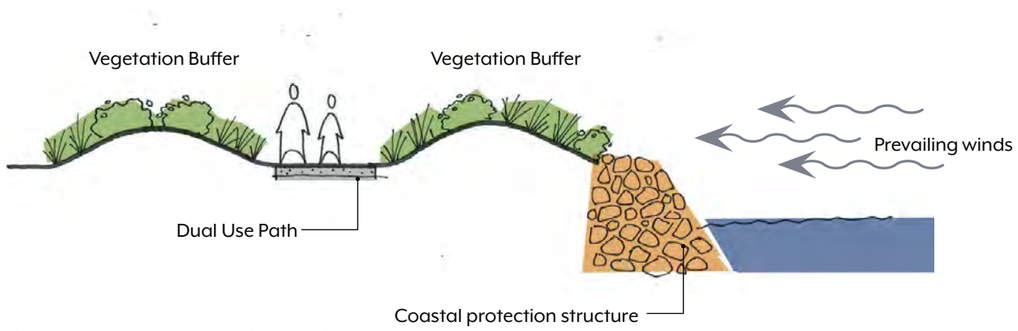
Destination
Creation of spaces that enhances the user experience for both local and tourists to Emu Beach

LANDSCAPE DESIGN PRINCIPLE SECTIONS

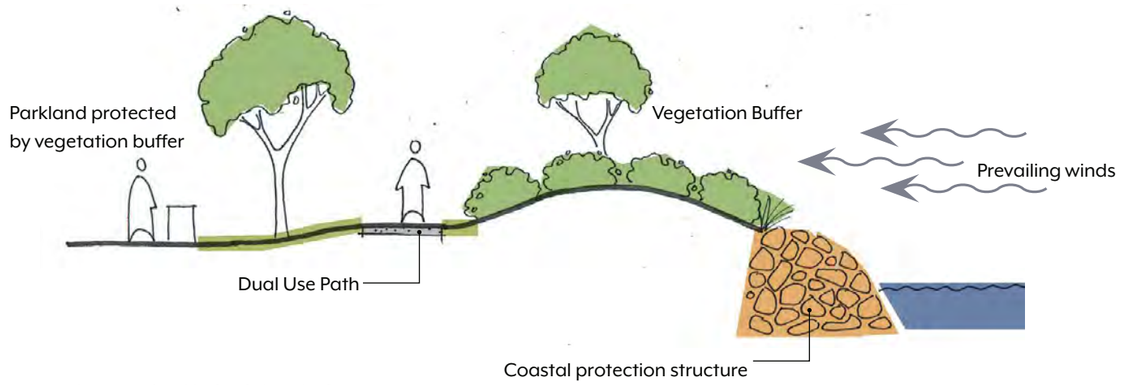
The following design considerations enhance and align to the key design principles, improving the comfort and amenity along the waterfront whilst offering multiple connection opportunities.



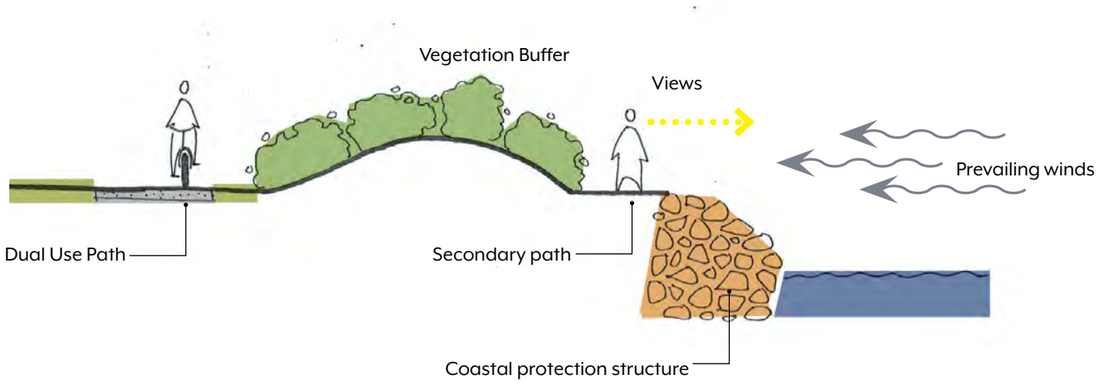
VEGETATION BUFFER



DUAL VEGETATION BUFFER



BUFFER TO PARKLAND



DUAL PATH + VIEWS

OVERALL ACTIVITIES PLAN

N

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04. Overall Landscape Masterplan

BARRY COURT TO MEDCALF PARADE

LEGEND

1. Realignment of dual use path. Location to follow existing fire brake and cleared vegetation areas where possible. Dual path to accommodate both cyclists and pedestrians. Seating and viewing platforms to be located along length of path.
2. Existing dual use path to be re vegetated following end of life. All existing donated memorial seating to be relocated following coordination with applicants.
3.Re-vegetation to existing informal beach access.
4. Griffith street formalised with new parking and vehicle turnaround.
5. Existing Griffith street and houses located within coastal risk zone
6. Realigned access to beach to limit wind driven sand including barrier fencing to protect dune vegetation.
7. Future dual use path connection.

COASTAL HAZARD LEGEND

Current HSD

Present day (2017)

2030

2050

2070

2090

2120

N

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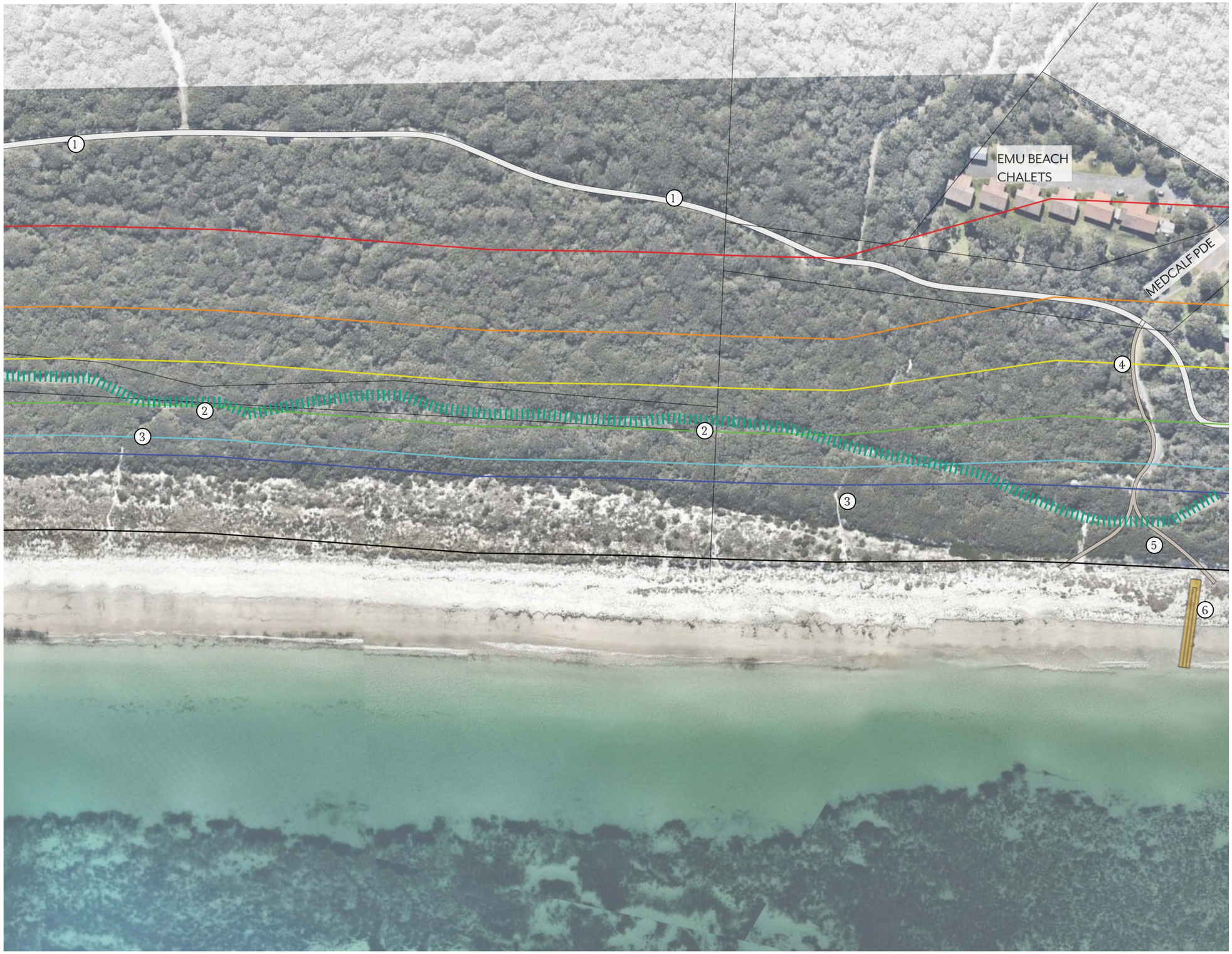

LEGEND

1. Realignment of dual use path. Location to follow existing fire brake and cleared vegetation areas where possible. Dual path to accommodate both cyclists and pedestrians. Seating and viewing platforms to be located along length of path.
2. Existing dual use path to be re vegetated following end of life. All existing donated memorial seating to be relocated following coordination with applicants.
3.Re-vegetation to existing informal beach access.
4. Upgrade to existing access to end of Medcalf Parade to allow for vehicle/maintenance access to beach and proposed coastal structures. Pedestrian access including timber viewing platforms.
5.Pedestrian and maintenance access to coastal structures and beach. Aligned to limit wind driven sand.
6.Coastal structure and re-vegetation to coast line

COASTAL HAZARD LEGEND

- Current HSD
- Present day (2017)
- 2030
- 2050
- 2070
- 2090
- 2120

MEDCALF PARADE TO EMU POINT CAFE

LEGEND

1. Realignment of dual use path. Dual path to accommodate both cyclists and pedestrians. Seating and viewing platforms to be located along length of path.
2. Upgrade to existing access to end of Medcalf Parade to allow for vehicle/maintenance access to beach and proposed coastal structures. Pedestrian access including timber viewing platforms.
3. Existing dual use path to be re vegetated following end of life and creation of new dual path. All existing donated memorial seating to be relocated following coordination with applicants.
4. Coastal structure and re-vegetation to coast line
5. Proposed realignment of lease boundary. (under review) Re-vegetation and new dual use path access
6. Proposed lease realignment (under review)
7. Access to beach and adjacent dual use path and caravan park
8. Formalised car park to end of Firth street
9. Proposed play space
10. Upgrade to existing coastal structures.
11. New park land to foreshore including shelters, picnic facilities, exercise equipment, open turf areas, shade trees and coastal planting.
12. New realignment of dual use path
13. Secondary coastal path and ocean view/seating opportunities.

COASTAL HAZARD LEGEND

Current HSD

Present day (2017)

2030

2050

2070

2090

2120

N

1:2000@ A3

LEGEND

1. Upgraded dual use path to accommodate both cyclists and pedestrians. Seating and to be located along length of path.
2. Upgrade to existing coastal structures including coastal planting.
3. Secondary coastal path and ocean view/seating opportunities.
4. Closure of Boongarrie street and the formalisation of parking bays and footpaths.
5. Fire/emergency and maintenance access.
6.New park land to foreshore including shelters, picnic facilities, exercise equipment, open turf areas, shade trees and coastal planting.
7. Formalised parking bays including footpath to Cunningham street
8. Re-vegetation to existing dune
9. Upgrade to existing parkland including shelters, picnic facilities, exercise equipment, open turf areas, shade trees and coastal planting.
10. Upgrade to existing beach access.
11. Upgrade to existing car park including new pavement for creation of a shared space.
12.Dual use path connection to Emu Point and cafe
13. Upgrade to existing parkland including shelters, picnic facilities, exercise equipment, open turf areas and shade trees.

COASTAL HAZARD LEGEND

Current HSD

Present day (2017)

2030

2050

2070

2090

2120

N

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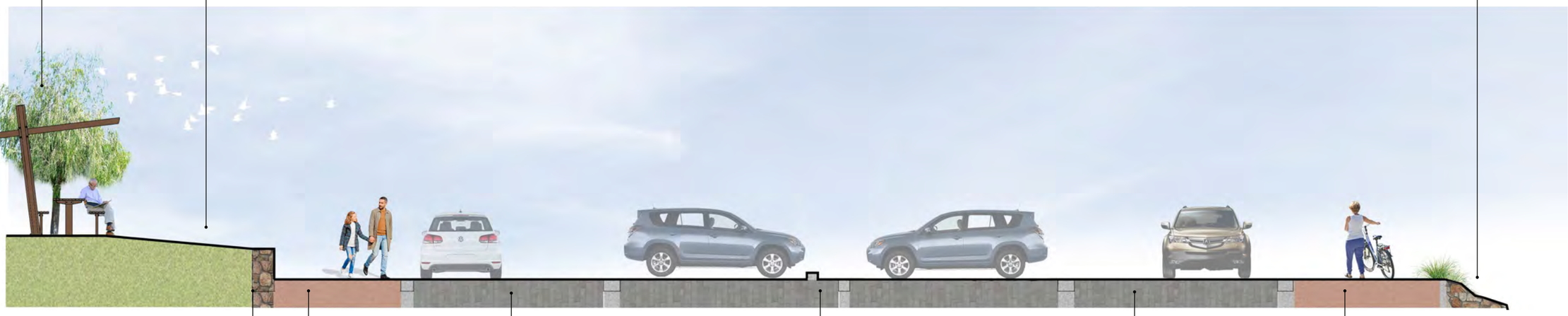
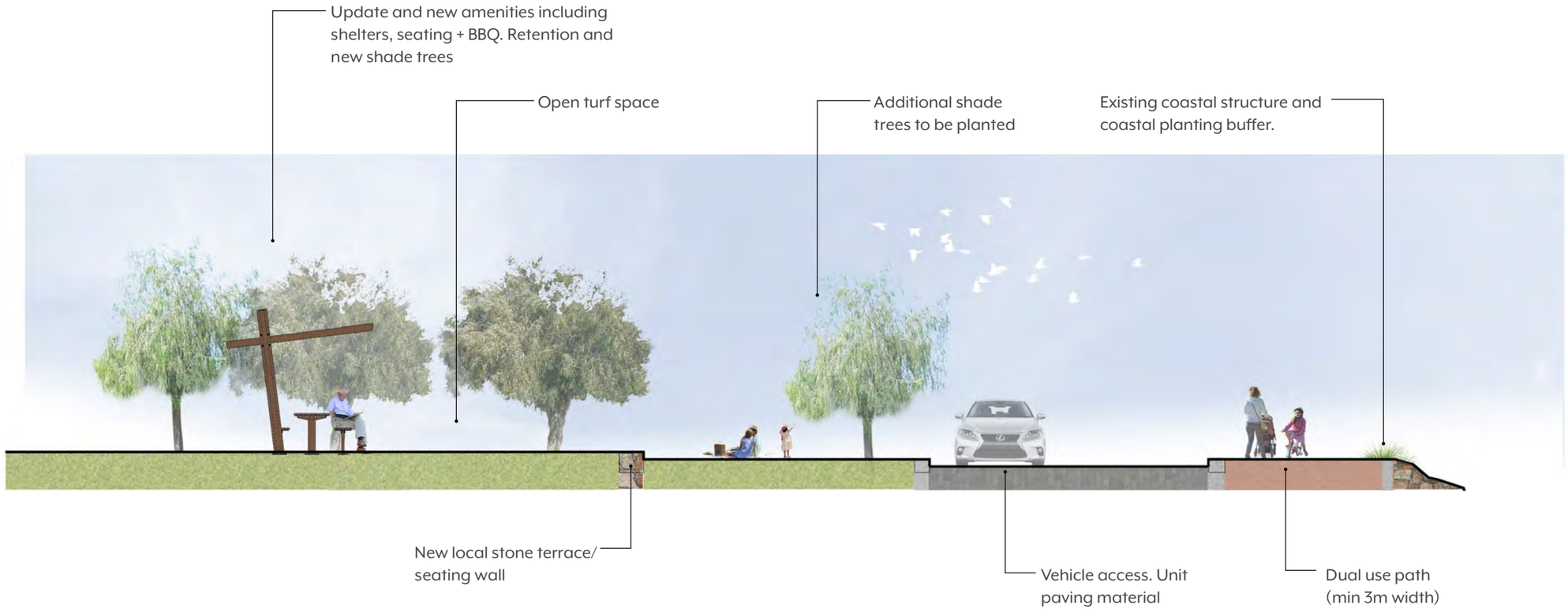
EMU POINT_DETAIL PLAN

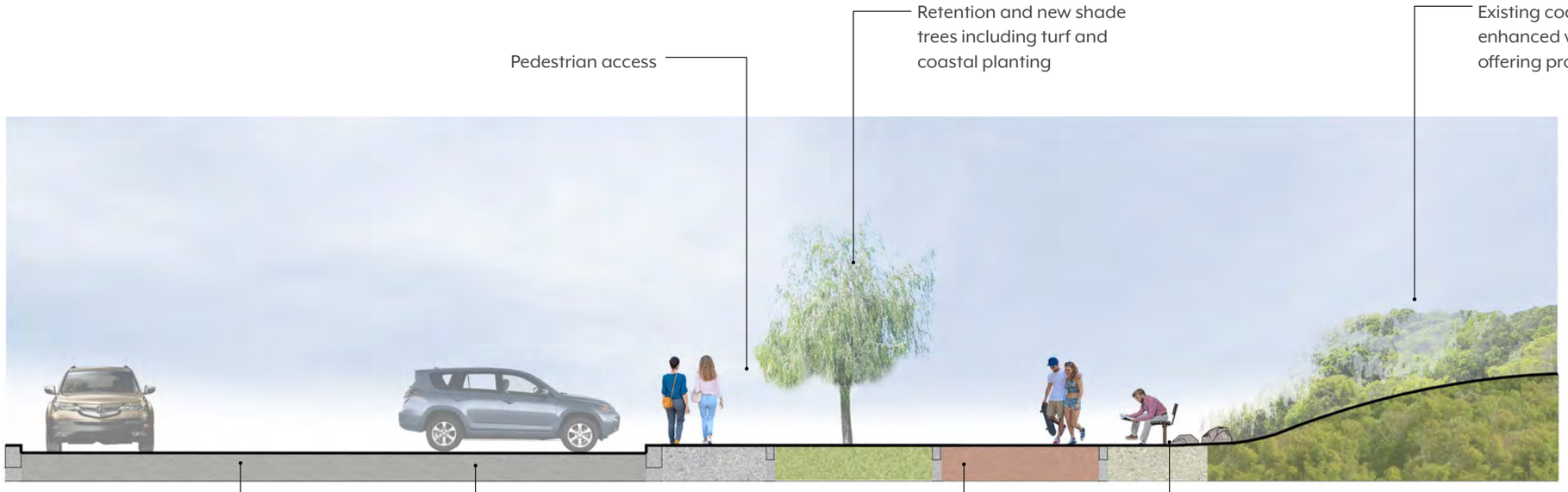
LEGEND

1. Emu Point plaza and public realm to existing cafe and public toilets including the retention of existing shade trees.
2. Dual use path (3m)
3. Dual use path termination - Port to Point connection. Flexible event space and disables access to platform
4. Accessible fishing platform
5. Dual use path
6. Formalised parking and shared space. Paved surface treatment.
7. Open turf space including updated amenities. (Shelters, BBQ, + Seating)
8. Existing and new local stone terrace seating walls
9. Car park entrance and change in surface treatment, allowance for car park to be closed for events.
10. Pedestrian access to Emu Point plaza
11. Exercise and beach node, including exercise equipment + Showers
12. Secondary footpath access to car bays
13. Formalised car bays to Cunningham street
14. Beach access to Emu Beach including dune fence protection
15. Re-vegetation to existing coastal dune including fence protection.
16. Open turf space including updated amenities. (Shelters, BBQ, + Seating)
17. Existing coastal dune.
18. Coastal planting to base of existing coastal structure
19. Streetscape coastal planting

TYPICAL SECTIONS




Update and new amenities including shelters, seating + BBQ. Retention and new shade trees
Open turf space
Additional shade trees to be planted
Existing coastal structure and coastal planting buffer.
New local stone terrace/ seating wall
Vehicle access. Unit paving material
Dual use path (min 3m width)

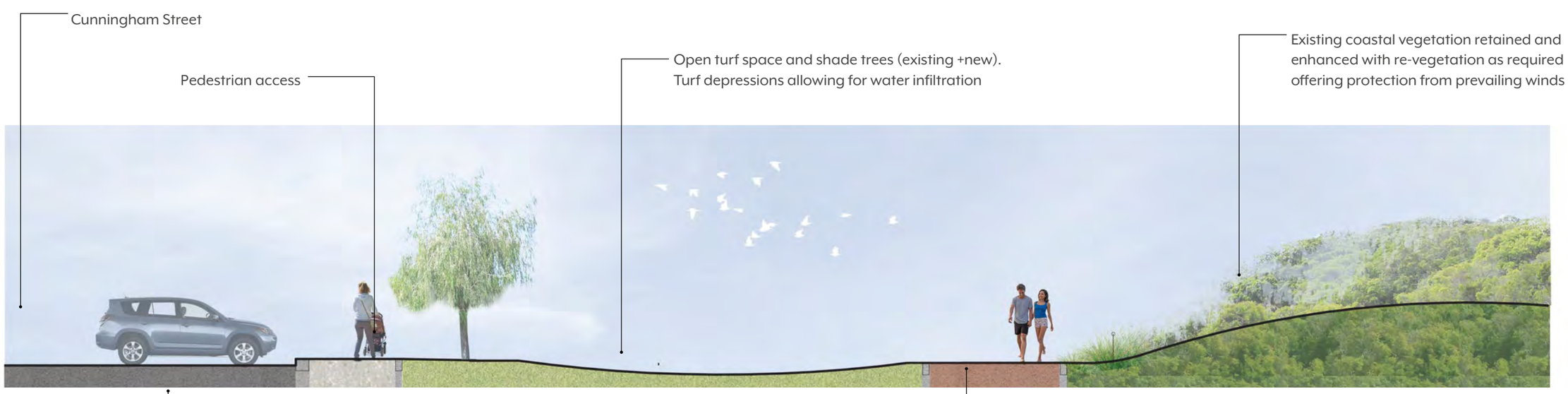

Pedestrian access
Retention and new shade trees including turf and coastal planting
Existing coastal vegetation retained and enhanced with re-vegetation as required offering protection form prevailing winds
Cunningham Street
Formalised parking bays
Dual use path
Dual use path (min 3m width)
Typical seating options located along dual use path

3

BOONGARRIE STREET DETAIL PLAN

LEGEND
1. Dual use path (3m) including seating opportunities.
2. Exercise node, including exercise equipment + seating and drinking fountains
3. Open turf space including updated amenities. (Shelters, BBQ, + Seating) Turf depressions to assist with protection of prevailing winds.
4. Re-vegetation to existing coastal dune including fence protection.
5. Beach access to Emu Beach including dune fence protection
6. Formalised parking to Cunningham street
7. Secondary footpath access to car bays.
8. Streetscape coastal planting
9. New Car park and termination of Boongarrie Street
10. Fire and maintenance access to parkland via new car park.
11. Mounded coastal vegetation offering protection from prevailing winds
12. Secondary coastal pedestrian path offering coastal connection
13. Destination zone offering seating and coastal views
14.Coastal planting to base of existing coastal structure
15. Re-vegetation to existing beach access and coastal structure including fence protection.
16. Open turf offering emergency vehicle access and turnaround

TYPICAL SECTIONS



Mounding coastal vegetation enhancing the environmental connection along the waterfront

Mounding coastal vegetation offering protection from prevailing winds and an optional pedestrian route.

Dual use path
(min 3m width)

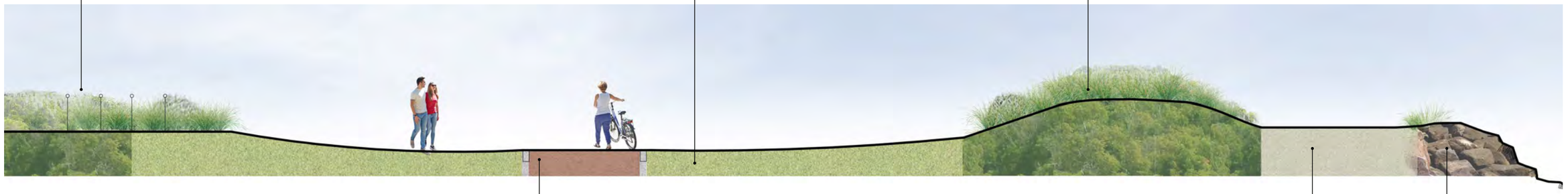
Secondary pedestrian path offering views along the coast. Flexible material (gravel) to limit maintenance in the event of over topping of the coastal structure.

Existing coastal structure and coastal planting buffer.

Mounding coastal vegetation enhancing the environmental connection along the waterfront

Open turf space and shade trees (existing +new). Turf depressions allowing for water infiltration and assist with “bunkering” from the prevailing winds

Mounding coastal vegetation offering protection from prevailing winds buffer from coastal protection wall



Dual use path
(min 3m width)

Secondary pedestrian path offering views along the coast. Flexible material (gravel) to limit maintenance in the event of over topping of the coastal structure.

Existing coastal structure and coastal planting buffer.

FIRTH STREET DETAIL PLAN

LEGEND

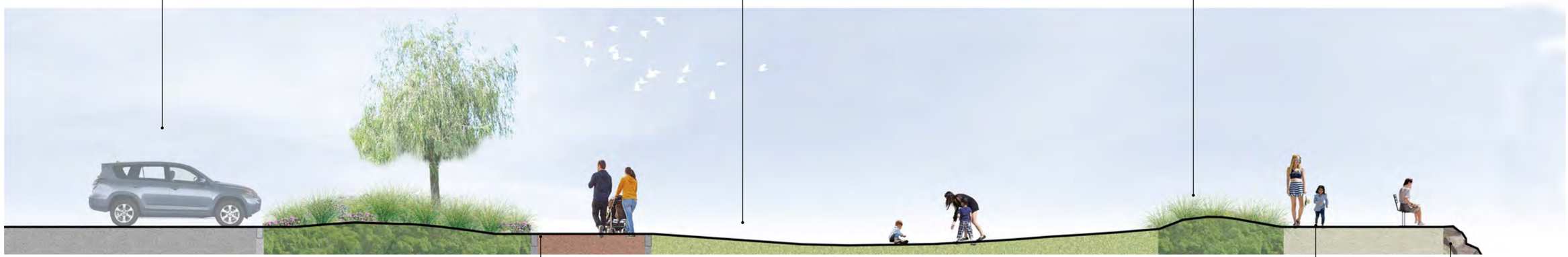
1. Realigned dual use path (3m) including seating opportunities.
2. Exercise node, including exercise equipment + seating and drinking fountains
3. Open turf space including updated amenities. (Shelters, BBQ, + Seating) Turf depressions to assist with protection of prevailing winds.
4. Existing coastal structure including coastal planting to base
5. Additional coastal structure rock work
6. Termination and formal parking bays to Firth Street. Parking bays overlooking coast line including emergency and maintenance vehicle access. New bays offering access to proposed play area, new parkland and ablution amenities
7. Re-vegetation to existing paths and vehicle access to back of coastal structure
8. Existing dual use path to be removed and re-Vegetated.
9. Proposed lease realignment (under review)
10. Mounded coastal vegetation offering protection from prevailing winds
11. Secondary coastal pedestrian path offering coastal connection
12. Destination zone offering seating and coastal views
13. Existing ablution block to be retained. New facilities to be located to future parking area
14. New ablution amenities
15. All ages play space area. To consist of various play elements/options including; nature based, sports, all ages and adventure theme
16. Exiting and new vegetation offering screening to adjoining properties.

TYPICAL SECTIONS

Termination and formalisation of Firth Street car park. Offering views to the ocean and access to proposed playground zone and ablution amenities.

Open turf space and shade trees (existing +new). Turf depressions allowing for water infiltration and assist with “bunkering” from the prevailing winds

Mounding coastal vegetation offering protection from prevailing winds buffer from coastal protection wall



Dual use path
(min 3m width)

Secondary pedestrian path offering views along the coast. Flexible material (gravel) to limit maintenance in the event of over topping of the coastal structure.

Existing coastal structure including spaces to rest

PROPOSED PARKING

The below diagram indicates the proposed formalised parking numbers and locations along Emu Beach.

Formal parking bays	**210**
Retained parking bays	**9**
TOTAL	21**9**

05. Design Palette

COASTAL MATERIAL PALETTE

The Emu Beach material palette will require selections to offer the following; robustness, long term sustainability and create a sense of place.

Extreme coastal conditions along the south coast including Emu beach will require materials to be resilient and tough. Constant salt winds and moisture along with frequent public use will require materials to be hard wearing whilst reducing overall maintenance requirements for the City.

A palette with a strong sense of place will play an important role in ensuring Emu Beach maintains it uniqueness while creating a memorable experience. The material palette reflects the local colours and textures whilst including materials currently used by the City of Albany.

SURFACE TREATMENTS

Limiting the number of surface treatments along Emu Beach assists in enhancing the visual amenity whilst maintaining the sites local character.

With the use of surface treatments public spaces can be defined and a hierarchy of spaces. Along the Emu Beach site key nodes and public spaces are to be defined with the use of 'Higher' specified elements with the cost effect surfaces nominated to large transitional spaces.

All pavements to meet the required Australian Standards and be readily available.

VERTICAL TREATMENTS

Emu Beach is well known by locals and visitors for its granite terrace walling, these walls are to be enhanced and protected where required with the addition of new walling where deemed appropriate.

The use of readily available and robust materials is recommended in areas where new walling may be required. These material to be utilised are to ensure the local granite is enhanced within the key public spaces.

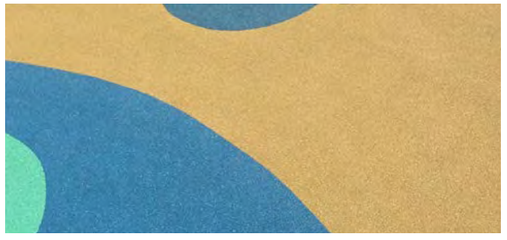
1. Exposed aggregate concrete - Sandstone Pebble

2. Asphalt

3. Composite deck

4. Unit Paver

5. Stabilised local granitic/gravel fines



6. Softfall

1. Local stone walling

2. Off-form concrete

3. Block Work Walling

FURNITURE AND FIXTURES PALETTE

All furniture and fixtures are required to withstand the coastal conditions of Emu beach and assist the city with low maintenance requirements. Consideration is required in relation to the balance of initial capital cost and the longevity of the materials and products to be installed.

Where required all steel elements to be of a marine grade finish. Whilst new elements to align with the City of Albany furniture suite to assist in maintenance (e.g. Bins, drinking fountain, BBQ).

1. Bench seating

2. Picnic Setting

3. CoA approved Shelter Large GZ24

3. CoA approved Shelter Small GZ39

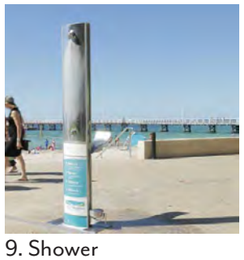
4. Barbecue

5. Bins

6. Exercise equipment

7. Bike Racks

8. Drinking Fountain



9. Shower

10. Bollards

11. Fencing

12. Way finding + interpretation

PLAY SPACE

A destination play space creates the opportunity to bring together both the local community and visitors to the region.

The inclusion of various play options ensures that all members of the community are catered for. With the opportunity to include intergenerational play elements with a range of activities including; multi use courts, nature based play, pump track and an all ages/ assessable playground.

Pump track - a multi use track for all ages offering locals and visitors year round entertainment and exercise

Nature play - responding to the surrounding natural coastal environment and encouraging children of all ages to explore and interact with ‘nature’

All ages/all assessable - a play space designed to cater for all ages and disabilities. With the added benefit of proximity to both parking and ablution facilitates

Multi-use courts - various courts offering individual and group exercise opportunities for both local and visitors to the region staying within the Emu Beach accommodation zone



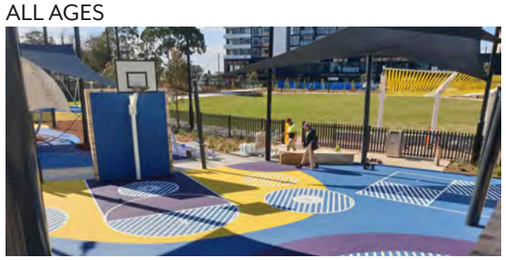
PUMP TRACK



NATURE PLAY



ALL AGES



MULTI USE COURTS

COASTAL PLANT PALETTE

Emu Beach foreshore, parkland and street scape has the opportunity to utilise both local and West Australian coastal species. Many of the species are available commercially allowing planting to enhance the local material palette whilst ensuring low water use and maintenance.

Low level planting is nominated to maintain site lines in key open public spaces with the inclusion of larger coastal shrubs to offer protection and buffer the strong prevailing coastal winds.
Native trees to be selected to offer shade along the parkland whilst ensuring the species are adaptable in the harsh coastal conditions.

LOW PLANTING


Spinifex hirsutus


Carpobrotus virescens


Westringia dampierii


Myoporum insulare


Kennedia coccinea


Scaevola nitida


Leucophyta brownii


Pimelea ferruginea


Banksia repens


Hibbertia racemosa


Lepidosperma gladiatum


Adenanthos cuneatus


Hardenbergia comptoniana


Ficinia nodosa


Atriplex cinerea


Hemiandra pungens


Conostylis candicans


Olearia axillaris

SHRUBS - WIND BREAK/BUFFER


Adenanthos sericeus


Melaleuca lanceolata


Templetonia retusa


Scaevola crassifolia


Acacia cyclops

TREES


Allocasuarina fraseriana


Agonis flexuosa


Eucalyptus gomphocephala


Eucalyptus utilis

RE-VEGETATION PALETTE

Rehabilitation and re-vegetation of the emu beach foreshore is critical to ensure the future of the key wildlife corridor increasing biodiversity whilst improving user experience. The below palette offers a typical selection for the foreshore rehabilitation and re-vegetation zone through seed collection obtained from site and/or the use of local native planting.

Works to the area shall be required to ensure weed and disease free soil including weed matting or mulch to minimize erosion and weed encroachment. The installation of both temporary and permanent fencing shall be required in some rehabilitation areas to ensure minimal disturbance from the public.

Allocasuarina fraseriana

Adenanthos sericeus

Spyridium globulosum

Eutaxia obovata

Jacksonia horrida

Leucopogon revolutus

Acacia pulchella

Adenanthos cuneatus

Dasypogon bromeliifolius

Agonis flexuosa

Banksia attenuata

Melaleuca striata

Pimelea rosea

Lysinema ciliatum

Melaleuca thymoides

Desmocladus flexuosa

Lepidosperma squamate

Lyginia barbata

Acacia littorea

Pimelea ferruginea

Hibbertia cuneformis

Lepidosperma costale

Lepidosperma gladiatum

Phyllanthus calycina

Rhagodia baccata

Spinifex hirsutus

Ammophila arenaria

07. Appendices

A_ Site Analysis

CHARACTER ZONES

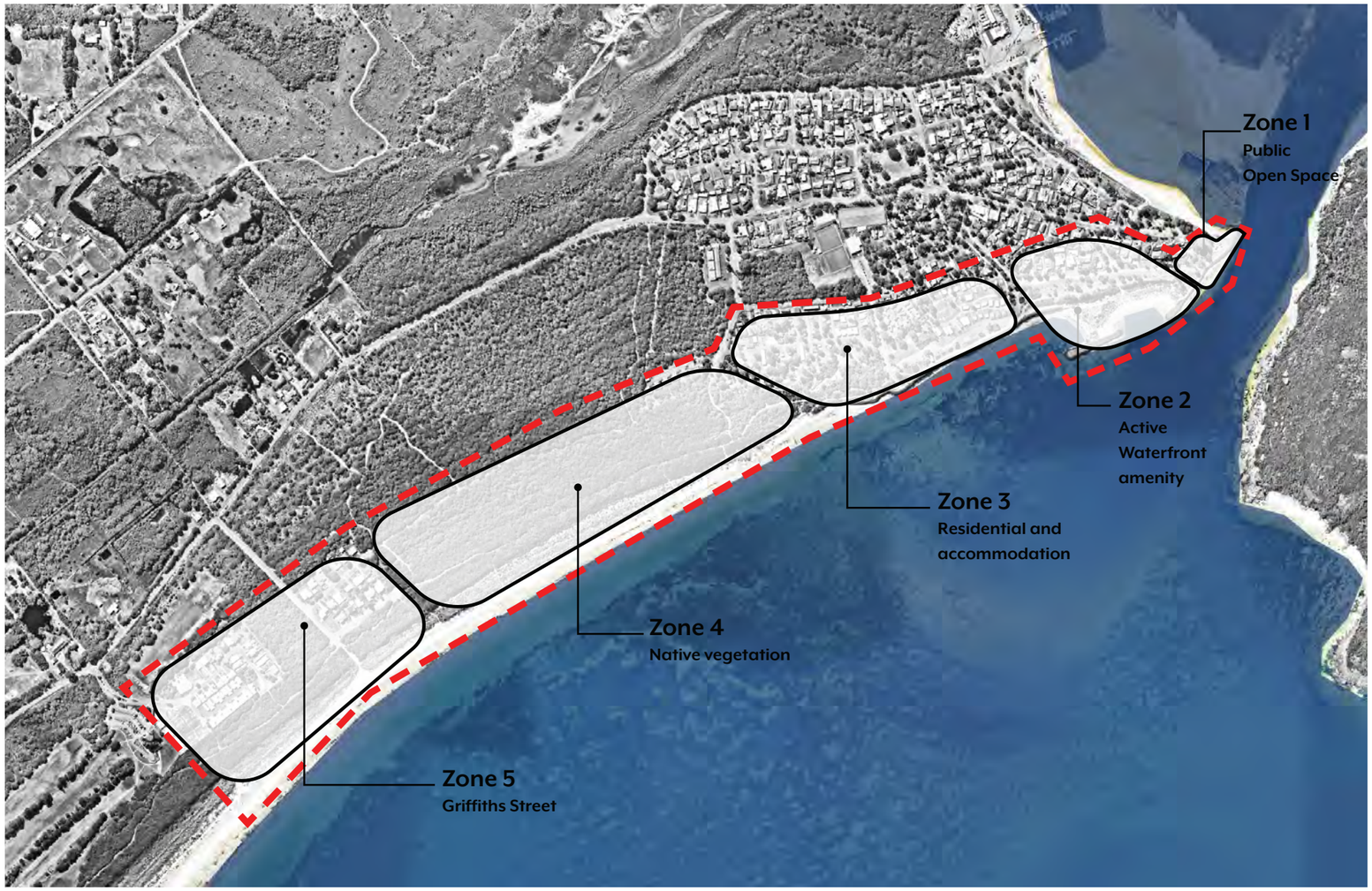
Zone 1:
Is characterised by its well-utilised park and large shady grassed picnic areas with established trees. Locals and tourists are attracted to the site due to its proximity to its beaches, fishing, parking, cafe and public toilets.

Zone 2:
A busy zone for active and passive recreation with close access to the nearby cafe and parking. This area contains popular spots for fishing and swimming due to the sheltered beaches formed by coastal structures and dune vegetation and grassed respite areas that are shaded by trees. Vegetation runs adjacent to the road and path, creating protected spots for picnics, play, exercise and barbecues. A residential suburb fronts onto the public open space and beach front.

Zone 3:
Tourist accommodation characterises the zone in this area. The road/car park and the dual-use path that run along the oceanfront is a key access and circulation route. However, the rock revetment limits direct access to the ocean in this area but provides fishing opportunities and coastal views. This zone identifies as a key transition point between the existing natural reserve and the managed parklands of Emu Beach

Zone 4:
Native remnant bushland makes up the majority of this zone. The dual use path runs parallel to the beach. This landscape is key in connecting Emu Beach and with the coastal cycle path.

Zone 5:
Two small pockets of residential development separated by remnant bushland sit at the south end of the site. Griffiths Street is a key beach access point for visitors to the site.



ZONE 1 ANALYSIS

LEGEND

Barbecue

Bins

Furniture (shelter/seat)

Fence

Exercise space

Existing Trees/Shade

Vehicle access

Pedestrian path

Pedestrian and cycle path

Coastal Protection Structures

Fishing spot

Prevailing Winds

Car parking (asphalt)

Public Toilet

Residential Zone

Cadastral boundary

CoA lease

COASTAL HAZARD LEGEND

Current HSD

Present day (2017)

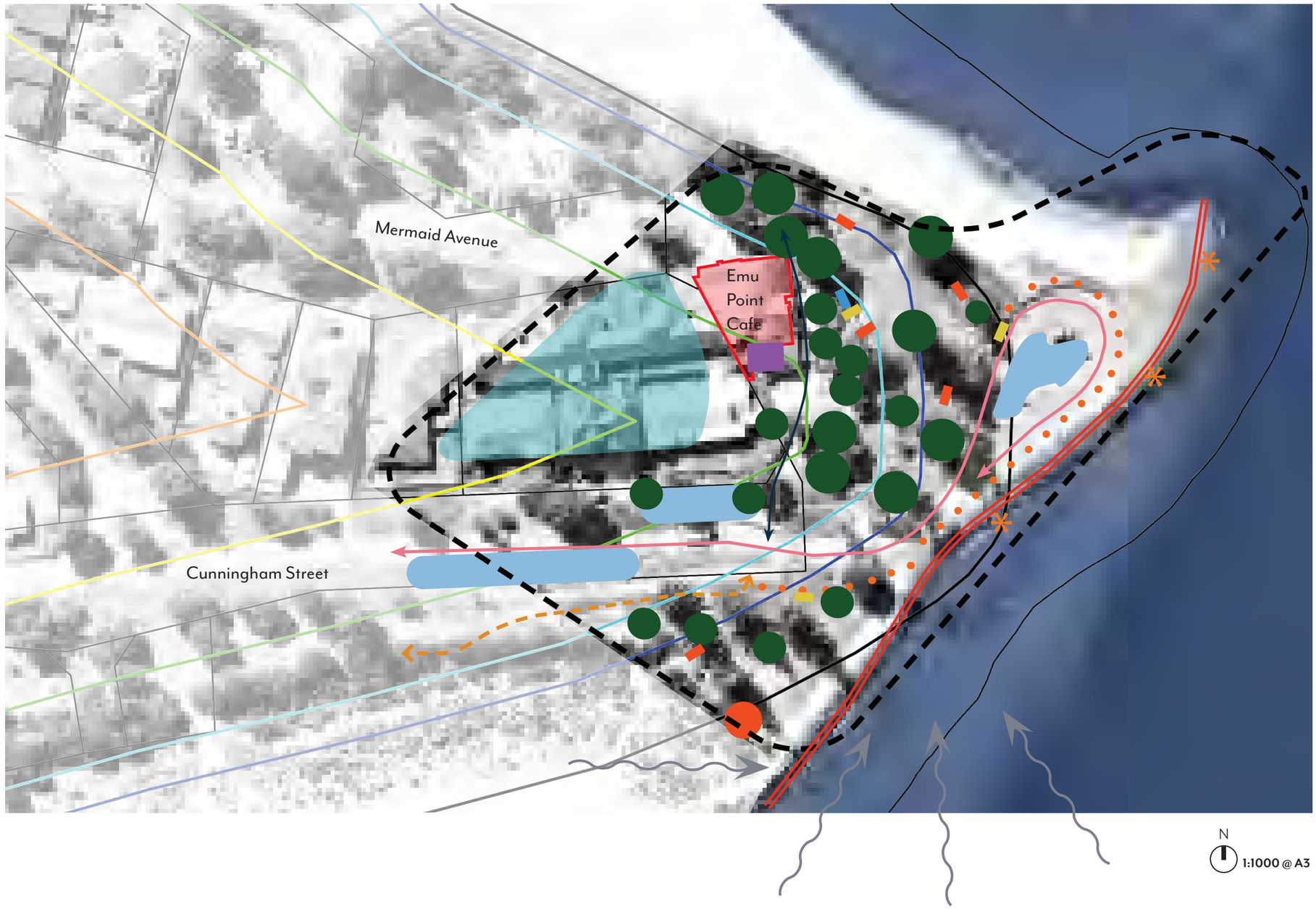
2030

2050

2070

2090

2120



ZONE 1 LANDSCAPE CHARACTER

1. Vehicle access and car park adjacent coastal structure. Vehicles given priority whilst separating park land and waterfront.

2. Connection to public toilets and cafe adjacent residential lots. Public toilets limited and often at capacity during peak times

3. Minimal existing public amenities including limited weather protection.

4. Car park and vehicle turn around. (Minimal bays x 8)

5. Minimal pedestrian access through park with pedestrians required to navigate various level changes. Dual use path terminates abruptly.

6. Existing terracing and level changes (limited universal access). Existing shade trees key feature through out parkland.


1


2.


3.


4.


5.


6.

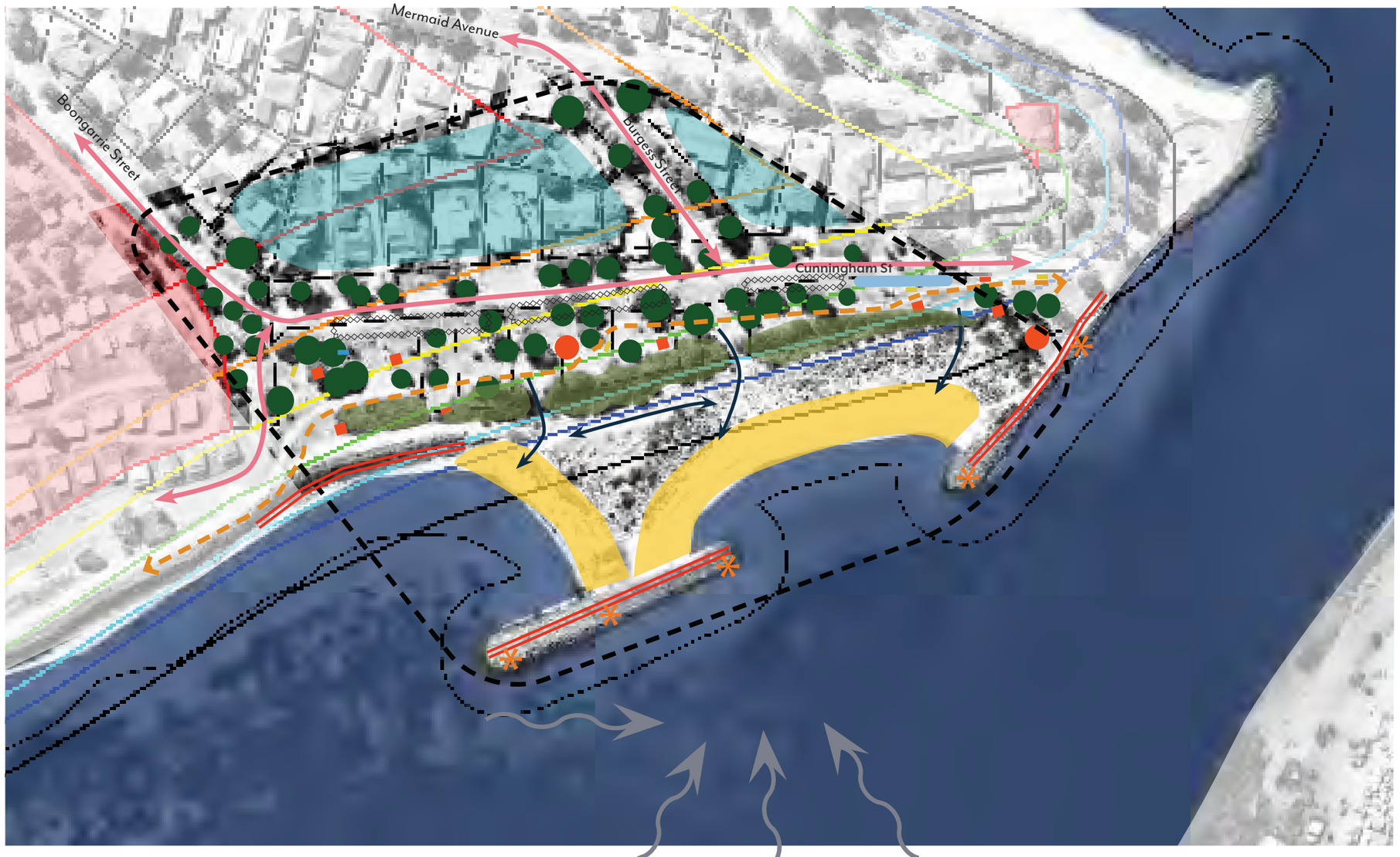
ZONE 2 ANALYSIS

Legend

- Barbecue
- Bins
- Street Furniture (shelter/seat)
- Fence
- Play space/Exercise
- Existing Trees/Shade
- Remnant vegetation
- Vehicle access
- Access to beach via dunes
- Pedestrian and cycle path
- Residential Zone
- Active Beach Zone
- Coastal Protection Structures
- Fishing spot
- Prevailing Winds
- Car parking (asphalt)
- Car parking (turf/gravel)
- Public Toilet
- Cadastral boundary
- CoA lease

COASTAL HAZARD LEGEND

- Current HSD
- Present day (2017)
- 2030
- 2050
- 2070
- 2090
- 2120



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ZONE 2 LANDSCAPE CHARACTER

1. Informal and limited access path ways to beaches and public amenities.

2. Existing amenities with limited weather protection, however utilising existing vegetation buffers for protection from prevailing winds.

3. Dual use path coastal path starts/ends adjacent existing car parking. Potential to formalise parking along Cunningham street (south side) and extend dual use path and include formalised pedestrian access

4. Limited and aging public amenities

5. Informal and limited access path ways to swimming beaches

6. Existing public exercise equipment/ limited bike amenities noted across the site


1


2.


3.


4.

5.


6.

ZONE 3 ANALYSIS

Legend

- Barbecue
- Bins
- Street Furniture (shelter/seat)
- Fence
- Play space/Exercise
- Existing Trees/Shade
- Remnant vegetation
- Vehicle access
- Vehicle access (car park)
- Access to beach via dunes
- Pedestrian and cycle path
- Accommodation Zone
- Active Beach Zone
- Coastal Protection Structures
- Fishing spot
- Prevailing Winds
- Car parking (asphalt)
- Public Toilet
- Cadastral boundary
- CoA lease

COASTAL HAZARD LEGEND

- Current HSD
- Present day (2017)
- 2030
- 2050
- 2070
- 2090
- 2120

N

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ZONE 3 LANDSCAPE CHARACTER

1. Key viewing opportunities along the waterfront, although minimal protection from sun and prevailing winds

2. Inconsistent materiality across the site including hardscape, furniture and fixtures.

3. Large areas of hardscape (asphalt) offering minimal infiltration opportunities.

4. Current laterite coastal protection a stark contrast against the Emu Beach natural landscape. If required landscape measures required to assist in 'hiding' from view where possible.

5. Large portions of zone 3 consists of in formal roads and car parking adjacent parkland and waterfront.

6. Underutilised existing public park


1


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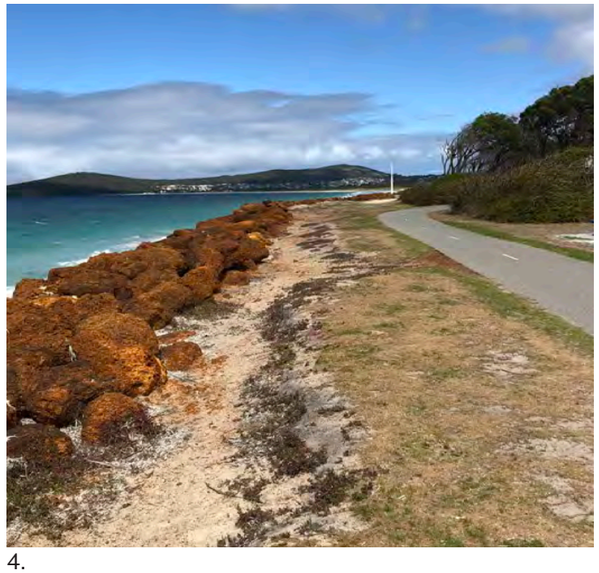
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ZONE 4 ANALYSIS

Legend

Barbecue

Bins

Furniture (shelter/seat)

Fence

Look out

Remnant vegetation

Coastal Protection Structures (Trial)

Vehicle access (fire break)

Access to beach via dunes

Pedestrian and cycle path

Accommodation Zone

Active Beach Zone

Fishing spot

Prevailing Winds

Car parking (asphalt)

Cadastral boundary

CoA lease

COASTAL HAZARD LEGEND

Current HSD

Present day (2017)

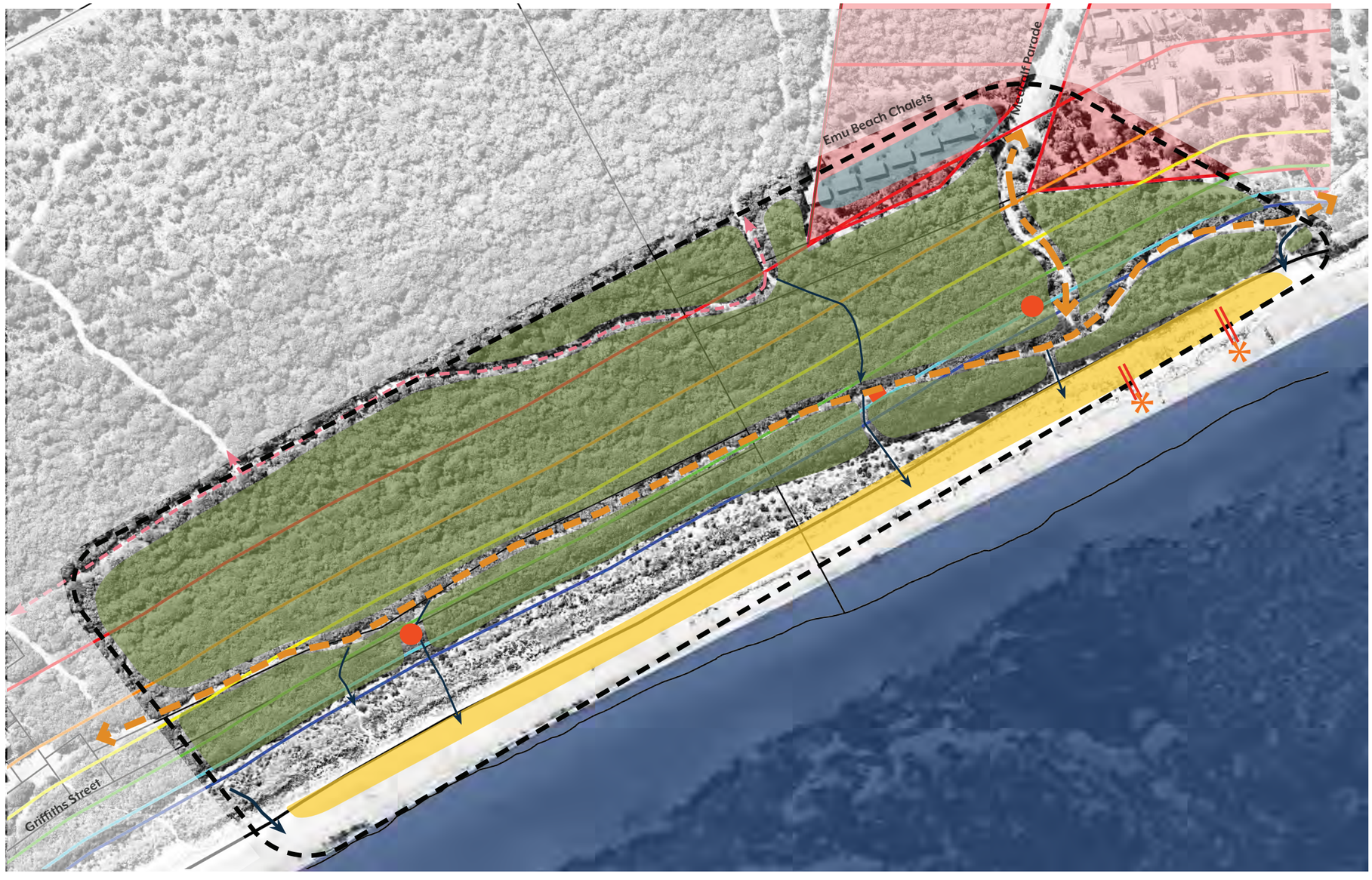
2030

2050

2070

2090

2120



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ZONE 4 LANDSCAPE CHARACTER

1. Existing coastal dual use path. Seating opportunities minimal with replacement required. (Note; many furniture elements 'commemorative/ donated')

2. Inconsistent beach access, generally closer to adjacent accommodation sites

3. Access through vegetation to adjacent accommodation sites (CoA lease titles)

4. Signage and way finding inconsistent. Entry to remnant native vegetation area offers a key opportunity to educate the public regarding the site.

5. Issues regarding movement/access of public through fragile existing and re-vegetation areas.

6. Existing coastal structure trials (groynes) and current erosion to coast line.

1

2.

3.

4.

5.

6.

ZONE 5 ANALYSIS

Legend

- Barbecue
- Bins
- Furniture (shelter/seat)
- Fence
- Accommodation/Residential Zone
- Active beach zone (including dog/horse exercise)
- Remnant vegetation
- Vehicle access (fire break)
- Access to beach via dunes
- Pedestrian and cycle path
- Prevailing Winds
- Car parking (asphalt)
- Cadastral boundary
- CoA lease

COASTAL HAZARD LEGEND

- Current HSD
- Present day (2017)
- 2030
- 2050
- 2070
- 2090
- 2120

N

1:3000@ A3

ZONE 5 LANDSCAPE CHARACTER

1. Existing Griffith's Street car park. Access to Horse exercise area (limited hours). Possible retreat of car park required due to CHRMAP recommendations.

2. Large areas of remnant vegetation lines the coastal dual use path. Possible retreat of Dual path in some areas required due to CHRMAP recommendations.

3. Barry Court road termination. Residential estate

4. Existing CoA infrastructure. Treated pine look out point.

5. Informal vehicle barriers along Griffith's st car park and informal tracks through bushland. Existing tracks/fire breaks noted as possible future dual use path locations to limit existing vegetation disturbance.

6. Seating opportunities minimal with replacement required. (Note; many furniture elements 'commemorative/donated')

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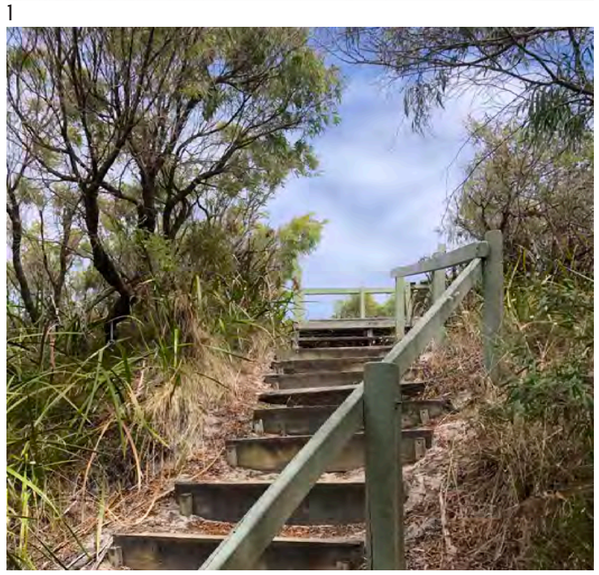

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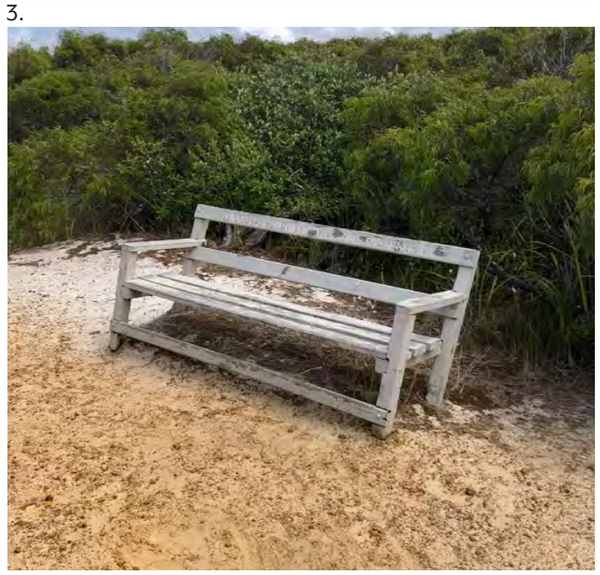

6.

COASTAL STRUCTURE HISTORY

The following diagram indicates the time line and location of the various coastal structures along the Emu beach waterfront.

Legend

1. Training Wall (mid 1980's)
2. Southern groyne + sand re-nourishment (1989)
3. Northern groyne (1991)
4. Detached breakwater headland + sand Re-nourishment (1995)
5. Original 'Emergency' rock revetment (1999)
6. Rock revetment extension (2001)
7. Rock revetment extension (2005)
8. Sandbag revetment (2011)
9. Trial GSC groynes (2014)

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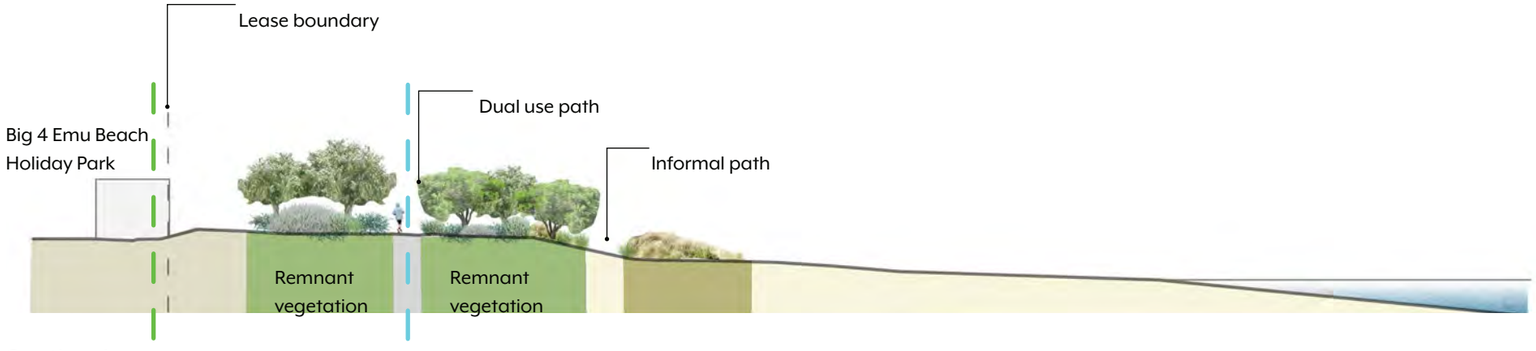
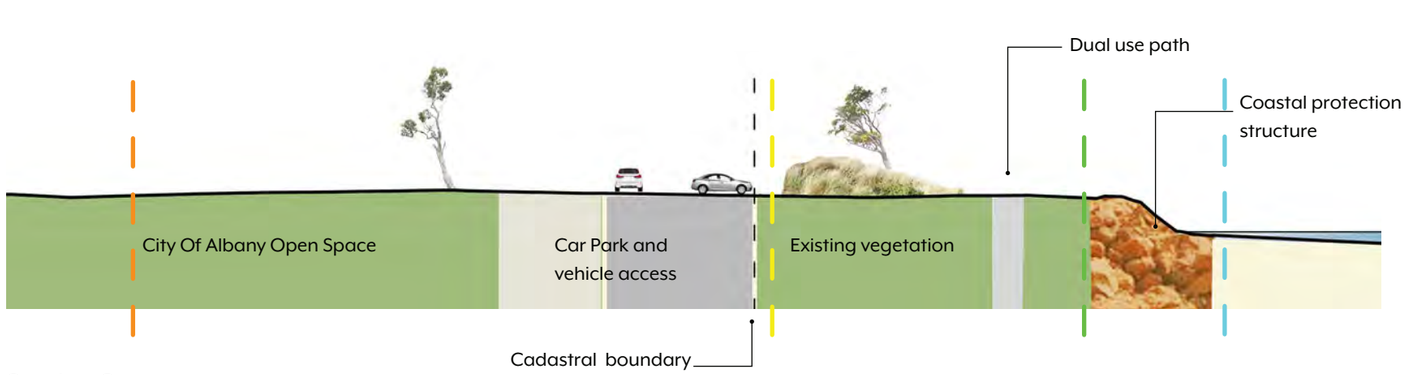
EXISTING SITE SECTIONS



Section 1



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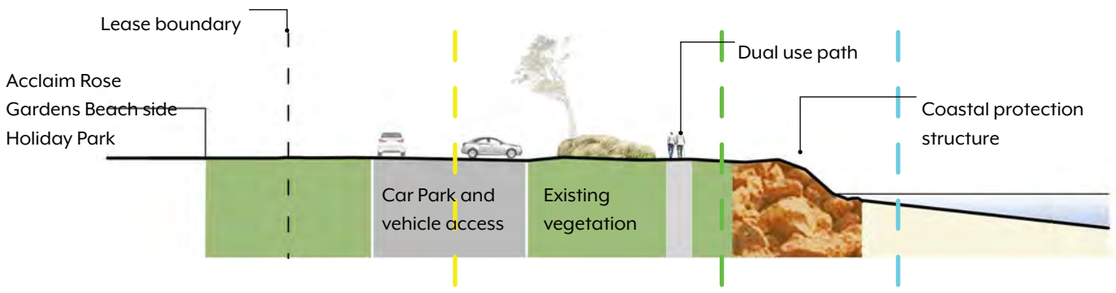
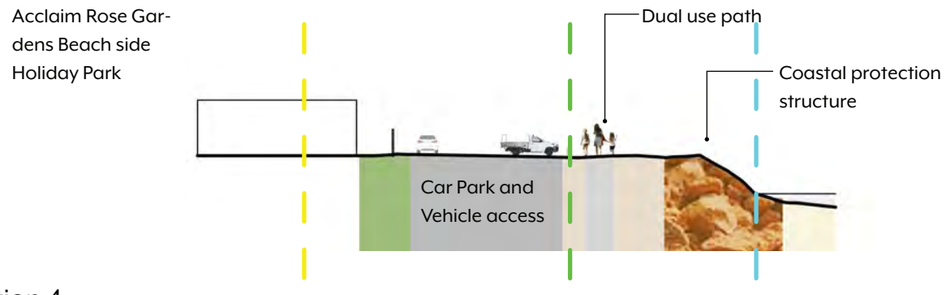


Section 3

COASTAL HAZARD LEGEND

2030
2050
2070
2090



Section 4

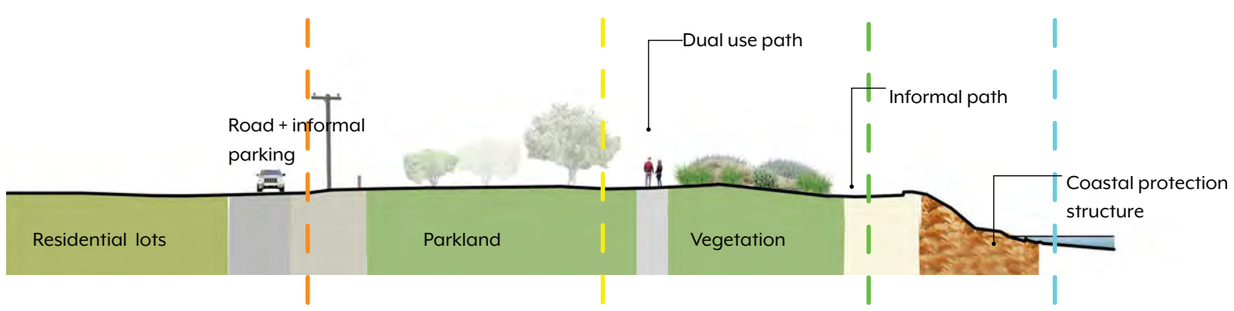
COASTAL HAZARD LEGEND

2030

2050

2070

2090



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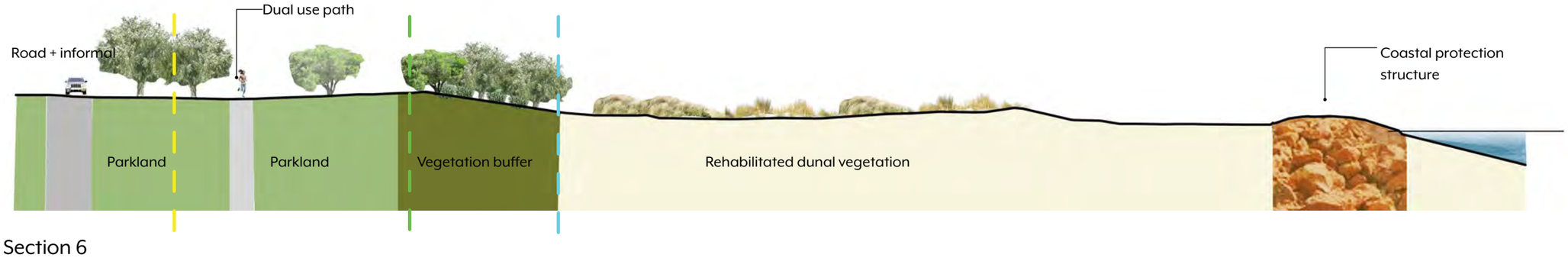


Section 6

COASTAL HAZARD LEGEND

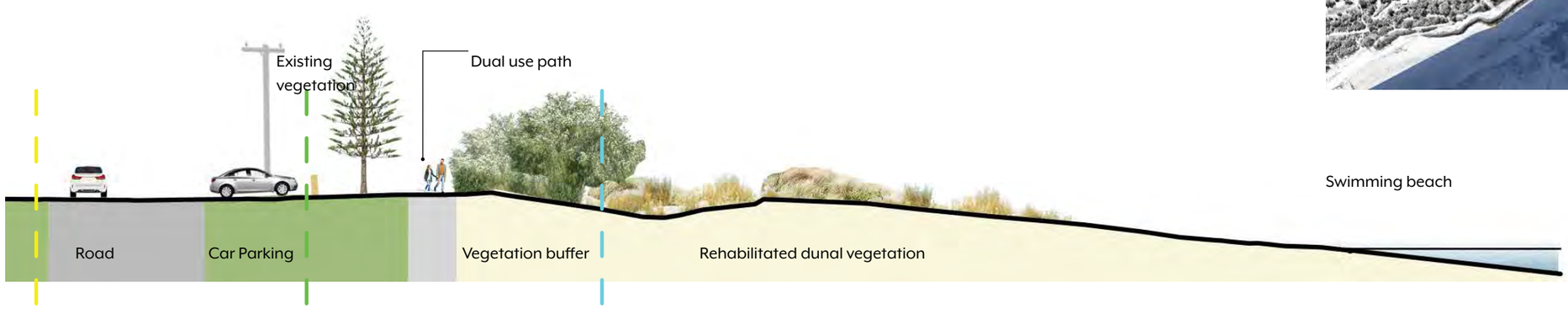
2030

2050

2070

2090

Swimming beach



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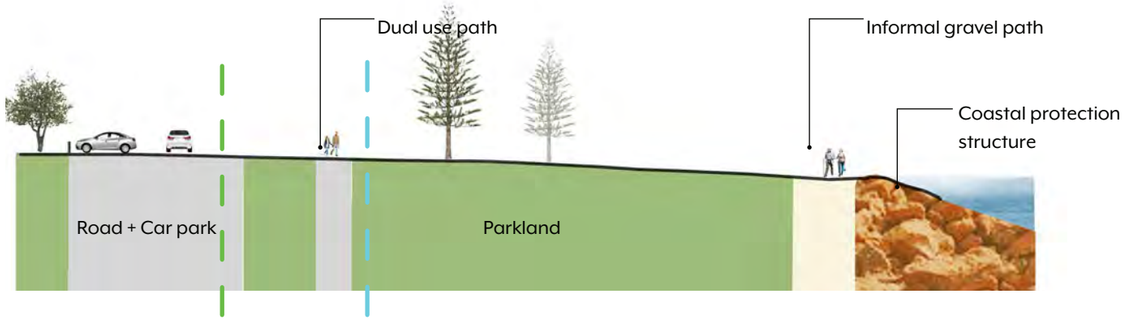

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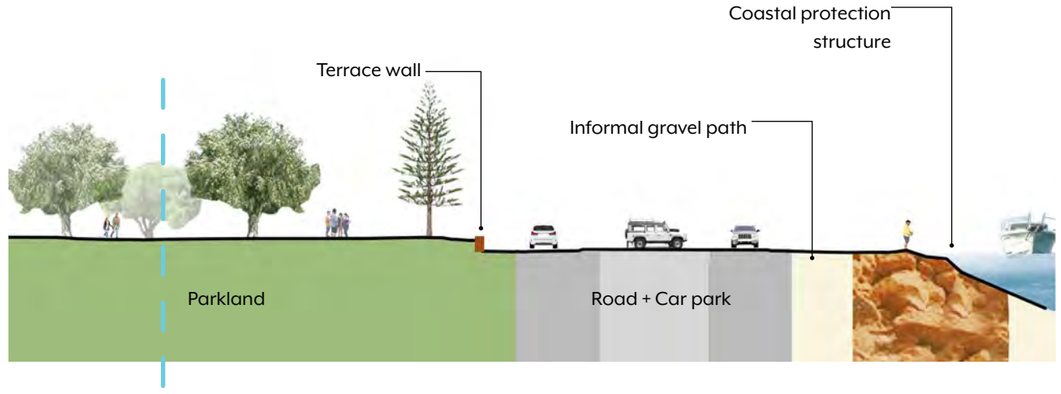

Section 9

EXISTING PARKING

The following diagram indicates the existing parking numbers and locations along Emu Beach. In peak periods vehicles are often located on informal verge treatments with limited formal path access including minimal disabled access.

Formal parking bays	**90**
Informal parking bays	**76** (approx)
Disabled bays	**3**

EXISTING ACTIVITIES

The following diagrams indicates the various locations and spread of existing activities along the Emu Beach site. These will assist the overall landscape masterplan to not only enhance but also increase the opportunities for new activities across the site.

- Dog exercise area
- Horse exercise area
- Swimming
- Kayaking
- Jogging/exercise
- Cycling
- Parking
- Holiday/caravan park
- Boating
- Barbecue
- Picnic area
- Play area
- Fishing

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SEE DESIGN

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Appendix B
Basis of design

bluecoast
CONSULTING ENGINEERS

City of Albany

City of Albany

Emu Beach Foreshore Management Plan

Basis of Design

4 June 2021

Report No: P19027-BOD-R4.00

Version	Date	Author	Reviewer(s)	Status	Signature
1.0	17/12/20	J. Lewis, H. Loehr	E. Watterson	50%	
3.0	29/03/21	J. Lewis, H. Loehr	E. Watterson	90%	
4.0	04/06/21	J. Lewis		100%	

Executive Summary

This Basis of Design (BoD) outlines the key features and assumptions that underpin the design development of the coastal adaptation options recommended as part of the Emu Point to Middleton Beach Coastal Hazard Risk Management Adaptation Plan (CHRMAP). The CHRMAP has been adopted by the City of Albany (the City) and will be used to inform the Emu Beach Foreshore Management Plan (FMP). The CHRMAP Aurora (2019) has identified several highly valued coastal assets in Management Units MU3, MU4 and MU5 that require protection out to the 50year panning horizon and have made the following recommendations.

- Recommendation 14 MU3: Properties on Griffiths Street - Managed Retreat. Relocate properties from Griffiths Street.
- Recommendation 15 MU3: Emu Beach Holiday Park - Managed Retreat of assets in the southern portion.
- Recommendation 16 MU3: Emu Beach Holiday Park - Renovation/Expansion of Groynes (geotextile sand container).
- Recommendation 17 MU3: Emu Beach Holiday Park - Upgrade existing protection structures.
- Recommendation 18 MU4: Foreshore Reserve - Seagrass replenishment program be continued and enhanced to include offshore placement of sand
- Recommendation 19 MU4: Foreshore Reserve - Revetment be upgraded along with redevelopment of Foreshore park and removal of sandbag revetment
- Recommendation 20 MU5: Oyster Harbour Beach - Sand Nourishment

In consultation with the City, stakeholders (including the WA Department of Transport and the WAPC) as well as community groups and using this BoD for design guidance, the following coastal adaptation options have been recommended as part of the FMP:

- Managed retreat of first line of houses along Griffiths Street (MU3) in the long term (10+ years).
- A change to less permanent assets/uses in southern lease boundary of the Emu Beach Holiday Park, with the City and the leaseholder working toward an agreed level of risk within this area, steering the discussions around future lease agreements in the short term (0-5years).
- Upgrade of the groyne field at Emu Beach (MU4) to rock structures including the addition of a third eastern groyne and a beach nourishment exercise in the short term (0-5years)
- Upgrade of the rock revetment from Emu Beach to Emu Point (MU4) to modern designs, including the use of local granite rock and a realignment in the medium to long term (10+ years).
- Sand nourishment to be placed in the eastern corner of Oyster Harbour (MU5) between the spur groyne and the eastern arm of the swimming enclosure following periods of erosion.

Table of Contents

List of Figures

List of Tables

1. Introduction

This preliminary Basis of Design (BoD) outlines the key features and assumptions that underpin the design development of the coastal adaptation options recommended as part of the Emu Point to Middleton Beach Coastal Hazard Risk Management and Adaptation Plan (CHRMAP). The CHRMAP has been adopted by the City of Albany (the City) and will be used to inform the Emu Beach Foreshore Management Plan (FMP). The CHRMAP is based upon a risk management approach developed by the Western Australian Planning Commission (WAPC) guideline document (WAPC, 2014) and deals with forecast impacts from coastal hazards.

The CHRMAP divided the beaches from Middleton Beach through Emu Point and Oyster Harbour into five distinct Management Units (MUs), this BoD is specifically concerned with the recommendations made in the CHRMAP Implementation Plan (Aurora, 2019) for MU3, MU4 and MU5: Emu Beach and Emu Point as seen in Figure 1. A map showing the existing coastal structures in the project area is presented in Figure 2. Aurora (2019) has identified several highly valued coastal assets in MU3, MU4 and MU5 that require protection in the short term (0-10 years) and have made the following recommendations.

- Recommendation 16 MU3: Emu Beach Holiday Park - Renovation/Expansion of Groynes (geotextile sand container).
- Recommendation 17 MU3: Emu Beach Holiday Park - Upgrade existing protection structures.
- Recommendation 19 MU4: Foreshore Reserve - Revetment be upgraded along with redevelopment of Foreshore Park and removal of sandbag revetment
- Recommendation 20 MU5: Oyster Harbour Beach - Sand Nourishment

A schematic of these recommendations can be seen in Figure 3 to Figure 7. Although not an engineered option directly involved with the design or upgrade of physical infrastructure, the following coastal adaptation recommendation was also presented:

- Recommendation 18 MU4: Foreshore Reserve - Seagrass replenishment program be continued and enhanced to include offshore placement of sand

The CHRMAP makes the following recommendations not directly involved with the design or upgrade of physical infrastructure or coastal/ foreshore redevelopment:

- Recommendation 14 MU3: Properties on Griffiths Street - Managed Retreat. Relocate properties from Griffiths Street.

- Recommendation 15 MU3: Emu Beach Holiday Park - Managed Retreat of assets in the southern portion.

In these locations, these recommendations can be considered to be longer-term (10+ years) and will be implemented upon the initiation of a trigger value, when the distance from the Horizontal Shoreline Datum (HSD) from an asset is 40m or less.

This technical note outlines the development and intent of the engineered designs, design standards, design life, planning horizons and design parameters based on site conditions as well as the proposed general alignment, extent, quantities and a high-level costing of each structure.

Figure 1: Emu Beach and Management Unit 3, 4, 5 (MU3,4,5) as defined in the CHRMAP (Aurora, 2019).

Figure 2: Existing coastal structure locations within MU3, MU4 and MU5.

Figure 3: MU3 Griffiths Street Recommended Adaptation Option: Managed Retreat. Relocate properties from Griffiths Street

Figure 4: MU4 Emu Point Caravan Park CHRMAP recommendations 15: Emu Beach Holiday Park - Managed Retreat of assets in the southern portion and expansion of groynes (source: Aurora, 2019).

Figure 5: MU4 Emu Point Caravan Park CHRMAP recommendation 17 MU3: Emu Beach Holiday Park - Upgrade existing protection structure (source: Aurora, 2019).

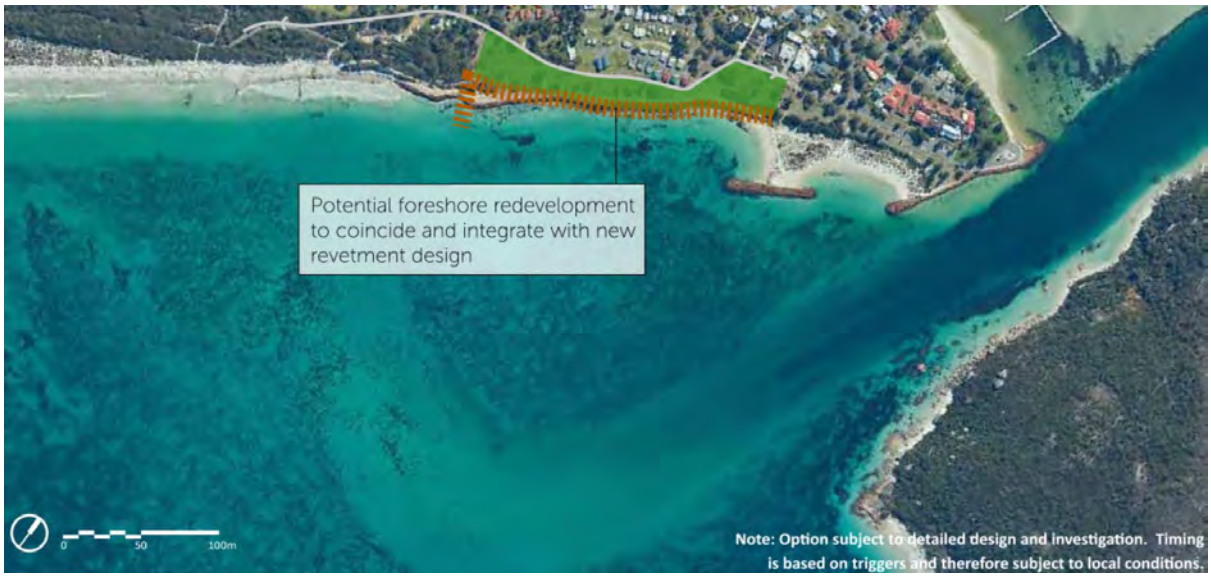


Figure 6: MU4 Foreshore Reserve CHRMAP recommendation19: Foreshore Reserve - Revetment be upgraded along with redevelopment of Foreshore park and removal of sandbag revetment (source: Aurora, 2019).

Figure 7: Recommendation 20: MU5 Oyster Harbour Beach - Sand Nourishment Eastern Oyster Harbour Beach (source: Aurora, 2019).

2. Functional requirements

The Foreshore Management Plan aims to develop coastal adaptation options such that:

- high quality community amenity will be provided that improves on the dilapidated and increasingly unsafe foreshore.
- they are developed in conjunction with the community and key stakeholders.

- acceptable uses, facilities, structures and land management practices within the foreshore reserve are defined.
- preliminary level of design for adaptation strategies is provided.
- overall landscape Master Plan including perspectives, levels, transitions and materials provided.
- an order of cost/opinion of probable cost is defined for future implementation concepts.
- key stakeholders and local community are meaningfully engaged and kept informed throughout the process.

The WAPC's Coastal Planning and Management Manual (WAPC, 2003) states that engineering structures and facilities need to be located and designed to take account of natural coastal trends, such as whether stretches of coast are eroding or building up over time, erosion of steep or rocky coastline, and dune formation and movement. With the following key principles to be adhered to during the design and implementation:

- Avoid locating facilities too close to an eroding shoreline or on the eroding side of a groyne where there is a risk of damage or loss. If structures must be located where they are prone to damage, for example fencing or signs, they may need to be designed to be easy to relocate, or their likely loss is factored into cost and maintenance schedules.
- Avoid building coastal structures which may induce shoreline erosion or dune movement, for example rock walls, solid boat ramps, concrete paths and steps onto the beach or closely spaced timber slat fencing at the base of dunes.
- Avoid locating solid structures in exposed locations where sand may scour or accumulate around them. Stabilise adjacent exposed sand through planting or mulching the surface.
- Ensure that sealed car parks and paved areas do not drain directly onto adjacent beach access paths, as path edges may become eroded. Instead, hard surfaces may be drained into adjacent vegetated areas. Ensure that sealed paths are properly contoured and drained, to avoid soil erosion along their edges.

3. Design standards and guidelines

Table 1: presents a summary of relevant design standards for both the “hard” rock coastal revetment and “soft” geotextile container structures recommended as part of the CHRMAP Implementation Plan at Emu Beach and Emu Point (Aurora, 2019).

Table 1: Compliance, industry standards, relevant acts, guidelines and policies for the design and construction of coastal engineering structures at Emu Beach.

Australian Standards	
ID	**Standard name**
AS 1726	Geotechnical site investigations
AS 2758.6	Aggregates and rock for engineering purposes Part 6: Guidelines for the specification of armour stone
AS 4497	Guidelines for the design of maritime structures

Other standards and procedures
Coastal engineering guidelines for working with the Australian coastline in an ecologically sustainable way. Prepared by the National Committee on Coastal and Ocean Engineering, Engineers Australia. Nov 2004.

Engineering design guidelines			
ID	**Document name**	**Source**	**Date**
CERC, 1984	Shore Protection Manual	Coastal Engineering Research Centre (CERC)	1984
EurOtop, 2018	Manual on wave overtopping of sea defences and related structures	EurOtop	2018
CIRIA, CUR, CETMEF 2007	The Rock Manual; the Use of Rock in Hydraulic Engineering	Construction Industry Research and Information Association (CIRIA)	2007
USACE, 2008	Coastal Engineering Manual (CEM), Engineer Manual 1110-2-1100	United states Army Corps of Engineers (USACE)	2008

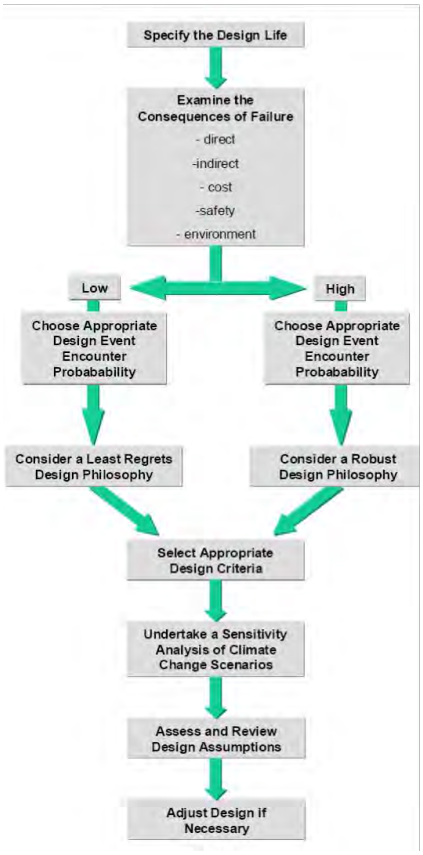
Governmental acts, regulations and policies
EPA 1986. The Western Australian Environmental Protection (EP) Act 1986
EPBCA 1999. The Australian Environmental Protection and Biodiversity Conservation Act 1999
EPSD 1981. Environmental Protection (Sea Dumping) Act 1981
WCA 1976. Waterways Conservation Act 1976

WCR 1981. Waterways Conservation Regulations 1981
BA 2015. Biosecurity Act 2015
AHA 1972. Aboriginal Heritage Act 1972
EPA 2016d. Technical Guidance - Protection of Benthic Communities and Habitats
EPA 2016e. Technical Guideline - Coastal Processes
EPA 2016g. Technical Guidance - Protecting the Quality of Western Australia's Marine Environment
Western Australian Marine Act 1982
Western Australian Planning and Development Act 2005 State Planning Policy no. 2.6 (SPP2.6)

4. Designers and construction risk assessment

4.1. Background

In assessing design standards, the coastal hazard risk assessment recommended by The National Committee of Coastal and Ocean Engineering of Engineers Australia (as shown to the right) should be followed. Given the uncertainties of factors affecting coastal engineering, particularly regarding the impact of climate change, the approach is one of combined risk and sensitivity analysis. The steps in the procedure are outlined in the following sections.



4.2. Specify the design life or planning horizon

The design life of the structure includes its performance over that period as well as the provision of future maintenance requirements. The design needs to recognise the accessibility and mobilisation of construction equipment required for maintenance.

4.3. Examine the consequences of failure

The impact of possible "failure" of the structure because of a large storm could have both direct and indirect consequences and needs to be assessed in terms of primary risk outcomes as issues of cost, safety, environment, downdrift erosion impacts and damage to public/private infrastructure. A 100-year damage coefficient for the structure needs to be selected based on minimum standards and acceptable damage levels.

4.4. Select the design event encounter probability

This quantifies the acceptable risk of "failure" of the facility for the duration of the chosen design life or planning horizon and needs to be based on the assessed consequences of failure. The CIRIA Rock Manual 2007, BS 6349-1:2000 (Maritime Structures, Part 1 Code of

practice for general criteria, BSI 07-2000) and AS 4997-2005 (Guidelines for the design of maritime structures) are widely used for the selection of the most appropriate design event.

The key design parameters for the BoD are based on existing information. Sensitivity analysis to these parameters needs to be examined to assess the sensitivity of the design at this initial concept design development stage including uncertainty related to climate change projections.

4.5. Consequences of failure

The importance of the rock revetment structures along MU3 and MU4 at Emu Point and Emu Beach was identified in the CHRMAP Hazard Mapping process (RHDV, 2017). The CHRMAP hazard lines both with and without the rock revetment is seen in Figure 8. This structure can be seen as the last line of defence for the private and public infrastructure landward of it, in terms of inundation and coastal flooding. As such, appropriate design of any upgrade or realignment of these structures is required to ensure the risk of failure is minimised through to the selected planning horizon.

Figure 8: MU4 Hazard Map with existing structures (top) without existing structures (bottom). (Source: RHDHV, 2017).

4.6. Accessibility and cost of repairs

Land-backed revetments are relatively easy to access for repair or upgrade. The costs of repairs to the rock revetment along Emu Point will be influenced predominantly by availability and cost of suitably sized machinery and supply and availability of suitable rock (size, quality and type). As a result, damage to the structure may remain unrepaired for some time if funds, equipment and material are not readily available for its repair/upgrade.

The condition assessment (Bluecoast, 2020a) has shown that although the structure is in generally poor condition it is a result of the quality of the rock and filtering design and not the ability of the revetment to withstand wave attack and overtopping. Due to the relatively low likelihood of failure from a design event (or succession of near-design events) it is assumed that this is fairly low risk to the project and all precautions be made during the funding and detailed design process that the potential for failure is minimised.

5. Design criteria

5.1. Design life

Australian Standard AS4997 Guidelines for the design of maritime structures recommends a design life of 25 years or more for all maritime structures other than temporary works and 50 years or more for anything other than small craft facilities.

5.2. Design events

Currently Western Australia do not have state-wide legislation with specific engineering design standards for coastal works. For Western Australia, the most relevant document available that sets out the State Governments strategy towards coastal planning, management and protection is the Coastal Zone Strategy for Western Australia 2017. In addition, the WA Sate Planning Policy SPP2.6 provides statutory guidance and informs matters related to sustainable coastal land use and development.

Generally, in Western Australia the management of coastal lands and assets (whether natural or built) on public land is the responsibility of the organisation with management authority, vesting or tenure of the area known as the local coastal manager – in this case the City of Albany. The Western Australia Department of Transport (DoT) provide technical advice and funding assistance through the administration of the Coastal Adaptation and Protection (CAP) grants. Technical advice in this instance will also extend to reviewing the design of coastal engineering structures.

For comparison, in Queensland, the Department of Environment and Heritage Protection's Operational Policy (DEHP, 2013), Coastal Protection and Management Act 1995, specifies building and engineering standards for tidal works. These standards provide the following advice for the design of revetments:

- Revetments (private or other than private) must be designed to withstand wave and water level conditions corresponding to the 2% Annual Exceedance Probability (AEP) event, which is equivalent to the 50-year ARI.

- The revetment is to be designed to not suffer major damage in this event, the proportion of armour units dislodged should not exceed 5%.

As a guide, if utilising these standards; for a 50-year design life and following the DEHP policy, the probability that the Emu Beach coastal structures will encounter the following design events over the design life is:

- 64% for a 50-year ARI event
- 40% for a 100-year ARI event.

WRL (2015) states that any coastal structure needs to be considered as a component of the overall risk within a project. Structures which are designed for a short/frequent Average Recurrence Interval (ARI) event, or which are retained in excess of their design life will incur substantial costs, which may be in the form of maintenance, repairs, consequential damage or political consequences. Structures which are designed for high/rare ARI events will have low maintenance costs and/or costs due to the risk of failure but will involve high upfront capital costs.

Design parameters for the proposed rock foreshore protection include ocean wave and water level conditions and the expected scour level at the toe of the structure. The toe scour level determines the required penetration of the structure to prevent undermining. The design water level and bathymetry at the toe of the structure influence the maximum depth limited breaking wave height that can physically impact the structure. In turn, the design wave and water level conditions at the structure affect the hydraulic performance (wave runup and overtopping) and stability of the structure which have a direct effect on the capital and maintenance costs. The values adopted for the design of the coastal protection works at Emu Point are:

Structure	Design Life	Design Event
Rock groyne	50 years	100-year ARI
Rock revetment	50 years	100-year ARI

This takes into consideration the use of a suitably sourced, natural hard rock material for any proposed rock structures, which should result in a more solid, stable structure with very little breakdown and fracturing of individual rock and, hence, little degradation of the structure over its lifetime. As such, we would expect the structure to last well beyond its design life, subject to the response to the selected design event(s).

The following sub-sections undertake a preliminary investigation into the determination of an appropriate design event for the engineered adaptation structures at Emu Beach and Emu Point recommended as part of the CHRMAP Implementation Plan (Aurora, 2019).

5.2.1. Design water level

King George Sound and the study site experience a semidiurnal, micro-tidal regime with a spring tidal range of 0.6m, calculated tidal planes and design water levels taken from the

Emu Point to Middleton Beach Coastal Adaptation and Protection Strategy (RHDHV, 2017) and can be seen in Figure 9.

Tidal plane parameter	Water level m MSL
Highest recorded	1.13
HAT	0.74
MHWS	0.34
MSL	0.00
MLWS	-0.26
LAT	-0.66
Lowest recorded	-0.90

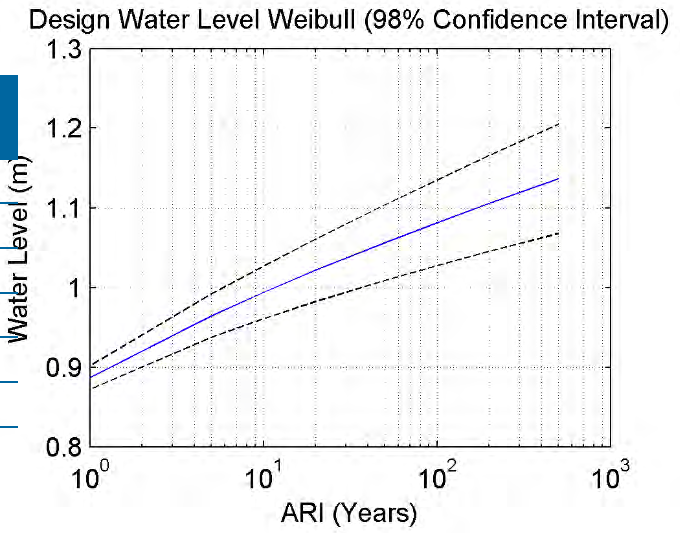


Figure 9: (left) Calculated tidal planes (relative to MSL) based on a harmonic analysis of a 28-year recorded water level signal within Princess Royal Harbour. (right) Annual Return Interval (ARI) for recorded water level (m MSL) based on a 30-year tidal dataset recorded at Princess Royal Harbour, Albany. (Source: RHDHV, 2017).

Sensitivity to Climate Change

In 2010 the magnitude of sea level rise (SLR) recommended for coastal setback planning in Western Australia was updated in SPP2.6 for planning periods up to 100 years. For the 100-year planning timeframe (2010 to 2110) DoT recommended a vertical SLR of 0.9m be adopted and found 0.3m for the 50-year planning timeframe appropriate (DoT, 2010). The recommended sea level rise scenario until the year 2070 is 0.4m from the baseline date of 2010 as presented in Figure 10: . SLR from 2020 to 2070 (50-year design life) is approximately 0.37m.

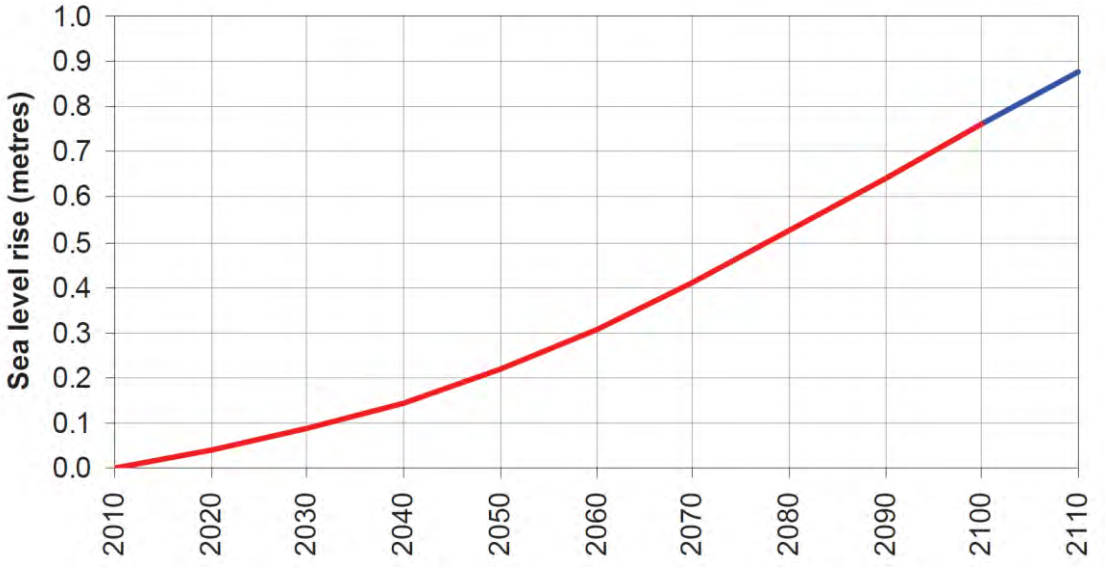


Figure 10: Recommended sea level rise (SLR) allowance for WA coast (source: DoT, 2010).

5.2.2. Design wave event

Although the design life of the structures has been selected as 50-years, the possibility of the structures encountering a 100-year ARI event is 40%. As such structural elements should be designed to an event of (at least) this magnitude. The following sections detail the methodology to determine the 100-year ARI design event that may be encountered at the proposed structure locations.

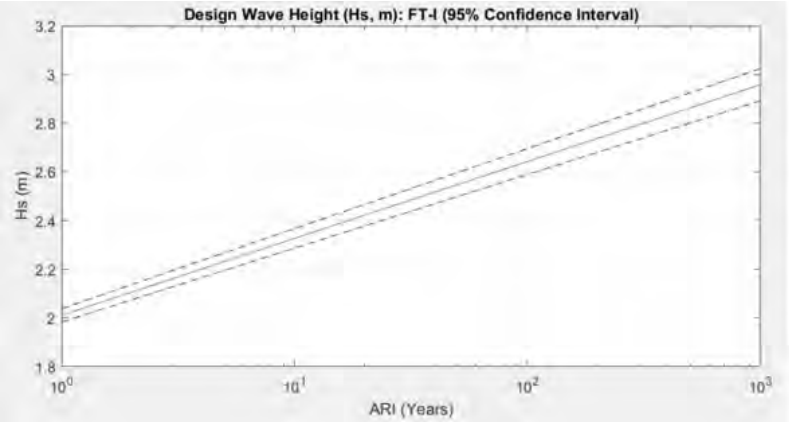
A detailed analysis has been undertaken of the nearshore wave climate at Emu Point in Appendix C. A 41year wave hindcast model was calibrated for King George Sound, driven by offshore wave parameters produced by the Collaboration for Australian Weather and Climate Research (CAWCR) regional hindcast model. Statistical and design wave parameters have been determined for a point 150m offshore of the Emu Point rock revetment (P2) and are provided in **Table 2** and Figure 12. The wave extraction points, and historical beach survey transects can be seen in Figure 11.

Figure 11: Emu Point beach transects and hindcast wave model extraction points

Table 2: Wave statistics taken from the central model extraction point (P2), 150m offshore of the Emu Point rock revetment from the 41 year hindcast wave model.

Parameter	Statistic	41-year hindcast record				
		Long Term Average	Summer	Winter	Autumn	Spring
Significant wave height (Hs) [m]	**Mean**	0.56	0.54	0.59	0.56	0.56
	99%ile	1.26	1.22	1.33	1.25	1.23
	Max	2.33	2.21	2.33	2.16	1.99

Parameter	Statistic	41-year hindcast record				
		Long Term Average	Summer	Winter	Autumn	Spring
Peak wave period (Tp) [s]	Mean	13.2	12.4	13.9	13.3	13.2
	% of time sea (Tp < 8s)	2%	4%	1%	2%	3%
	% of time swell (Tp > 8s)	98%	96%	99%	98%	97%
Peak Wave Direction (Dp) [˚TN]	Weighted Average	119	121	119	119	119
	Average	119	121	118	119	119
	St. Dev.	4	4	4	4	4



ARI (year)	Hs (m)	Hs (98% Confidence Intervals)
5	2.23	2.20 – 2.27
50	2.55	2.50 - 2.60
100	2.64	2.59 – 2.70
500	2.86	2.80 – 2.93

Figure 12: Design wave heights (H_S) from the central model extraction point (P2) from the 41 year hindcast wave model

5.2.3. Joint probability of water level and waves

Analysis of the joint occurrence of observed significant wave heights and observed water levels at Emu Point was undertaken to determine design levels of each. The observed water level includes the still water level components of wind setup and inverted barometric setup but exclude any wave-driven contributions. The observed joint occurrences of the two parameters is shown in Figure 13 suggests that there is a slight positive bias between the

observed wave heights and water levels, i.e. larger wave heights often coincide with higher water levels.

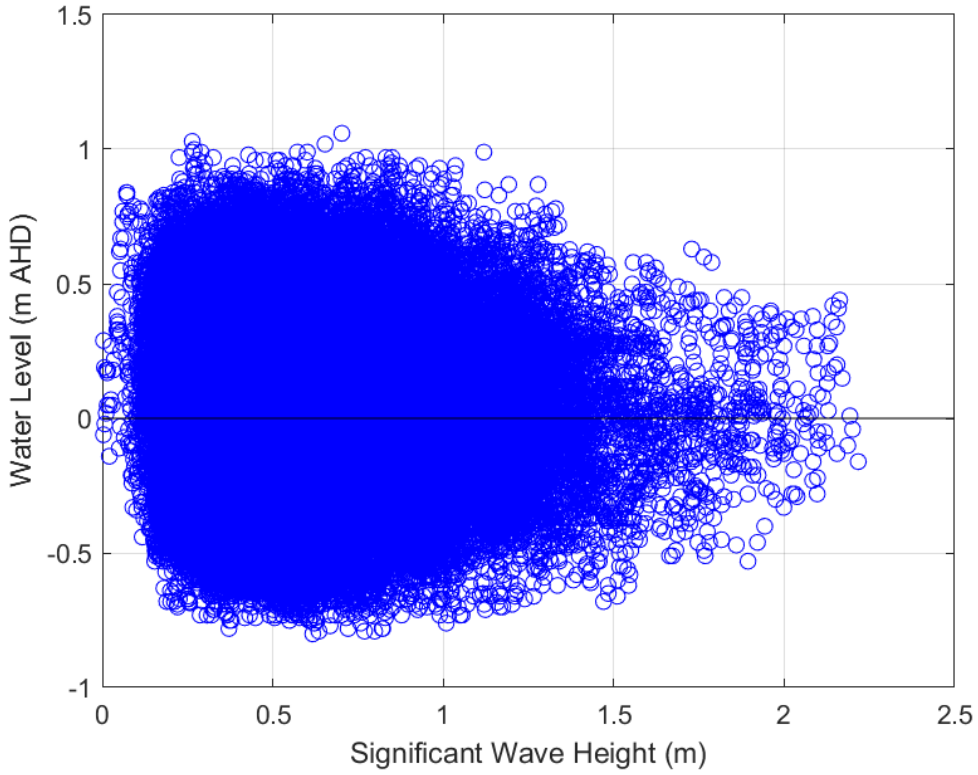


Figure 13: Joint occurrence of significant wave heights at the central model extraction point (P2) from the hindcast wave model and water levels recorded at Port of Albany since 1987 (33-year record).

The joint probability (or return period) of extreme still water level and significant wave heights (or coincidence of the two) was calculated using a multivariate copula analysis. Copulas are mathematical functions that characterise the correlation structure among multiple time-independent random variables. Using significant wave heights calculated at the central model extraction point (P2) from the hindcast wave model and water levels recorded at Port of Albany, the joint probability was calculated using independent extreme wave events (peak significant wave heights) as the primary variable and corresponding maximum water levels within a three hour period before or after the peak wave event (see Figure 14).The analysis estimated the joint 100-year ARI values as:

- Significant wave height of 2.2m
- Total still water level of 1.06m above AHD

These values have been adopted for the design of the coastal structures at Emu Point.

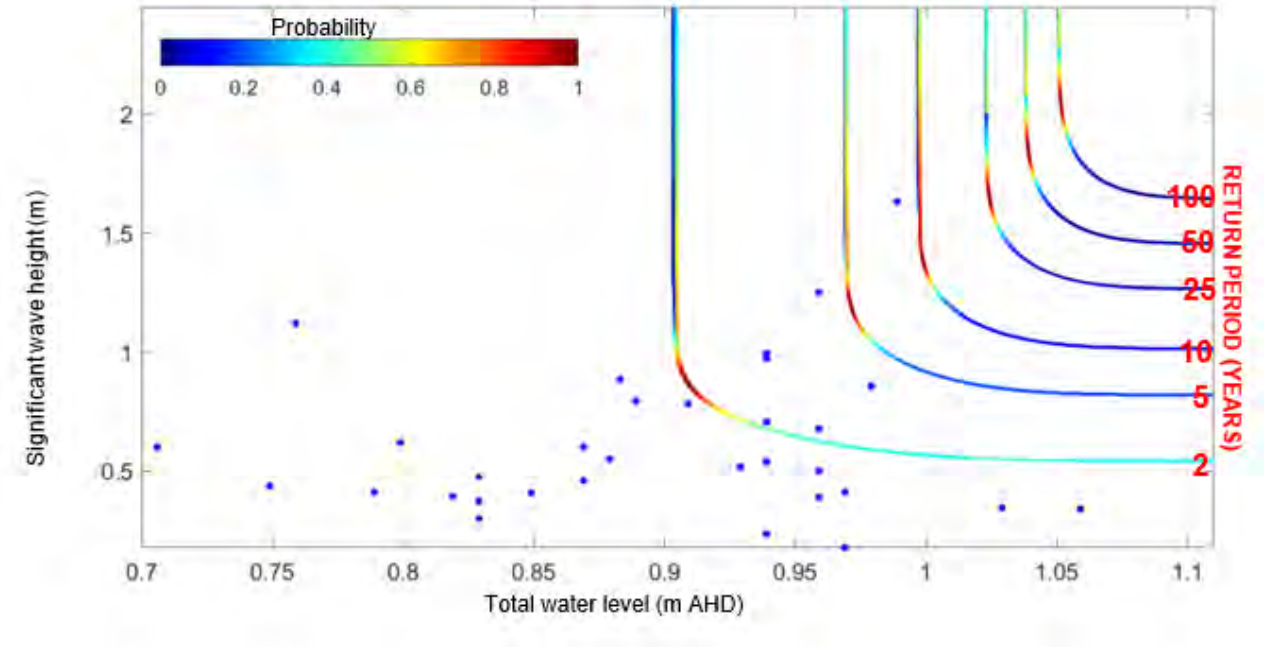


Figure 14: Bivariate return periods (RP) of water level and significant wave height.

5.2.4. Adopted design wave and water level

A summary of the joint 100-year ARI (i.e., ~1% AEP) wave conditions and water levels adopted for the preliminary design of coastal structures at Emu Point is presented in Table 3. Peak wave period has been determined from joint frequency analysis of significant wave height and peak wave period at the central model extraction point (P2) from the 41year hindcast wave model.

Table 3: Overview of adopted joint wave and water level scenarios for the design of coastal structures

Planning period	Still water level (m AHD)	Significant wave height (m)	Peak wave period (sec)
Present day (2020)	1.06	2.2	15
50year (2070)	1.43	2.2	15

5.3. Scour depth

Figure 16 illustrates the variability in bed level directly offshore of the structure (at approximately 45m from the landward survey point), providing an indication of the lowest measured profile elevation at the structure toe. Scour depth is important to understand when determining the design water levels and depth-limited wave height at the structure and is a determining factor as to the level and design of the structures toe.

A range of empirical methods have been employed regarding the determination of the design scour level; historical engineering “rules of thumb”, erosion modelling and published data on profile change. It is expected that scour levels at the structure will be primarily

dominated by wave forces (and wave-wave interactions), whereas the discharge from Oyster Harbour is a minor component.

5.3.1. Rule of thumb

In NSW, the scour level of approximately -1.0 m AHD is commonly adopted as an engineering rule of thumb for rigid coastal structures located at the back of the active beach area with -2 m AHD frequently adopted for vertical coastal structures due to increased wave reflections. This is based on stratigraphic evidence of historical scour levels and observed scour levels occurring during major storms in front of existing permeable and non-permeable revetments along the NSW coast (Nielsen et al. 1992; Foster et al. 1975). It should be noted that the open coast wave climate along the NSW coast is more energetic than Middleton Beach.

5.3.2. Erosion modelling

SBEACH modelling was undertaken as part of RHDHV (2017) for Emu Point in order to determine the S1 Storm Erosion allowance as per the WA SPP2.6 Guidelines. The SBEACH model is a two-dimensional numerical cross-shore sediment transport and profile change model developed by the United States Army Corps of Engineers, Coastal Engineering Research Center. The results of the SBEACH modelling at Emu Point (assuming a pre-structures profile) can be seen in Figure 15, showing an approximate -1m AHD scour level in the nearshore.

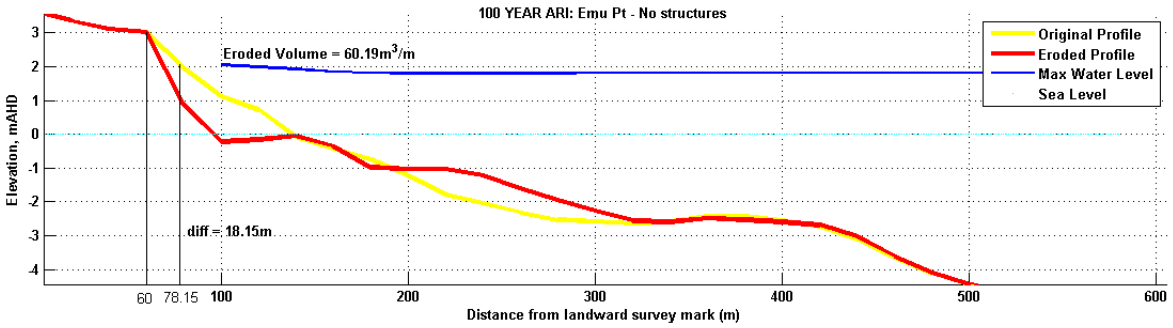


Figure 15 SBEACH storm erosion – 100year ARI at Emu Point (source: RHDHV, 2017).

5.3.3. Published data

Gordon (1987) published the expected range of vertical change in front of a revetment on the NSW coast as a function of average sand levels at the foot of the wall. Chapman and Smith (1983) introduced the concept of a “swept prism” based on approximately 9 years of ongoing measurements on the Gold Coast. Results from these methods are shown in Table 4. At Emu Point it can be assumed that there is approximately +0.00m AHD of sand at the toe of the structure, as such the maximum expected scour level at the structure derived from the three published methods is -2.75 m AHD.

Table 4 Vertical change of reference elevations due to scour from published field measurements.

Average sand level (m AHD)	Vertical Change from Reference			Minimum estimated sand level from all references (m AHD)
	Gordon (1987) High Demand (m)	Gordon (1987) Low Demand (m)	Chapman and Smith (1983) (m)	
0	+/- 2.25	+/- 1.8	+/- 2.75	-2.75

5.3.4. Historical analysis

The closest surveyed beach transect to the rock revetment is EP-01, located just to the west of the detached breakwater, as seen in Figure 11. The lowest historical bed level recorded at the toe of the rock revetment (Aug 2020, at approximately chainage 36) chainage is seen to be around -1m AHD. The as-constructed drawings of the rock revetment (Figure 17) show that the toe design has been excavated to a depth of approximately -1.75m AHD.

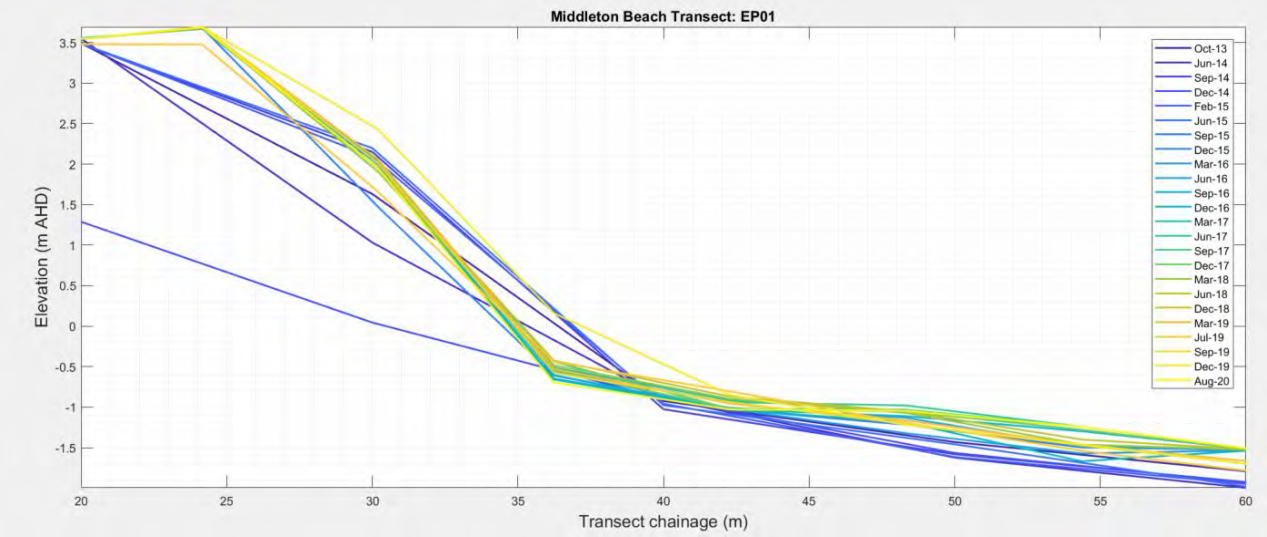


Figure 16: Transect EP-01 at Emu Point between October 2013 and August 2020.

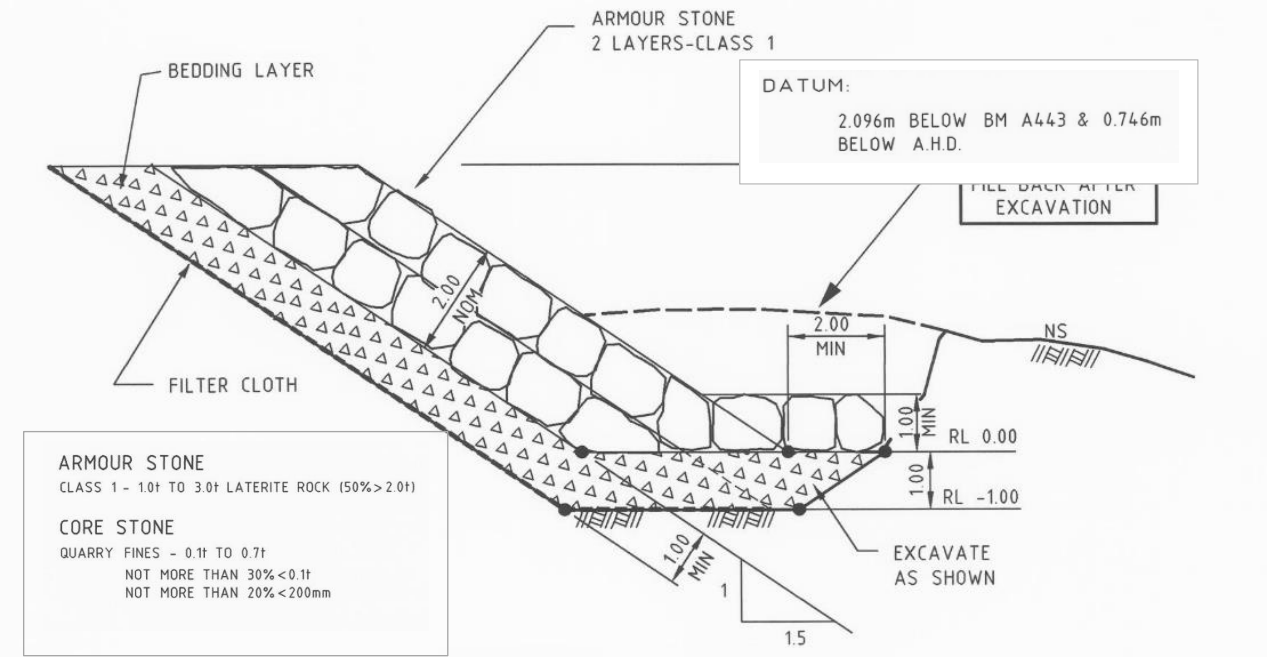


Figure 17: Emu Point Foreshore stabilisation revetment typical cross-section, May 2007 (Source: DoT, DWG 452-12-2)

5.3.5. Adopted scour depth

A comparison of all the scour depth calculations can be seen in Table 5. It is recommended that, as a minimum, the adopted design scour depth should be to the same depth as the current design (-1.75m AHD). This level is recommended as the current structure was not seen to be exposed in the condition assessment (Appendix A), with no sections of the wall seen to have significant scour. Given the importance of this parameter to the design, it is suggested that this be determined through a more detailed analysis as part of the detailed design process. When the trigger values identified in the CHRMAP implementation Plan for the revetment upgrade have been reached, an analysis of recent bathymetric trends and updated numerical modelling should be undertaken.

Table 5: Estimate of scour levels at toe of structure.

Method of Approximation	Scour Level (m AHD)
Rule of thumb	-2.00
SBEACH	-1.00
Gordon (1987)	-2.25
Chapman and Smith (1983)	-2.75
Existing design	-1.75

6. Coastal protection recommendations

Figure 4 to Figure 7 provide the recommended engineered adaptation options as part of the CHRMAP Implementation Plan (Aurora, 2019). The report offers three engineered concept layouts with the note that these designs are to be confirmed and developed further within the Foreshore Management Plan and refined in the detailed design phase. The design development and consideration of the layout and extent of the proposed engineered adaptation structures through MU3 and MU4 are described below.

The CHRMAP, Aurora (2019), RHDHV (2017) and PRDW (2013) identified the following key design constraints which relate to the present and future management of MU3, MU4 and MU5:

- The rock revetment in its current location is critical to the preservation of important coastal assets.
- The current Emu Beach Holiday Park lease area (a recognised important City asset) is at an increased risk of inundation due to its proximity to the active beach in that area.
- The first row of houses on Griffiths are vulnerable due to the access road's proximity to the foreshore when the road and services are damaged, legal access to the lots will be affected and the properties will be impacted.
- There is some evidence that the trial GSC groyne structures may retain sediment between them but due to their reduced length and lowered profile allow excess sediment to bypass.
- The shared path and foreshore reserve at the western end of the rock revetment is at an increased risk of inundation due to its proximity to the active beach in that area.
- Eastern Oyster Harbour Beach is subject to seasonal erosion which limits the amount of useable beach in this area.

Observing the above design constraints and incorporating the three recommended CHRMAP options (Figure 3 to Figure 6), the following adaptation option has been developed. Coastal Adaption Option 1 consists of a triggered upgrade to the existing rock revetment as well as extension, upgrade and continuation of the GSC trial groynes with a targeted beach nourishment campaign between the eastern GSC groyne (Coastal Structure B) and the western extent of the rock revetment. The adaptation option incorporates the following key design elements:

- Upgraded rock revetment following upgraded alignment (coastal structure A).
- Trial GSC groyne field be upgraded, as follows:

The groynes to be rebuilt using locally sourced granite, incorporating the current GSC as core material.

Another groyne be added to the east (towards Emu Point) at a maximum distance of 80m from the eastern groyne (structure 5, Figure 2). The addition of this groyne is aimed at retaining an aerial beach between the new groyne and rock revetment (Coastal Structure A).

The length of the groynes be extended at a maximum distance equal to the seaward location of the rock revetment, (an approximate extension of 10-15m further seaward). All groynes to be extended landward and buried to the location of the 3m MSL beach contour (existing vegetation line).

- Beach nourishment campaign to infill a beach between the eastern GSC groyne (Coastal Structure B) and the western extent of the upgraded rock revetment (Coastal Structure A). The nourishment will be graded and profiled over the dry beach (between 7m MSL and MHWS contour) to match as close to possible the natural profile of Middleton Beach to the west.
- Triggered beach nourishment in the eastern corner of Oyster Harbour between the spur groyne and the eastern arm of the swimming enclosure.
- Opportunistic beach nourishment placed on Emu Point and Emu Beach to be sourced from coastal works between Ellen Cove and Oyster Harbour or dredging works within King George Sound, Oyster and Royal Princess Harbours. Sand sourced from these activities is to be cleaned and placed on either:

The upper beach between the eastern GSC groyne (Coastal Structure B) and the western extent of the upgraded rock revetment (Coastal Structure A) between the 7m and MHWS contours, or the western lee of the detached breakwater.

Timing and trigger points for each of these options are described further in the following sections.

Figure 18: Coastal adaptation recommendations: rock revetment upgrade, upgrade of GSC trial groynes with beach nourishment and amendment of Big4 lease boundary.

6.1. MU3

6.1.1. Planned retreat

The CHRMAP Implementation Plan (Aurora, 2019) makes two recommendations around the planned retreat of assets within the MU3/MU4 management units:

- Recommendation 14: MU3 Properties on Griffiths Street - Managed Retreat. Relocate properties from Griffiths Street
- Recommendation 15: MU3 Emu Beach Holiday Park - Managed Retreat of assets in the southern portion.

Griffiths Street

As seen in Figure 19, the first row of houses on Griffiths Street are the most vulnerable private property to coastal inundation within MU3 as they are located furthest seaward without any 'hard' coastal protection. This row of houses is approximately 120m to the current 0m AHD shoreline (Horizontal Shoreline Datum, HSD) with the natural foreshore berm (with a height of approximately +9m AHD), the dual use footpath and the access road (Griffiths Street) between the properties and HSD.

Griffiths Street is currently the only access to the properties and as such should the road and services be damaged, legal access to the lots will be affected and the properties will be

impacted. Aurora (2019) stated that the preferred option for the Griffiths Street assets is as follows:

- Short term (0-10 year): Sand nourishment and continued monitoring
- Long-term (10+ years): Managed Retreat, to be initiated by a coastal response Trigger Value.

The Trigger Value for the long-term coastal adaptation (Managed Retreat) is stated as when HSD is less than 40m from the road (Griffiths Street). Monitoring should be undertaken every two years in spring and after any significant storm erosion event to understand increased likelihood of risk and determine if more expeditious relocation is required. The March 2019 survey puts the 40m trigger line landward of the established foredune and at a distance of approximately 70m to HSD.

RHDHV (2017) has shown that this area is seen to be accreting. Figure 20 supports this theory, with beach transects taken along the nearby profile MB-05 showing accretion offshore (depths less than -4m AHD) as well as growth to the incipient dune face (between 0 – 4m AHD). Historically, the last time that the foredune was exposed is believed to be the storm of August 1984, as seen in Figure 20. This storm was approximated to be a 1 in 100-year event (RHDHV, 2017). Following this event, the beach has shown long-term accretion.

Although the trigger point is not expected to be activated in a subsequent event of similar magnitude as that of 1984, it is recommended that should this occur, in the first instance sand nourishment be undertaken and monitored to ensure the long-term accretionary trend continues along this part of the beach. In the meantime, the recommendations of Aurora (2019) to put in place strategies to facilitate managed retreat should be commenced.

The CoA's Local Planning Strategy (CoA, 2019) recognises the implementation of the CHRMAP as Investigation Area 12 and addresses CHRMAP Recommendation 1 (managed retreat). The following overarching recommendations of the CHRMAP will be actioned by the CoA to facilitate managed retreat:

- LPS Special Control Area (Recommendation 2 in the CHRMAP)
    - Complete the CoA's LPS No.1 review, which is currently being progressed, to include the vulnerable zone (the modelled hazard area to 2120) in a Special Control Area. It is proposed that the Special Control Area will alert existing and future landowners to seek information from the CoA and enable notification to landowners if they seek a development approval.
- Recommendation 8: Purchase of Property Investigation: Investigate the opportunity to acquire land as it become available on the public market

Figure 19: Contour map of the Griffiths Street foreshore from March 2019 showing the 40m seaward offset Coastal Adaptation Trigger Point and long-term beach transect MB-05
Note: These contours are taken form the March 2019 survey where contour heights within heavily vegetated areas represent the top of the vegetation.

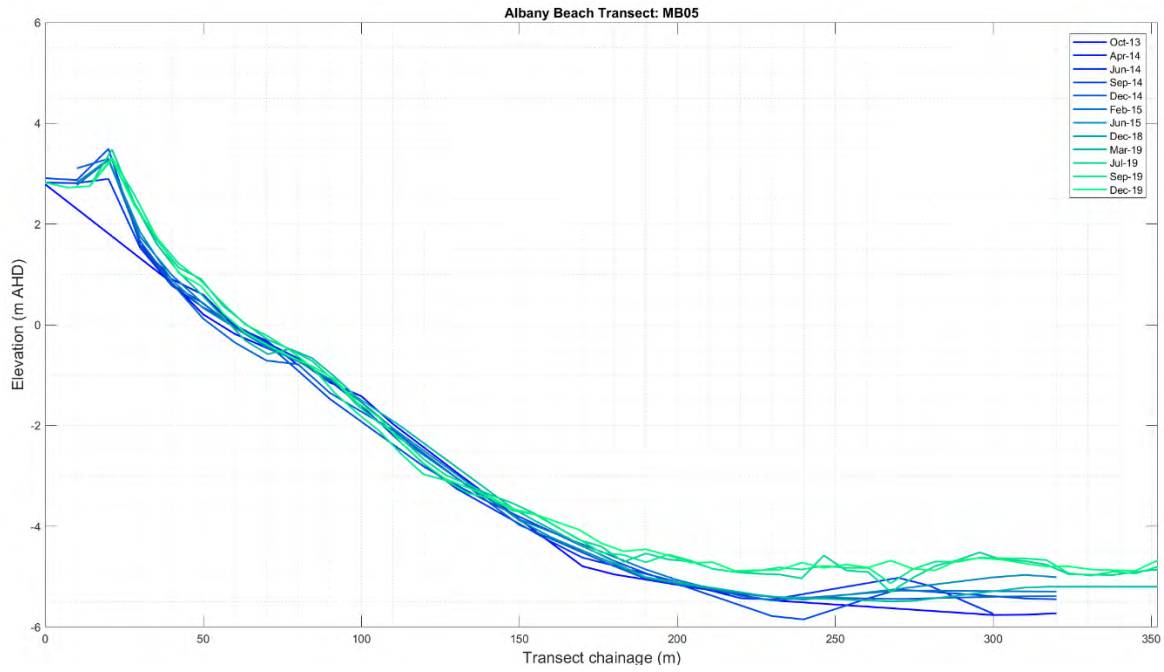


Figure 20: Beach transect MB-05 comparison plot between October 2013 and December 2019.
Note: MB-05 is the closest long term measured transect to Griffiths St

Figure 21: Photographs of erosion scarp following August 1984 storm event. (source: Briss family as reported in URS 2012).

6.2. MU4

6.2.1. Planned retreat

Similarly, to the Griffiths Street managed retreat, Recommendation 15 calls for the managed retreat of vulnerable assets within the Emu Beach Holiday Park (EBHP) southern lease area. The same trigger value of 40m (of EBHP assets to HSD) has been recommended at this site. As seen, in Figure 22 this trigger value is close to being initiated with the beach in its current eroded state, with a distance of approximately 25m to HSD. As a result, the City has been working with the leaseholder to plan for staged retreat of assets within the southern portion of the site as well as commence discussions around the re-alignment of the current lease boundary as seen in Figure 22.

Following the proposed nourishment, upgrade of GSC groynes and rock revetment (detailed in the following sections and seen in Figure 22) it is expected that the trigger value for managed retreat of EBHP assets will not be initiated for some time. It is also expected that the upgrade works will provide a beach with a greater appeal to users. With a widened and a greater protected foreshore, there exists an opportunity to continue to allow accommodation within the southern portion of the current site through the provision of less permanent assets/uses such as unpowered camp sites and parklands on the foreshore area, provided there is an appropriate emergency management plan for responding to extreme storm activity. It is recommended that the City and the leaseholder work toward an agreed level of risk within this area, steering the discussions around future lease agreements.

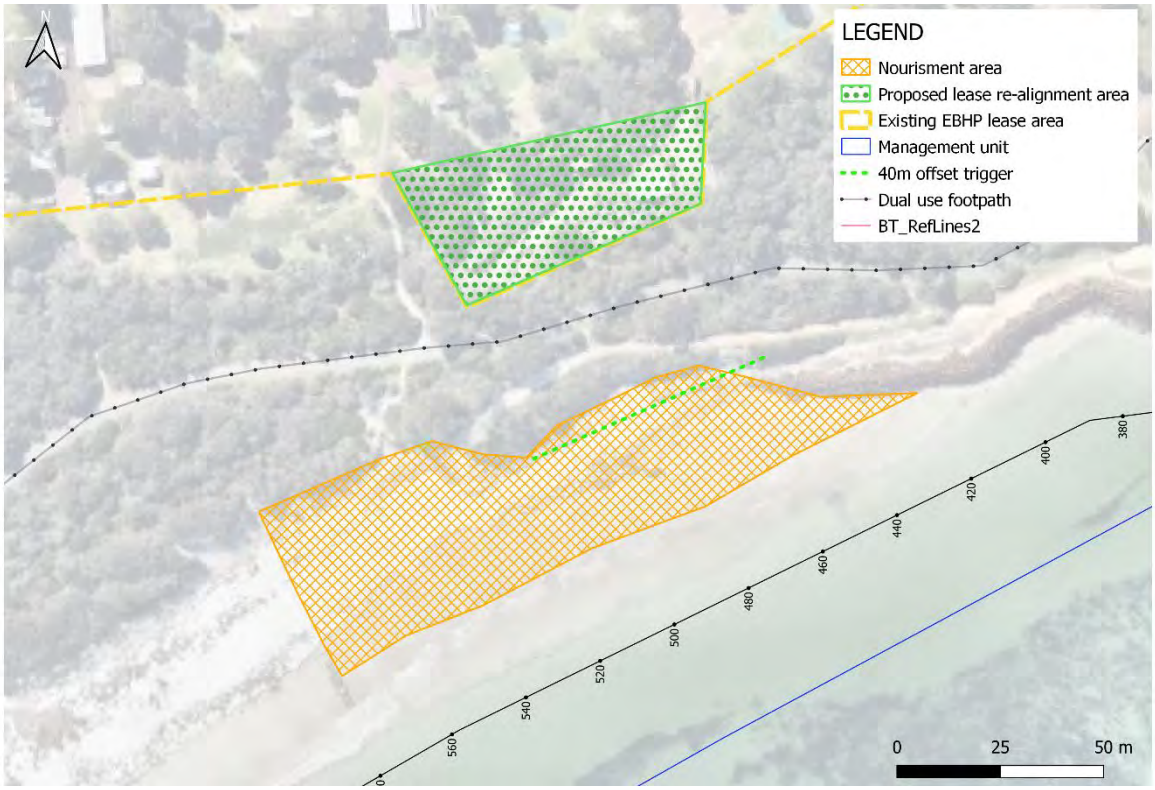


Figure 22: Emu Beach Holiday Park southern lease area and 40m offset trigger value

6.2.2. Rock revetment

The rock revetment structures are reported to be in poor condition; EvoCoast (2017) and Bluecoast (2020). Similarly, Aurora (2019) state that the condition of these structures is critical to the safety of the coastal assets inland of the revetment, stating:

- Camping grounds, caravan sites and out-buildings may be impacted in the short term if renovations to the revetment are limited to the original construction locations. Further structures and infrastructure landward of the Central Road are vulnerable from 2070.
- Emu Point Rock Revetment - based on current condition the structure is expected to mitigate the immediate likelihood of erosion. After this period, a retrofit of the coastal protection could provide protection for the ensuing period.

The shoreline is controlled by the structures and the risk to assets is dependent on the structures' integrity. An updated condition assessment of the coastal protection structures (including the GSC trial groynes) can be seen in **Appendix A.** The assessment shows that although the structures are generally in poor condition, they are meeting their functional objective of protecting the coastal assets in their lee and preventing overtopping and inundation. The structures, however, are seen to pose a safety hazard should the public be permitted to access them. With this in mind, the following recommendations concerning their upgrade are made:

1. The landscaping component of the FMP should include measures to discourage public access to the coastal protection structures; both the rock revetment and the GSC trial groynes.

A condition assessment of the coastal protection structures following a standardised and agreed method should be undertaken, as a minimum every 3 years.

The trigger value for the upgrade of the rock revetment structures should be, either of the following:

A condition assessment rating of 'Very Poor' resulting from the standardised assessment (or less than 1.5 in Appendix A) for any section of the structure.

Greater than three (3) overtopping events of the structure within a 12-month period where the overtopping event is determined by a coastal engineer as reaching the overtopping limit for damage to grass covered areas (after EurOtop 2018), described in Table 6.

Table 6: Limits for wave overtopping for structural design of revetments with grass covered crest and leeward slope (adapted from: EurOtop (2018), table 3.1)

Wave height at structure, Hm0 (m)	Mean discharge, q (l/s/m)
1 – 3	5
< 1	5-10
<0.3	>10

Alignment

The alignment of the rock revetment structure, although generally straight can be seen to have a number of turns or 'kinks', most notably the 90° landward turn at Firth Street (Figure 23 and Figure 24) which is believed to be due to the piecemeal nature of its implementation. The most eastern section of the structure was originally developed in response to the storm event of 1999 and was subsequently extended towards the west as further erosion was realised. A full summary of the structure's history can be found in the Condition Assessment (Appendix A) and in RHDHV (2017).

Prior to the engineering interventions along Emu Point, the shoreline generally reacted to the size, shape, depth and orientation of Lockyer Shoal. An historic vegetation line analysis undertaken by the Department of Transport (DoT, 2012) can be seen in Figure 23. The shoreline is seen to have an approximate 30-40m variation in beach width between the commencement of the analysis in 1943 and the last recorded vegetation line in 2012. The historic vegetation lines all appear to follow the same gentle crenulate shape commencing in the east reaching their most seaward protuberance around Firth Street before turning inland on a deeper curvature to the west, this shoreline was observed both prior to and following the implementation of any rock revetment works.

Generally, the rock revetment structure follows the alignment of the most landward vegetation line of 1943, the only deviations being the two 90° landward 'kinks'; the most

easterly being in the vicinity of the public toilet block and the more pronounced kink at Firth Street. These kinks were subsequent extensions to the revetment as erosional end-effects were being experienced at the termination of each revetment. These 'kinks would link the new western structure to the older eastern structure as the shoreline at the time of construction in this area would have moved further inland.

It is recommended that the upgraded revetment follow the general alignment of the historic vegetation lines, eliminating any of these kinks. Generally, it is recommended that the revetment not be moved further seaward of its current location as it is contradictory to the managed retreat ethos. A seaward relocation may also invoke further approvals and an extension to the seabed lease granted by Southern Ports Albany (SPA) for the current structure. A conceptual alignment for the proposed upgrade of Coastal Structure A can be seen in Figure 24, here the dashed red line represents the structure toe.

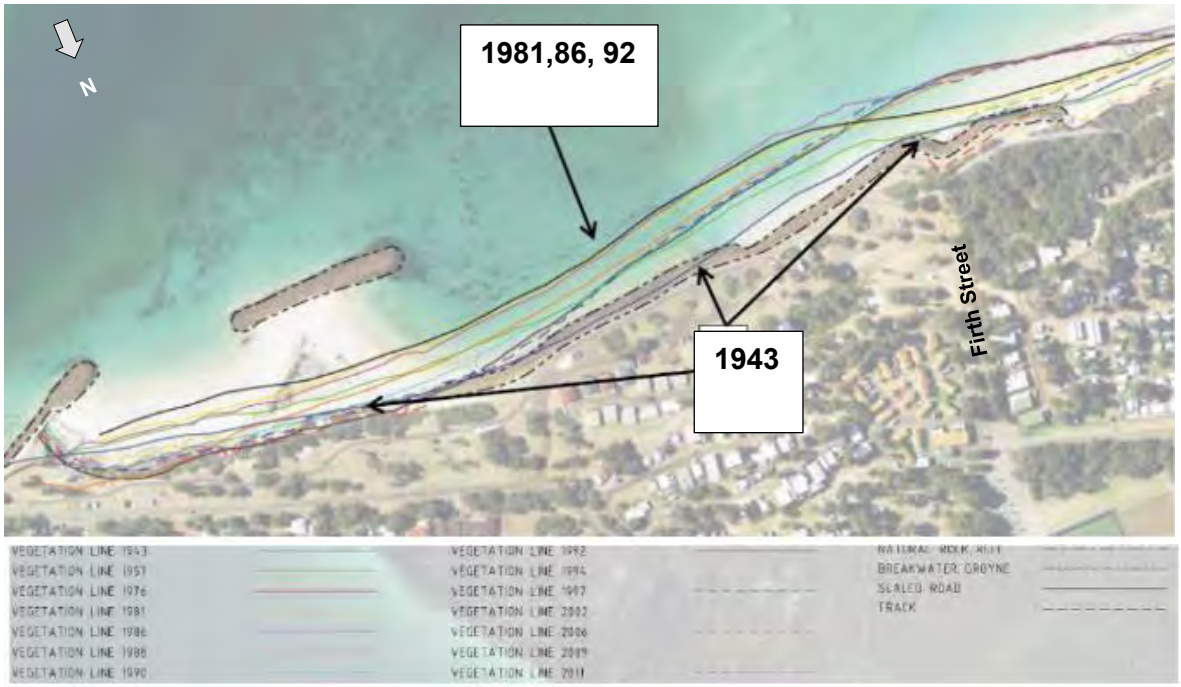


Figure 23: Analysis of aerial photography using vegetation lines (source: DoT, 2012)

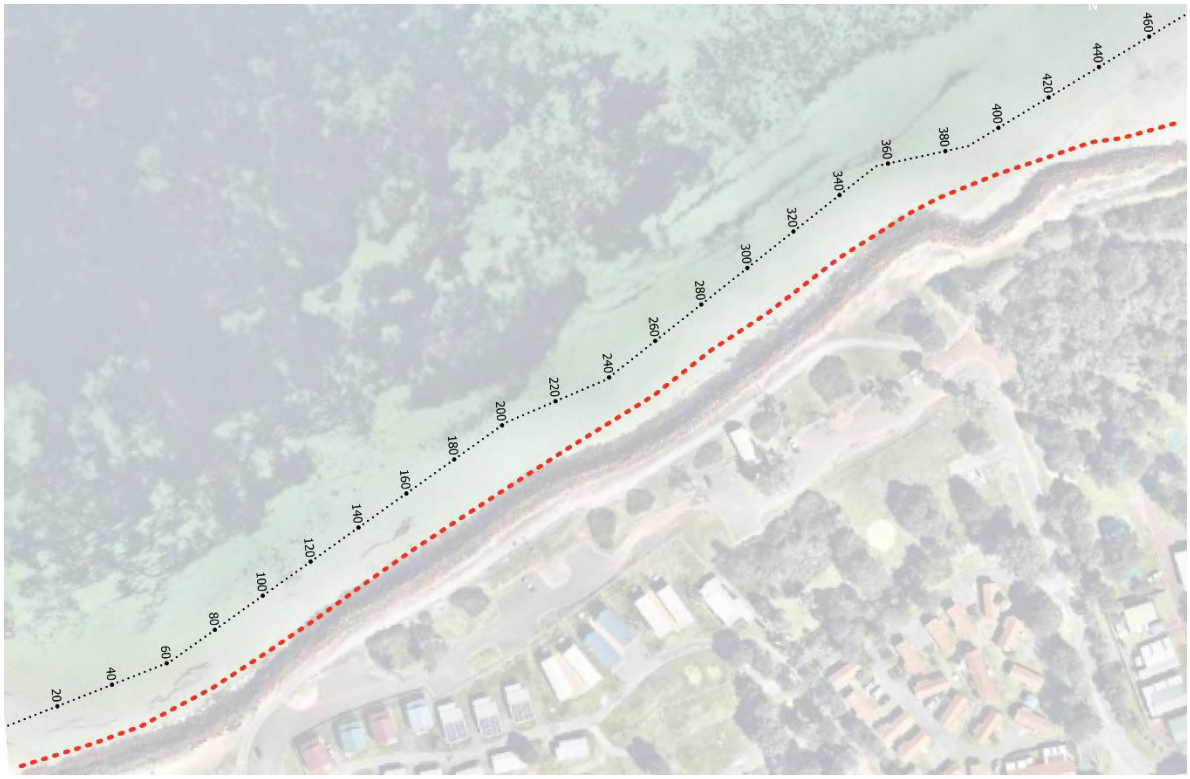


Figure 24: Current and proposed alignment of Coastal Structure A. The dotted red line represents the alignment of the rock revetment toe.

Rock type

It is recommended that the upgraded revetment be constructed with locally sourced granite, to a design guided by this BoD as part of the FMP and further specified in the detailed design. Although more expensive, granite is proven to be a more durable material than that of laterite (being used currently), with chipping, cracking and degradation of the rock much less likely, reducing the risk of contamination to the receiving water and sediment. Granite rock is in good supply in the region with a few potential sources that will promote competition among suppliers. Granite matches the natural environment of Emu Beach and Emu Point and does not contrast with the vistas through to Mount Martin across Oyster Harbour. In addition, the higher density of granite means that individual armour rock sizes will be smaller. Smaller armour units will increase stability and will have a small improvement in reducing wave reflections.

Crest height

The current crest height of the rock structures attained from the As-Constructed drawings and verified through the recent Condition Assessment (Appendix A) is seen to be between 2.9-3.6m above AHD. This equates to a height of 2.2-2.9m above Highest Astronomical Tide (HAT). In comparison, the crest of the ‘wave deflector’ wall at Ellen Cove was designed to a height of 2.55m AHD (or approximately 1.8m above HAT). This wall, however, is buried deep in the upper dune area, not currently exposed to waves as is the case at Emu Point.

It is expected as sea level rises and the condition of the laterite rock revetment continues to deteriorate, the trigger values for update of the rock revetment will be initiated. It is

recommended at this stage; a detailed design of the proposed rock revetment be undertaken, and that crest level is calculated with updated values based on sea level rise projections, scour depth and design wave heights at that time. Detailed designs undertaken at the time of construction will also include updated modelling, including overtopping calculations. As a preliminary estimate (for costing purposes) it is sufficient to estimate a similar design crest height of the current revetment design. The current height of the structure is seen to maintain the setback of the CHRMAP hazard line to the revetment alignment even to the 2120 horizon, Figure 8 (top).

Rock size, grading, filtration and revetment slope design

Rock sizing of the current laterite structure can be seen in Figure 25. As the condition assessment (Appendix A) has shown little movement or damage to the armour rock, a similar rock sizing can be assumed at this stage in order to inform preliminary concept designs and costing. As the upgraded structure is proposed to be built from granite (of a higher density than laterite), changes to the approximate sizing of the armour and core can be seen in Table 7

The condition assessment (Appendix A) showed that parts of Coastal Structure A exhibited bridging of the armour rock suggesting loss of the core material. This failure may be attributed to a number of causes, however, is most likely due to the lack of (or failure of existing) geotextile base layer and/or incorrect filter design and the loss of finer material through these voids. To prevent loss of the foundation or fine material

it is recommended to incorporate an underlying geo-synthetic textile (geotextile) layer to ensure longevity of the design. Alternatively, a filter design could be considered but a properly designed and constructed geotextile underlay design is likely to be more cost efficient.

The slope of the existing revetment is approximately 1V:1.5H (Appendix A and Figure 25). This steep revetment induces significant wave reflections. A large scour hole exists offshore of Coastal Structure A and is expected to be exacerbated by the wave reflections from the wall. A reduction in the slope of the revetment should be considered, say to 1V:3H, this may reduce the amount of wave reflections from the wall.

A preliminary concept of the rock revetment can be seen in Appendix B. If feasible at the time of implementation, it is recommended that beach nourishment in front of the structure be undertaken, burying the toe of the wall (to at least HAT) in the hopes of returning a natural beach to this location.

Table 7: Rock size conversions between laterite and granite for rock revetment based on DoT's concept design for comparison of rock sizes.

Rock Class	Material	Density	Approximate size (nominal diameter)
Class 1: Armour	Laterite	1.6 t/m^3	1.0t = 1.02m 2.0t (M50) = 1.1m

1.0t – 3.0t			3.0t = 1.47m
D50: 2.0t	Granite	2.65t/m^3	1.0t = 0.86m
			2.0t (M50) = 0.91m
			3.0t = 1.24m
Class 2: Core	Laterite	1.6 t/m^3	0.1t = 0.47m
0.1t – 0.7t			0.7t = 0.90m
	Granite	2.65t/m^3	0.1t = 0.40m
			0.7t = 0.76m

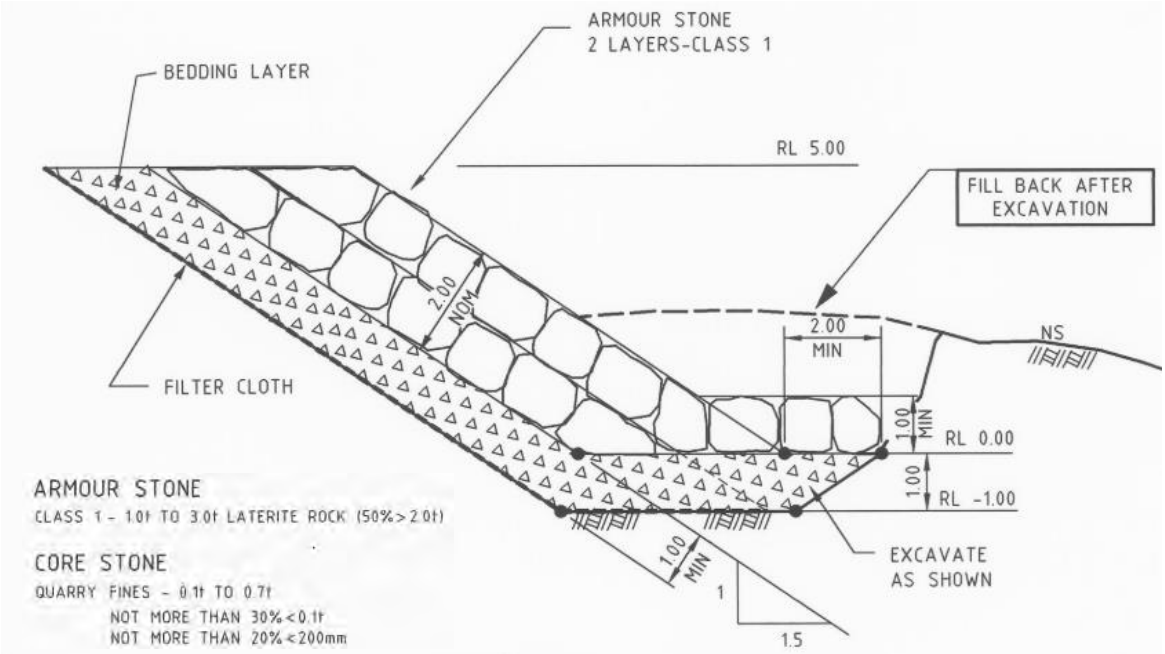


Figure 25: Design profile of Coastal Structure A (sourced from: DoT, 2007)

6.2.3. Groynes

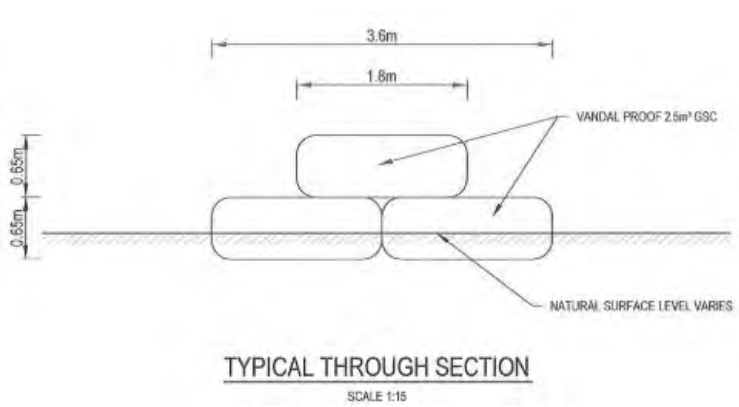
In April 2014, the City installed two trial groynes to the west of the rock revetment at Emu Point. During construction, the area around the groynes was nourished with approximately 10,000m^3 of sand. The extent and layout of the GSC groynes can be seen in the as-constructed drawings in Figure 26. The groynes were installed as a trial to assess what the effect would be of a shore perpendicular structure with the aim of maintaining a beach in this area preserving the nourishment and to provide a natural buffer during storm events.

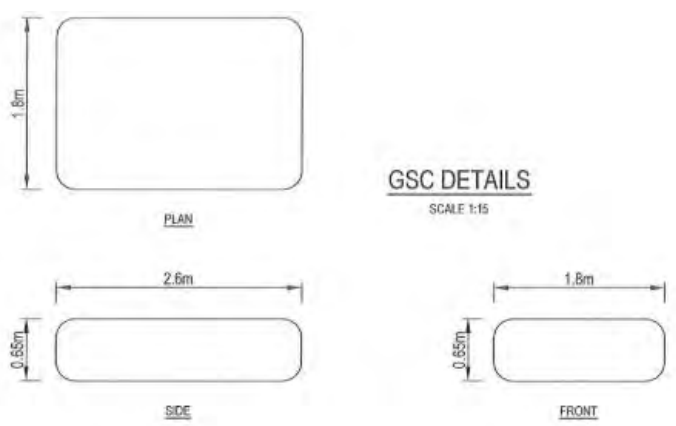
It has been six years since the commencement of the trial GSC groynes and due to their exposure to cyclic wave action and UV, their condition is beginning to deteriorate rapidly. More concerning is the threat to overall public safety if access to the structures is continued.

A performance review of the current structures is provided in Appendix C, building upon prior reviews undertaken by PRWD (2015c) and RHDHV (2017). The key findings of the performance review have been used to inform the upgraded design; these are:

- Minor erosion to the west of the two groynes indicates a low rate of net westerly longshore sediment transport.
- Due to the relatively short length (and low-profile) of the groynes, sand can bypass the structures.
- The beach monitoring transect MB-09 is located between the two groynes. It is seen to have the most stable (dry) beach since the introduction of the groynes, with all contours above 0m AHD retaining their seaward position even during the recent storm event of August 2020.
- The long-term comparison of the beach along the MB-09 transect prior to and following construction of the GSC groynes has shown a slight accretion of the dry beach (i.e., seaward movement). Whereas the two directly adjacent transects (MB-07, MB-08) have shown net recession.
- The stability of the dry beach between the two groynes provides evidence of their efficiency in retaining the upper beach. Stability in the upper beach is most likely related to the short distance between the two groynes.

Both condition assessments of the GSC groynes has shown deterioration which has resulted in repair and replacement of individual units. The original design intention of the groynes as "trial" structures has now passed, with the impact on the coastline being understood from the coastal monitoring program. It is recommended that a groyne field in this current location be upgraded to ensure coastal adaptation requirements are met for at least 50 years. This should be done by assessing the most suitable layout (size and orientation) and number of structures required and to upgrade the GSCs to suitably sized, locally sourced granite boulders.





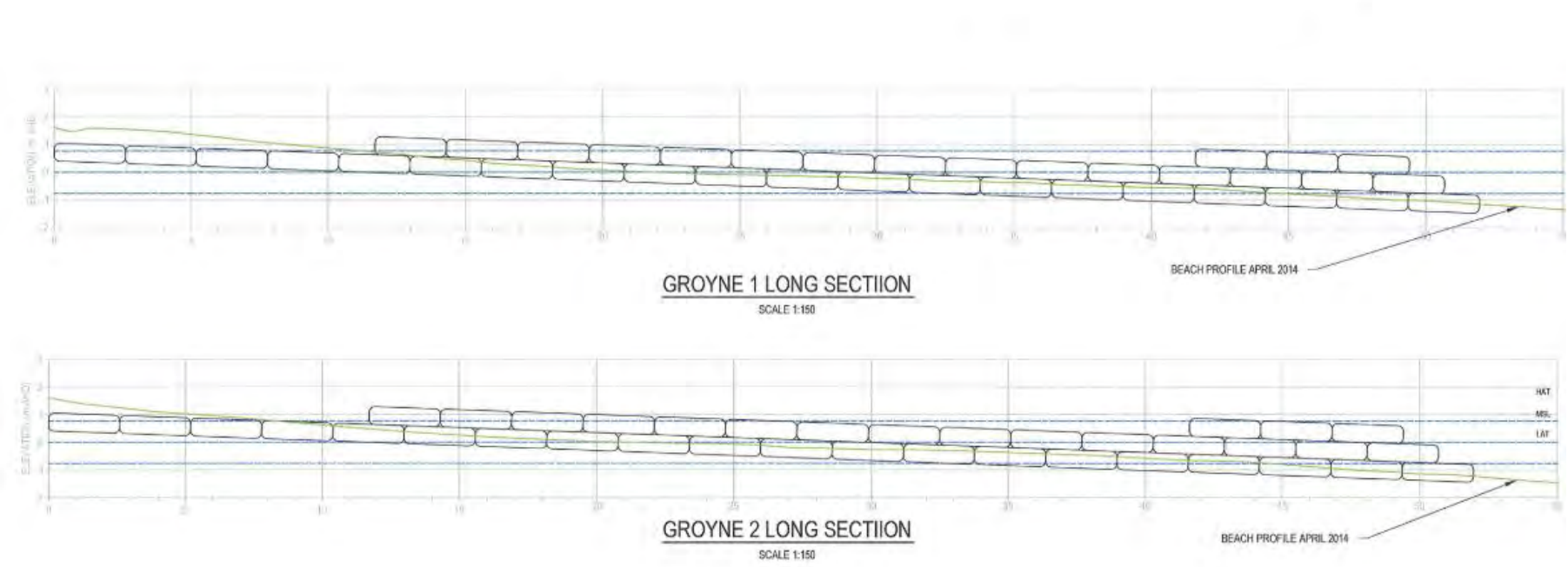


Figure 26: As-constructed drawings of the trial GSC groynes at Emu Beach (source: City of Albany)

Design development

Groynes are structures that extend from the shore into the active zone of longshore sediment transport (LST) and control the natural movement of beach material. They are analogous to natural headlands. They alter the orientation of the beach to be more in line with incident wave crests and intercept longshore currents, reducing LST and promoting sediment accretion on their updrift side with corresponding erosion on the downdrift side. Groynes do not directly counter erosion and recession but provide assistance in developing a more stable shoreline and sand buffer, or transfer the processes to other locations (WRL, 2013).

Functional groyne design includes the following key design parameters; length, width, crest level, spacing, permeability, orientation, location, water depth - these are represented in Figure 27. The best indication of how a proposed structure will perform is the performance of a similar structure in a similar physical environment. The most suitable comparisons for the material and stability can be made of the rock revetment structure at Emu Point. Evaluation of length, location and spacing can be made from the trial groynes. A condition assessment and performance review of each of these structures is provided in Appendix A and Appendix C.

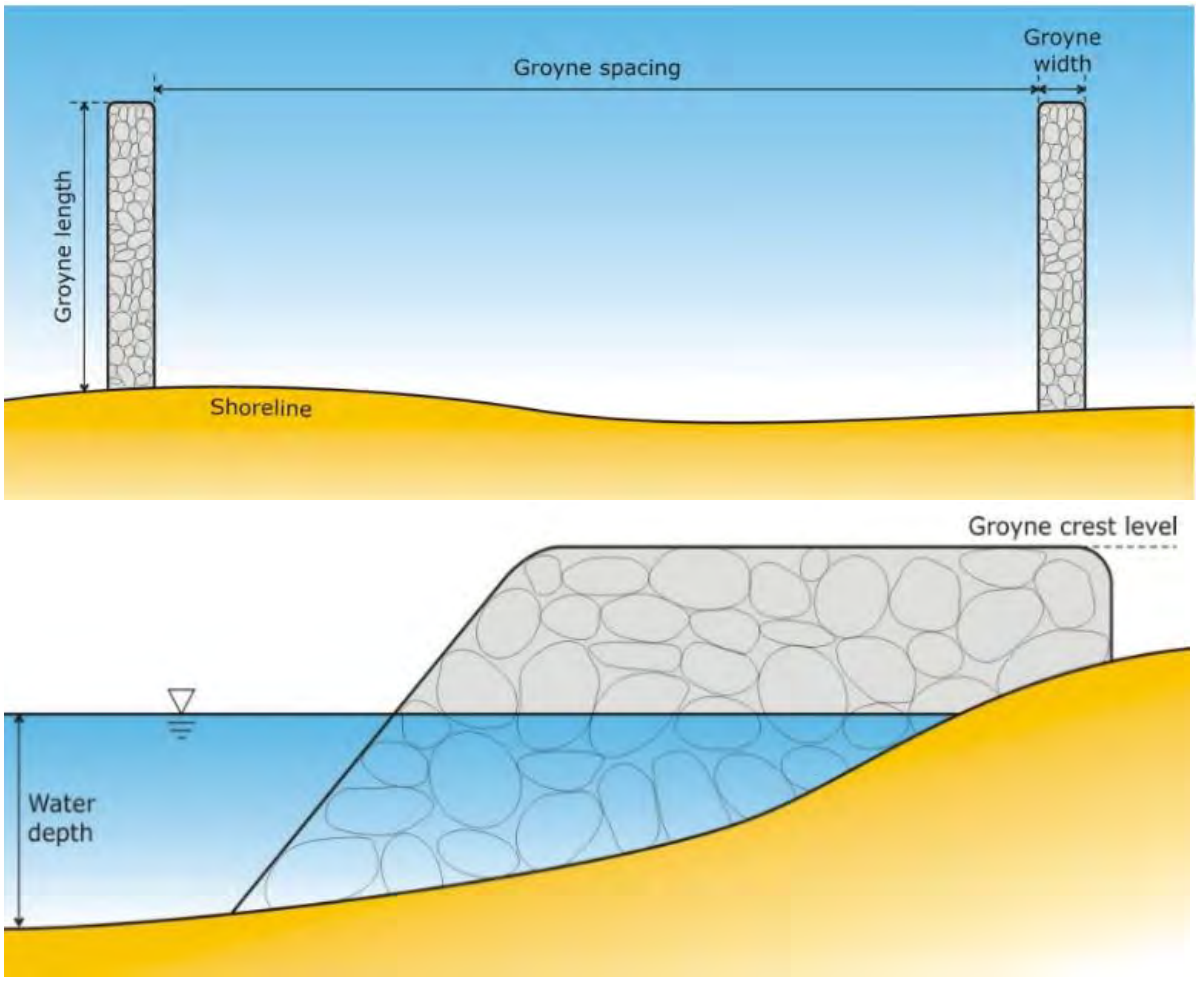


Figure 27: Groyne field design parameters, plan (above) and profile views (below). (Source: WRL, 2013).

Groyne permeability

Groyne permeability relates to the structures ability to block the nearshore current, interrupting the LST over the entire groyne length. Permeable groynes act differently to traditional groynes as they do not directly catch and trap sand. Instead, permeable groynes work by slowing the longshore current and decreasing the capacity of the current to transport sand. They may also reduce the downdrift erosion/recession associated with impermeable groyne design under certain conditions (WRL, 2013).

Permeable groynes are suited to shores with low-medium wave and current exposure. Impermeable type groynes were selected for the concept groyne design. This selection was made on the basis that there are no long-lasting permeable groynes on marine coastlines in Australia and that there are problems associated with damage to these structures from wave impacts.

Groyne length

Beach stabilisation using groynes is generally feasible in areas characterised by a dominant direction of LST. There has been four previous studies SKM (1993), MP Rogers (2003), PRDW (2013) and RHDHV (2017) investigating the net LST regime at Emu Point. There is contention as to the mechanism inducing the net LST along Emu Point. However, the consensus is that east of Boongarie St, sediment moves east to west (towards Ellen Cove) at a rate of between 10-11,000m^3/year. SKM (1993) hypothesized net transport along the western portion of Emu Beach was in the opposite direction from west to east (i.e., towards Oyster Harbour) at around 8,000m^3/yr. An investigation into LST potential was also undertaken in Appendix C using wave parameters extracted from a 40 year hindcast model 150m offshore of the trial GSC groynes. The CERC equation (Shore Protection Manual, US Army Corps of Engineers, 1984) was utilised to verify the rates of LST proposed in the previous studies. The calculations showed that LST does move in both directions, with an overall east to west net transport in the order of magnitude found in the previous studies. The net deposition inside Oyster Harbour and the growth of Lockyer Shoal provides evidence of gross transport also moving in an easterly (as well as cross-shore) direction.

The length of the trial GSC groynes are shown to extend seaward to a distance where the lower (toe) layer of GSC's lie at approximately -1m AHD (Figure 26). The beach is stable between the two trial groynes as well as the lower GSC layer (see Condition Assessment Report). It is recommended that the length of the groynes be extended at a maximum distance equal to the seaward location of the rock revetment, (an approximate extension of 10-15m further seaward) in the hopes of extending and maintaining a dry beach following a (recommended) corresponding beach nourishment campaign.

Groyne spacing

There are several engineering 'rules of thumb' for the determination of the most effective spacing between groynes. Spacings are generally expressed as a ratio of groyne spacing to groyne length. Published design values can be seen in

Table 8.

Table 8: Published design values of groyne spacing to groyne length ratio

Source	Groyne spacing length ratio	comments
Kraus et al (1994)	**2-4**	For groynes on sandy beaches
Fleming (1993)	**0.8-2.7**	Survey of (wave reflecting) timber groynes across the UK
SPM (1984)	**2-3**	Shore Protection Manual
USACE (2006)	**2-4**	Coastal Engineering Manual
Silvester (1992)	**2-14**	As a function of the incident wave angle. No field or laboratory data was cited to support this method.

The effectiveness of a groyne field at retaining a beach is maximised by reducing the spacing between adjacent groynes (WRL, 2013). The spacing between the two GSC groynes at Emu Point is approximately 80m which yields a groyne spacing to length ratio of 2 (as approximately 10m of the 50m groyne length is buried). As the performance analysis has shown (Appendix C), for these groynes to be effective at maintaining a beach between them, it is recommended that an additional groyne be added to the east (towards Emu Point) at a maximum distance of 80m from the eastern groyne (structure 5, Figure 2). The addition of this groyne is aimed at retaining an aerial beach between the new groyne and the start of the rock revetment. The new groyne is designed to retain a beach updrift of the existing groyne field.

Groyne orientation

In line with the SPM (1984) a groyne orientation perpendicular to the shoreline is recommended. If groynes are angled slightly downdrift, more curvature of the beach in the shadow zone can develop due to enhanced diffractive effects around the groyne. However, angling of groynes downdrift to the long-term average LST can cause exacerbated erosion during events in which the drift direction is reversed. This can occur at Emu Point due to the bi-modal flow regime.

Groyne crest level and width

The crest level of each of the proposed groynes is influenced by several factors which will minimise the amount of construction materials used, control sand movement over the top of the groynes and accommodate land-based construction equipment that might operate directly on the structures. As the trial of the GSC groynes has now completed, more permanent structures are proposed. In line with the material proposed for the revetment at Emu Point, it is recommended that the new groynes be built from suitably sourced local, granite boulders.

For practical construction and to minimize additional material being transported, it is recommended that the existing GSC groynes be used as the core material for the proposed rock groynes. As such, it is recommended the existing crest level of 1m AHD be adopted for core material along the full length of each groyne. Two layers of secondary and primary armour of the size noted in Table 7 be used to cap the structure.

The increased crest height may limit pedestrian access around the structures, which is currently provided by walking over the GSC groynes. It is anticipated that by burying the landward extent of the groynes and by re-establishing the dune system through a beach nourishment campaign, that access will be provided around the landward end of the groynes.

Design scour level

An extension of 15m of each of the groynes places the seaward end of the structures at approximately the 100m chainage mark along MB-09, as seen in Figure 37 (Appendix C). The lowest historical bed level recorded at this chainage is seen to be around -1m AHD. Design scour level for these structures should be, as a minimum -1.75m AHD. This level approximates the original toe design level of the rock revetment of -1.75m AHD.

Constructability of the groynes will be more difficult given the extension into the surf zone and the toe design level being below sea level. It is expected that beach nourishment would be undertaken in conjunction with the groyne upgrades and will be strategically placed to assist with construction activities with the formation of temporary working platforms.

6.2.4. Beach nourishment

The state of the beach directly to the west of the rock revetment can be seen in Figure 28. A large erosion scarp is present on the back beach, overtopping of the damaged GSC revetment and deterioration of the GSC groynes can also be seen. On higher tides, swash is seen to pass over and around both the landward and seaward ends of both groynes. Following the upgrade of the groynes, it is recommended that a beach nourishment campaign be undertaken in order to re-establish a beach in this location.

Figure 28: Erosion and state of the beach and GSC trial groynes and GSC revetment at Emu Beach, taken 26th February 2020 (top) and August 2020 (bottom).

Nourishment design

When determining an appropriate beach nourishment design, it is essential to determine whether the nourishment is to be placed for coastal protection or beach amenity. Aurora (2019) states that managed retreat is the most suitable option for this section of coast. Community consultation as part of the CHRMAP process showed that the main activities for visitors to Emu Point include walking, swimming and sitting on the beach all of which are conducive to the provision of beach amenity and a suitably wide sandy beach. As such, any nourishment design in this area should be undertaken with the aim of improving beach amenity, currently noted as being poor.

It is unrealistic to expect an acceptable beach width during or following an extreme storm event. Realistic criteria should be set regarding acceptable beach width to assist with project design and/or to establish triggers for more action (Carley & Cox, 2017). The performance review of the GSC trial groynes and sand nourishment (Appendix C) showed overall stability exhibited between the two trial structures (as seen in the historical beach transect analysis of MB-09). In contrast, to the east of the two GSC groynes, the beach has experienced

intermittent erosion events, both seasonal and event based. During these events, access to the beach from the dual-use footpath becomes dangerous due to steep escarpments and scattered remnants of the GSC revetment are seen on the dune face. As such, an appropriate beach width criterion could include:

- After a 1-year ARI erosion event, there is a minimum 10m wide dry beach on a mean high-water spring tide under average wave conditions (above say 1m AHD).
- Should beach access become dangerous due to high (>1m) vertical dune scarps, suitable reinstatement activities (nourishment or beach scraping) should be undertaken.

Carley & Cox (2017) state that the required sand volume on a beach needs consideration of the following factors (as a minimum):

- Storm erosion.
- The sediment budget, including ongoing underlying recession, littoral drift and headland bypassing
- Future recession due to sea level rise
- Wave runup
- Actual composition of borrowed sand and its loss rate when emplaced
- Borrow area volumes available
- Availability of suitable plant for renourishment.

From the findings of the Performance Review (Appendix C) and adhering to the proposed beach width criteria above, the stability seen between the two GSC groynes would be desirable between the three proposed (upgraded) groynes extending to the rock revetment in the east. The nourishment is to be graded and profiled over the dry beach above MHWS to the top of the beach scarp (this height varies but is on-average at the 7m dune contour) and is to match as close to possible the natural profile of Middleton Beach to the west to re-establish the natural profile. Care should be taken not to cover healthy vegetation with sand. Prior to placement of sand, it is recommended to remove any dead vegetation and fill beach to the top of scarp (elevation varies). Care should be taken when placing fill on subaerial beach above 2mAHD. Generally, slopes in this area should be reduced as much as possible and should scarps develop between 2m to 7m AHD they should also be reprofiled and blended to natural beach profile to reduce risk of falls on vertical dune scarps.

Figure 29 shows the extent of the proposed nourishment campaign, representative beach profiles through the proposed area as well as an ‘idealised’ extracted profile further to the west (at chainage 700). A comparison of the idealised profile as well as the three extracted profiles within the nourishment area (Big4_W, Big4_E and Big4_Mid) can be seen in the lower part of Figure 29. The profile analysis shows steep (1V:0.5H) escarpments at each of the representative profiles on the upper dune face from approximately 7m AHD, in comparison to the gentler slope (1V:3H) seen in the idealised profile further to the west. Using the idealised profile as a template for the re-nourishment program from the 7m AHD upper dune to the MHWS contour places an estimated beach nourishment volume at approximately 6,000m^3 over the 190m distance between the upgraded western groyne and

the rock revetment (Coastal Structure A). Nourishment placed below a height of 2m AHD should be profiled to resemble as much as possible that seen in the lower portions of MB-09. This will reduce the severity of scarps occurring immediately following the nourishment works as profiles will match those that have shown long-term stability. It is recommended that a nourishment campaign of this magnitude (minimum 6,000m^3) be undertaken during the groyne upgrade works in the short-term: 0-5 years.

Reprofiling of the proposed area to the idealised profile will provide a more natural looking beach that blends with that to the west and reduce the likelihood of sudden erosion scarps following the placement of the nourishment. It is recommended that following the removal of damaged GSC units, the current GSC revetment be buried in the nourishment program and that subsequent dune vegetation promptly follow re-establishment of the beach. Please note that the placement of nourishment on the beach is not to cover healthy vegetation. Wrack may be placed in the upper dune areas (higher than 3m AHD) prior to covering with clean fill.

The performance analysis undertaken in **Appendix C** shows a relatively small net longshore transport to the west. As such, depending on the shoreline position and beach state at the time of construction a small amount of source fill should be used to fill the beach directly to the west of proposed groyne C to facilitate westerly transport around the structures and into the western portion of Emu Beach.

The historical transect analysis (Appendix C) provides evidence that the nourishment should be undertaken in summer. The ideal time would be the month of November when the transition from winter westerlies (winds) to summer easterlies occur and prior to the school holiday period when there will be a high number of beach users.

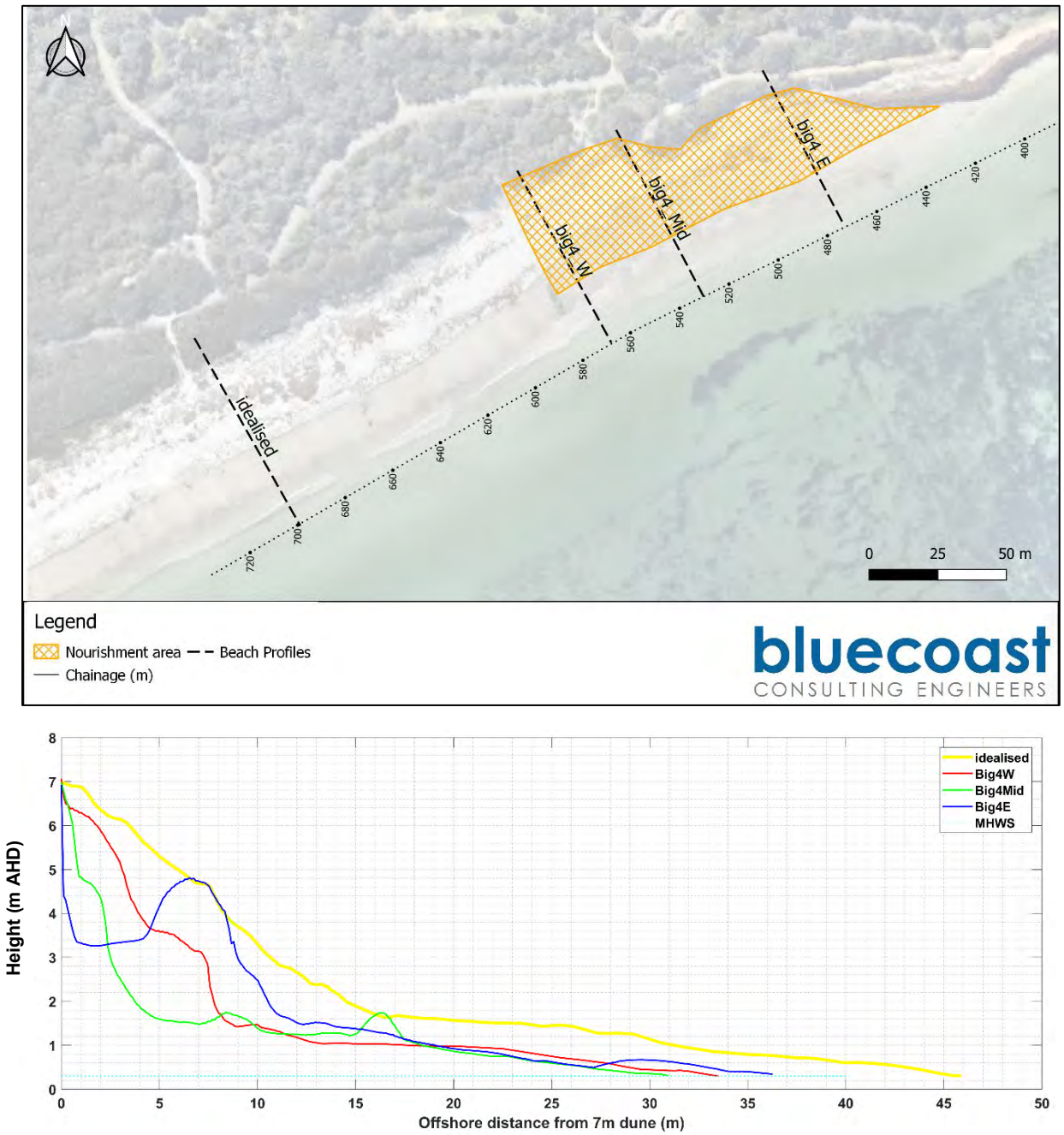


Figure 29: Proposed beach nourishment area (top) and analysis of existing beach profiles (below) taken from December 2018 beach survey

Sediment source

There are several sources of sand that may be suitable for use for the beach nourishment design:

- Within Middleton Beach embayment, most suitably from the western extent from the Golf Course towards Ellen Cove: D50 = 200-250µm, imported at a cost of $4-$7/m3 (PRDW, 2017)

- Great Southern Sands (GSS) a landscaping supply store approximately 10km from the site by road: D50 = 400-450µm, imported at a cost of $15-$25/m3 (PRDW, 2017)
- Opportunistic dredge spoil from Oyster and Princess Royal Harbour (PSD, volume and cost unknown)
- Whale World accreted beach area (PSD, volume and cost unknown)

From a coastal engineering perspective, the coarser GSS sand would have greater placement longevity due to the larger particle size having a higher propensity to withstanding mobilisation. However, as the beach has been designed for amenity as the primary objective, properties such as colour and homogeneity with the existing beach sediment are more important to the nourishment design. In addition, the overwhelming price difference to mobilise material to site points in favour of sediment coming from within the Middleton Beach embayment. The approximate 6,000m^3 volume ideally should be sourced in the vicinity of MB03, MB04 and MB05. The layer to be removed should not exceed 0.2m. Assuming sand is taken over a 30m wide stretch of beach, the sand must be sourced over approximately 1,050 m length of beach. Exceeding the 0.2m depth excavation limit at any location is not desirable, as this exceeds the natural rate of sand accretion.

It is also recommended that opportunistic beach nourishment be undertaken into the future. Should coastal works be commenced along the beaches or upper dunes from Ellen Cove to Oyster Harbour or dredging works within King George Sound, Oyster and Royal Princess Harbours, any sediments should be stockpiled for nourishment. Sand sourced from these activities is to be assessed as being suitable for use as beach nourishment (i.e., PSD analysis and quality). Should the sourced sediment be shown to be similar in terms of grain size (or slightly coarser), composition, angularity and colour than that at Emu Point, then it is recommended to be placed in the following locations:

On the upper beach between the eastern GSC groyne (Coastal Structure B) and the western extent of the upgraded rock revetment (Coastal Structure A) between the 7m and MHWS contours, or the western lee of the detached breakwater.

Proposed beach nourishment locations can be seen in Figure 16.

Overfill ratio

Typically, borrow material will not exactly match the native beach (unless sourced within the direct vicinity as recommended above or as seen in backpassing design). If there is a large difference in sediment size between imported material being used for nourishment and the native beach sand the shoreline profile will respond accordingly:

- Borrow material that is finer will result in a flatter equilibrium beach profile than the natural profile and significantly more borrow sand is required to meet target nourishment volumes (compared with the requirements for nourishment with matching borrow and native sand). Use of material finer than the native material should be avoided, if possible, but such material still may be suitable. CEM (2006) recommends against using finer material that may result in a gentler beach slope adjacent to groynes intended to block the longshore movement of sand.
- Borrow material that is coarser than the native material will produce a beach which is at least as stable as the native beach. Fills with coarser material (such as those imported from GSS, above) provide improved resistance to storm-induced erosion. A

lesser volume of coarser fill will be required to create a beach of a given width, compared to the volume of native beach sand that would be needed, however a noticeably steeper beach may form. A steeper beach and different texture of the coarser fill may also provide an amenity issue.

It is recommended that due to the difference in size between the GSS material and the native sediment size, that sand is sourced from within the Middleton Beach embayment or Oyster Harbour. Sediment sampling undertaken in 2013 by CoA has shown that swash zone sediments between MB-08 to MB-02 has a maximum PSD range of D_{50} = 0.215-0.23mm. It is recommended, however that prior to the nourishment campaign it is recommended that updated PSD samples are taken at the both the nourishment and source sites as well as updated survey to determine volumes required.

Should the source sediment prove to be finer than the native site, an overfill ratio will be used to calculate exact volumes of source material required. The overfill ratio R_A is a factor for the required volume of imported sand to make up an equivalent volume of native sand. CEM (2006, p V-4-24) recommends an overfill ratio of 1.0 to 1.05, or a range of D_{50} of ±0.02 mm for the sand size seen at the project site.

Machinery and delivery method

CoA have CAT 623 and 615 Scrapers available to transport sand along the beach, the turning circles of these scrapers is 11m. If the nourishment work is to be undertaken by the CoA, these turning circles should be considered in the project workflow, noting that access to Emu Point may become only viable along the beach front due to the steep back beach adjacent to the rock revetment. It is also expected that these works will generally be undertaken during low tide only.

It is recommended that these works are undertaken in times that the number of beach users are at a minimum. In addition, both the source and project areas must be suitably fenced off from public access during construction times to ensure there is sufficient separation of sand feed from amenity issues. Any access points along the project site, including the source sites and haulage routes should also be restricted to the public and monitored for safety issues.

6.3. MU5

6.3.1. Eastern Oyster Harbour beach

The eastern section of Oyster Harbour Beach is prone to seasonal erosion reducing recreational amenity due to the point of no useable beach. Aurora (2019) recommends sand nourishment to maintain beach widths. Sand for the nourishment can usually be sourced within Oyster Harbour due to the seasonal sand movement along the beach. The area most prone to erosion is the eastern corner of the beach adjacent to the Emu Point spur groyne, as seen in Figure 30.

The trigger for sand nourishment has been stated in Aurora (2019) as; when a dry sandy beach width of less than approximately 10m from the erosion scarp or high-water line to the retaining wall at the widest section of the beach. Due to the vulnerability of the eastern end of the beach, it is expected that this trigger is generally activated for most of the year and as such an alternate trigger value may need to be employed. Figure 31 and Figure 32 show historic beach transects OH-01, located in the eastern corner of Oyster Harbour and OH-02

to the west of the swimming enclosure respectively. It can be seen that there is very rarely a dry beach (between the hard revetment wall and HSD) wider than 10m at OH-01. Whereas at OH-02 this distance is seen to be in the order of 25-30m for all historical transects surveyed.

It is recommended that should HSD at OH-01 be surveyed at less than 5m (or the distance of two people walking abreast) from the hard revetment that sand nourishment be placed in this compartment as follows:

Sand nourishment is to be placed in the eastern corner of Oyster Harbour between the spur groyne and the eastern arm of the swimming enclosure.

The sand is to be placed at a height of +1.5m AHD from the hard revetment to an offshore distance of 10m.

The sand is then to be graded down to 0m AHD to the length of the spur groyne.

This placement pattern can be seen in Figure 33. Sand should be sourced from locations within Oyster Harbour in the first instance such as at the western extent (adjacent to the boat pens) or from the tombolo in the lee of the swimming enclosure. If there is not sufficient sediment from these locations, clean beach sand is then to be sourced from locations along Middleton Beach and Ellen Cove.

Figure 30: Contour map of eastern Oyster Harbour Beach. Beach transects OH-01 and OH-02 can be seen in red with the back beach hard revetment depicted by the black dashed line.

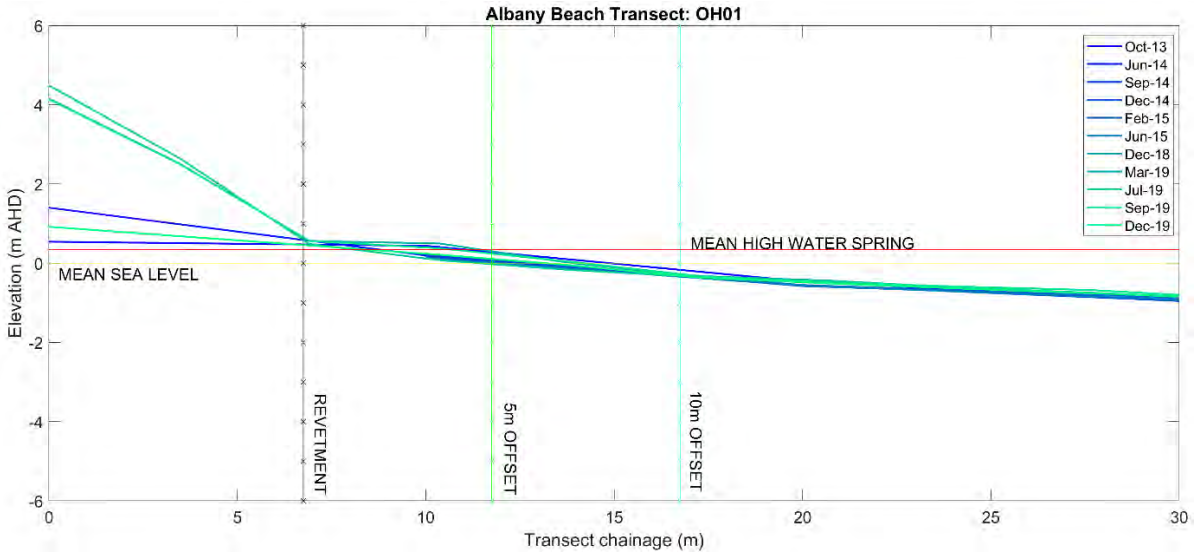


Figure 31: Albany Beach Transect OH-01 between October 2013 to December 2019

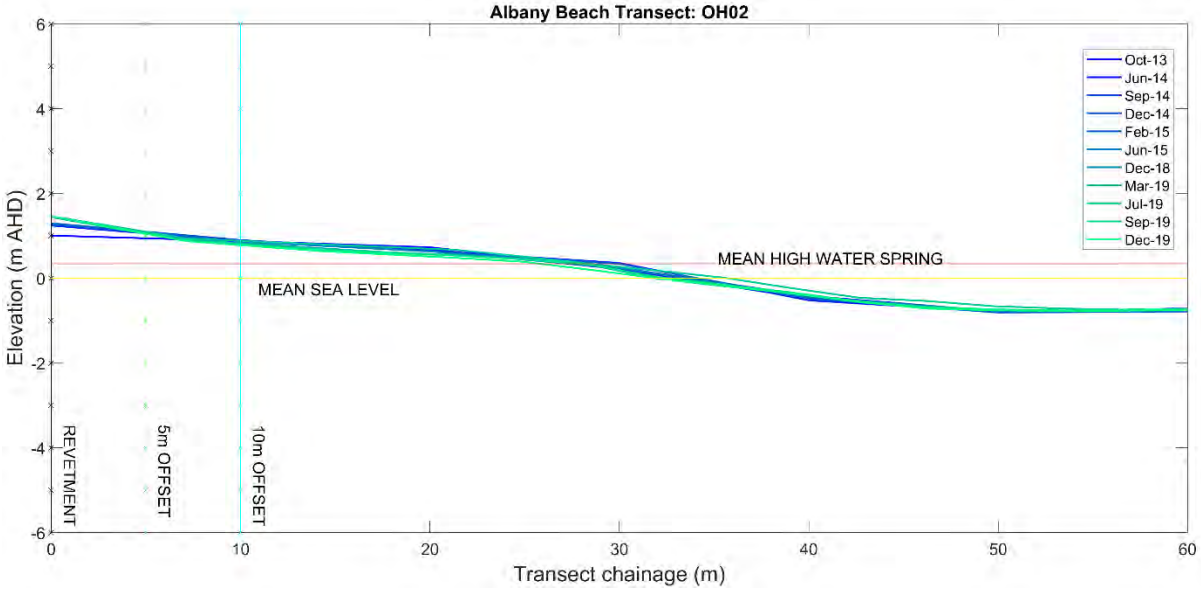


Figure 32: Albany Beach Transect OH-01 between October 2013 to December 2019.

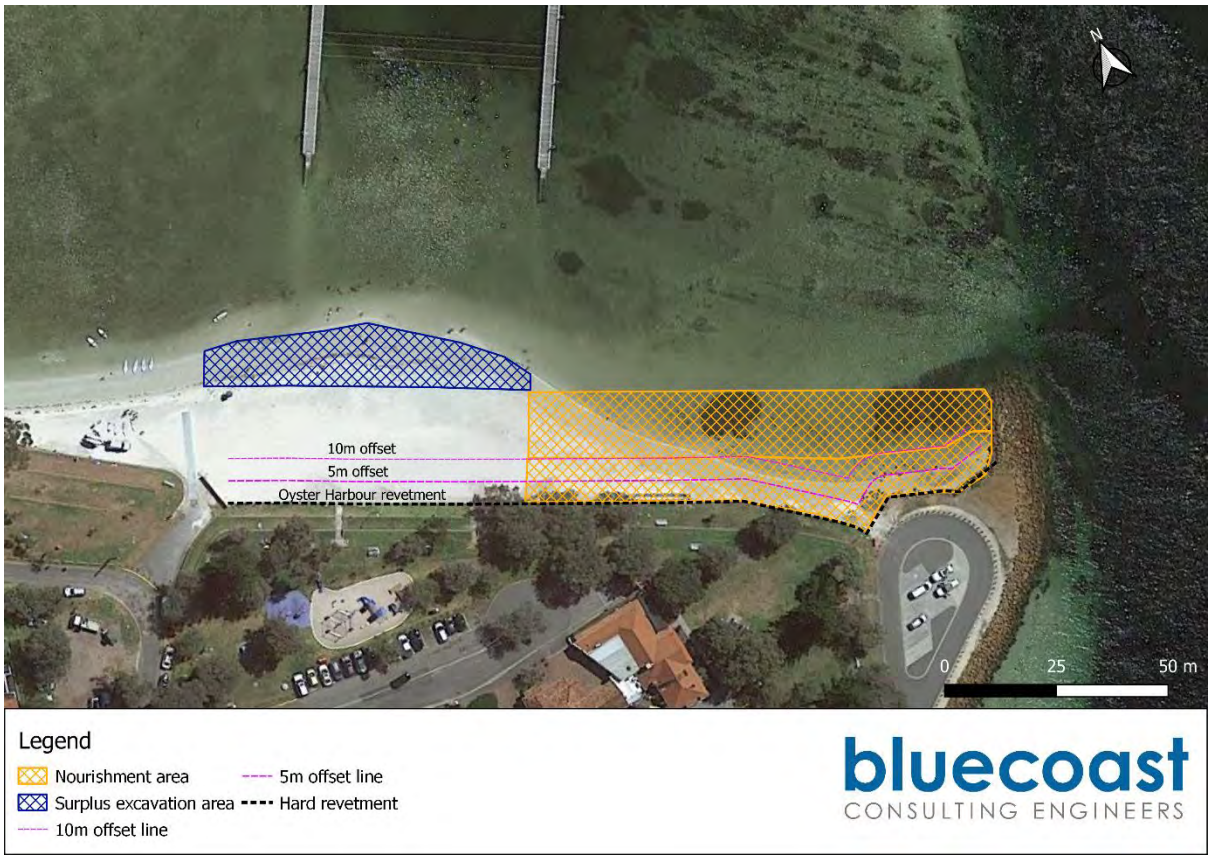


Figure 33: Eastern Oyster Harbour beach adaptation option.

6.4. Predicted coastal response

Preliminary shoreline modelling was undertaken as part of the CHRMAP hazard mapping study (RHDHV, 2017). Figure 34 shows typical ebb flow circulation patterns (and sediment transport potential) on 2016 bathymetry in the vicinity of Emu Point. RHDHV (2017) stated that the formation of a circulation cell in the lee of Lockyer Shoal was seen to feed the ebb current jetting out of Oyster Harbour.

Sediment transported within the easterly current would be deposited at the edge of the Oyster Harbour stream, feeding the Lockyer Shoal. During flood currents this sediment would be deposited within Oyster Harbour or within the channel, to be redistributed to the shoal on the subsequent outgoing tide due to the ebb-dominated asymmetry in tidal current velocities. (RHDHV, 2017)

This implies that any additional sediment placed along Emu Point has the propensity to travel east into the circulation cell to feed the growth of Lockyer Shoal. In this sense the placement of sand on the erosion-affected shoreline at Emu Point will not only improve amenity for a period of time but will also assist in meeting Recommendation 18 of the CHRMAP:

Recommendation 18 MU4: Foreshore Reserve - Seagrass replenishment program be continued and enhanced to include offshore placement of sand.

The performance review of previous beach nourshment (Appendix C) reaffrims the seasonal and bi-modal sediment transport regime in this area, with an overall net westery transport of around 11,000m^3/year. Following the introduction of the third groyne to the west, it is expected that the beach should remain stable as seen between the two trial GSC groynes.

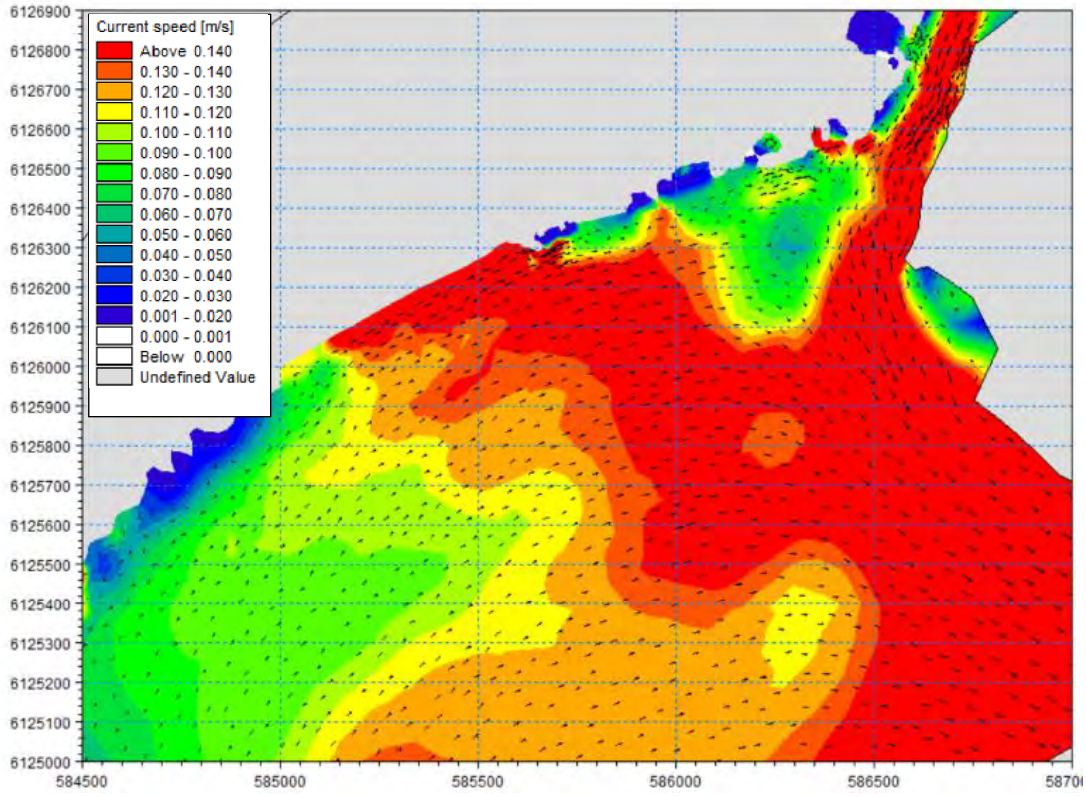


Figure 34: Current speed and direction modelled through "calm" wave conditions during a typical ebb tide period on the 2016 bathymetry. (Source: RHDHV, 2017)

7. Coastal adaptation pathway

Management Unit	Coastal trigger	Expected timeline	Coastal adaptation measure
MU4 Groynes	Design life exceeded/failure of GSC trial groynes	Short term (0-5 years)	Upgrade of the groyne field to rock structures including the addition of a third eastern groyne
MU4 Beach width	Any coastal works undertaken along the beaches or upper dunes from Ellen Cove to Oyster Harbour or dredging works within King George Sound, Oyster and Royal Princess Harbours.	Short term (0-5 years)	Sediment gained through these works should be stockpiled. Opportunistic beach nourishment to be undertaken on the upper beach between the eastern GSC groyne and rock revetment and in the western lee of the detached breakwater.
MU4 **Beach width**	Beach access at Emu Point becomes dangerous due to high (>1m) vertical dune scarps.	Short term (0-5 years)	Suitable reinstatement activities (nourishment or beach scraping) should be undertaken.
MU5 Beach width	A dry sandy beach width of less than approximately 10m from the erosion scarp or high-water line to the retaining wall at Eastern Oyster Harbour to the widest section of the beach.	Short term (0-5 years)	Sand nourishment is to be placed in the eastern corner of Oyster Harbour between the spur groyne and the eastern arm of the swimming enclosure.
MU4 Rock revetment	A condition assessment rating of 'Very Poor' or more than three (3) overtopping events of the Emu Point rock revetment within a 12-month period.	Long term 10+ years	Upgrade of the rock revetment to modern designs, including the use of local granite rock and realignment.
MU3 Beach width	Horizontal Shoreline Datum (HSD) is less than 40m from the road (Griffiths Street).	Long term 10+ years	Managed retreat of first line of houses along Griffiths Street
MU4 Beach width	Horizontal Shoreline Datum (HSD) is less than 40m from the Emu Beach Holiday Park	Long term 10+ years	Change to less permanent assets/uses in southern lease boundary of (EBHP). The City and the leaseholder work toward an agreed level of risk within this area, steering the discussions around future lease agreements.

8. Summary

This Basis of Design (BoD) has been developed to outline the physical characteristics, coastal processes and design assumptions that will be used to underpin the design development of the seven coastal adaptation options recommended as part of the CHRMAP (Aurora, 2019) for management units MU3-MU5. In consultation with the City, stakeholders (including the WA Department of Transport and the WAPC) as well as community groups and using this BoD for design guidance, the following coastal adaptation options have been recommended as part of the FMP:

- Managed retreat of first line of houses along Griffiths Street (MU3) in the long term (10+ years).
- A change to less permanent assets/uses in southern lease boundary of the Emu Beach Holiday Park, with the City and the leaseholder working toward an agreed level of risk within this area, steering the discussions around future lease agreements in the short term (0-5years).
- Upgrade of the groyne field at Emu Beach (MU4) to rock structures including the addition of a third eastern groyne and a beach nourishment exercise in the short term (0-5years)
- Upgrade of the rock revetment from Emu Beach to Emu Point (MU4) to modern designs, including the use of local granite rock and a realignment in the medium to long term (10+ years).
- Sand nourishment to be placed in the eastern corner of Oyster Harbour (MU5) between the spur groyne and the eastern arm of the swimming enclosure following periods of erosion.

The key design characteristics determined through this BoD process for coastal structures and management are as follows:

Coastal structure / management	Design parameter	Value
Rock groyne (MU4)	Design life	50years
	Design event	100years
	SWL (2020)	1.06 m AHD
	SWL (2070)	1.43m AHD
	Hs	2.2 m
	Tp	15 sec
	Scour depth	-1.75m AHD
	Rock type	Locally sourced granite, density (2.65t/m^3)
	Rock size	Class 1 Armour: 1.0t – 3.0t

Coastal structure / management	Design parameter	Value
		Class 2 Core: 1t – 0.7t
	Groyne length	+10-15m current length
	Groyne spacing	80m
Rock revetment (MU4 - MU5)	Design life	50years
	Design event	100years
	SWL (2020)	1.06 m AHD
	SWL (2070)	1.43m AHD
	Hs	2.2 m
	Tp	15 sec
	Scour depth	-1.75m AHD
	Rock type	Locally sourced granite, density (2.65t/m3)
	Rock size	Class 1 Armour: 1.0t – 3.0t
		Class 2 Core: 1t – 0.7t
Nourishment (MU4, MU5)	Sediment source	Within Middleton Beach embayment (for MU4) or Oyster Harbour (for (MU5)
	D50	200-250µm
	Overfill ratio	1.0 to 1.05 (D50 of ±0.02 mm)

9. References

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1 Water Research Laboratory (WRL), School of Civil and Environmental Engineering, The University of New South Wales, Manly Vale, NSW

2Tweed Shire Council (TSC), Murwillumbah, NSW

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Appendix A: Condition assessment of coastal protection structures at Emu Beach and Emu Point

bluecoast
CONSULTING ENGINEERS

Technical Note

To:	Giles Glasson (RPS Group),
From:	James Lewis and Evan Watterson
Copy:	Anthony McEwan (City of Albany), Emma Evans (City of Albany)
Reference:	P19027TN02.1.DOCX
Date:	13 January 2021
Subject:	Emu Beach Foreshore Management Plan – Condition assessment of coastal protection structures at Emu Beach and Emu Point

Introduction

This technical note presents the findings of a coastal engineering condition assessment undertaken on the coastal protection structures at Emu Point and Emu Beach by Bluecoast Consulting Engineers (Bluecoast) as part of the Emu Beach Foreshore Management Plan (FMP). The condition assessment encompasses the following structures within the project area:

- approximately 460m of laterite rock revetment
- a 40m long detached rock breakwater made from laterite
- two shore-normal geotextile sand container (GSC) trial groynes of varying length
- approximately 80m of GSC revetment

The objective of this coastal engineering condition assessment is to define the current structural characteristics of the structures through visual inspection complimented with reference to ‘for construction’ or as-constructed drawings which have been provided in Append A for reference.

Background

The southern foreshore of Emu Point has been heavily engineered since a significant storm event impacted the area in 1984. The storm deepened the ebb-tide delta offshore of Emu Point known as Lockyer Shoal. In addition to the deepening of the shoal, the storm event also removed a large seagrass meadow in its lee. Lockyer Shoal and the seagrass meadows previously provided natural protection to the shoreline. Following their removal, private and public infrastructure became at risk from coastal erosion and inundation hazards. A series of coastal protection works were undertaken in the proceeding years beginning with the training of the Oyster Harbour entrance and subsequent westward progression of coastal

protection structures. RHDHV (2017) provides a timeline of coastal protection works from Ellen cove to Oyster Harbour. A brief historical summary of the structures investigated in the condition assessment is provided in Figure 1.

In 2018, EvoCoast undertook a condition assessment of coastal protection structures across the City and their findings have been referenced herein where relevant.

Figure 1: History of construction of coastal structures at Emu Point (source: RHDHV, 2017)

Methodology

Following review of previous condition assessments, drawings and historical information relating to the coastal protection structures at Emu Point and Emu Beach the approach used for the condition assessment of the current state of the structure involved:

- visual inspection; and
- interrogation of drone survey and historical drawings.

Assessment criteria and ratings

Three criteria were assessed:

1. Structural condition.
2. Safety risk.
3. Functional performance.

A rating scale from one to five was adopted for each category as outlined in Table 1.

Table 1: *Condition assessment rating scale.*

Rating	Assessment criteria		
	Structural	**Safety risk**	**Function performance**
5 (Excellent)	None or very little damage	None	No loss of function
4 (Good)	Minor damage	Minor	Minor loss of function
3 (Fair)	Moderate damage	Moderate	Moderate loss of function
2 (Poor)	High level of damage	High	Major loss of function
1 (Failed)	Very high level of damage.	Very high	Complete loss of function

Based on guidelines provided in the CIRIA Rock Manual (CIRIA, 2007) and Oliver et al. (1998) the following defect categories were considered for the detailed assessment of structural condition:

- Loss of crest elevation, which is primarily due to settlement of the revetment or groyne or its foundation.
- Core exposure/loss, which occurs when underlayer or core is removed from the structure by waves passing through openings in the armour layer.
- Armour displacement typically occurs as a result of damage by large waves (i.e. erosion of the armour rocks) a sign of undersized units.
- Armour settling, which may occur along or transverse to the armour slope due to the consolidation or settlement of underlayer, core or foundation soils.
- Bridging, which is a form of armour loss that may apply to the side slopes or crest and occurs when the underlayers settle but the top armour layer remains in position.
- Loss of interlocking means armour is more susceptible to movement and can be unstable.
- Drifters, which is a single piece of armour dislodged from the structure.
- Slope steepening, which occurs when the slope of a structure settles on soft ground.
- Slope sliding, which is due to settlement or scour at the toe that can cause the armour layer to move downwards.

Visual inspection

The visual inspection of the coastal protection structures was undertaken on the 26th February 2020 by one of Bluecoast's senior coastal engineers. Prior to the inspection the structures were divided into eleven (11) separate elements based on the structure type, orientation or construction history. A chainage system was also developed along the structures crest, see Figure 2. Photos from the inspections are shown in Figure 3.

Using a field tablet, scores for the relevant structural defect categories across each of the predefined segments were entered directly into an online database. The overall structural condition rating for each segment was then rounded down to the average of the individual defect ratings.

Safety and functional rating were based on a single score assessed by the inspecting coastal engineer based on visual inspection and the assumed design intent of the structure to serve as coastal protection against coastal erosion and inundation.

Dimensions of a randomly selected 3m swath of armour rocks across each segment were estimated and used to determine an approximate rock diameter. Defects and other observations made during the inspection were noted and photos were gathered by segment.

The rock quality was assessed in accordance with the CIRIA Rock Manual (2007), with attention placed on the quality of and damage to individual armour rocks. This quality assessment was used to approximate how much damage or deterioration has occurred.

Drone survey

Concurrent to the on-ground condition assessment two drone surveys were undertaken in December 2018 and March 2019 as part of the Albany coastal Monitoring program. Using the results of the drone survey the crest level and revetment slope for each section was calculated. Aerial photographs captured using the drone were also reviewed to assist in defining defects and condition ratings.

Figure 2: Structure segments and crest chainage system defined for the existing structure as well as structural condition rating for structure based on visual and drone inspection on 26th February 2020.

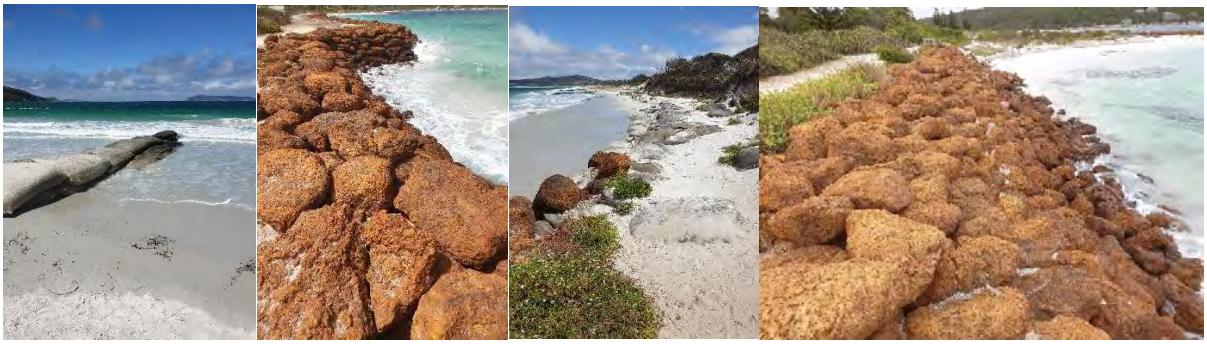


Figure 3: Fieldwork photographs; from left Coastal Structure C, CS-A5, CS-A6, CS-A1.

Results

The scores for the condition assessment have been placed on an online database accessible via this link:

https://bluecoast-ce.github.io/EmuPointConditionAssessment/

Each scoring category can be viewed individually, as well as the final score, which is also labelled on the image in Figure 2. Observations made during the inspection are presented in addition to photos of each segment against relevant modes of failure. Figure 1 presents the overall structural condition rating spatially. All scores are available in the above online database

Table 2 presents a summary of the structural characteristics based on the condition assessment results. Table 3 presents the structural, safety and functional ratings along with main comments identified from the inspection.

Table 2: Structural characteristic of Emu Point and Emu Beach Coastal Structure based on condition assessment results.

Name	Chainage	Material	Crest elevation (m AHD)	Slope	Armour grading (D50 in mm)
Detached Breakwater	-20 - 20	Rock	3.3	1V:0H	1000-1250
Coastal Structure A1	0 - 50	Rock	1.6	1V:1.2H	500-1000
Coastal Structure A2	50 - 130	Rock	2.3	1V:1.1H	1000-1250
Coastal Structure A3	130 -230	Rock	2.1	1V:1H	500-1000
Coastal Structure A4	230 - 360	Rock	2.8	1V:1H	500-1000
Coastal Structure A5	360 - 410	Rock	3.0	1V:1H	1000-1250
Coastal Structure A6	410 - 460	Rock	2.9	1V:1H	500-1000
GSC Revetment	460 - 540	GSC	1.6	1V:1.5H	600
Remnant GSC	495	GSC	1.0	-	600

Coastal Structure B	580	GSC	1.5	1V:1.5H	600
Coastal Structure C	660	GSC	1.7	1V:1.5H	600

Table 3: Overview of Emu Point coastal structures condition assessment results

Segment ID Name	Condition rating (1 = failed, 5 = excellent)			Comments
	Structural	Safety	Functional	
Detached Breakwater Chainage: -20 to 20m	3.3	3	4	Laterite detached breakwater with connected tombolo that shows signs of intermittent wash through. There is a 20m setback to established vegetation from the structure. The laterite shows signs of cracking and crumbling rock. Bridging is evident atop the structure. Large voids are present in the structure, reflected waves can be seen, however there are no signs of scour at toe or slumping. There is no evidence of geotextile underlay. Seaweed can be seen growing on seaward face.
Coastal Structure A1 Chainage: 0 to 50m	1.6	1.5	3	Scour and end effects are evident on beach, with public beach access closed for safety reasons. Signs of revegetation and sand nourishment are present on beach. Armour rock shows signs of cracking and crumbling. There are no signs of significant overtopping with established vegetation in crest, any overtopping is due to small amount of sea-spray and onshore winds. There are no obvious signs of scour at toe. Large voids in structure and signs of smaller rock slumping at toe. There are some signs of geotextile underlay on eastern extent.
Coastal Structure A2 Chainage: 50 – 130m	2.3	1.5	3	Armour showing signs of cracking and crumbling. There are no signs of significant overtopping with sparse vegetation in crest, however, there is a small depression behind crest most probably caused by high amount of sea-spray overtopping structure from waves and strong onshore wind. There are no signs of scour at toe but large voids in structure. No signs of slumping and no evidence of geotextile underlay.
Coastal Structure A3 Chainage: 130 -230m	2.1	1.5	3	There are signs of armour rock cracking and crumbling. No signs of significant overtopping, however there is no vegetation in crest and high amount of sea-spray overtopping structure from waves and wind. There are no signs of scour at toe and no signs of slumping. Some evidence of geotextile underlay in crest.
Coastal Structure A4	2.8	2	3	Armour showing signs of cracking and crumbling. As with CS-A3, there are no signs of significant

Segment ID Name	Condition rating (1 = failed, 5 = excellent)			Comments
	Structural	Safety	Functional	
Chainage: 230 – 360m				overtopping with sparse vegetation in crest, however there is a small depression behind crest most probably caused by high amount of sea-spray overtopping structure from larger waves and strong onshore wind. There are no signs of scour at toe but large voids in structure. No signs of slumping and no evidence of geotextile underlay.
Coastal Structure A5 Chainage: 360 – 410m	3	2	4	This section was constructed later than the eastern segments, there is a 90° landward turn in the revetment alignment which causes confused wave action at toe of wall. There is a high volume of sea spray overtopping although wave run up is only on the lower 25% of the structure. There is no evidence of significant overtopping with sparse vegetation visible on landward edge of crest. Armour shows signs of cracking and there are large voids in structure. There are no signs of scour at toe or slumping and no evidence of geotextile underlay.
Coastal Structure A6 Chainage: 410 – 460m	2.9	2	3	This is the most western extent of the rock revetment, starting at a similar height to the eastern sections, the crest tapers down to beach level terminating into the GSC revetment. Armour shows signs of cracking and there are large voids in structure. There are no signs of overtopping with vegetation in crest. There are no signs of scour, slumping and no geotextile underlay is evident.
GSC revetment Chainage: 460 – 540m	1.6	1	3	GSC revetment with 2+2+1 layout (2 layers of 2 bags side-by-side + 1 single width crest layer). Revetment shows extensive damage with displaced units. Subsequent repairs have been made to sections of the groyne with newer bags placed atop failed units. Units have evidence of vandalism and subsequent repair. The revetment has been overtopped repeatedly with scouring on landward side and dune erosion present with vegetation loss. The western extent is showing seawall end effects with large landward erosion scarp. The in-tact section of revetment shows signs of functionality in retaining a shoreline.

Segment ID Name	Condition rating (1 = failed, 5 = excellent)			Comments
	Structural	Safety	Functional	
Remnant GSC Chainage: 495m	1	1	1	One 2.5m^3 GSC bag found submerged offshore of GSC revetment. It is understood that this GSC was strategically placed when surplus units were left following constriction of the GSC revetment. This individual unit has no coastal protection function and poses a safety risk to public access.
Coastal Structure B 580m	1.5	1	2	GSC "trial" groyne structure consisting of 2.5m^3 geotextile bags. Groyne is 12 units long (unburied section) with: - 2+2+1 stacking for offshore section (7 long) - 1+1 stacking for landward section (5 long) Top layer of bags has been renewed and randomly placed. There are signs of bag displacement in both the top and underlayers. There is also evidence of vandalism. Scouring can be seen to -500mm below bed level on western seaward bags (5th bag on).
Coastal Structure C 660m	1.7	1	2	GSC "trial" groyne structure consisting of 2.5m^3 geotextile bags. Groyne is 9 units long (unburied section) with: - 2+2+1 stacking for offshore section (5 long) - 1+1 stacking for landward section (4 long) Top layer of bags has been renewed and randomly placed. There are signs of bag displacement in both the top and underlayers. There is also evidence of vandalism. Scouring can be seen to -500mm below bed level on western seaward bags.

Comparison to previous condition assessment

In June 2017, EvoCoast undertook a condition assessment of the coastal structures at Emu Point as part of the City's Asset Management Framework, this is provided in Appendix B as reference. The assessment rated the structures on five (5) levels: very good, good, moderate, poor, and very poor. Table 4 provides a comparison of the EvoCoast (2017) to the 2020 condition assessment. It should be noted EvoCoast (2017) rated Coast Structure A (CS-A1 to CS-A6) over its entirety noting that also noted that the condition of the structure varied over its length, with some sections in worse condition than others and that the lowest rating identified has been applied to the entire structure.

The comparison of the two condition assessments has shown very similar evaluations of the coastal protection structures, except for the condition of the GSC groynes with the latest assessment providing a much lower assessment rating.

Table 4: Comparison of 2017 EvoCoast and 2020 condition assessment of Emu Point coastal structures

Structure name	EvoCoast (2017) rating	2020 rating
Detached Breakwater	Very Good	3.3 (Fair to Good
Coastal structure A	Poor	1.6-2.9 (Poor to Fair)
GSC Revetment	Very Poor	1 (Failed)
Coastal Structure B	Moderate	1.5 (very poor)
Coastal Structure C	Moderate	1.7 (very poor)

Summary

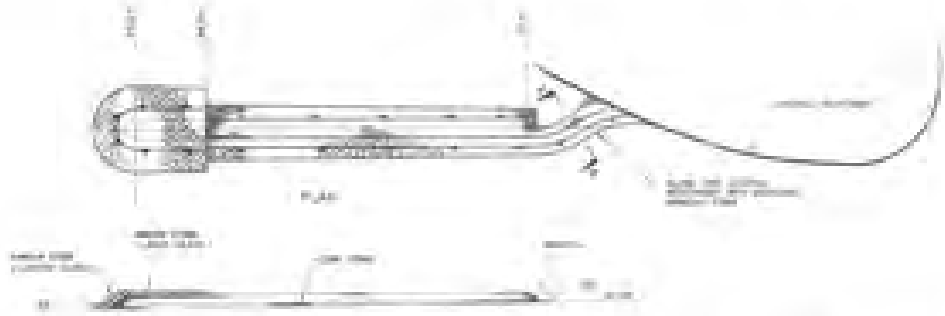
The visual inspection of the coastal protection structures at Emu Point and Emu Beach was undertaken on the 26th February 2020. The visual inspection as well as interrogation of design drawings and drone surveys was used to rate the structural, safety and functional condition of the structures. Overall, the rock structures were rated as **fair** to **good,** whereas the GSC structures were generally rated as **poor**.

Future maintenance or upgrade works of the structures, should consider the following:

- The quality of the armour rock layer was generally seen to be fair but there were isolated areas of poor-quality armour with significant degradation, crumbling and cracking. Granite should be used if a re-build of the revetment is to be undertaken.
- The quality of the original construction was not to contemporary standards for rock revetments. Future upgrades should include a sufficient thickness of filter material (sand) and geotextile underlay.
- It is recommended that any upgrades of the seawall endeavours to minimise the amount of wave reflections off the structure. This could be undertaken by creating a milder sloped structure, creating a berm type profile or by burying the lower (wave-exposed) portion.
- Both the GSC and rock structures are openly accessible to the public which may cause safety issues. It is recommended that upgrades to the foreshore be made that separate these structures from the natural thoroughfare of the public.
- All the GSC structures are seen to be in a degraded state and currently pose a safety hazard to the public.
- There is a significant amount of erosion of the beach between Coastal Structure A and B. The GSC revetment although in a state of disrepair and frequent overtopping has been seen to offer some stabilisation of the shoreline in this location.
- RHDHV (2017) showed some evidence as to the effectiveness of the GSC trial groynes at retaining a beach on their eastern side, although very little. This is due to the seaward structure length and height, as sediment can pass over and/or around the structures. Future upgrades of these structures should incorporate an increase in both seaward length and height (of at least to Coastal Structure B).
- Visual inspection of the structure confirms, as suggested by the construction history, that rock has been progressively added to the revetment in a westerly direction. This implies that end-effects have been caused by each structure that has been built which have subsequently attempted to be remedied by the construction pf additional structures. This is an important factor to note especially in terms of public perception of the coastal protection structures built in this area.

Appendix A: As-constructed drawings

LOCALITY PLAN



PLAN

LONGITUDINAL SECTION

GROYNE

MATERIAL LEGEND

SECTION A-A

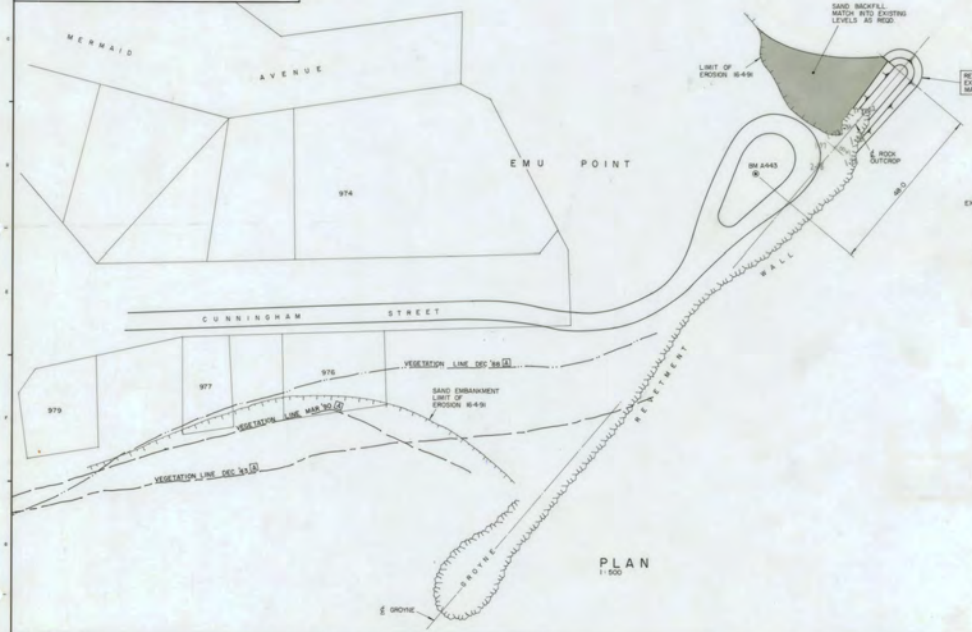
CROSS SECTIONS

MARINE & HARBOURS — WESTERN AUSTRALIA

ALBANY - EMU POINT
FORESHORE STABILISATION
GROYNE & BEACH NOURISHMENT

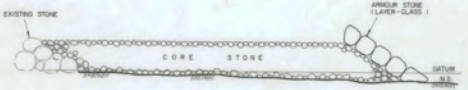
452 - 1

LOCALITY PLAN
1:10 000

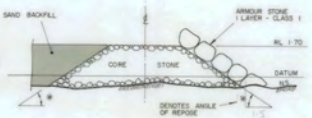


PLAN
1:500

MATERIAL LEGEND
ARMOUR STONE CLASS I - 1·0t TO 3·0t LATERITE ROCK (50% > 2·0t)
CORE STONE - QUARRY FINES UP TO 1m (50% > 0·4t)



LONGITUDINAL SECTION
1:100



CROSS SECTION
1:100

GENERAL NOTES
1. ARMOUR STONE SIZE & SHAPE IS FOR ILLUSTRATIVE PURPOSES ONLY. DO NOT SCALE STONE DIMENSIONS.
2. FOR EROSION DETAILS SEE DRG 91044, TOWN OF ALBANY (WORKS & TECHNICAL SERVICES)

REV	DATE	AMENDMENT	DRN	CHKD APPROVED
A	F3.5 1-8-91	VEGETATION LINES ADDED TO PLAN	SV	SMP

DRG SIZE A1 | PLAN A | FILE No 234/87 | SURVEY RO/MD

SCALE: AS SHOWN
UNLESS OTHERWISE STATED DIMENSIONS IN m
DATUM: 3·096m BELOW BM A445 AND 0·746m BELOW AHD

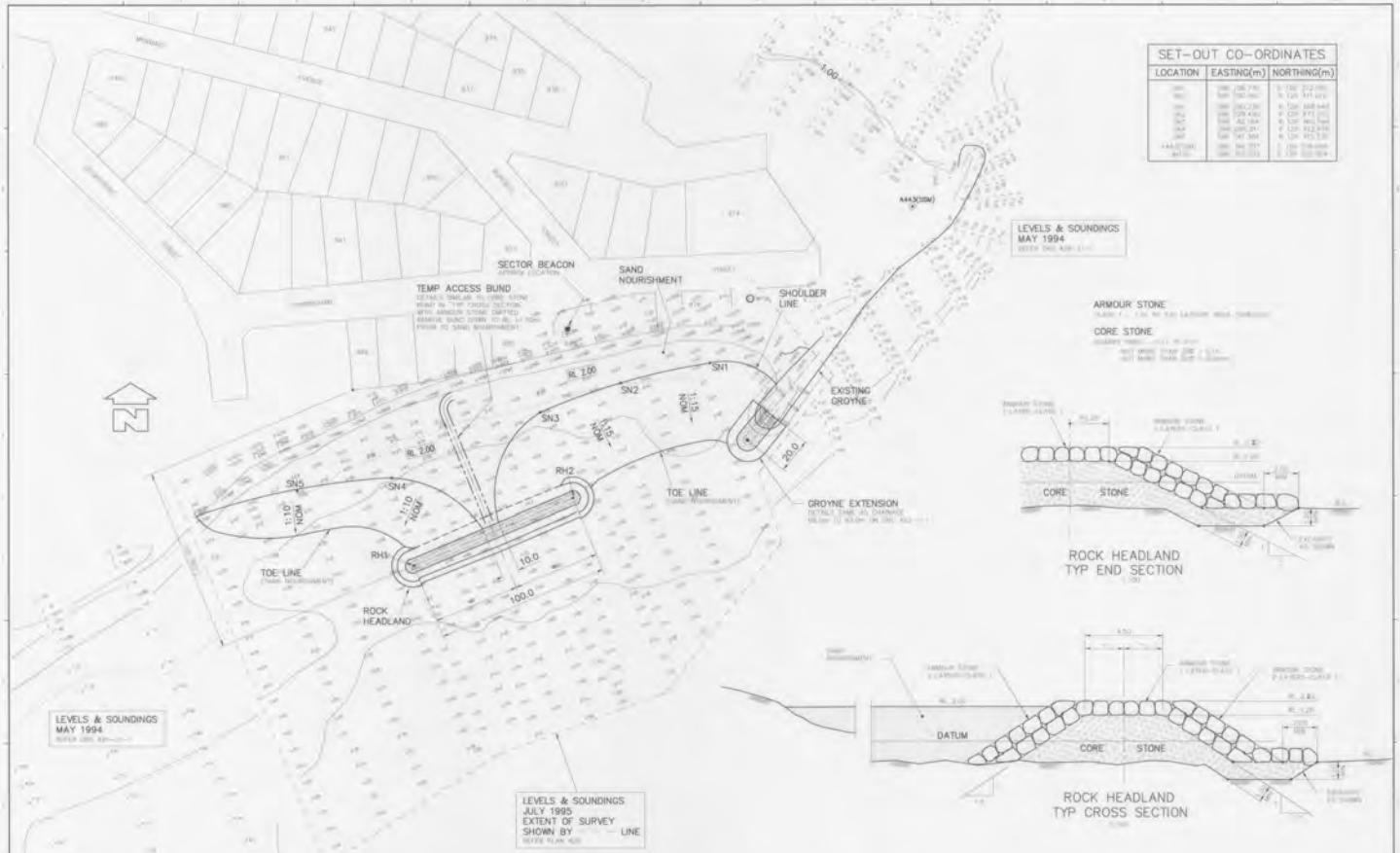
DESIGNED
CHECKED
DRAWN S.C.Smith
CHECKED
E/NEER
CHECKED

APPROVED / CIVIL DESIGN
APPROVED / ELECTRICAL DESIGN
APPROVED / BRANCH MANAGER
APPROVED / PROJECT MANAGER
21/5/91 DIRECTOR ENGINEERING

DEPARTMENT OF MARINE & HARBOURS – WESTERN AUSTRALIA

ALBANY - EMU POINT
FORESHORE STABILISATION
REVETMENT WALL EXT. & BEACH NOURISHMENT

DRAWING NUMBER 452 - 3 - 1 | REV A



GENERAL NOTES:

1. THIS DWG TO BE READ IN CONJUNCTION WITH THE SPECIFICATION.
2. THIS DWG BASED ON DESIGN BY M.P. ROUSSEL & ASSOCIATES.

SCALE: 1 : 1000 @ A1 SHOWN

DATUM:

DEPARTMENT OF TRANSPORT – WESTERN AUSTRALIA

ALBANY – EMU POINT
FORESHORE STABILISATION
ROCK HEADLAND & BEACH NOURISHMENT

DRAWING NUMBER 452 – 7 – 1 0

GENERAL NOTES

ARMOUR STONE

CORE STONE

NOT MORE THAN

NOT MORE THAN

SCALE 1:1000

DATUM

DRAWN E MOLONEY

DEBBINGTON CARTOGRAPHICS

I SUPANZ & E MOLONEY

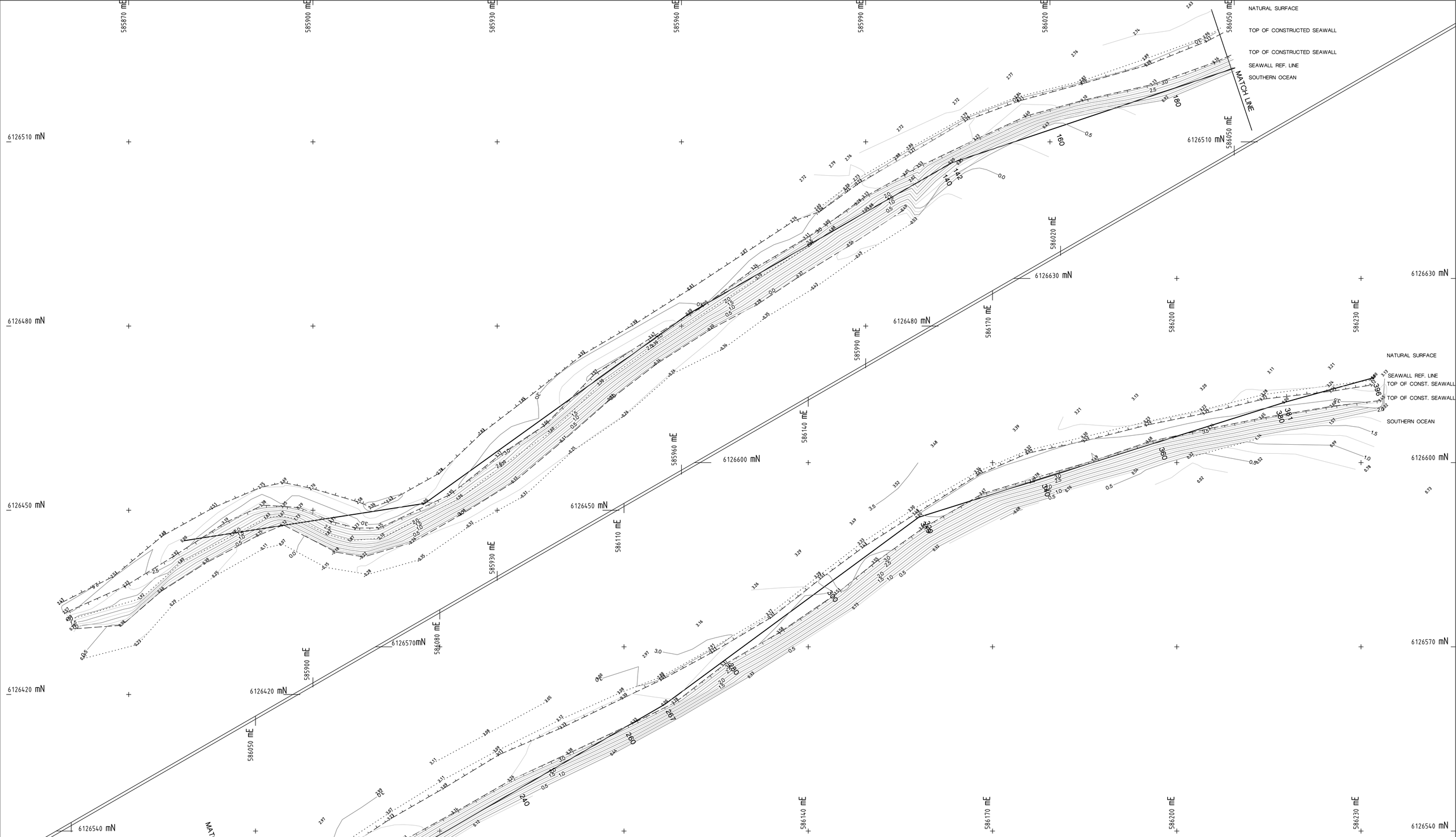
AUTHORISED

TRANSPORT - WESTERN AUSTRALIA

ALBANY - EMU POINT
FORESHORE STABILISATION
SEAWALL OPTION
GENERAL ARRANGEMENT & DETAILS

DRAWING NUMBER 452 - 12 - 2

A1



0452-14-01

JOHN KINNEAR & ASSOCIATES
Consulting Surveyors
234 STIRLING TERRACE
PO BOX 293
ALBANY WA 6331
PHONE (08) 9842 1353 FAX (08) 9842 1570
JKA REF. 8114B

AS CONSTRUCTED SURVEY
EMU POINT SEAWALL
EMU POINT
ALBANY

Datum; AHD

Job No; 8114

Surveyor; AJ

Date; MAY 2007

Approved; JK

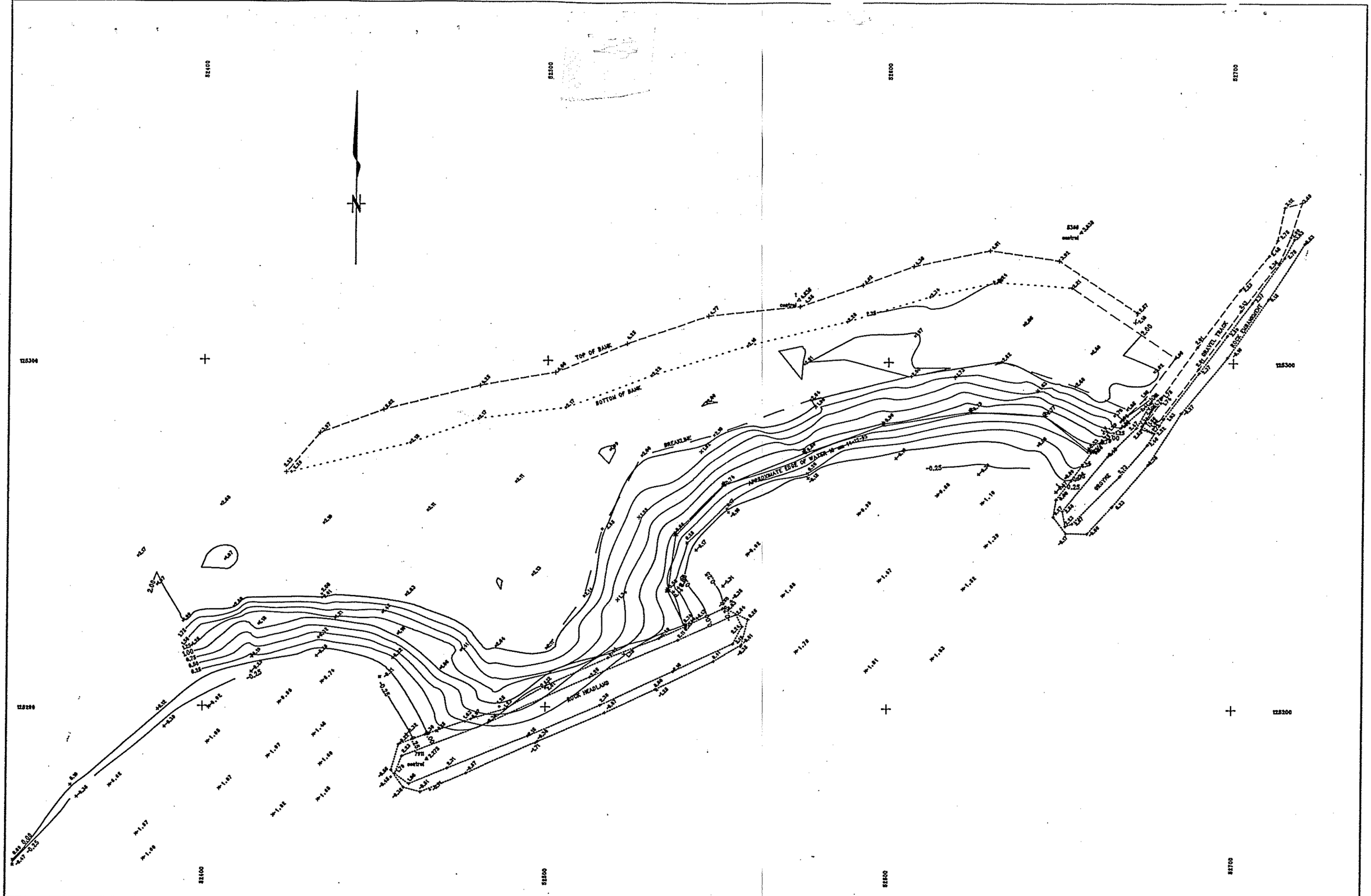
Scale; 1;300 (A1)

Scale; 1;600 (A3)

Sheet 1 of 1

Drawing No;

DWG8114D



LIScad CAD File Name: 10194AA2.C03	NOTE:- THIS DRAWING IS THE PROPERTY OF HARLEY, HEDDERWICK & WEBBER PTY LTD. IT MUST NOT BE COPIED OR ALTERED WITHOUT THE CONSENT OF THE OWNER.	Revision	Details	Date
Parcel Data Set: 10194AA2		A	ADDITIONAL LEVELS- TOE LINE TO -1.5m DEPTH	19-1-96
Primary Data Set: 10194AA2				
Job Directory Name				
	Issued To			

EMU POINT GROYNE

Scale	1 : 1000 APPLICABLE TO ORIG. DRAWING ONLY!
Survey	EAH/SJB 14-12-95
Drawn	SJB 19 JAN 96
Checked	
Level Datum	AHD
Horiz Datum	

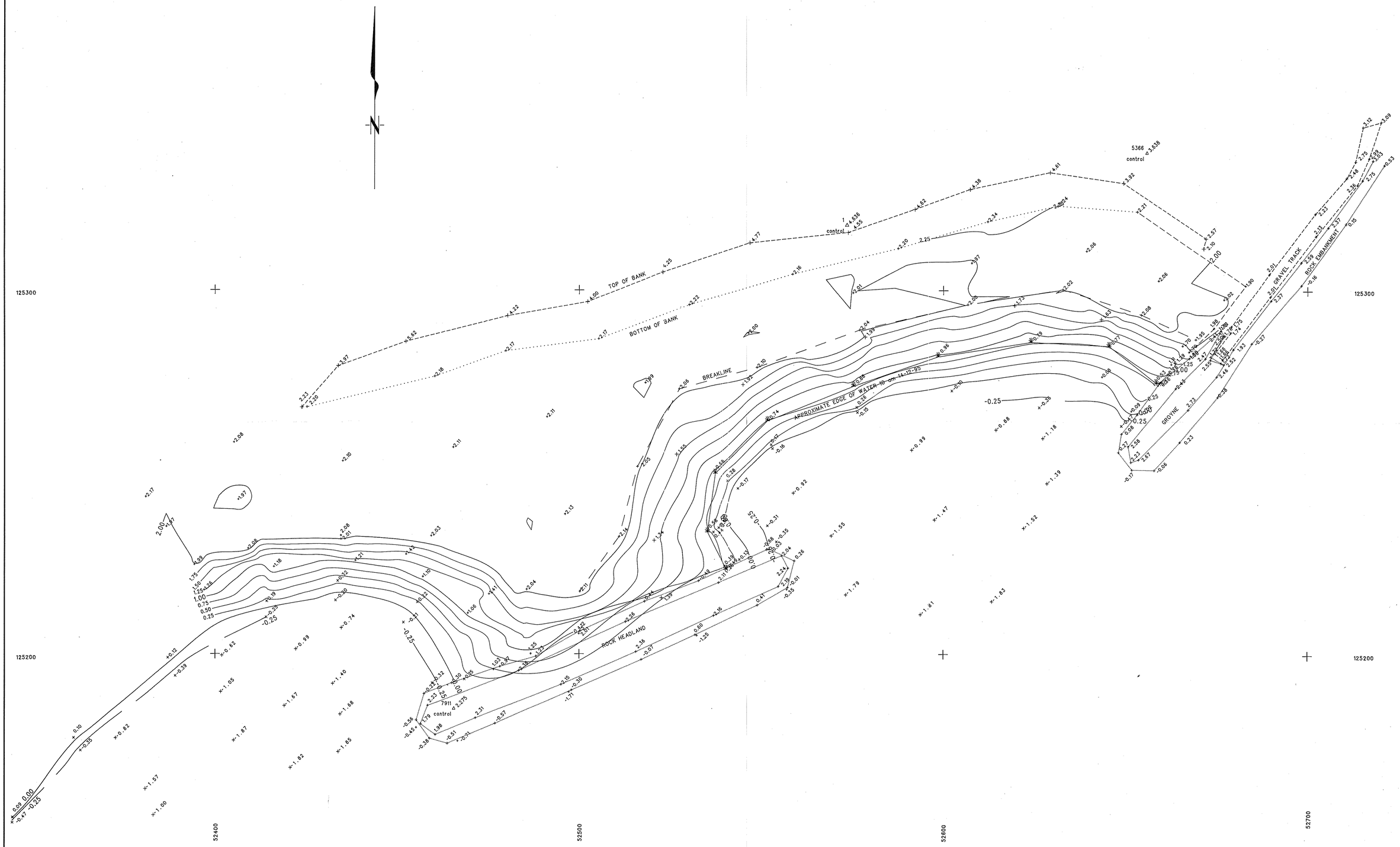
LEVELS OVER AS CONSTUCTED ROCK HEADLAND, GROYNE AND BEACH EMU POINT-ALBANY
FOR AD CONTRACTORS

HARLEY, HEDDERWICK & WEBBER PTY LTD
CONSULTING LICENSED SURVEYORS
P.O. BOX 5397
115 STIRLING ROAD
ALBANY W.A. Phone (098) 417 333
A.C.N. 060 191 796

MEMBER CSWA

DRAWING No 10194-03 REV'N A

93106



LIScad CAD File Name: 10194AA2.G02	NOTE:- THIS DRAWING IS THE PROPERTY OF HARLEY, HEDDERWICK & WEBBER PTY LTD. IT MUST NOT BE COPIED OR ALTERED WITHOUT THE CONSENT OF THE OWNER.	Revision	Details	Date
Parent Data Set: 10194AA2		A	ADDITIONAL LEVELS- TOE LINE TO -1.5m DEPTH	19-1-96
Primary Data Set: 10194AA2				
Job Directory Name	Issued To			

EMU POINT GROYNE

Scale	1:500
	APPLICABLE TO ORIG. DRAWING ONLY
Survey	EAH/SJB 14-12-95
Drawn	SJB 19 JAN 96
Checked	
Level Datum	AHD
Horiz Datum	

LEVELS OVER AS CONSTUCTED ROCK HEADLAND, GROYNE AND BEACH EMU POINT-ALBANY
FOR AD CONTRACTORS

HARLEY, HEDDERWICK & WEBBER PTY LTD
CONSULTING LICENSED SURVEYORS
P.O. BOX 5207
116 SERPENTINE ROAD
ALBANY W.A. Phone (098) 417 333
A.C.N. 009 101 786

MEMBER CSWA

DRAWING No 10194-02 REV'N A

93106

SET–OUT CO–ORDINATES		
LOCATION	EASTING(m)	NORTHING(m)
RH1	586 108.730	6 126 372.565
RH2	586 200.960	6 126 411.212
SN1	586 280.236	6 126 488.949
SN2	586 228.490	6 126 477.522
SN3	586 182.164	6 126 460.594
SN4	586 096.211	6 126 422.676
SN5	586 041.384	6 126 415.330
A443(SSM)	586 396.307	6 126 576.666
JM150	586 303.592	6 126 525.924

MERMAID AVENUE
BOONGARRIE STREET
CUNNINGHAM STREET
BURGESS STREET
941 934 946 935 937 936 969 951 955 970 965 974 961 957 976 980 984

SECTOR BEACON
APPROX LOCATION

SAND NOURISHMENT

TEMP ACCESS BUND
DETAILS SIMILAR TO CORE STONE BUND IN "TYP CROSS SECTION" WITH ARMOUR STONE OMITTED.
REMOVE BUND DOWN TO RL +1.00m PRIOR TO SAND NOURISHMENT.

SHOULDER LINE

JM150

A443(SSM)

SN1 SN2 SN3 SN4 SN5 RH1 RH2

RL 2.00

1:15 NOM

1:10 NOM

20.0

10.0

100.0

105 (REF)

EXISTING GROYNE

TOE LINE (SAND NOURISHMENT)

GROYNE EXTENSION
DETAILS SAME AS CHAINAGE 68.0m TO 83.0m ON DRG 452–1–1

ROCK HEADLAND

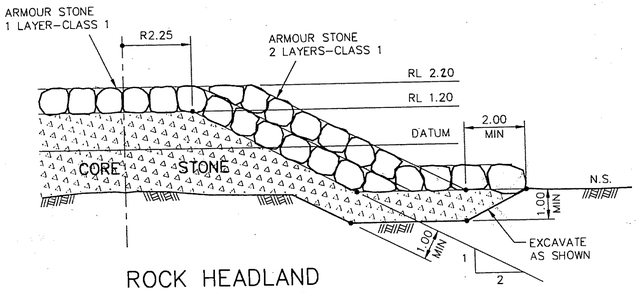
LEVELS & SOUNDINGS
MAY 1994
REFER DRG 426–21–1

LEVELS & SOUNDINGS
MAY 1994
REFER DRG 426–21–1

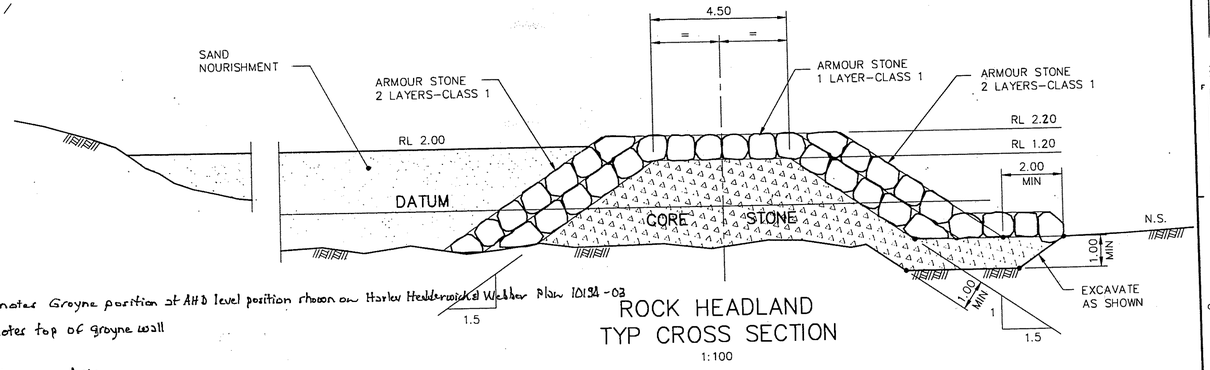
LEVELS & SOUNDINGS
JULY 1995
EXTENT OF SURVEY
SHOWN BY — — — LINE
REFER PLAN 426

ARMOUR STONE
CLASS 1 – 1.0t TO 3.0t LATERITE ROCK (50%>2.0t)

CORE STONE
QUARRY FINES – 0.1t TO 0.7t
NOT MORE THAN 30% < 0.1t
NOT MORE THAN 20% < 200mm



ROCK HEADLAND
TYP END SECTION
1:100



ROCK HEADLAND
TYP CROSS SECTION
1:100

– – – – Denotes Groyne position at AHD level position shown on Harley Headbrook Webber Plan 10134-03

——— Denotes top of groyne wall

Levels in red are on A.H.D.

E.A. HARLEY Lic. Surv. 29.1.96.

GENERAL NOTES:
1. THIS DRG TO BE READ IN CONJUNCTION WITH THE SPECIFICATION
2. THIS DRG BASED ON DESIGN BY M.P. ROGERS & ASSOCIATES

D	14.8.95	RL 2.20 WAS 2.30	SCS	MPR
C	2.8.95	ROCK HEADLAND RL 2.30 WAS RL 2.00 JULY 95 HYDROGRAPHIC SURVEY WAS PORTION OF MAY 1994	SCS	MPR
B	12.4.95	HEADLAND BREAKWATER CHANGED TO ROCK HEADLAND	SCS	MPR
A	10.10.94	ISSUED FOR INFORMATION ONLY	SCS	
REVN	DATE	AMENDMENT	DRN	DESIGN APPROVAL

CAD/G SIZE A1 | M/FILM | FILE No | SURVEY BOOKS

SCALE: 1 : 1000 & AS SHOWN
UNLESS OTHERWISE STATED DIMENSIONS IN m
DATUM: 2.096m BELOW BM A443 & 0.746m BELOW A.H.D.

DESIGNED	M.P. ROGERS	10.10.94
CHECKED	M.P. ROGERS	24.4.95
DRAWN	S.C. SMITH	
CHECKED	M.R. BAIRD	
D/MOD		
CHECKED		

0 10 20 30 40 50 100 150mm
BAR MEASURE INDICATES IF SCALES HAVE BEEN VARIED

APPROVED / /	CIVIL DESIGN
APPROVED / /	ELECTRICAL DESIGN
APPROVED / /	BRANCH MANAGER
APPROVED / /	PROJECT MANAGER
AUTHORISED 24/4/95	M. PAUL DIRECTOR COASTAL & FACILITIES MANAGEMENT

DEPARTMENT OF TRANSPORT – WESTERN AUSTRALIA

ALBANY – EMU POINT FORESHORE STABILISATION ROCK HEADLAND & BEACH NOURISHMENT

DRAWING NUMBER 452 – 7 – 1 REVN D

\DWG\ALBANY\AL452071

93106

Appendix B: EvoCoast condition assessment 2017

simple solutions for complex coastal problems

Att: Emma Evans, Rhys Skipper
City of Albany
PO BOX 484
Albany, WA, 6331

Our Ref: EVO-AL-002-L-001-A
Your Ref: PO 90181 & 90768

Date: 21st June 2017

Sent by email: emmae@albany.wa.gov.au; rhyss@albany.wa.gov.au

Dear Emma & Rhys,

Coastal Structures Asset Management

EvoCoast was commissioned by the City of Albany (City) to assist in adding coastal protection structures into the City's asset management framework. This letter memo summarises the work undertaken and provides supporting information to the digital GIS shape-files.

The objective of this study was to collect sufficient information to add each of the identified structures into the City's asset management database. Information was collected in accordance with the City's specifications for digital spatial data, namely:

- Spatial Data Specification (Draft Version 1 2017)
- Built Specification (Draft Version 1 2017) Table 2.3 "retaining walls"

Study Area

The following nineteen structures have been included in this assessment:

- Oyster Harbour wall;
- Emu Point structures – north groyne; rock training wall; south groyne; detached breakwater; rock revetment; sandbag revetment; sandbag groyne one, and; sandbag groyne two.
- Ellen Cove wall;
- Peace Park – rock revetment;
- Frenchman Bay Road – rock revetment;
- Lower King structures – four Lower King Bridge abutment rock revetments; rock foreshore structure, and; two timber foreshore walls. Please note the timber structures adjacent to the Lower King Bridge abutment rock revetments (directly under the bridge) are not part of this scope and have not been inspected.

Condition Rating Scale

A condition rating scale suitable for the assessment of coastal structures was developed for the City's inclusion in the Built Specification, and is included in the attached Table A-1. The proposed condition rating scale is based on the five (5) levels: very good, good, moderate, poor, and very poor.

The condition rating scale is based on a simplified version of the US Army Corps of Engineers' technical report *Condition and Performance Rating Procedures for Rubble Breakwaters and Jetties* (Oliver et al 1998) and the UK Environmental Agency *Managing Flood Risk – Condition Assessment Manual* (EA 2006). Where possible wording and terminologies have been further modified to be consistent with the City's existing specifications.

Methodology

Below is a summary of the key steps and assumptions undertaken to collect and analyse the information on each of the structures for the completion of the GIS shape-file attributes:

a. Visual land-based condition inspections were undertaken by EvoCoast staff on 9th, 10th March and 30th May.
b. Accurate feature survey by professional surveyor (John Kinnear & Associates) was undertaken on 30th May.
c. A review of previous condition inspection reports was undertaken where they were available.
d. A shape-file for each of the structures was produced in accordance with the City's specifications and is provided as an attachment to this letter.
e. Each shape-file includes an attribute table summarising the information for each structure, along with a statement of the structure's condition, remaining design life and replacement cost.
f. In accordance with the City's specifications three structures (Oyster Harbour Wall, Ellen Cove Wall and the Peace Park Revetment) were split into subsections during surveying, due to interruptions by other structures (such as steps, ramps etc.) or significant changes in dimensions. In these instances, all attributes except for Height and Width are common across all structure sections. For example, replacement cost in a table for a structure section indicates the cost for the whole structure, not just that section.
g. The condition of many of the structures varies over their length, with some sections in worse condition than others. For the purpose of this assessment the lowest rating identified has been applied to the entire structure.
h. If information was not available estimates have been made where it seemed reasonable to do so, based on our prior knowledge of the structures and observations during the site inspections. If no reasonable estimates were available the fields have been left blank.

Expected life

The expected life of each structure has been estimated assuming a starting design life of 25 years as corresponding to very good condition. This is a common design life for coastal structures in Western Australia and assumes no or very limited maintenance will be undertaken over the life of the structure. Structures in very poor condition are considered to have failed and have an effective expected life of zero. Condition ratings in between these two ratings have corresponding expected life of less than 25 years. For coastal structures

the expected design life diminishes more rapidly as the condition level falls. The assumed remaining life relative to the condition is as follows:

- Very good – remaining life 100% or 25 yrs;
- Good – remaining life 90% or ~ 22 yrs;
- Moderate – remaining life 60% or ~ 15 yrs;
- Poor – remaining life 20% or ~ 5yrs
- Very poor – remaining life 0% or 0 yrs

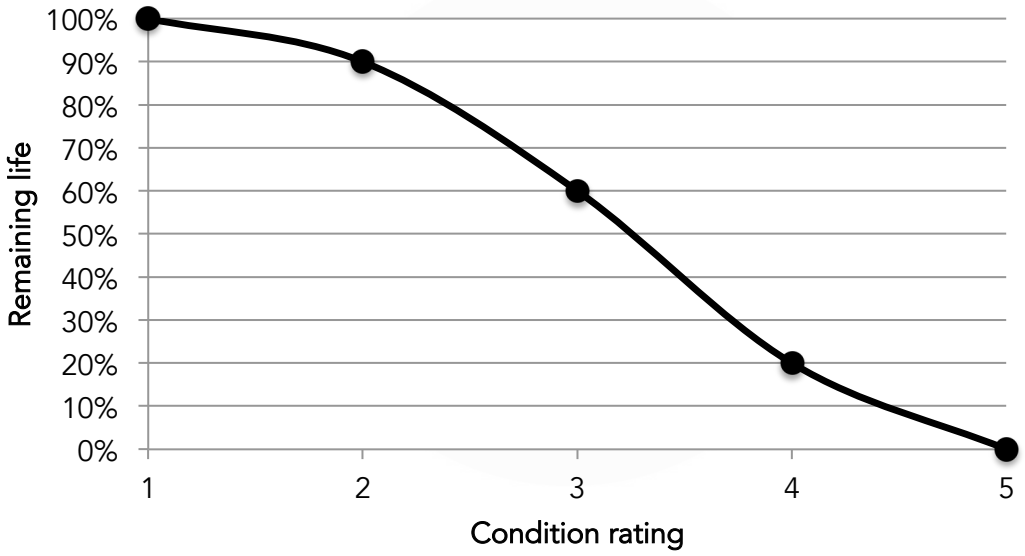


Figure 1. Remaining life relative to condition rating (1. very good, 2. good, 3, moderate, 4. poor, 5. very poor)

Where available, other factors have also been considered when estimating the expected life of individual structures, including the characteristics of the structure, comparison to design records (if available), its defects, and any previous condition inspections to take deterioration rates into consideration.

Replacement costs

Replacement costs have been calculated as a fair value estimate, based on rebuilding structures, using per metre rates for typical sections. Design and as-constructed information and drawings were sourced from the City and Department of Transport where available. The following assumptions were also made:

a. Structure characteristics (e.g. armour layer width, toe depth) were assumed when actual information was not available.
b. Representative armour sizes were sourced from measuring rocks on site.
c. Estimates of armour layer width assumed as three times nominal armour dimensions.
d. Estimates of filter layer width assumed as half the armour layer width.
e. Cross sectional areas of armour and core were estimated and factored by assuming 25% voids for armour and 15% for filter.
f. Standard densities of 2.5 T and 2.65 T per cubic metre were used for laterite and granite respectively.
g. Sloping rock structures assumed basic design of shaped fill, with geofabric layer and then core/filter layer and then two layers of rock armour.

h. Complex design features were approximated by modifying some characteristics of structure design.
i. Rock groynes and breakwaters are assumed to be two-sided revetments.
j. For vertical walls cost estimates have quantified materials, labour and machinery required to estimate per metre rates for standard sections.
k. For sandbag structures estimates are based on costs per sandbag and utilise recent maintenance cost information as a guide.
l. Allowance has been included for design, project management, preliminaries, mobilisation and demobilisation as a factor of 20%.
m. Allowance has been included for contingency as a factor of 30%.

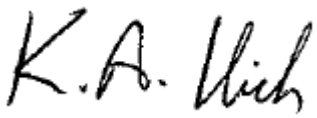
Condition summary & recommendations

A summary of the inspected structures is as follows:

- five structures are in **very good** or **good** condition and require no immediate action;
- eight structures are in **moderate** condition with defects which require regular monitoring and should be scheduled for routine maintenance;
- six are in **poor** or **very poor** condition with significant defects which require repairs that would be considered greater than routine maintenance. These structures require future investigation into the cause of failure, recommended re-build design and urgency of repairs.

Table A-2 attached provides a simple summary of the structures inspected, their function, a representative photo, condition rating, and defects summary. Although prioritisation has not been given to these structures it is recommended that immediate attention be given to the Lower King Bridge - southeast abutment rock revetment. This structure is in very poor condition and has failed. Some immediate repairs are required to prevent undermining of the road.

Kind Regards



Karl Ilich
Coastal Engineer and Project Manager
EvoCoast Pty Ltd
0411 324 494
karl@evocoast.com.au

Attachments:

a. Table A-1 – Coastal Structures Condition Rating
b. Table A-2 - Summary of structures inspected, their function, condition and defects.
c. Digital GIS shape-files
d. Submission metadata file (text file)

Table A-1. Coastal Structures Condition Rating

Rating	Condition	Example	Description
1	Very Good		No defects, or very minor defects that will have no effect on performance. No repairs required.
2	Good		Minor defects that will not reduce overall performance of the asset. Structural integrity is not likely to be threatened, even if condition should deteriorate somewhat. Repairs can be deferred but should be scheduled for out years as routine maintenance.
3	Moderate		Defects that could reduce performance of the asset. Structural integrity is likely to be threatened if condition should deteriorate. Repairs are required now or soon in order to prevent accelerated deterioration. Defects should be regularly monitored as condition may be unstable or subject to rapid change.
4	Poor		Defects that would significantly reduce performance of the asset. Further investigations may be needed. Structural integrity may be threatened. Repairs are required now to prevent accelerated deterioration and/or loss of

			structural integrity. Repairs may exceed routine maintenance and require partial rebuild.
5	Very Poor		Severe defects resulting in complete performance failure. Structure may have completely or partially failed. Repairs are now overdue and would no longer be considered routine maintenance. Partial or total rebuild is likely to be required. Design and performance requirements should be reviewed.
0	Not rated		Asset has not been rated

Table A-2. Summary of structures inspected, their condition and recommendations

Structure name	Description & function	Photo	Condition	Condition notes
Oyster harbour wall	Vertical grouted rock wall that stabilises/retains foreshore area		Moderate	Some defects in older portion of structure – grouting missing in places, cracking, evidence of piping of fill material through holes in structure face
Emu Point - north groyne	Rock groyne connected to training wall that stabilises western side of Emu Point channel and protects foreshore area from erosion		Moderate	Some defects – loss of crest elevation; unstable rocks on main structure; tie in to back of beach wall has slope steepening and loss of interlocking

Structure name	Description & function	Photo	Condition	Condition notes
Emu Point - training wall	Sloping rock seawall that stabilises western side of Emu Point channel and protects foreshore area from erosion		Moderate	Some defects – loss of crest elevation; loss of interlocking with some slumping probably due to loss of core/filter
Emu Point - south groyne	Rock groyne connected to training wall that stabilises western side of Emu Point channel and protects foreshore area from erosion		Good	No significant defects

Structure name	Description & function	Photo	Condition	Condition notes
Emu Point - detached breakwater	Sloping rock breakwater that shelters the beach behind it by protecting from incoming waves. Provides sheltered beach front and protects foreshore area from erosion		Very good	No significant defects
Emu Point - rock revetment	Sloping rock seawall that protects foreshore area from erosion		Poor	Some significant defects – significant slope steepening in some sections, likely due to settlement of toe, causing loss of interlocking between armour rocks and filter exposure; crest washout holes, likely due to overtopping

Structure name	Description & function	Photo	Condition	Condition notes
GSC revetment	Sloping sandbag seawall that provides some protection of foreshore area from erosion		Very poor	Structure has failed – bags have split open and washed away; significant reduction in crest height; overtopping has eroded foreshore behind structure
Sandbag groyne 1 (east)	Trial sandbag beach groyne which helps to stabilise beach and limit impact of erosion scour at end of seawall structures		Moderate	Some defects - Several sandbags have holes and several are deflated in size Note: Maintenance undertaken in Autumn 2017 to add bags to crest of structure
Sandbag groyne 2 (west)	Trial sandbag beach groyne which helps to stabilise beach and limit impact of erosion scour at end of seawall structures		Moderate	Some defects - Several sandbags have holes and several are deflated in size Note: Maintenance undertaken in Autumn 2017 to add bags to crest of structure

Structure name	Description & function	Photo	Condition	Condition notes
Ellen cove wall	Vertical grouted rock wall that stabilises/retains foreshore area and separates from beach		Moderate	Some defects – grouting missing in places; rocks missing from crest of structure; some concrete panels tilting
Frenchman Bay Road revetment	Sloping rock seawall that protects foreshore area and path and road from erosion		Good	Minor defects include some slumping, armour range too wide and some small/core rock placed on top of armour

Structure name	Description & function	Photo	Condition	Condition notes
Peace Park revetment	Sloping rock seawall that protects foreshore area from erosion		Very good	Minor defects – Loss of interlocking in isolated sections, and; toe rocks disconnected from structure
Lower King - foreshore rock structure	Layer of rock which stabilises the tidal zone to support reed planting		Good	Minor defect – several rocks located outside of structure footprint towards water

Structure name	Description & function	Photo	Condition	Condition notes
Lower King - timber wall 1	Function is unclear - may have historically stabilised foreshore reserve for landscaping		Very poor	Structure has failed - timber sections missing; connecting bolts rusted through; structure no longer retaining sand
Lower King - timber wall 2	Function is unclear - may have historically stabilised foreshore reserve for landscaping		Very poor	Structure has failed - timber sections missing; connecting bolts rusted through; structure no longer retaining sand

Structure name	Description & function	Photo	Condition	Condition notes
Lower King Bridge - NW abutment rock revetment	Sloping rock seawall that protects bridge abutment and road from erosion		Very poor	Structure has failed - slope steepening, likely caused by slumping of toe; significant exposed core and fill; significant armour loss from slope
Lower King Bridge - SW abutment rock revetment (aka causeway)	Sloping rock seawall that protects bridge abutment and road from erosion		Moderate	Some defects - loss of interlocking at top of slope, likely due to settlement of toe; slope steepening; some washout at crest; large armour size range

Structure name	Description & function	Photo	Condition	Condition notes
Lower King Bridge - SE abutment rock revetment (aka causeway)	Sloping rock seawall that protects bridge abutment and road from erosion		Very poor	Structure has failed - majority of armour lost; large sections of core and fill exposed
Lower King Bridge - NE abutment rock revetment	Sloping rock seawall that protects bridge abutment and road from erosion		Moderate	Some defects - grouted section of structure has slumped ~50mm; slope steepening; displaced toe rocks; exposure of core and fill

Appendix B: Coastal protection concept designs, preliminary bill of quantities and costing

10.1. Emu Point rock revetment upgrade concept design

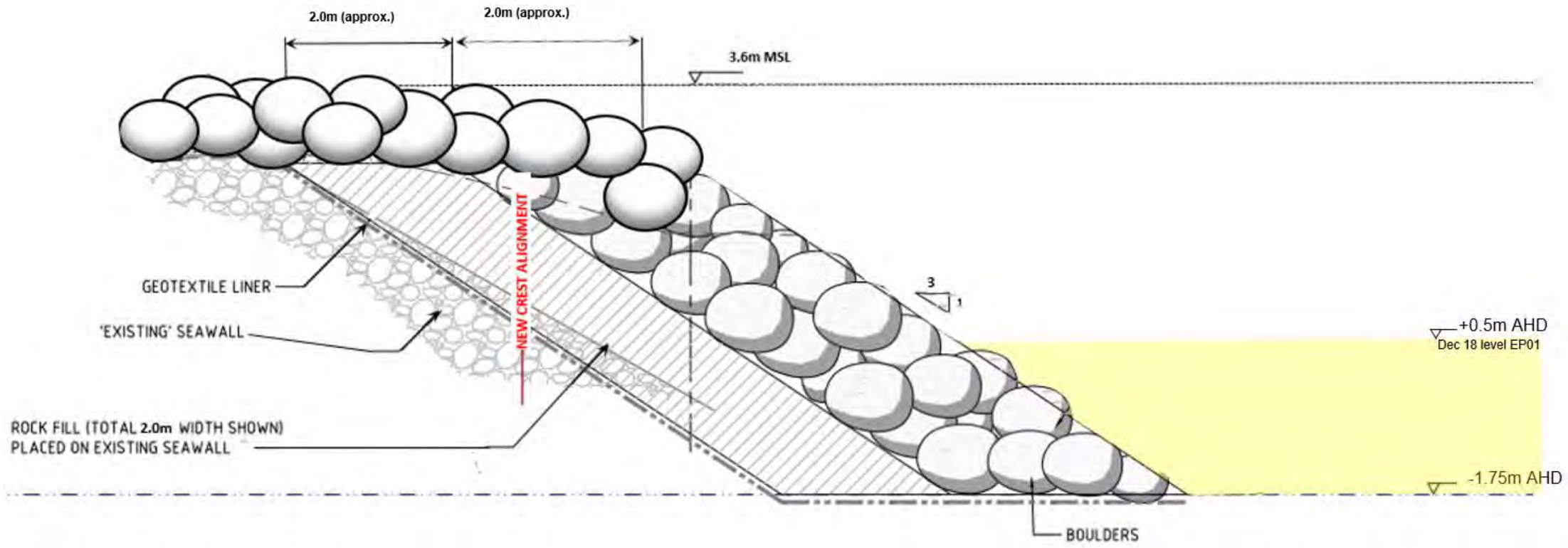


Figure 35: Coastal Adaptation Option 1: Rock revetment (Coastal Structure A) upgrade concept design. Please note all dimensions and levels are approximate and are to be confirmed during detailed design

Material	Size	Approximate cross-sectional area (m^2)	Approximate volume for 460m length of wall (m^3)	Approximate tonnage for 460m length of wall (t)	Approximate rate for deliver and build (2020 AU$)	Estimated cost for upgrade (2020 AU$)	Source of quote and estimated error
Armour Rock	D50: 2.0t	18.3	8,418	13,680	$121.50 / t	$1,662,120	LandCorp quote K1265/2 for Middleton Beach revetment, July 2016. Rates have been marked up with CPI from 2016 to 2020 based on construction industry values for WA from Rawlinson's (2020)
Filter layer	0.27t	6.2	2,852	5,297	$179.50 / m^3	$511,934	
Geotextile layer	1200R	26m	12,580m^2		$7/m2	$88,060	
					Total	$2,262,114	

10.2. Emu Beach groyne field upgrade concept design

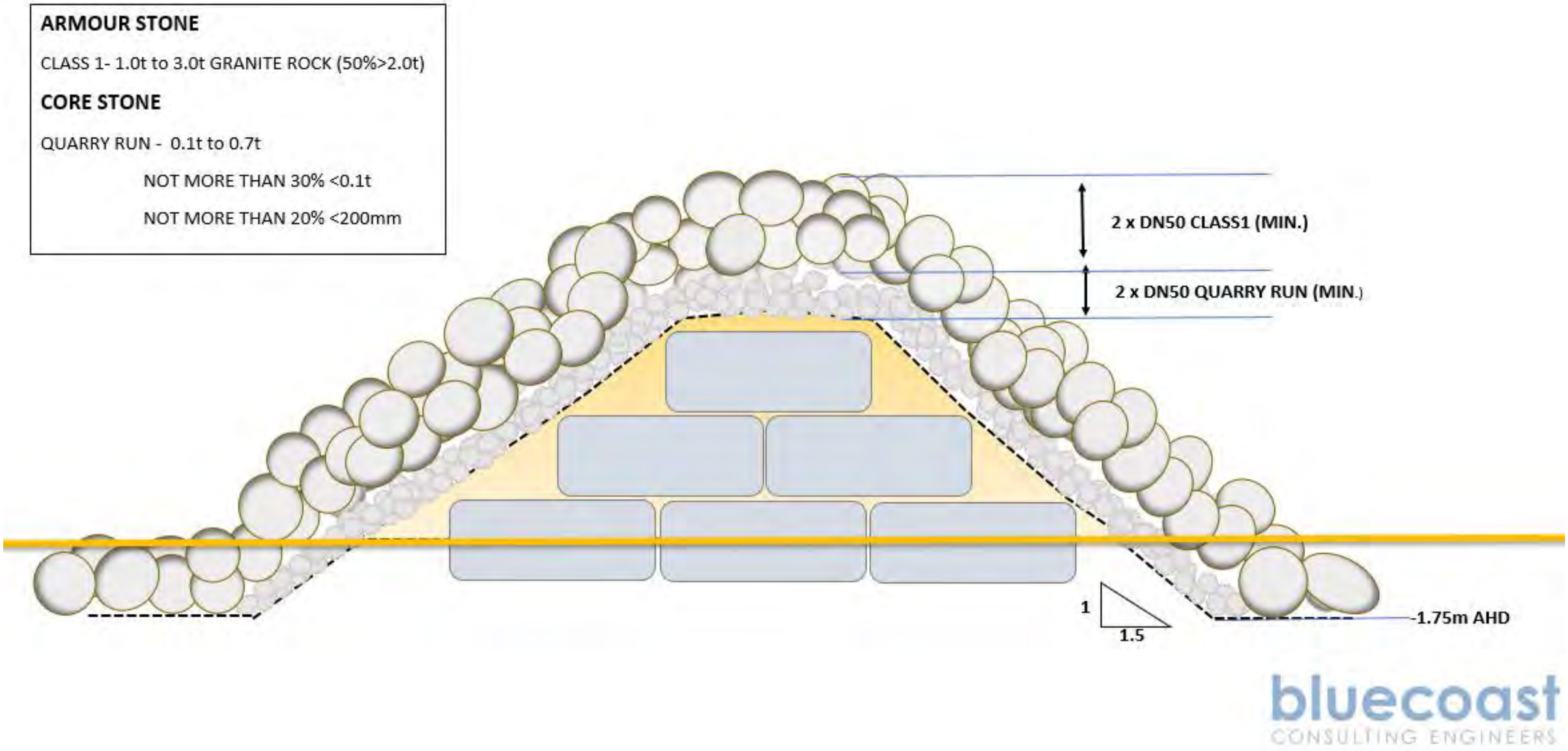


Figure 36: Coastal Adaptation Option: GSC Groyne upgrade concept

Figure 37: Coastal Adaptation Option: Groyne upgrade concept, Plan View

Structure ID	Fill volume (m^3)	Geotextile (m^2)	Quarry run volume	Class 1 volume	Estimated cost for upgrade (2020 AU$)	Source of quote and estimated error
Coastal Structure B	215	795	650m^3 / 105t	1800m^3 / 2880t	$ 468,100.00	LandCorp quote K1265/2 for Middleton Beach revetment, July 2016. Rates have been marked up with CPI from 2016 to 2020 based on construction industry values for WA from Rawlinson's (2020). Beach Nourishment quote is highest value for Middleton-sourced sediment PRDW (2017).
Coastal Structure C	215	795	650m^3 / 105t	1800m^3 / 2880t	$ 468,100.00	
Coastal Structure D	585	795	650m^3 / 105t	1800m^3 / 2880t	$ 470,690.00	
TOTAL	1015	2385	1950m^3 / 315t	5400m^3 / 8640t	$ 1,406,890.00	

Appendix C: Review of existing coastal protection measures at Emu Point

11.1. Introduction

This technical note has been written with the aim of providing a performance review of the existing coastal protection measures at Emu Point. Following the conclusion of the CHRMAP Implementation Plan (Aurora, 2019), additional coastal monitoring data has been collected at Emu Point as well as further detailed numerical modelling undertaken through the Albany Artificial Surf Reef (ASR) Project. In addition, further degradation of the existing coastal protection structures and a large storm event in August 2020 has renewed interest in revisiting the coastal protection recommendations made in the implementation plan by examining the efficiency of the existing structures.

Figure 38 shows a map with the locations of available location of available metocean data used in the design process of the ASR, it also provides a preliminary indication of Albany ASR site and Emu Point.

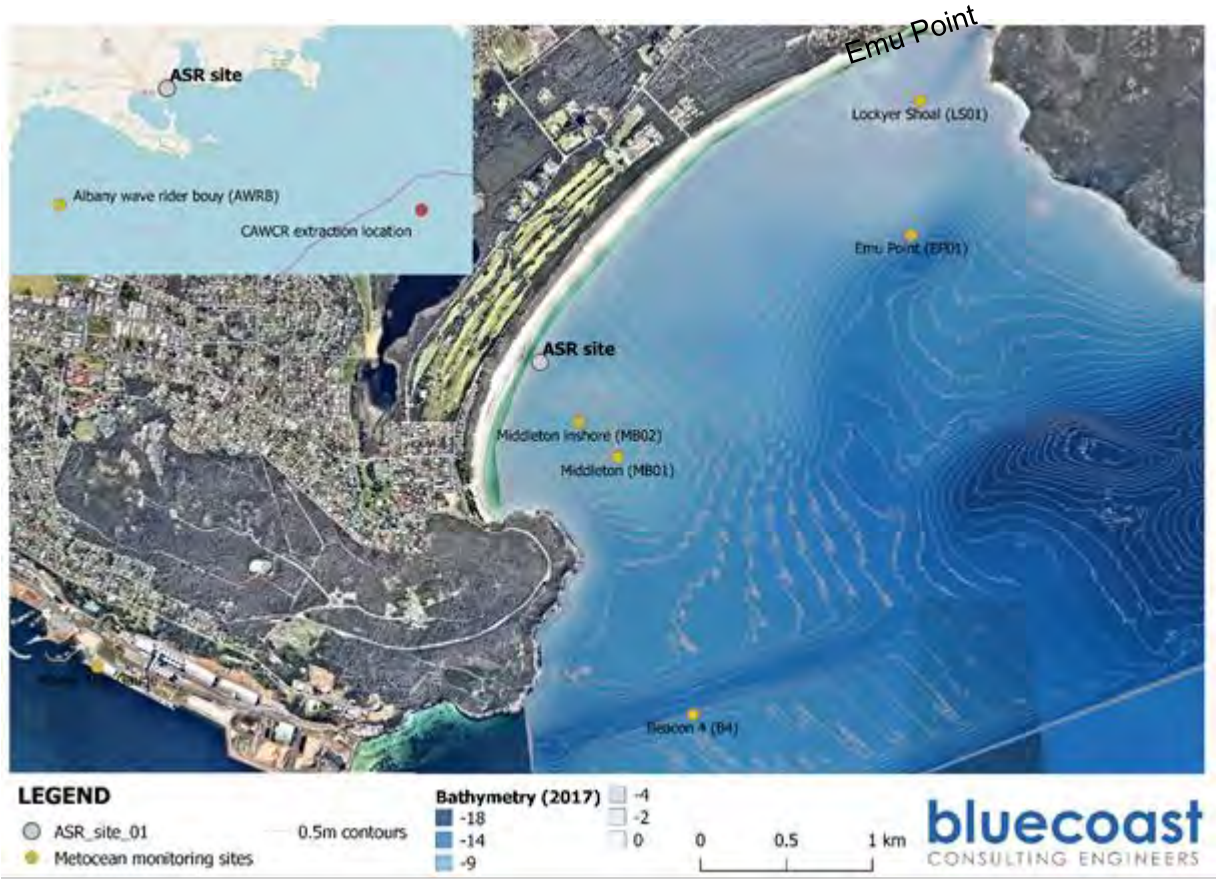


Figure 38*:* Metocean data locations in relation to Emu Point and the Albany ASR site.

11.2. Emu Point nearshore wave climate

The Emu Point to Middleton Beach Coastal Adaptation and Protection Strategy: Coastal Vulnerability Study and Hazard Mapping (RHDHV, 2017) undertook a detailed 38-year hindcast wave modelling exercise of King George Sound. The model was calibrated to wave

measurements collected by an Acoustic Wave and Currents (AWAC) instrument deployed in 8m offshore of Emu Point by DoT. A subsequent hindcast wave model was calibrated to this data in 2020 with additional boundary data used to bring the duration of this simulation to 41 years (1979-2020) as part of the design studies for the Albany Artificial Surf Reef project (Bluecoast, 2020). To improve calibration and ensure precision, the model resolution was increased in the nearshore and further validation was undertaken against newly recorded data from an AWAC device placed in the lee of Lockyer Shoal, see Figure 40.

In order to gain an understanding of the wave climate in the nearshore at Emu Point to inform coastal protection activities, hindcast wave data was extracted from this model at three locations approximately 150m offshore of the rock revetment and trial GSC groynes at Emu Point, 250m apart from each other shown in Figure 40. A summary of the nearshore wave climate at each point can be seen in

Table 4. The weighted average wave directions were calculated based upon the wave energy of each reading, as follows:

Dp weighted = (Hs^2 x Tp x Dp) / sum (Hs^2 x Tp)

The nearshore wave climate at Emu Point can be defined as follows:

- Offshore wave direction (seaward of King George Sound) generally has very little influence on the directionality of nearshore waves at Emu Point due to the 'funnelling' effects of the Sound and the long distance the incoming waves must travel across a relatively uniform bathymetry. Following this passage, incoming swells are basically aligned to the orientation of the bathymetry/shoreline prior to reaching the shoreline.
- Near Emu Point, Lockyer Shoal has the biggest effect on the transformation of waves prior to reaching the shoreline. Waves refract around the western edge of the shoal, with wave directions at P1 and P2 seen to be between 119°N-120°N all year round with very little variation (max standard deviation of 4°). These wave directions are not perpendicular to the shoreline.
- Wave directions at P3 appear to be less influenced by the shoal as wave directions are generally aligned perpendicular to the shore. It is assumed that there is some refraction around the eastern extent of the shoal experienced at this location, see Figure 42: .
- There is very little variation in seasonal wave heights and the sites are dominated by swells (wave periods greater than 8 seconds). The more exposed sites at Middleton Beach experience a greater proportion of wind waves (wave periods less than 8 seconds) in the Summer months due to the fetch that is set up across the Sound during the Summer easterlies. The location of Emu Point on the eastern extent of the Sound means these fetches are significantly reduced.

Design wave conditions have been calculated at the central extraction point (P2) based on the results of the 41-year wave hindcast. The independent event peak storm significant wave heights were subjected to an extreme value analysis using the maximum likelihood method, fitting to the Weibull distribution. Design wave conditions in terms of significant wave height are presented in Figure 41 for a range of Annual Recurrence Intervals (ARI). Figure 41 presents the

recommended design wave conditions at P2 for wave events with an ARI of 5, 50 and 100 years. It should be noted that this location is in approximately 3-4m of water, approximately 150m offshore of the structures at the project site. Due to the shallow water depth at the extraction location it is expected that waves will be depth-limited, and that Lockyer Shoal will reduce a significant proportion of the wave energy in larger events. Figure 39 shows the Q-Q plots for the calibration of the hindcast model. The model is seen to slightly over-estimate larger wave heights, meaning design wave heights provided in Figure 41 are conservative.

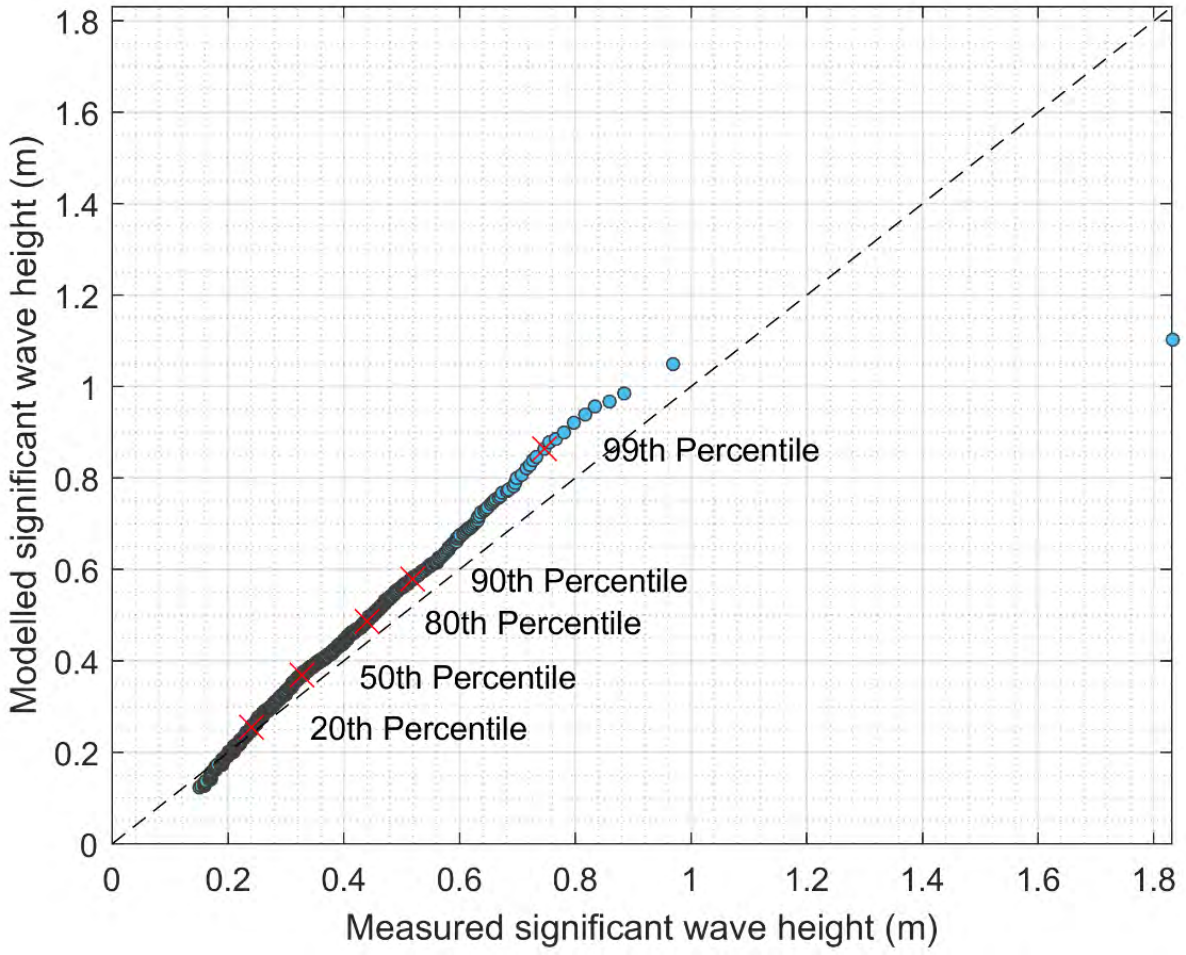
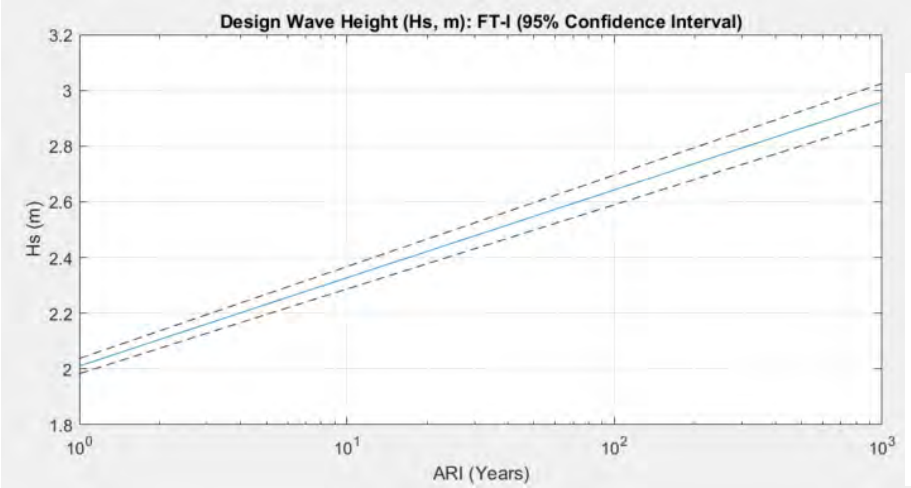


Figure 39: Calibration (Q_Q) plots of modelled waves heights against measured wave heights at the Emu Point and Lockyer Shoal AWAC devices (DoT) from the 41-year wave hindcast model.

Figure 40: Emu point monitoring locations and hindcast model extraction location

Table 9: Operational wave climate for points P1, P2, P3 extracted offshore of Emu Point from the transformed 41year wave hindcast

Parameter	Statistic	41-year hindcast record														
		LTA			Summer			Winter			Autumn			Spring		
Significant wave height (Hs) [m]	Point	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3	P1	P2	P3
	Mean	0.39	0.56	0.43	0.39	0.54	0.48	0.39	0.59	0.38	0.39	0.56	0.43	0.38	0.56	0.41
	99%ile	0.60	1.26	1.24	0.59	1.22	1.35	0.62	1.33	1.14	0.60	1.25	1.22	0.59	1.23	1.21
	Max	2.03	2.33	2.68	1.76	2.21	2.68	2.03	2.33	2.63	1.78	2.16	2.59	1.54	1.99	2.45
Peak wave period (Tp) [s]	Mean	13.1	13.2	13.2	12.3	12.4	12.3	13.8	13.9	13.8	13.3	13.3	13.3	13.1	13.2	13.2
	% of time sea (Tp < 8s)	3%	2%	3%	4%	4%	4%	1%	1%	1%	3%	2%	3%	3%	3%	3%
	% of time swell (Tp > 8s)	97%	98%	97%	96%	96%	96%	99%	99%	99%	97%	98%	97%	97%	97%	97%
Peak Wave Direction (Dp) [˚TN]	Weighted Average	120	119	145	12	121	146	120	119	145	120	119	145	120	119	145
	Average	120	119	145	121	121	145	119	118	145	120	119	145	120	119	145
	St. Dev.	2	4	1	2	4	1	2	4	0	2	4	1	2	4	1



ARI (year)	Hs (m)	Hs (98% Confidence Intervals)
5	2.23	2.20 – 2.27
50	2.55	2.50 - 2.60
100	2.64	2.59 – 2.70

Figure 41: Design wave heights (H_s) of the central model extraction point (P2) from the 41 year hindcast wave model

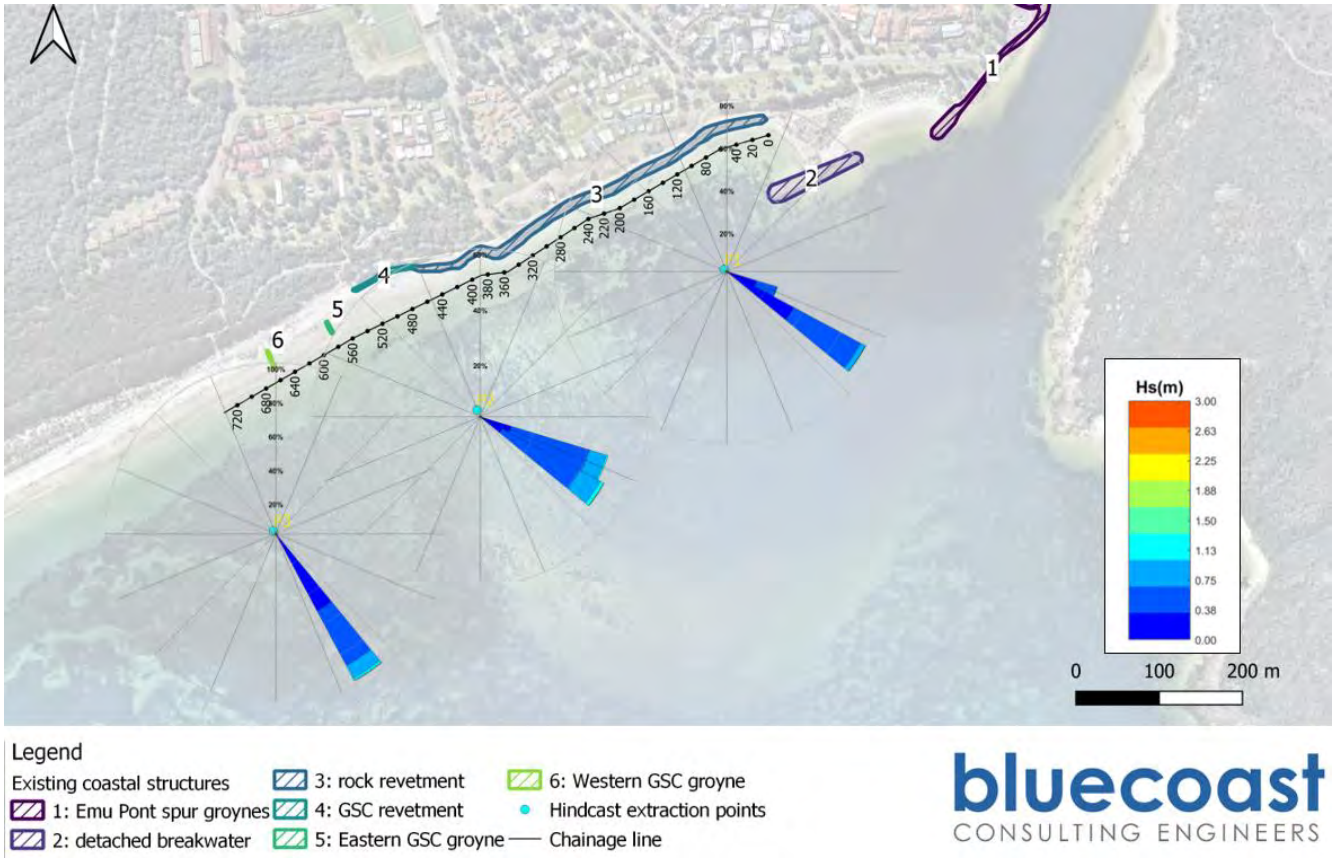


Figure 42: Long-term average wave roses from the three-model extraction point (P1, P2, P3) from the 41 year hindcast wave mode

11.3. Emu Point morphological change

The Emu Point to Middleton Beach Coastal Adaptation and Protection Strategy: Coastal Vulnerability Study and Hazard Mapping (RHDHV, 2017) undertook a detailed investigation into coastal processes along the whole embayment, utilising past reports, metocean and survey data and numerical modelling. A summary of the findings for Emu Point from this report as well as updated information from subsequent monitoring is provided below:

- The erosion observed at Emu Point and over the Lockyer Shoal is due to the complex balance between tidal, wave driven and fluvial forces
- The loss of seagrass meadows and the major storm event that occurred in August 1984 were key factors in the subsequent erosion.
- The introduction of coastal structures at Emu Point in response to the erosion of 1984 have modified the natural sediment transport pathways.
- Construction of the training wall and groynes at Emu Point has resulted in a disconnection of the Emu Point and Oyster Harbour sediment cells. That is, the net addition of sediment to the Emu Point cell has ceased (PRDW, 2013a).
- There has been a disruption of the clockwise sediment circulation cell that operated between Emu Point, Emu Point Channel and Lockyer Shoal due to training and coastal structures that changed the flow regime of Emu Point Channel (PRDW, 2013a).
- Wave energy reflected from the rock revetment has resulted in scour and a general lowering of the seabed in front of the revetment (URS, 2012 and PRDW, 2013a).
- Erosion of Lockyer Shoal has resulted in reduced nearshore wave refraction and a subsequent straitening of the shoreline around the Firth Street salient (MP Rogers, 2003).

The City has been undertaking beach monitoring through the seasonal collection of beach transect data along Middleton Beach, Emu Point and Oyster Harbour since October 2013. Historic beach transect evolution at the four main survey locations within the project area (MB-07, MB-08, MB-09, EP-01) can be seen in Figure 40.

Analysis of the historical transects show that since October 2013, there has been:

- A general shallowing of all locations in the offshore portion of the transect (below -3m AHD) by up to 1m, representing accumulation of Lockyer Shoal.
- The greatest erosion of the upper beach face (above 0m AHD) occurred during the most recent survey in August 2020 as a result of the large storm event at that time.
- The 0m AHD shoreline location can vary by up to 50m across transects MB-07, MB-08 and MB-09.
- MB-08 and MB-09 have very steep upper dune faces (between 1m AHD to 4m AHD) which has shown a small amount of landward movement

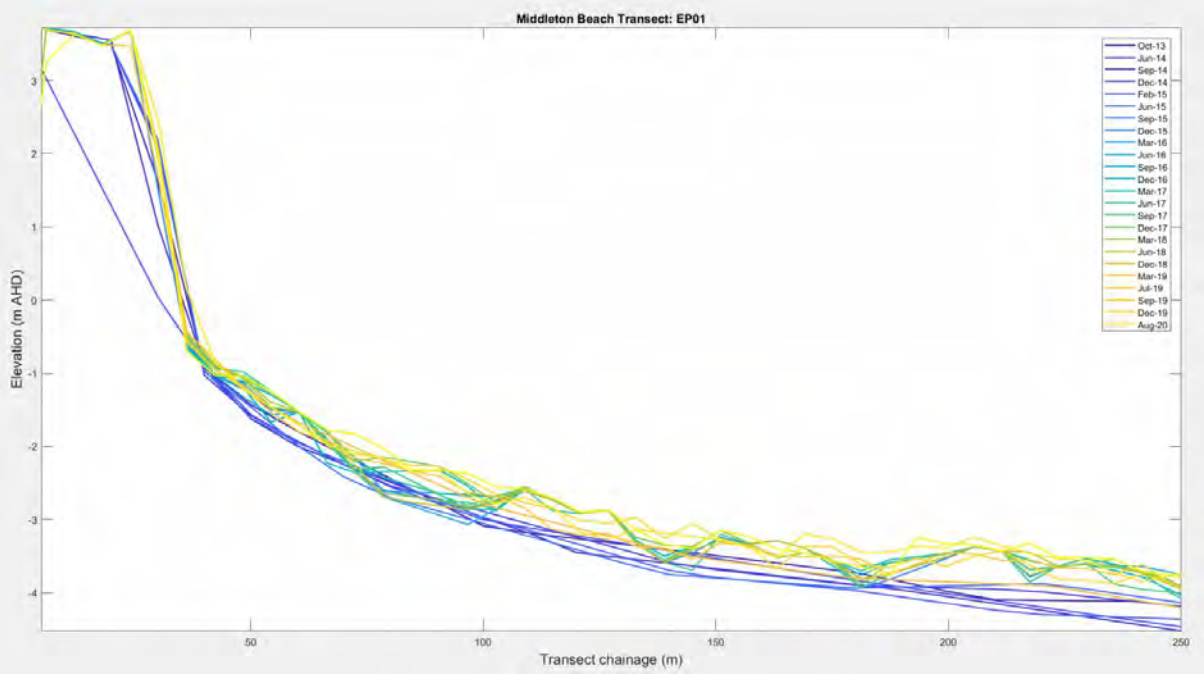


Figure 43: Seasonal beach transect data from October 2013 to August 2020 at transect EP-01

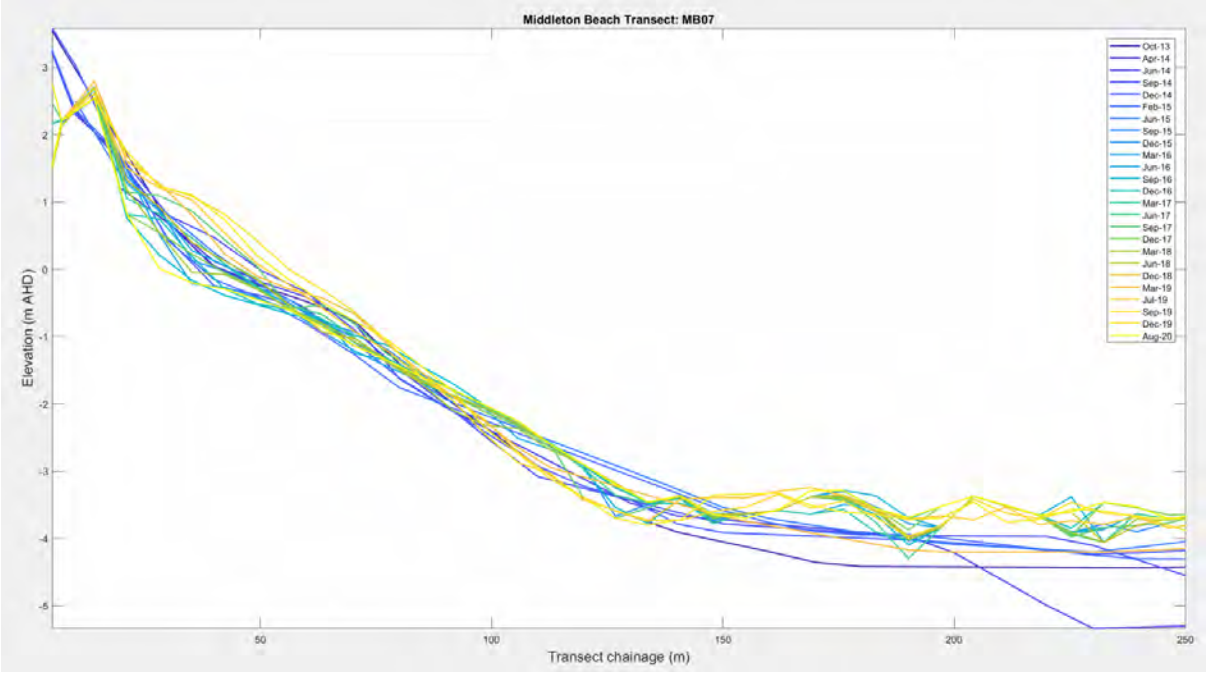


Figure 44: Seasonal beach transect data from October 2013 to August 2020 at transect MB-07

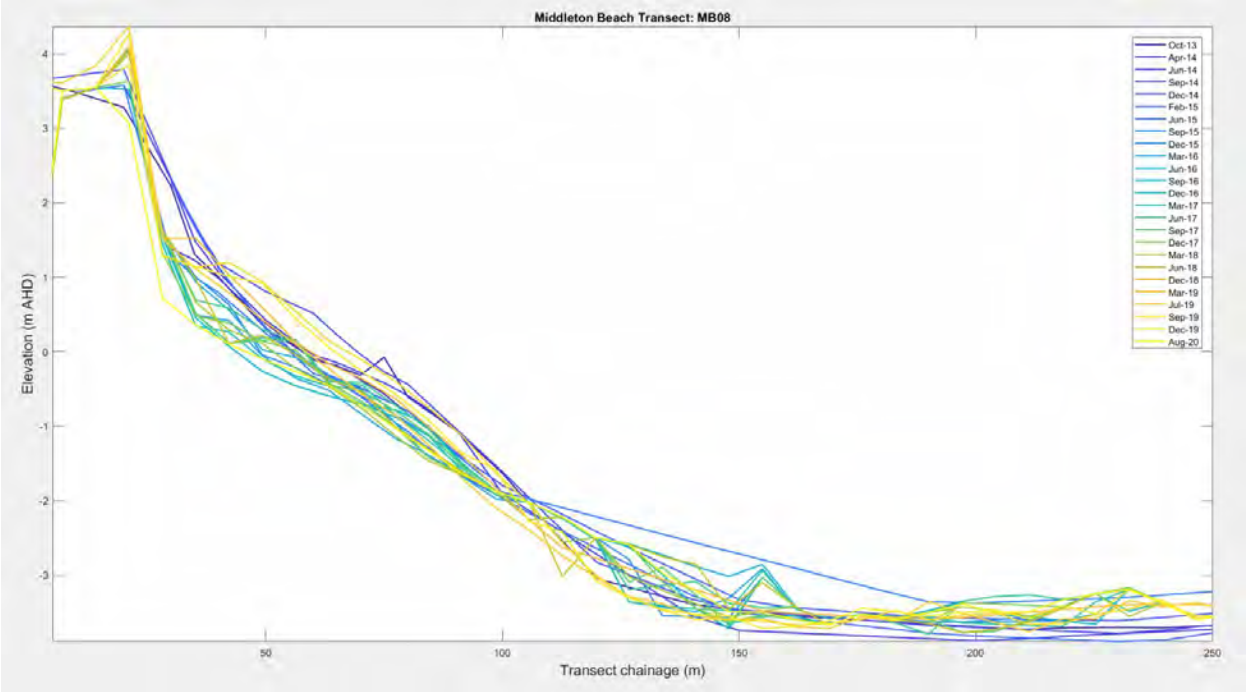


Figure 45: Seasonal beach transect data from October 2013 to August 2020 at transect MB-08

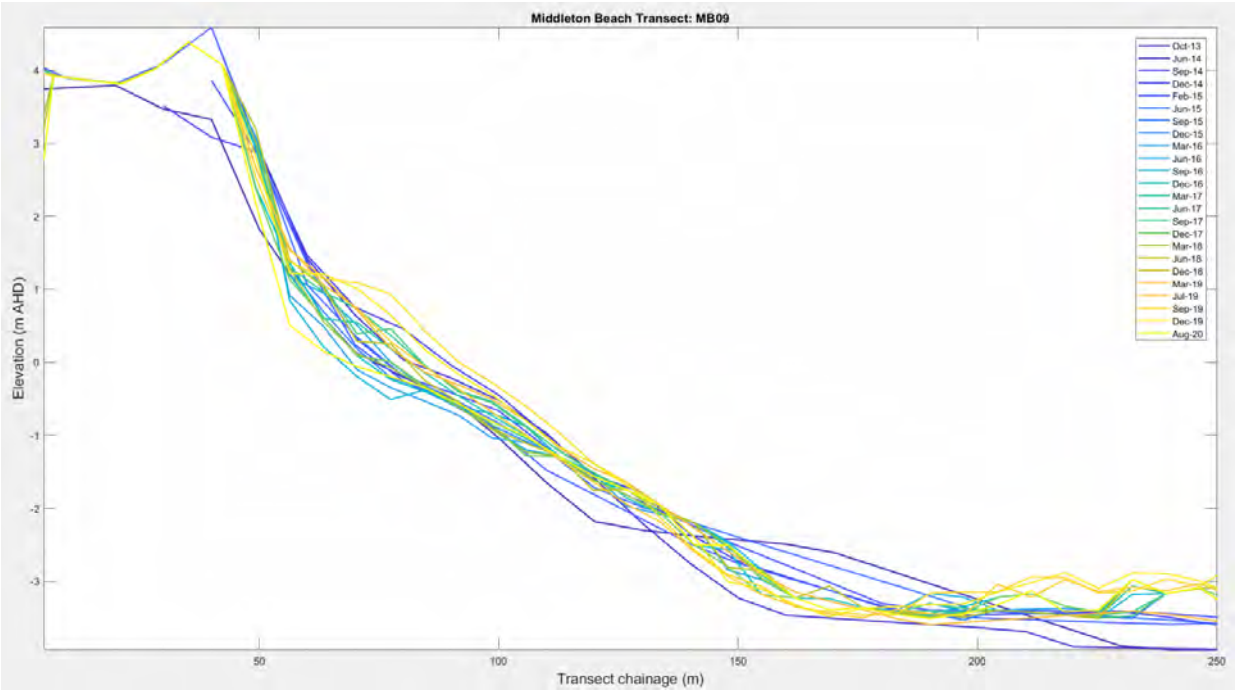


Figure 46: Seasonal beach transect data from October 2013 to August 2020 at transect MB-09

11.4. Emu Point sediment transport

As seen in the historical beach transect data, there is a clear short-term cross-shore response to storms, where sand is removed from the upper beach face and deposited into the deeper parts of the profile. However, as far as longshore transport, RHDHV (2017) has shown that there has been net erosion in the Emu Point area since the introduction of coastal protection structures. Whilst at the same time, the eastern portion of Middleton Beach from Ellen Cove to the Golf Course has shown a net accretionary trend, suggesting net longshore transport towards the west.

There has been four previous studies SKM (1993), MP Rogers (2003), PRDW (2013) and RHDHV (2017) investigating the net LST regime at Emu Point. There is contention as to the mechanism inducing the net longshore transport along Emu Point. However, the consensus is that east of Boongarie St, sediment moves east to west (towards Ellen Cove) at a rate of between 10-11,000m^3/year. SKM (1993) also hypothesized net transport along the western portion of Emu Beach was in the opposite direction from west to east (i.e., towards Oyster Harbour) at around 8,000m3/yr. Numerical modelling undertaken as part of RHDHV (2017) has shown complex 2D circulation processes associated with Lockyer Shoal, Oyster Harbour inlet as well as the wave transformation processes associated with the shoal and interplay of established seagrass beds.

The most widely used formula for longshore transport (LST) is commonly known as the CERC equation (Shore Protection Manual, US Army Corps of Engineers, 1984). This method is based on the principle that the longshore transport rate (LST, incl. bed load and suspended load) is proportional to longshore wave power (P) per unit length of beach. The CERC formula has been calibrated using field data from sand beaches. This formula has been used to get an estimate of sediment transport potential at each of the hindcast wave extraction points (P1, P2, P3). The formula was applied to the extracted wave parameter timeseries from 2001 to 2020, the approximate period since the last (major) extension of the revetment at Emu Point. The mean monthly LST potential and mean monthly wave parameters at each hindcast extraction point are presented in Figure 47 to Figure 49.

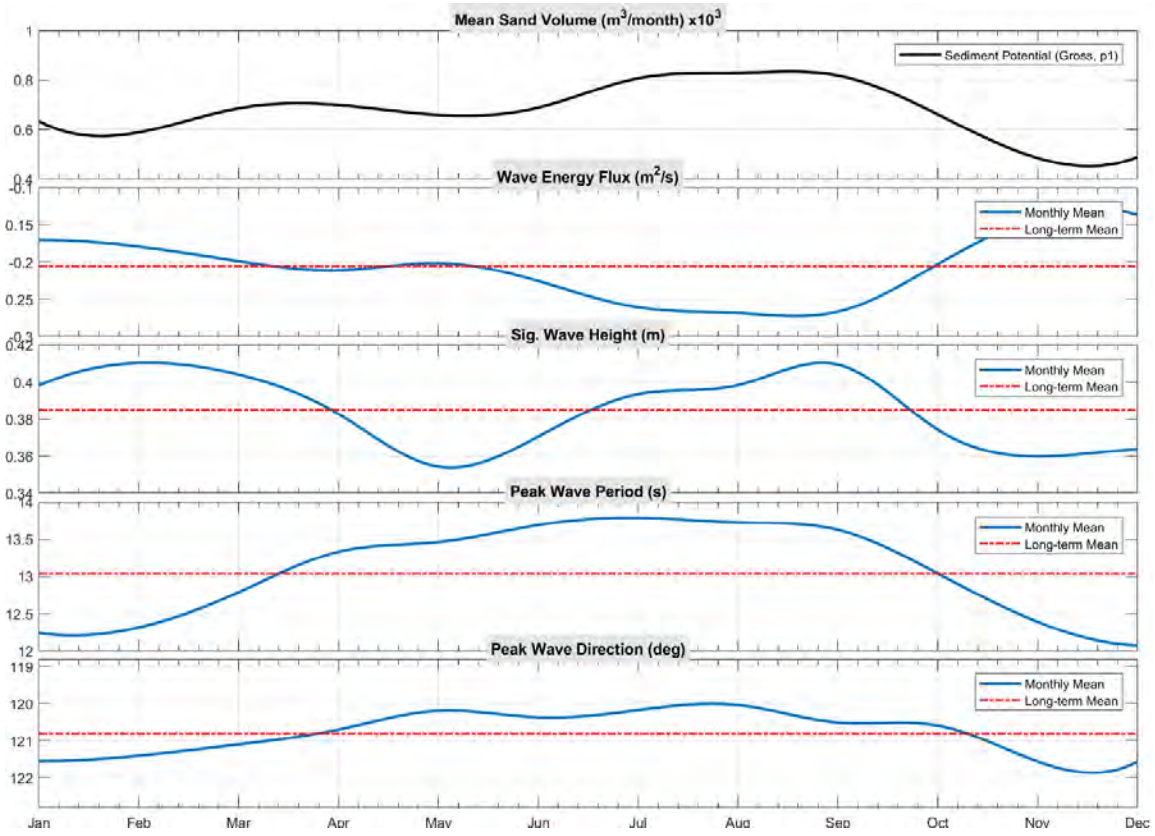


Figure 47: Mean longshore sediment transport potential at hindcast extraction point P1 after CERC (1984)

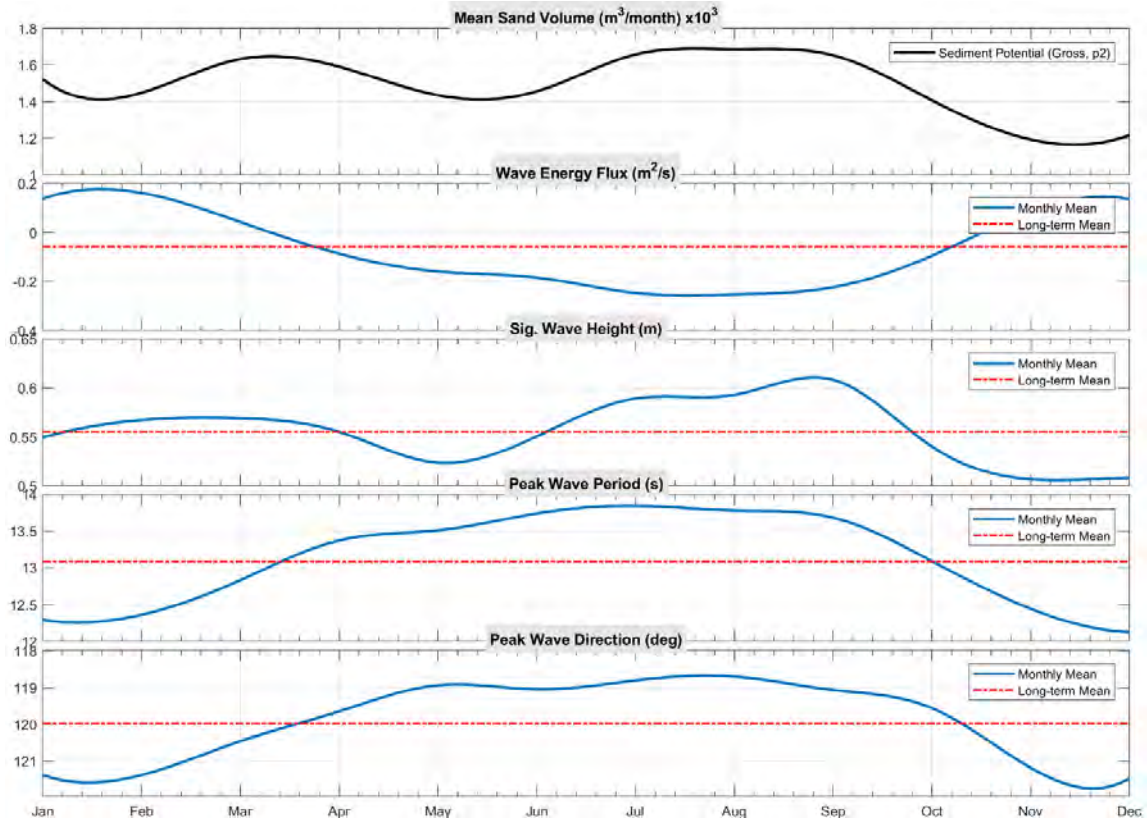


Figure 48: Mean longshore sediment transport potential at hindcast extraction point P2 after CERC (1984)

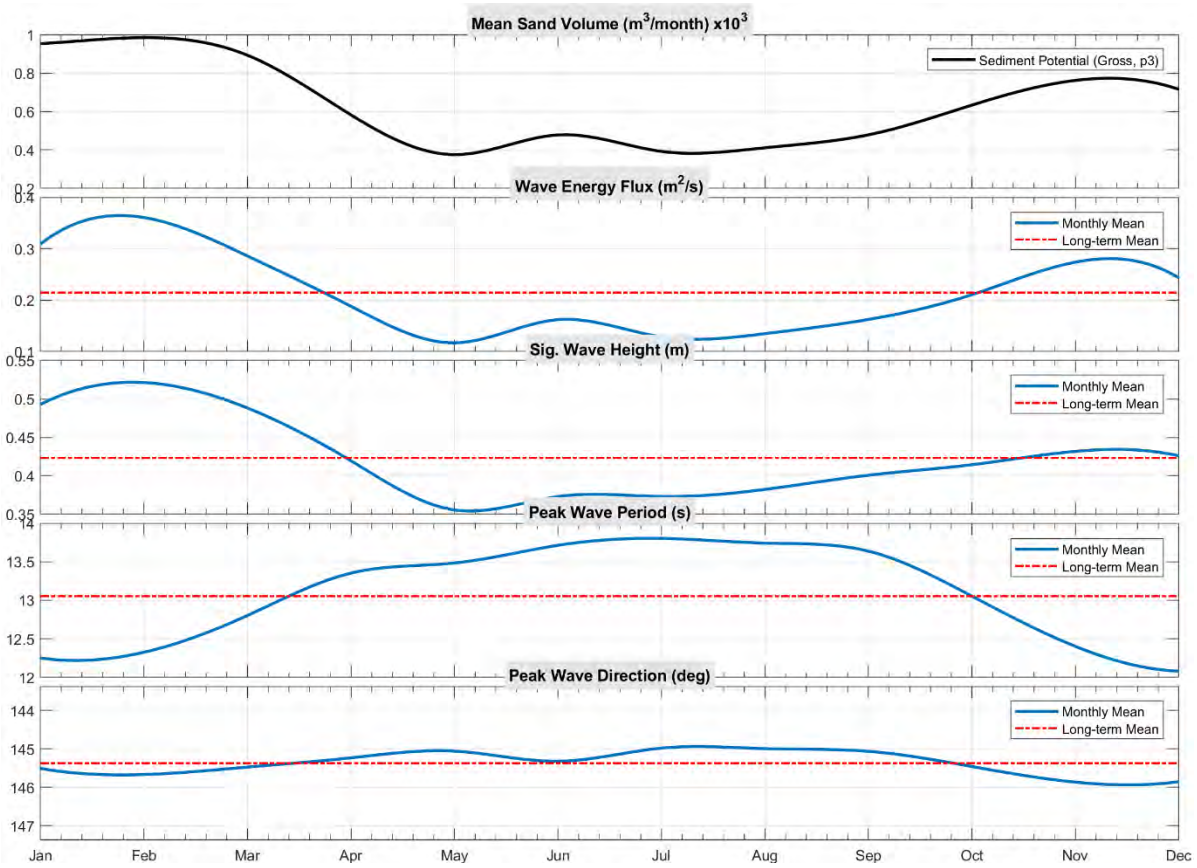


Figure 49: Mean longshore sediment transport potential at hindcast extraction point P3 after CERC (1984)

11.5. Performance review: geotextile synthetic container (GSC) groynes

In April 2014, the City installed two trial groynes to the west of the rock revetment at Emu Point. During construction, the area around the groynes was nourished with approximately 10,000m^3 of sand. The extent and layout of the trial GSC groynes can be seen in the as-constructed drawings in Figure 26. The groynes were installed as a trial to assess what the effect would be of a shore perpendicular structure with the aim of maintaining a beach in this area preserving the nourishment and to provide a natural buffer during storm events.

PRWD (2015c) and RHDHV (2017) undertook reviews of the groynes by comparing aerial photographs taken before and after the trial groynes were installed. The reviews showed the following:

- There was no indication of a major build-up of sand by the two groynes.
- There is evidence of minor erosion to the west of the groynes indicating net longshore transport direction is directed this way. Due to the magnitude of the erosion, this is believed to be small.
- There is evidence that the groynes have influenced the shape of the coastline with a measured 2° difference in coastline orientation around the groynes
- Sand is bypassing the end of the short trial groynes.

- There are indications that the erosion occurring prior to groyne installation has stabilised.

Following the PRWD (2015c) and RHDHV (2017) review of the trial GSC groynes, further performance review work is set out herein. The performance review is aimed at assessing the structures' ability to retaining sand and utilises the latest beach monitoring data. Figure 51 to Figure 53 shows the seaward location of different aerial beach contours (0m, 1m, 2m AHD) from a static landward control point along beach transects MB-07, MB-08 and MB-09. Table 10 summarises the horizontal movement seaward (indicating accretion) or landward (erosion) of the three transect lines on Emu Beach as well as two adjacent transects to the west (MB-05 and MB-06). The horizontal movement has been calculated by finding the difference between the location of each contour prior to the implementation of the GSC trial groynes (October 2013) and the mean location of each contour following construction (April 2014 to August 2020).

A major storm event occurred in August 2020 causing significant erosion across all transects. This event was thought to have skewed the mean contour locations (since April 2014), so a sensitivity test was undertaken whereby this event was removed when calculating mean contour location. The sensitivity test showed a maximum difference in mean contour location of 0.4m across all transects and contours and as such this data point has been left in the calculation of the mean contour locations post-GSC implementation. The following key findings have been inferred from the analysis:

- An erosive trend across all transects was seen to have occurred between January 2015 to January 2018. A subsequent accretionary can be seen to follow this until the storm event of August 2020.
- MB-08, the eastern most transect, is seen to experience erosion or landward movement of all aerial beach contours examined since October 2013.
- The highest erosion that can be seen across all transects is a 20m landward movement of the 2m AHD contour along MB-08. It is expected that this may also be caused by the end-effects associated with the rock revetment.
- MB-07, has seen relative stability in the 2m contour, whilst the 0m and 1m contours show seasonal trends with accretion happening following the winter months and erosion at the end of Summer. The 0m and 1m has shown a net recession over the monitoring period.
- MB-05, the most western transect (located in the Middleton Beach sediment cell) has shown net accretion.
- MB-06, which may be more representative of the trial GSC groyne site (or status quo), has shown relative stability since the trial GSC groynes were implemented, with only small variations in movement of the contours.
- Net sediment transport trends were estimated by calculating the landward or seaward movement of the 1m contour at each transect between successive transect surveys. An approximate m^3/m value was determined by calculating the area between successive transects.
- Between 2013 and 2014 (when the GSC groynes were constructed) there was seen to be an average loss of -2.5 m^3/m between MB-06 and MB-07, equating to an approximate 750m^3 above the 300m stretch of beach.

- Following implementation of the groynes (2014 to 2019) there has seen a net average accretion of around +0.2 m^3/m over the 780m stretch between MB-05 and MB-08 or approximately 156 m^3. Conversely in the 2020 event the same stretch was seen to experience a net erosion of 195 m^3.

The most stable transect in the analysis is seen to be MB-09 which is located between the two trial GSC groynes. All contours have retained their seaward position even during the storm event of August 2020. The long-term comparison shows a slight widening of the subaerial beach (i.e., seaward movement). Whereas the two directly adjacent transects (MB-07, MB-08) have shown net recession. The stability of the subaerial beach between the two groynes provides evidence of their efficiency and is most likely related to the short distance between the two groynes.

Both condition assessments of the GSC groynes has shown deterioration which has resulted in repair and replacement of individual units. The original design intention of the groynes as "trial" structures has now passed, with the impact on the coastline being understood from the coastal monitoring program. It is recommended that a groyne field in this current location be upgraded to ensure coastal adaptation requirements are met for at least 50 years. This should be done by assessing the most suitable layout (size and orientation) and number of structures required and to upgrade the GSCs to suitably sized, locally sourced granite boulders.

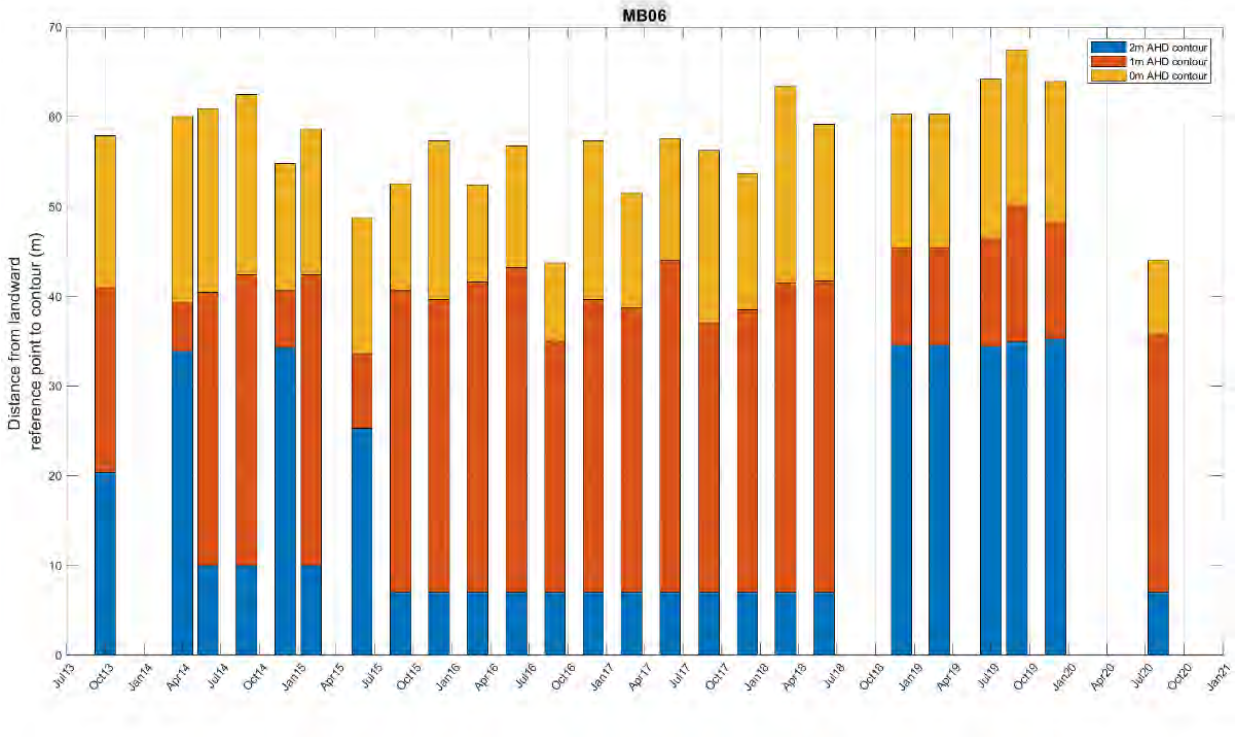


Figure 50: Seaward location of different aerial beach contours (0m, 1m, 2m AHD) from a static landward control point along beach transect MB-06.

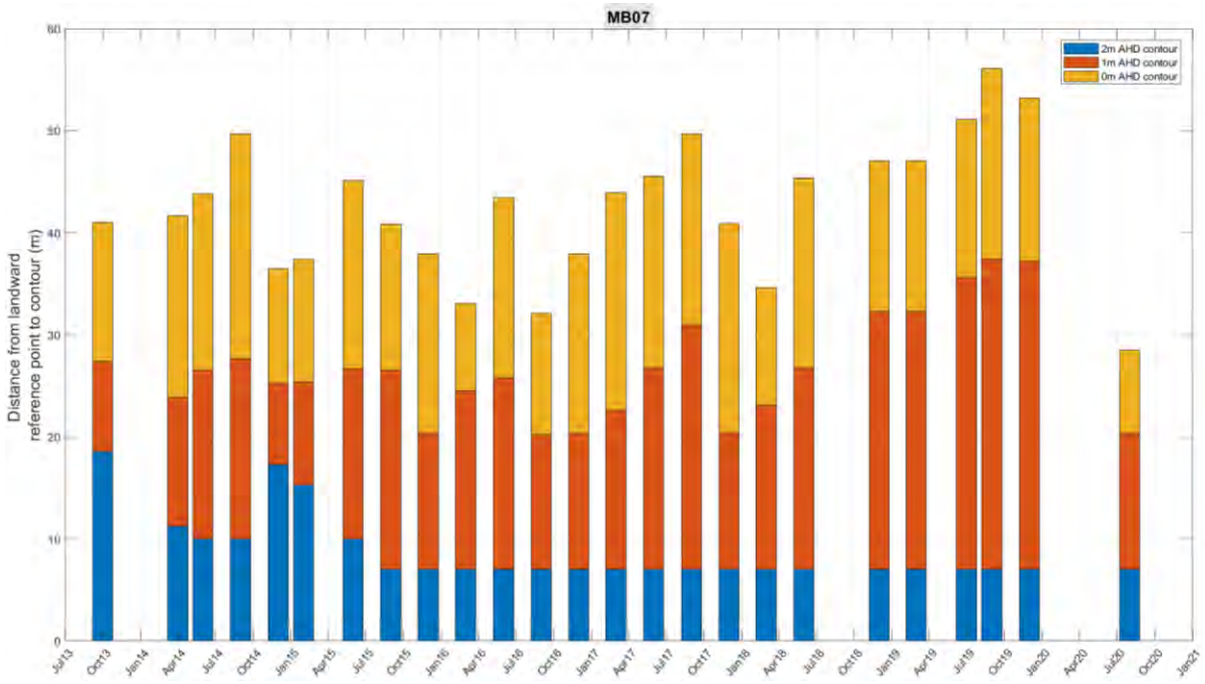


Figure 51: Seaward location of different aerial beach contours (0m, 1m, 2m AHD) from a static landward control point along beach transect MB-07.

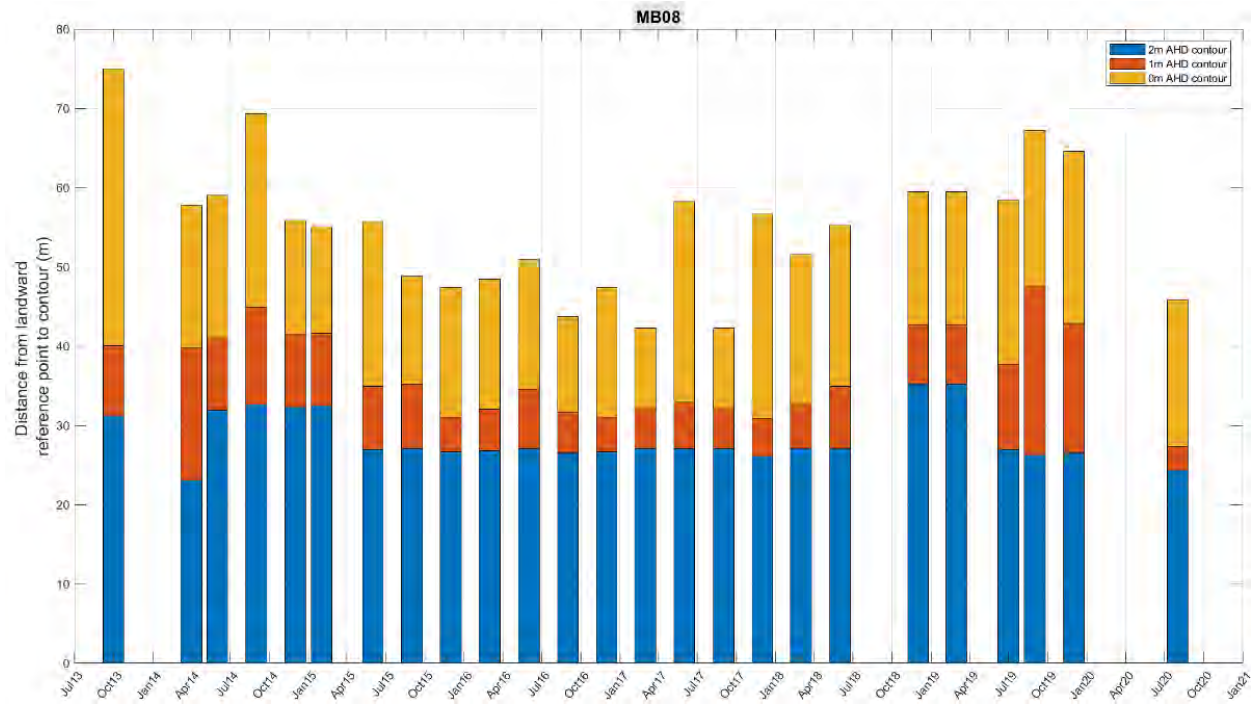


Figure 52: Seaward location of different aerial beach contours (0m, 1m, 2m AHD) from a static landward control point along beach transect MB-08.

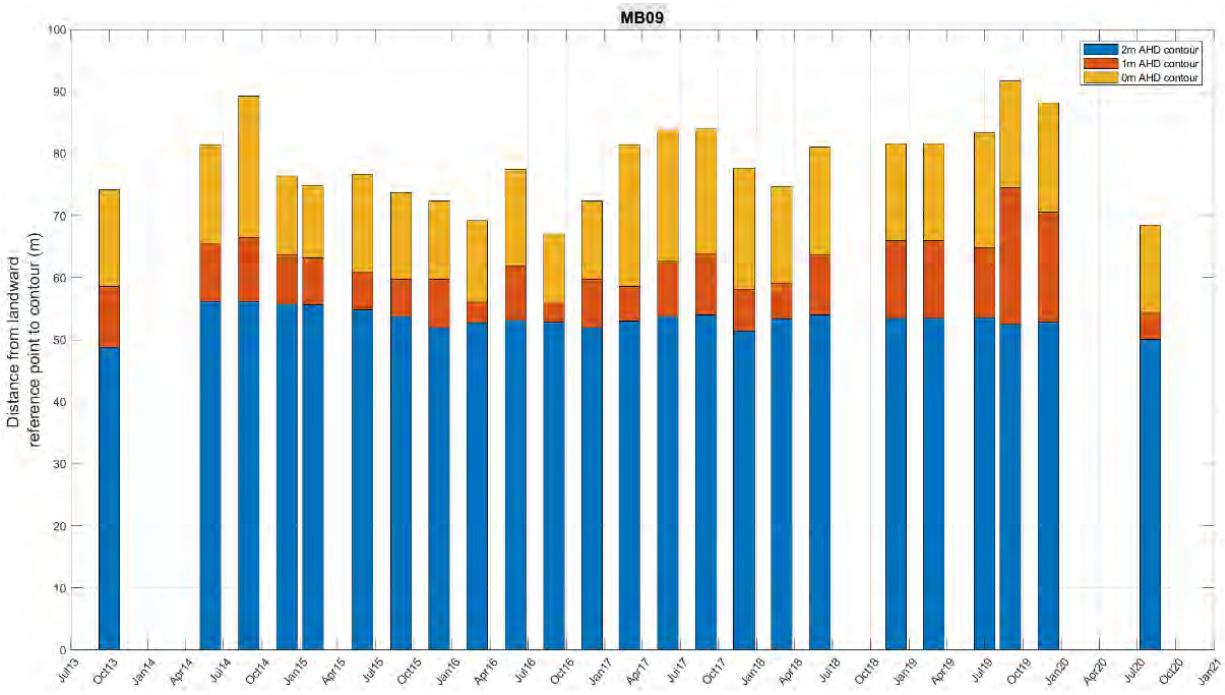


Figure 53: Seaward location of different aerial beach contours (0m, 1m, 2m AHD) from a static landward control point along beach transect MB-09.

Table 10: Horizontal movement of mean 0m, 1m, 2m AHD contour locations compared to contour locations prior to the construction of the trial GSC groynes and nourishment in April 2014, reference map below.

Transect (East-West)	Horizontal movement of mean contour location post GSC trial groynes (m) -ve is erosion, +ve is accretion		
	2m AHD contour	1m AHD contour	0m AHD contour (shoreline)
MB-05	1.1	3.2	13.8
MB-06	-0.9	0.4	-4.2
MB-07	1.6	-0.7	-10.2
MB-09	4.5	3.8	4.7
MB-08	-20.8	-3.5	-3

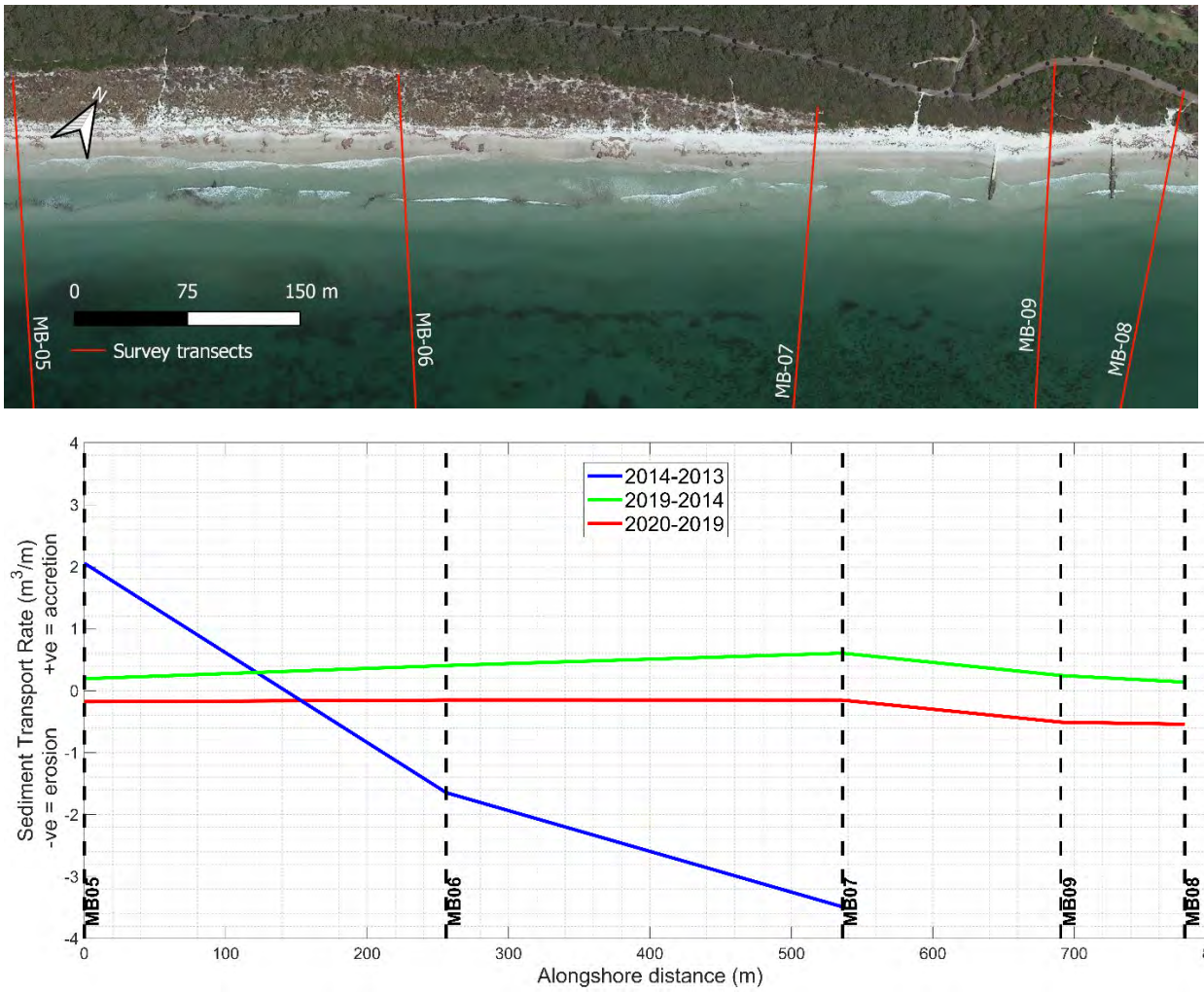


Figure 54: Sediment transport rates (m^3/m) between MB-05 and MB-08 for the periods 2013 to 2014, 2014 to 2019 and 2019 to 2020. Note: erosion is negative.

11.6. Performance review: sand nourishment

In April 2014, CoA installed two trial groynes to the west of the rock revetment at Emu Point. During construction, the area around the groynes was nourished with approximately 10,000m^3 of sand trucked from Ellen Cove. Subsequent nourishment of Emu Point has only been undertaken to replace lost and damaged GSC's:

- In 2016, sand was imported from an external (unknown) source to fill replacement GSCs at a cost of $15,616 (quantity unknown)
- In 2017, sand was imported from an external (unknown) source to fill replacement GSCs at a cost of $31,825 (quantity unknown)

The previous section showed the stability of the beach between the two GSC groynes since their construction. The exact volume of nourishment delivered to this section of the beach is unknown. However, from the City-supplied construction drawings of the GSC groynes (Figure 55) the proportion of fill area between the two GSC groynes (and the upper beach) accounts for approximately 34% of the nourished area in the design. This equates to approximately 3,400m3

of sand which has been successfully maintained between the groynes over the 7 years since construction.

Figure 55: Geotextile and container groyne construction drawings, 07 April 2014 (Source: City of Albany)

11.7. Performance review: rock revetment

A condition assessment was undertaken to inform the FMP of the rock revetment structures at Emu Point and is provided in Appendix A. The condition assessment builds on the previous assessment undertaken by EvoCoast in 2017. Both assessments showed the revetment to be in a generally poor condition, posing a safety hazard to public access. The structures, however, were seen to still be operative and performing their coastal protection functionality.

The central section of the rock revetment built in 2007 was designed to have a 50-year design life and although are in poor condition have had no reported maintenance undertaken in the 13 years since construction. Over-topping events have also not been reported and there has been no evidence of undermining of the structure toe due to scour or failure of the structure. The poor quality of the structure detailed in the two condition assessments is primarily associated with the degradation of the laterite rock used for construction. It is recommended that any upgrades to the rock structures at Emu Point utilise local granite not only for the increased durability of this material, but also the higher density resulting in smaller rock sizes, as well as the general aesthetics and ability to blend with surrounding areas.

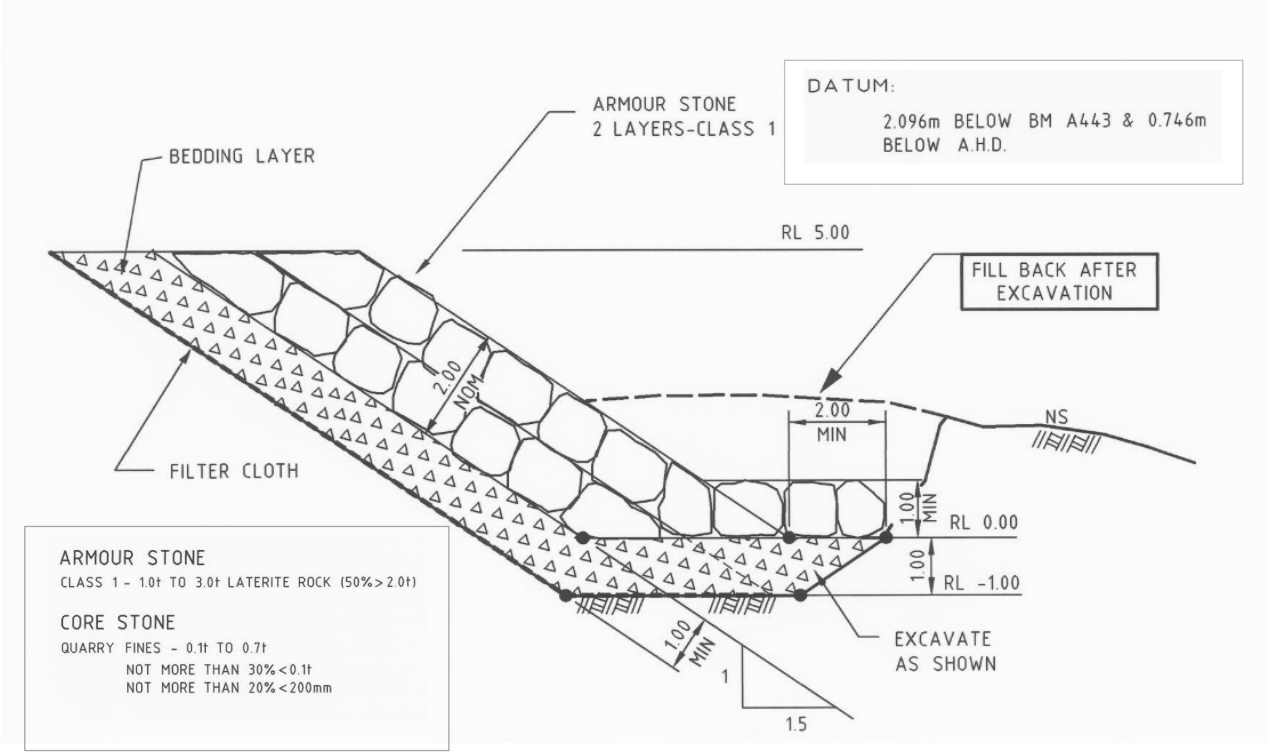


Figure 56: Emu Point Foreshore stabilisation revetment typical cross-section, May 2007 (Source: DoT, DWG 452-12-2)

Appendix C
Long-term management plan

APPENDIX C: LONG-TERM MANAGEMENT PLAN

Table C-1: Life cycle and cost of foreshore assets

Asset type	Structural lifespan	Asset value (excl. GST)	Low/ med/ high value	Key maintenance milestones and costings	Proposed location (refer to foreshore concept plan)	Proximity to coastal vulnerability (years)	Adaptation plan (i.e. asset will be relocated to location × in approximately 25–30 years)
Paving types							
Exposed aggregate concrete paving	35 years	$190,000	Med	High pressure clean and replace cracked/heaved panels every five years ($10,000)	As shown	100+	
Unit paving – feature plaza	35 years	$150,000	Med	High pressure clean and replace cracked/heaved panels every five years ($5,000)	As shown	100+	
Unit paving – trafficable car park/shared space	35 years	$225,000	Med	High pressure clean and replace cracked/heaved panels every five years ($5,000)	As shown	100+	
Dual use path red asphalt (3 m)	25 years	$500,000	High	High pressure clean and resurface cracked pavement every five years ($5,000)	As shown		Asset will be reinstated/ relocated as required following severe erosion events
Interpretive banding paving and TGSIs	35 years	$10,000	Med	Replace cracked/heaved panels every five years ($1,000)	As shown	100+	
Broomed concrete paving	35 years	$100,000	Low	High pressure clean and replace cracked/ heaved panels every five years ($4,000)	As shown	100+	
Stabilised gravel coastal paths	5 years	$85,000	Low	Infill all holes and stabilise loose surfaces every year (one year) ($4,000)	As shown	100+	
Decking (composite fishing platform)	25 years	$175,000	High	High pressure clean and replace boards as required. Oil every two years ($8,000)	As shown	100+	
Play surface sand	1 year	$5,000	Low	Replenish and sift every six months ($600)	As shown	100+	
Play surface rubber	5 years	$45,000	Med	High pressure clean and repair cracks every five years ($1,000)	As shown	100+	
Wall, stairs and fences							
Local granite terrace retaining walls	50 years	$150,000	High	High pressure clean, graffiti coating and repair cracks every ten years ($1,300)	As shown	100+	
Dune revegetation fence	50 years	$55,000	Med	Remove marks as required ($100)	As shown	100+	
Concrete stairs	35 years	$25,000	Med	High pressure clean and replace cracked/ heaved panels every five years ($500)	As shown	100+	
Granite boulders	1000 years	$20,000	Med	Remove marks as required ($100)	As shown	100+	
Furniture / facilities							
Picnic tables	20 years	$255,000	Med	Remove marks annually ($500)			
Bench seats	10 years	$60,000	Med	Remove marks annually ($500)	As shown	100+	
Bike racks	20 years	$20,000	Med	Remove marks annually ($500)	As shown	100+	
Beach shower and foot washer	10 years	$35,000	High	Remove sand fortnightly and repair plumbing as required ($200) to manufacturer's warranty and specification	As shown	100+	
Drinking fountains	20 years	$35,000	High	Remove marks annually and repair plumbing as required ($500) to manufacturer's warranty and specification. Same as product used in town square development, with integrated dog water bowl.	As shown	100+	
Rubbish bins	20 years	$60,000	Med	Remove marks annually ($500)	As shown	100+	
Bollards	30 years	$6,000	Med	Remove marks annually and repair as required ($500)	As shown	100+	
Shelter	30 years	$350,000	High	Repair and oil timberwork and paint steelwork annually ($1,500)	As shown	100+	
Barbecue – electrical	20 years	$160,000	High	Annual maintenance and repair as required ($500) to manufacturer's warranty and specification. Cleaning required weekly dependent on time of year and usage	As shown	100+	
Exercise equipment	20 years	$55,000	High	Annual maintenance and repair as required to manufacturer's warranty and specification	As shown	100+	
Playground and equipment	20 years	$850,000	High	Annual maintenance and repair as required to manufacturer's warranty and specification	As shown	100+	
Ablution block	20 years	$250,000	High	Annual maintenance and repair as required ($5,000)	As shown	100+	
Lighting – all energy efficient and products to be consistent with concurrent COA developments							
Park lights on poles	50 years	$190,000	High	Annual maintenance and repair as required to manufacturer's warranty and specification ($1,000)	As shown	100+	
Streetlights on poles	50 years	$300,000	High	Non-standard Western Power standard lighting to be on separate circuit for metered supply ($1,000)	As shown	100+	
Up-lighting	20 years	$100,000	High	Annual maintenance and repair as required to manufacturer's warranty and specification ($1,000)	As shown	100+	
Events power outlets	30 years	$50,000	High	Annual maintenance and repair as required to manufacturer's warranty and specification ($1,000)	As shown	100+	
Parklands							
Proposed tree 45L–1,000 L	200 years	$100,000	Med	Prune and stake annually ($5,000)	As shown	100+	

Asset type	Structural lifespan	Asset value (excl. GST)	Low/ med/ high value	Key maintenance milestones and costings	Proposed location (refer to foreshore concept plan)	Proximity to coastal vulnerability (years)	Adaptation plan (i.e. asset will be relocated to location × in approximately 25–30 years)
Roll-on turf	10 Years	$450,000	Med	Mowing fortnightly ($1,000), Easily accessible surrounds are preferable for mowing and maintenance	As shown	100+	
Mass planting	5 years	$300,000	Low	Weed control quarterly ($5,000)	As shown	100+	
Irrigation to parkland soft works (turf and planting)	5 years	$150,000	Med	Repair as required annually ($10,000)	Co-located with mass planting and turf areas. Rehabilitation areas would not be irrigated.	100+	
Mulching	1 year	$150,000	Low	Top up annually ($5,000)	As shown for planting areas	100+	
Rehabilitation planting	10 Years	$250,000	Med	Weed control quarterly ($5,000)	As shown	25+	Asset will be reinstated as required following severe erosion events
Subtotal		$5,911,000					
Coastal engineering							
Emu Point rock revetment	50 years	$3.5 million (does not include associated foreshore upgrade and infrastructure)	High	Annual coastal structures monitoring by the CoA – $1,000 per annum) Allowance for additional more detailed inspection of structures – $5,000 per decade Allowance for maintenance of rock armoured section at years 30 and 40 (~5% of capital cost for rock armoured section per occurrence) – $50,000 per occurrence	General alignment of current seawall with ‘smoothed’ sections where current ‘kinks’ occur	100+ years	Asset likely to require upgrades in the medium to longer term, with timing dependant upon the condition of the rock revetment
Emu Beach groyne field + nourishment	50 years	$2.03 million (high level estimate of material and construction costs)	High	Annual coastal structures monitoring by the CoA – $1,000 per annum) Allowance for additional more detailed inspection of structures – $5,000 per decade Allowance for maintenance of rock armoured section at years 30 and 40 (~5% of capital cost for rock armoured section per occurrence) – $50,000 per occurrence	Emu Beach where existing trial GSC groyne field is	25+ years	Asset will be constructed in the short term (0–5 years)
Oyster Harbour sand nourishment	5 years	$10,000 (high level estimate of material and scraping costs)	Med	Annual coastal monitoring by the CoA – $1,000 per annum for Oyster Harbour)	Eastern Oyster Harbour landward of swimming enclosure	25+ years	Will be undertaken in the short term (0–5 years)
Subtotal		$5,540,000					
Total		**$11,451,000**					

Appendix D
Weed control methods

APPENDIX D: WEED CONTROL METHODS

Table D-1: Approach to controlling weed species

Weed species	Control method		Optimal control time										
Scientific name	**Herbicide**	**Manual**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**
Carpobrotus edulis			Naturalised stabiliser (keep)											
Tetragonia decumbens			Naturalised stabiliser (keep)											
Asparagus aethiopicus	Spray 0.2 g metsulfuron methyl + Pulse® in 15 L water (or 2.5 - 5g/ha + Pulse®). Best results when flowering.								J	A				
Trachyandra divaricata	Wipe with 50% glyphosate solution before flowering. For dense infestations in degraded areas spot spray 0.4 g chlorosulfuron plus 25 ml wetting agent in 10 L of water when plants actively growing.	Manually remove isolated or small infestations prior to flowering.						J	J	A				
Conyza sumatrensis	Most susceptible to glyphosate at early development of rosette stage. Apply 25 ml/10L glyphosate after stem elongation and before flowering in late spring to summer each year when the plants are actively growing. A mixture of 50% glyphosate can be used to wipe the stems of plants. Lontrel® 4 g/10 L (200 g/ha) + wetting agent can be spot sprayed for fairly selective control.	Hand pulling of small and/or isolated infestations after stem elongation prior to seed set is effective on loose soils, but difficult on heavier soils. Mowing is ineffective.						J	J	A	S	O	N	
Senecio elegans	Apply Lontrel® at 10 ml/10 L + wetting agent before stem elongation in late spring.	Hand remove isolated/small populations.										O	N	
Sonchus asper	Apply Lontrel® at 10 ml/10 L + wetting agent preferably when plants are at the rosette stage.	Slashing is often ineffective as plants can continue producing flowers and seed. Remove small and/or isolated populations manually prior to seed set.						J	J					
Crassula glomerata	Cut down close to ground and then immediately paint stump with straight Roundup®.	Be careful to remove all pieces of plant, as fragments easily resprout.							J	A	S			
Euphorbia paralias	When actively growing, spray with 50 mL glyphosate (360 g/L) + 0.2 g metsulfuron + Pulse® in 10 L water.	Hand remove small isolated infestations, ensuring use of appropriate personal protective equipment and safety guidelines. Consider possible dune erosion.	J								S	O	N	D
Medicago polymorpha	Lontrel® at 10 ml/10 L + wetting agent provides effective control in early winter. Otherwise metsulfuron methyl 0.1 g/10 L + wetting agent or 1 g/10 L of Logran® applied in early winter provides reasonably selective control. Repeat annually for several years.	Relatively tolerant to glyphosate, grazing and mowing. Hand pull isolated plants in winter before flowering.						J	J	A				
Melilotus albus	2,4-D, MCPA, MCPB, 2,4-DB, dicamba, chlorsulfuron, clopyralid, triclopyr	Conn and Seefeldt (2009) suggest that a combination of a range of herbicides and non-chemical methods may be most effective in the long term.	J	F	M								N	D
Trifolium angustifolium	Spot spray with 1% glyphosate before flowering, otherwise spot spray Lontrel® 3 ml/10 L (150 ml/ha) up to the six leaf stage.								J	A	S			
Trifolium tomentosum	Spot spray with 1% glyphosate before flowering, otherwise spot spray Lontrel® 3 ml/10 L (150 ml/ha) up to six leaf stage.								J	A				
Pelargonium capitatum			Naturalised stabiliser (keep)											
Orobanche minor	Soil fumigation to kill seeds (methyl bromide or metham sodium) Selective control through very low rates of glyphosate applied to hosts, which concentrates in attached broomrapes. Selective control through growth of host crops with tolerance to Group B herbicides. Host denial through maintaining broadleaf weed free cereals, grass pastures.						J	J	A	S	O	N		
Ehrharta longiflora	Alternatively spray with Fusilade Forte® 30 ml/10 L or 1.6 L/ha (based on 500 L water/ha) + wetting agent or for generic fluazifop-p (212 g/L active ingredient) 18 ml/10 L or 1 L/ha + wetting agent before flowering stem emerges, or at 3–5 leaf stage. Secondary seedling flush often occurs, repeat treatment if necessary.	Hand remove small infestations.								A	S	O		
Ehrharta villosa	Spray with Verdict 520® 10 ml/10 L (500 ml/ha) or glyphosate 1% + penetrant. Several sequential applications will likely be required.		J	F	M	A						O	N	D
Lagurus ovatus	In selective situations spray with 16 ml/10 L (800 ml/ha) Fusilade® Forte + spray oil or for generic fluazifop-p (212 g/L active ingredient) 10 ml/10 L or 500 ml/ha + spray oil any time before flowering. A lower rate of 13 ml/10 L Fusilade® Forte or for generic fluazifop-p (212 g/L active ingredient) 8ml/10 L can be used in winter at the 2–8 leaf stage before stem elongation.	Prevent seed set. Hand remove small isolated infestations.						J	J	A				
Lolium rigidum	Spray with grass selective herbicide such as Fusilade® Forte in winter 4–6 weeks after opening rains. For larger plants up to flowering, increase rates of grass selective herbicide three to four fold. In agricultural areas, populations may be resistant to these herbicides and glyphosate may be needed. Spray 10 ml/10 L glyphosate when plants are vegetative up to when seed heads are emerging. Late season applications of herbicide can reduce the numbers of seeds produced, viability and seedling fitness.	Prevent seed set. Hand pull.						J	J	A	S	O		
Dischisma arenarium	Spot spray 0.2% glyphosate.								J	A	S			
Spinifex sericeus			Naturalised stabiliser (keep)											
Ammophila arenaria	Spray with 1% glyphosate + penetrant. Grass selective herbicides are less effective. Requires ongoing manual removal and/or treatment of regrowth. Fire may provide an effective window for control, as it removes thatch and stimulates regrowth, creating ideal conditions for effective herbicide uptake.	Dig out small infestations. Consider staggering removal to manage erosion and allow native species to re-establish.									S	O	N	
Cakile maritima	Fairly selective control can be achieved by spot spraying Logran® at 0.5 g/10 L. Wick application with 50% glyphosate or foliar spraying with 1% glyphosate provides reasonable control and can be used at flowering to reduce seed set.	Assess carefully whether it is displacing native taxa or possibly having other impacts at the site prior to considering any control program. Manual removal is effective but must be done at least every eight to ten weeks. Ensure material is removed off site, as once pods are formed, seed will often mature if plants have been uprooted.						J	J	A	S	O	N	
Arctotheca calendula	For large infestations apply Lontrel® 6 ml/10 L (300 ml/ha) in early growth stages. Glyphosate at 0.2% will provide some selective control if the plants are young or at the budding stage, otherwise spot spraying glyphosate at 10 ml/L will control capeweed at all growth stages.	Chip out small infestations, ensuring root is severed well below ground level to prevent re-sprouting from the crown. A combination of chemical and physical control with follow up treatment provides optimal control.						J	J	A	S	O	N	

Appendix E
Revegetation species

APPENDIX E: REVEGETATION SPECIES

Table E-1: Beach herbland / grassland revegetation species

Life form	Scientific name
Beach grasses and herbaceous species adopted for the most exposed locations	
Shrub <3 m	*Leucopogon parviflorus*
Shrub <3 m	*Atriplex isatidea*
Shrub <3 m	*Rhagodia baccata*
Shrub <3 m	*Scaevola nitida*
Sedge/ rush	*Ficinia nodosa*
Herb	*Carpobrotus virescens*
Herb	*Tetragonia implexicoma*
Herb	*Tetragonia tetragonoides*
Herb	*Lyginia barbata*
Semi-stable dune colonisers adapted to partially protected	
Shrub <5 m	*Acacia cyclops*
Shrub <5 m	*Spyridium globulosum*
Shrub <3 m	*Olearia axillaris*
Shrub <3 m	*Allocasuarina humilis*
Shrub <3 m	*Leucopogon parviflorus*
Shrub <3 m	*Atriplex isatidea*
Shrub <3 m	*Rhagodia baccata*
Shrub <3 m	*Hibbertia furfuracea*
Shrub <3 m	*Acacia cochlearis*
Shrub <3 m	*Acacia littorea*
Shrub <3 m	*Scaevola nitida*
Shrub <1 m	*Dampiera fasciculata*
Shrub <1 m	*Opercularia hispidula*
Sedge/ rush	*Ficinia nodosa*
Sedge/ rush	*Lepidosperma gladiatum*
Herb	*Carpobrotus virescens*
Herb	*Tetragonia implexicoma*
Herb	*Tetragonia tetragonoides*
Herb	*Lyginia barbata*
Set back / less-exposed dune situations and swales	
Tree	*Agonis flexuosa*
Shrub <3 m	*Olearia axillaris*
Shrub <3 m	*Allocasuarina humilis*
Shrub <3 m	*Hibbertia cuneiformis*
Shrub <3 m	*Hibbertia furfuracea*
Shrub <3 m	*Acacia cochlearis*
Shrub <3 m	*Acacia littorea*
Shrub <1 m	*Chorizema ilicifolium*
Shrub <1 m	*Eutaxia parvifolia*
Shrub <1 m	*Gompholobium tomentosum*
Shrub <1 m	*Dampiera fasciculata*
Shrub <1 m	*Opercularia hispidula*
Sedge/ rush	*Ficinia nodosa*
Sedge/ rush	*Lepidosperma gladiatum*
Climber	*Billardiera fusiformis*
Herb	*Lyginia barbata*