REPORT TYPE: FINAL

Adapt West – Shaping our Shores: Ecological Values Assessment

DEECA

17th July 2025

Artwork by Melissa Barton. This piece was commissioned by Alluvium and tells our story of caring for Country, through different forms of waterbodies, from creeklines to coastlines. The artwork depicts people linked by journey lines, sharing stories, understanding and learning to care for country and the waterways within

This report has been prepared by
EcoFutures Consulting Australia Pty Ltd for Department of Energy, Environment and Climate Action (DEECA) under the contract titled 'Port Phillip Bay western shoreline Regional and Strategic Partnership - Assessment of ecological values (RFQ Number: T2024-0175)'.

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Cover image:	Lagoon at Avalon Coastal Reserve and Saltmarsh near the Melbourne Water Western Treatment Plant (WTP) (EcoFutures)

Alluvium recognises and acknowledges the unique relationship and deep connection to Country shared by Aboriginal and Torres Strait Islander people, as First Peoples and Traditional Owners of Australia. We pay our respects to their Cultures, Country and Elders past and present.

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1 Introduction

1.1 Project overview

EcoFutures Consulting Pty Ltd (EcoFutures) were engaged by the Department of Energy, Environment and Climate Action (DEECA) to undertake an ecological values assessment of the western shoreline of Port Phillip Bay which was comprised of assessing indicative vulnerabilities of ecological values under coastal hazards impacts. This project forms part of Stage 2 of the *Adapt West – Shaping our Shores* project.

1.1.1 Adapt West – Shaping our Shores

Regional and Strategic Partnerships (RaSPs) are a tool of the *Marine and Coastal Act 2018*, created to bring rightsholders and stakeholders together as partners to act on regionally significant issues. The Port Phillip Bay western shoreline RaSP was established between ten partners. It provides a forum for partners to collaborate, share knowledge, and strategically plan for the future. *Adapt West – Shaping Our Shores* is the project being delivered by the Port Phillip Bay western shoreline RaSP. The Port Phillip Bay western shoreline RaSP has been created to:

- respond to climate change and coastal hazard impacts on the marine and coastal values of the Port Phillip Bay western shoreline.
- develop an overarching Coastal Hazard Adaptation and Resilience Plan (CHARP).
- strengthen relationships and partnerships amongst key rightsholders and stakeholders.

The CHARP will direct a coordinated response to coastal hazard impacts for the region that cuts across jurisdictional boundaries. By 2026, the plan seeks to establish shared priorities, funding, and management roles to progress adaptation. This ensures sustainable decision-making and protection of the region's unique ecosystems and communities. The program follows the framework set out in the *Victoria's Resilient Coast – Adapting for 2100+* framework and guidelines ('VRC framework'). This study was undertaken as part of Stage 2: Values, vision and objectives of the VRC framework.

1.1.2 Study area

From Greenwich Reserve in Newport to the Hovells Creek Estuary at Limeburners Bay in Corio, the study area covers nearly 85 km of the Port Phillip Bay western shoreline (Figure 1). The area has one of the fastest growing populations in Victoria and extends across three local government areas (LGAs) from the City of Hobsons Bay in Melbourne's south-western suburbs, continuing south-west through the City of Wyndham, and extending into the north-eastern portion of the City of Greater Geelong. It covers land governed by Parks Victoria, DEECA, Melbourne Water and private landholders.

Approximately 16,000 hectares of the study area are covered under the *Port Phillip Bay (western shoreline) and Bellarine Peninsula Ramsar Site* and wetlands listed under the Directory of Important Wetlands in Australia (DIWA). The study area supports internationally significant ecosystems ranging from woodlands, freshwater systems, estuaries and coastal wetlands, intertidal shorelines, seagrass and sub-tidal beds.

Major watercourses within the study area enter the Bay, including the Yarra River mouth at Newport, Kororoit Creek between Williamstown and Altona, Cherry Creek and Laverton Creek in Altona, Skeleton Creek at Cheetham Wetlands, the Werribee River, Little River at the Western Treatment Plant, and Hovells Creek, which flows into Limeburners Bay.

The marine environment that abuts the rocky shores and intertidal sandy beaches of the western side of Port Phillip Bay includes seagrass beds, large areas of macroalgae, and subtidal rocky reefs. There are two marine protected areas within the study area: Point Cooke Marine Sanctuary (290 ha), where mud and sand beaches and basalt reefs provide habitat for many species, and Jawbone Marine Sanctuary (30 ha), which in addition to containing basalt reef, seagrass beds, and saltmarsh, also contains the largest extent of mangroves in the Bay.

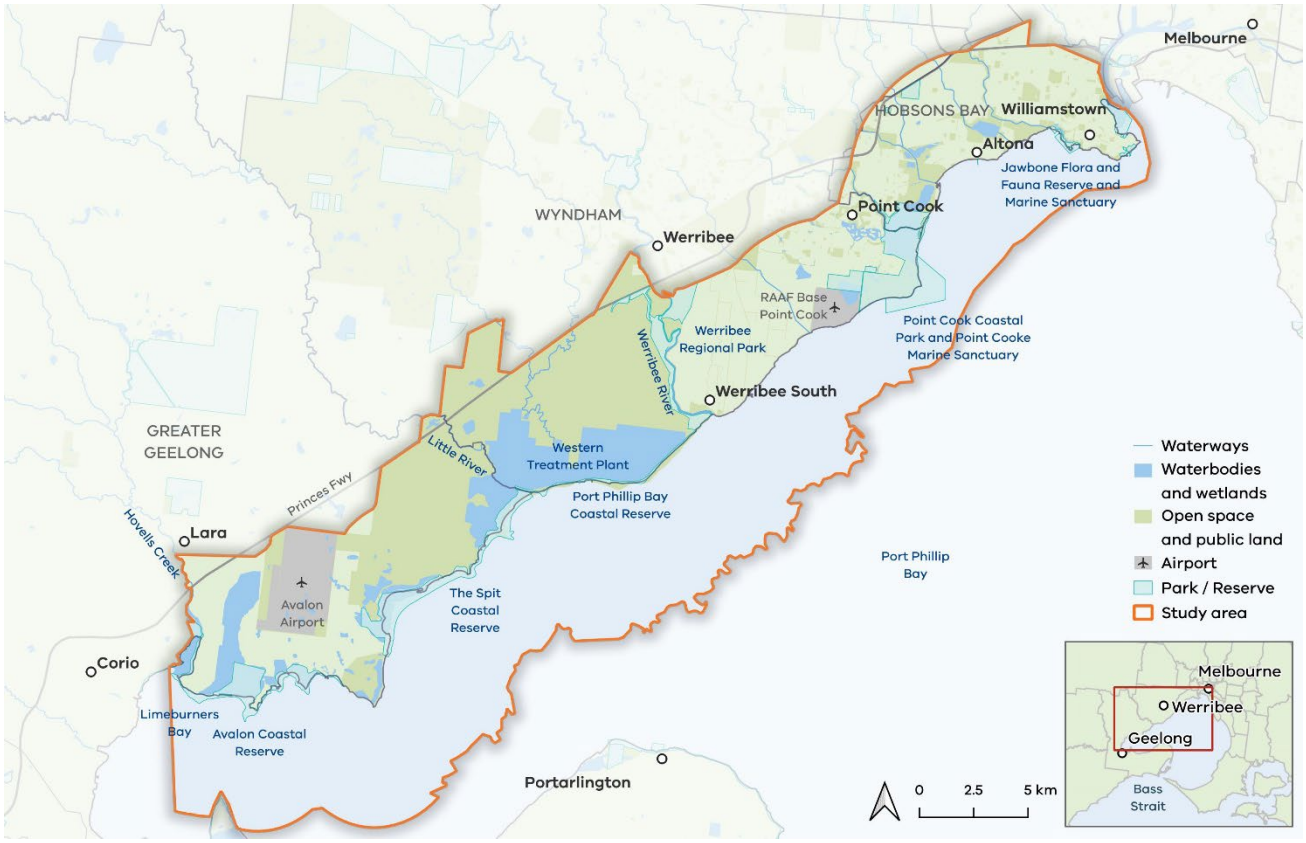


Figure 1. Study area (Source: DEECA)

1.1.3 Project purpose and objectives

The purpose of this project is to provide an ecological values assessment for the marine and coastal environment of the Port Phillip Bay western shoreline (the *Adapt West – Shaping Our Shores* study area), suitable for informing coastal hazard adaptation planning by the RaSP.

The aim of this project is to:

- Conduct a desktop review of ecological values captured in existing studies, monitoring activities and datasets conducted by several agencies (for example Parks Victoria and Melbourne Water).
- Collate and organise ecological values information and spatial data in key themes.
- Provide an indicative vulnerability assessment of ecological values to coastal hazard impacts, including erosion, inundation and groundwater. This will inform vulnerability and risk assessment stages of adaptation planning outlined in the *Victoria's Resilient Coast – Adapting to 2100+* (VRC framework).

This ecological values assessment follows the requirements and guidance set out in the VRC framework, *Marine and Coastal Act 2018*, and Marine and Coastal Policy 2020.

1.1.4 Scope of this project

The project focuses on the ecological values and ecosystems within the study area extent. It draws upon publicly available information and any existing internal datasets provided by Melbourne Water and DEECA. The project considers the broad landscape beyond the study area extent to identify vulnerability levels of the ecological values.

1.2 Project engagement

The project engaged with the RaSP Project Working Group (PWG) and Specialist Advisory Group (SAG) to provide feedback and direction on the scope and method of the work and key milestones throughout the project. The RaSP Project Working Group consists of representatives from the ten partners (Table 1). The Specialist Advisory Group (SAG) consisted of Danny Rogers from Arthur Rylah Institute (ARI) and Chris Purnell from BirdLife Australia who have deep ecological knowledge for the Port Phillip Bay western shoreline. They provided expert advice on the ecosystem habitat and vulnerability assessment through two workshops conducted in October 2024.

Table 1. Port Phillip Bay western shoreline RaSP partners

RaSP partner		Reason for selection
VICTORIA State Government | Energy, Environment and Climate Action	*Department of Energy, Environment and Climate Action (DEECA)*	Lead partner agency, asset and land manager and lead department for the *Victoria's Resilient Coast – Adapting to 2100+* program.
Bunurong Land Council Aboriginal Corporation	*Bunurong Land Council Aboriginal Corporation (BLCAC)*	Registered Aboriginal Party representing Bunurong community and protecting cultural and heritage values for the Sea Country of eastern Port Phillip Bay, across west to the Werribee River.
Wadawurrung Traditional Owners Aboriginal Corporation	*Wadawurrung Traditional Owners Aboriginal Corporation (WTOAC)*	Registered Aboriginal Party representing Wadawurrung community and protecting cultural and heritage values for Sea Country from the Werribee River to Limeburners Bay and beyond.
HOBSONS BAY CITY COUNCIL	*Hobsons Bay City Council (HBCC)*	Local Government authority and land manager for coastal areas from Spotswood to Altona Meadows.
wyndhamcity city. coast. country	*Wyndham City Council (WCC)*	Local Government authority and land manager for coastal areas from Sanctuary Lakes / Point Cook to Little River.
CITY OF GREATER GEELONG	*City of Greater Geelong (CoGG)*	Local Government authority and land manager for coastal areas from Little River to Limeburners Bay and beyond.
CORANGAMITE CMA	*Corangamite Catchment Management Authority (CCMA)*	Agency with responsibilities for catchment and floodplain management of that part of the RaSP within its region.
Melbourne Water	*Melbourne Water (MW)*	Agency with responsibilities for stormwater & wastewater infrastructure (including the Western Treatment Plant), inland waterways, catchment and floodplain planning and advice.
Parks VICTORIA	*Parks Victoria (PV)*	Local manager for land and marine parks and reserves.
VICTORIA State Government | Department of Transport and Planning	*Department of Transport and Planning (DTP)**	State government department responsible for key transport, planning, land, precinct and policy functions within a single department to create thriving places and connected communities.

*DTP joined the RaSP as a partner in August 2024.

2 Project approach

Two distinct stages to the project were completed (Figure 2):

1. Data collation, identification and classification of ecological themes (details in Sections 2 and 3)
2. Vulnerability assessment (details in Section 4)

The processing steps to undertake the classification of ecological themes and vulnerability assessments are described in Sections 2 and 4.

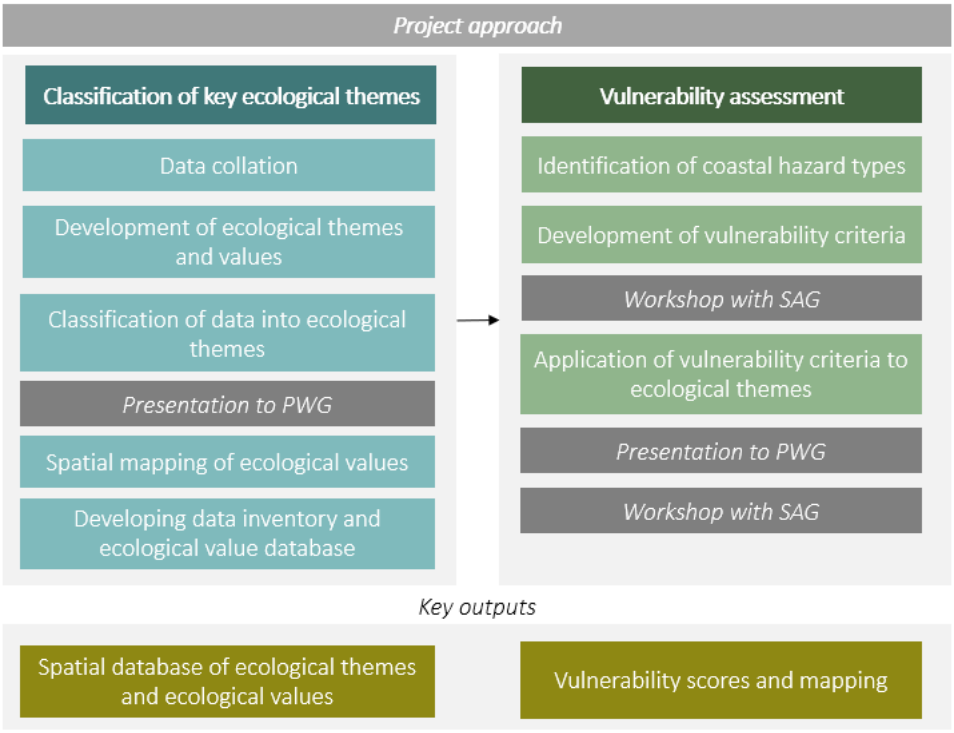


Figure 2. Project approach

A key output of this project is the spatial database of ecological themes and values, including the hazard vulnerability details. These datasets will form a part of upcoming technical work, as part of coastal hazard adaptation planning for the Adapt West project – especially the vulnerability and risk (Stage 4) and adaptation pathways planning (Stage 5) assessments. See Section 5 for the list of spatial outputs from this project.

2.1 Data gathering and filtering

A comprehensive data set, including environmental habitats and species distributions, is essential to understand ecological values and conduct further assessments, such as risk and vulnerability.

To inform the vulnerability assessment, we gathered a suite of spatial data from a wide range of ecological datasets (e.g., species observations, distribution modelling, ecological vegetation classes, and Marine Areas) from various sources. This included statewide publicly available data from DEECA and NatureKit as well as Melbourne Water, literature, surveys, and expert knowledge.

We reviewed and analysed 52 spatial datasets and 17 ecological / management reports (See Appendix A, Table 32 and Table 33). Quality assurances and quality controls were conducted on all spatial datasets to understand the quality, spatial coverage and suitability of the data. These measures were implemented to prepare for the vulnerability assessment and ensure the data were analysed and reviewed systematically.

We found that many spatial datasets overlapped. We prioritised those which were more recently produced, had higher resolution, and/or offered greater coverage for inclusion in the assessment. The selected spatial datasets were filtered, then split based on the habitat characteristics of their attributes, and subsequently grouped to form Habitat layers and Broad Conservation Group layers (Section 3) for evaluation in the vulnerability assessment (Section 4).

Detailed information on the data used in the analysis as well as quality assurances and controls can be found in Appendix A.

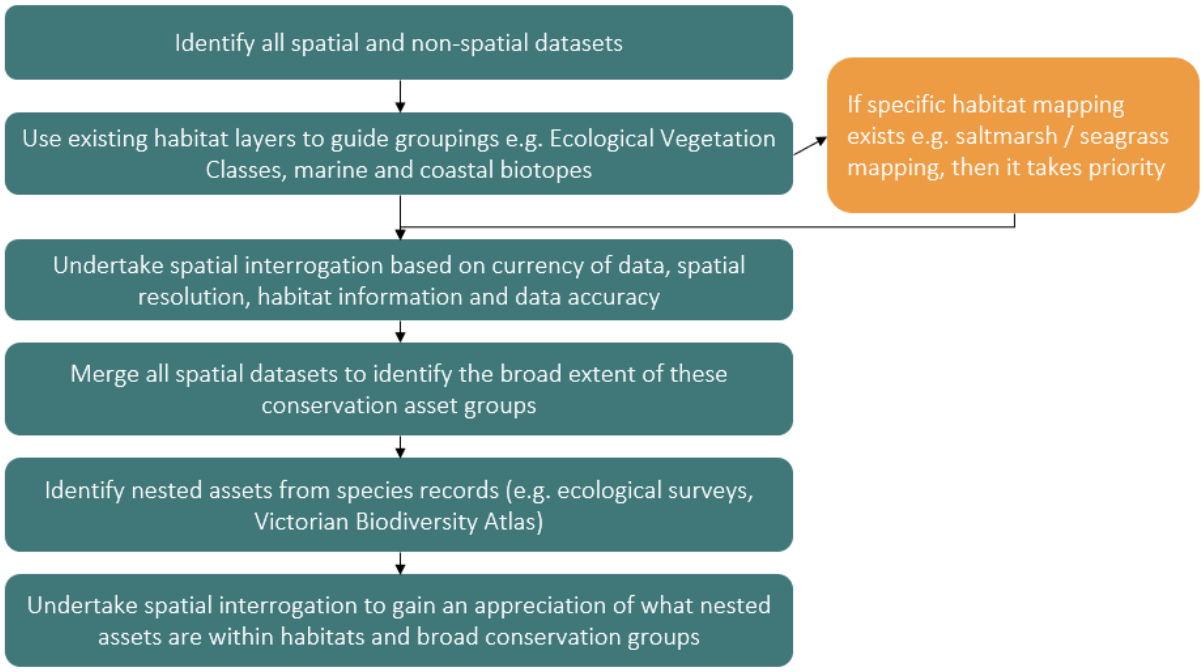


Figure 3. Data gathering and filtering process

2.2 Development of key ecological themes

The ecological and biodiversity values of the Port Phillip Bay western shoreline were identified and classified into key ecological themes for the purpose of conducting a broad-scale indicative vulnerability assessment.

The assessment adapted the classification of key ecological themes based on Park Victoria's conservation action planning framework where the framework was used to classify a variety of *conservation assets* into *broad ecological groups* for conservation planning across Victoria.

This approach works well for landscape-scale conservation planning and applies to all eighteen parks landscapes across Victoria (Parks Victoria, 2024). It is an approach designed by Nature Conservancy for providing principles and practices for long-term environmental conservation management widely used internationally (Conservation Measures Partnership, 2020). This project applies this same approach of classifying ecological values into conservation assets.

Vulnerability assessment of ecological and biodiversity values to coastal hazard impacts requires the examination of both large-scale and small-scale ecological themes and assets.

Conservation assets of Port Phillip Bay western shoreline were classified and further refined into:

- large-scale ecosystem **Broad Conservation Groups** (defined in 2.2.1)
- smaller scale **Habitat Groups,** with **nested assets** within these groups (defined in 2.2.2 and 2.2.3)

This structure is summarised in Figure 4 (see Section 3 for more details).

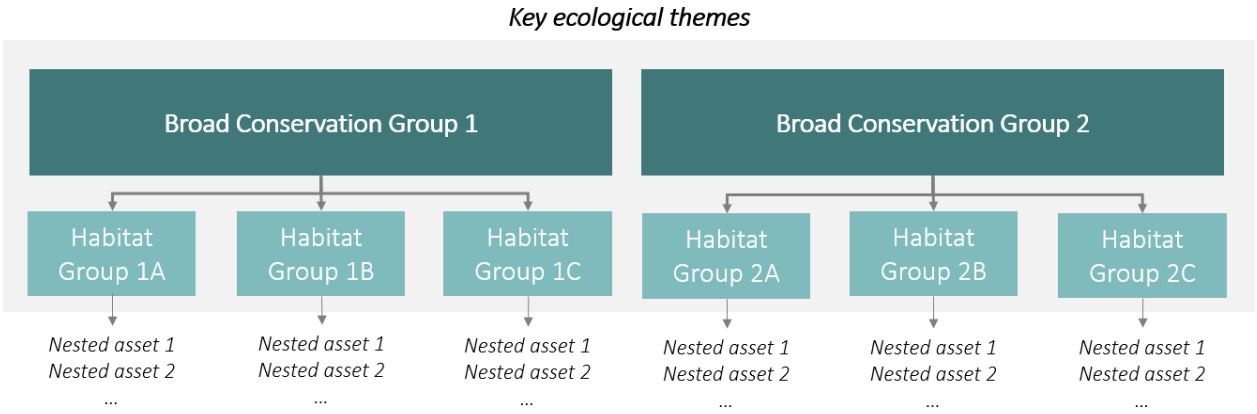


Figure 4. Classification of key ecological themes into Broad Conservation Group and Habitat Group.

Broad Conservation Groups are classified further based on their unique ecological habitat functions, as different Habitat Groups will be impacted differently by each coastal hazard within the broader ecosystem types. It is also important to consider the distribution and abundance of a conservation asset in the region, especially as some habitats and nested assets can be found across multiple Broad Conservation Groups. Capturing this in our approach enables more in-depth analysis to inform asset prioritisation within the vulnerability and risk assessment.

As with the Park Victoria's conservation action planning framework, a detailed understanding of the ecological values further informs the vulnerability assessment. It is crucial to consider what species, what specific habitat features, or ecosystem services are within each Habitat Group to inform a finer understanding for conservation planning, or in this assessment, understanding its vulnerability to coastal hazard impacts. Within each Habitat Group are finer-scale assets which this project termed as '**nested assets**' (Figure 4).

Nested assets identify the finer details for each Habitat Group within each Broad Conservation Group. These nested assets are series of values present within the Broad Conservation Group, or that rely on the Broad Conservation Group for their health. These assets include species assemblages, ecological communities, habitat features and ecosystem services. Keystone species, threatened and / or endemic species are also included if they have specific conservation

requirements. Specific communities or species of cultural importance to Traditional Owners may also be included, though this was not explicitly identified in this project and can be added in future iterations.

Why this grouping is important in our approach

Refining the Broad Conservation Group into Habitat Groups and nested assets is essential for the vulnerability assessment. Some habitats and nested assets span multiple Broad Conservation Groups. The location of these habitats/assets within some waterways, the marine and littoral zones, along with their proximity to potential coastal hazard impacts, influences the presence of certain species, ecological functions, and processes, as well as the level of hazard exposure and its vulnerability (i.e. marine environment, intertidal zone).

For example, saltmarshes occur in several Broad Conservation Groups and play a vital role in carbon sequestration due to their vegetation and sediment accretion in aerobic soil. Saltmarshes are more abundant in littoral (intertidal) areas than marine ecosystems, and their vegetation composition varies based on salt-tolerance and length of exposure to tidal inflows, both of which affect their ecological functions.

Therefore, it is crucial to evaluate saltmarsh habitats in intertidal, waterway and marine ecosystems separately. These habitats differ in proximity to the ocean, vulnerability to coastal hazards, and the impact on conservation assets. For instance, saltmarshes in the marine zone are more vulnerable to storm tide and permanent inundation, while intertidal saltmarshes are more vulnerable to changes in salinity (see Section 4.6.4 and 4.6.5).

2.2.1 Broad Conservation Groups

The study area was classified into five Broad Conservation Groups based on easily distinguishable, coarse-scale ecosystems and communities with similarities in biodiversity and natural values and management drivers. The assessment developed these groups because they have different responses to coastal hazard types and have selected the classification with an appropriate scale meaningful for the vulnerability assessment.

- Dry Forest / Woodlands, Plain Grasslands, and Agricultural Areas: All terrestrial habitat including grassy woodlands, grasslands and agricultural areas.
- Freshwater Systems: Wetlands and Waterways: All Freshwater Systems, including freshwater settling ponds in Western Treatment Plant.

- **Beaches and Dunes:** All areas that may contain limited extents of beaches and dunes including associated EVC types, tidal flats, dry sand containing wrack, and roosting sites.
- **Littoral Zone:** Intertidal zone habitat including saltpans, saltmarsh, mangroves, saline wetlands, estuaries and other low-lying coastal habitats. Some seagrass, rocky reefs and Soft Sediments can occur within the Littoral Zone.
- **Marine Areas:** All Marine Areas within the subtidal zone (sublittoral, circalittoral and infralittoral benthic habitat) which includes seagrass, rocky reefs and Soft Sediments. Some saltmarsh communities may occur, but very rarely, below the intertidal zone and may be temporary and related to shifting sediments, changing sea levels or other coastal changes.

These Broad Conservation Groups (BCGs) formed the basis of our mapping process. The data collation involves collecting and evaluating spatial habitat mapping datasets such as Ecological Vegetation Classes (DEECA), State-wide Marine Habitat Mapping (DEECA, 2024) and Benthic Habitat Layer (University of Tasmania, 2024) to identify which habitat and ecosystem should be classified into the appropriate Broad Conservation Group. The spatial datasets were then split and re-classified into each Broad Conservation Group based on attribute information such as habitat names.

It should be noted that distinguishing between neighbouring Broad Conservation Groups was challenging, particularly between Littoral Zone and Marine Area. To prioritise consistency within the study area and preventing overlapping of Broad Conservation Group, the Littoral Zone and Marine BCGs were delineated based on the Tidal Zone and Benthic Depth as determined by the Benthic Habitat Layer produced by Seamap Australia (University of Tasmania, 2024). Specifically, all Littoral Zones are within the Intertidal Zone while all Marine Areas are within the Subtidal Zone and consists of circalittoral, infralittoral and sub-littoral zones. Because the interface between Littoral and Marine Broad Conservation Group is dynamic in reality, the exact delineation of these two groups will vary in accuracy on the ground.

2.2.2 Habitat Groups

Broad Conservation Groups with multiple distinctive ecological features and habitats were further evaluated and categorised to form Habitat Groups (Figure 4). For example, within the Littoral Zone BCG, we identified several habitats including rocky reefs, soft sediments, and saltmarshes. We filtered and split spatial layers according to these Habitat Groups, then merged to create distinct Habitat Group layers in the GIS workspace. However, other BCGs, such as the Beaches and Dunes did not have distinct Habitat Groups within them and so were mapped and evaluated at a broader scale as areas that may have limited extents of beach and/or dunes present.

2.2.3 Nested assets

We identified nested assets using spatial and non-spatial datasets, with a full list provided in Appendix A. These nested assets were gathered from a wide range of sources, including expert knowledge, existing habitats from management plans and other studies, recorded species observations, modelled distributions of species occurrence, and assets already identified in similar Parks Victoria's Conservation Action Plans. Since the list of nested assets is extensive for each Habitat Group, this study will only showcase key species and processes relevant to each Habitat Group and Broad Conservation Group. Some of these species are listed in the *Flora and Fauna Guarantee Act 1988* (FFG Act) and *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). For the specific status, please refer to EPBC status: https://www.dcceew.gov.au/environment/epbc and FFG Act: https://www.environment.vic.gov.au/conserving-threatened-species/threatened-list.

2.3 Coastal hazard types

The list of coastal hazard types was provided by DEECA for the purpose of this assessment. They are identified and defined in the VRC framework (Table 2).

Table 2. Coastal hazard types and definition for Victoria (DEECA, 2023)

Coastal hazards category	Coastal hazard types	Descriptions
Coastal inundation	Storm tide inundation	Temporary event-based inundation.
	Permanent inundation	Regular or persistent inundation by the regular tidal cycle.
Coastal erosion	Short-term erosion	Event-based erosion of sediment (storm bite) and recovery.
	Long-term erosion	The progressive retreat of shoreline position over time.
Changes in groundwater salinity and depth	Salinity	Movement of saltwater into freshwater aquifers / groundwater and changing groundwater quality (e.g., salinity).
	Groundwater depth	Changes in water table depth, shallow groundwater becoming surface water.
Other	Off-shore sediment dynamics	Changes in form and processes associated with offshore Bathymetry and sediment transport.

2.4 Data assumptions and limitations

There are assumptions and limitations to the datasets used for the project which are important to understand in interpreting the results in this report:

1. Delineation of Habitat Groups – Determining the boundaries between different Habitat Groups and their Broad Conservation Groups presented a clear challenge. This is because habitats can have large overlapping and often dynamic boundaries. This required making decisions on where to draw the line at the edge of habitats. We used available habitat spatial layers and relied on the most accurate habitat mapping, described further in the 3rd limitation (Accuracy), to guide our judgement in delineating the Habitat Groups.
2. Environmental dynamics – The coast of Western Port Phillip Bay is an inherently dynamic environment, susceptible to small-scale daily changes and larger-scale shifts during storm events. As a result, the boundaries between the Broad Conservation Groups and Habitat Groups are likely to change. Since we cannot predict where these boundaries will shift based on the environmental conditions at any given time, we have relied on the static spatial boundaries from the habitat mapping datasets included in this study as the most reliable source of information on Habitat Group boundaries.
3. Accuracy – Due to many overlapping datasets, data that was more recently produced, higher resolution, and/or offered greater coverage were prioritised for inclusion in this assessment in an effort to improve the accuracy of the data included in this report.

   In addition to spatial data, mapping documents representing unique species distributions have been digitised for inclusion into the overall dataset. Flora point data was also digitised into polygons to provide a better representation of species overall distributions across habitats. Quality assurance and controls were performed to ensure the digitised data accurately represents the corresponding reporting and point information.
4. Representation – It is not possible to fully and accurately spatially represent all the biological diversity and environmental features present throughout the entirety of the Port Phillip Bay western shoreline. This is due to

insufficient spatial data for many species as well as the challenges posed in surveying the entirety of this study area. Relying solely on publicly available data could lead to an underrepresentation in the species presence and overall vulnerability and irreplaceability scorings.

We have therefore relied on available occurrence data and have made assumptions about the species likely to be present in a given Habitat Group based on existing information from scientific literature or expert knowledge. For example, the Golden Sun Moth occurs in native grasslands areas dominated with wallaby grasses, which are known to only occur in the Plains Grasslands and Agricultural Areas within the Adapt West study area (see Table 5).

3 Ecological values assessment

3.1 Protected areas and reserves

The western shoreline of Port Phillip Bay is home to many significant ecosystems, with its diverse habitats supporting a variety of state, nationally, and internationally important natural values across the terrestrial, coastal and marine environments. Many areas along the western shoreline of Port Phillip Bay are within protected areas and reserves, the most notable being the internationally listed Port Philip (Western Shoreline) Bellarine Peninsula Ramsar Site, spanning approximately 16,000 hectares (Table 3).

The study area contains at least 18 fauna species listed on the *International Union for Conservation of Nature* (IUCN) *Red List*, the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and the *Flora and Fauna Guarantee Act 1988* (FFG Act), many of which are critically endangered and vulnerable. These protected areas and threatened species face a range of threats from climate change, catchment management, invasive species, and coastal hazard impacts.

Protected areas and reserves are often designated for management of important natural values and consist of multiple ecosystem types and habitats. These habitats respond differently to different threats. Since this study focuses on the impacts of coastal hazards, identifying these habitats and threatened species within these protected areas is critical for the subsequent coastal hazard risk assessment.

Table 3. Protected areas, reserves and assets within western shoreline of Port Phillip Bay

Category	Specific protected areas
Ramsar-listed sites	Point Cook/Cheetham, Werribee River / Avalon, Cheetham Wetlands, Western Treatment Plant, The Spit Wildlife Reserve, Avalon Coastal Reserve, Point Wilson/Limeburners Bay, Corio Bay
Marine sanctuaries	Jawbone Marine Sanctuary (IUCN Category III), Point Cooke Marine Sanctuary (IUCN Category II)
Significant parks and reserves	• *IUCN Category Ia*: Laverton Grasslands Flora Reserve, Jawbone Flora and Fauna Reserve, Altona Nature Conservation Reserve, The Spit Wildlife Reserve, Limeburners Lagoon (Hovells Creek) Flora and Fauna Reserve • *IUCN Category IV*: Altona Meadows Natural Features Reserve
Other Parks and Reserves	Point Cook Coastal Park, Port Phillip Bay Coastal Reserve, Werribee Park, Werribee South Jetty, Werribee Regional Park, Williamstown Workshop, Piers & Stony Creek Backwash, Point Gellibrand Heritage Park, Altona Pier, Altona Coastal Park, Paisley/Challis Wetlands and Flora and Fauna Reserve, Point Wilson, Grahams Reserve Wetland (Conservation Reserve)
Significant marine asset areas	• *Bioregional*: Curlewis Bank nearshore, Stingaree Bay, Corio Bay northern shoreline • *State*: Port Phillip Bay sediment basin > 10m, Western Treatment Plant Coastline, Altona - Point Cook reefs • *Local*: Point Wilson Mud, Williamstown - Altona reefs, Curlewis Bank offshore, Point Wilson Pier, Limeburners Bay Estuary,
Environmental Conservation Council (ECC) management areas	Werribee River and estuary

3.2 Broad Conservation Groups

The assessment identified five Broad Conservation Groups within the study area (Figure 5). Within each Broad Conservation Group is a list of Habitat Groups and associated nested assets. This will be described in the sections below.

Marine Areas constitute 49.26% of the total study area, followed by Dry Forest/Woodlands, Plains Grassland and Agricultural Areas (18.12%), Littoral Zone (5.34%), Freshwater Systems: Wetlands and Waterways (4.90%) and Beaches and Dunes (0.18%) (Figure 6).

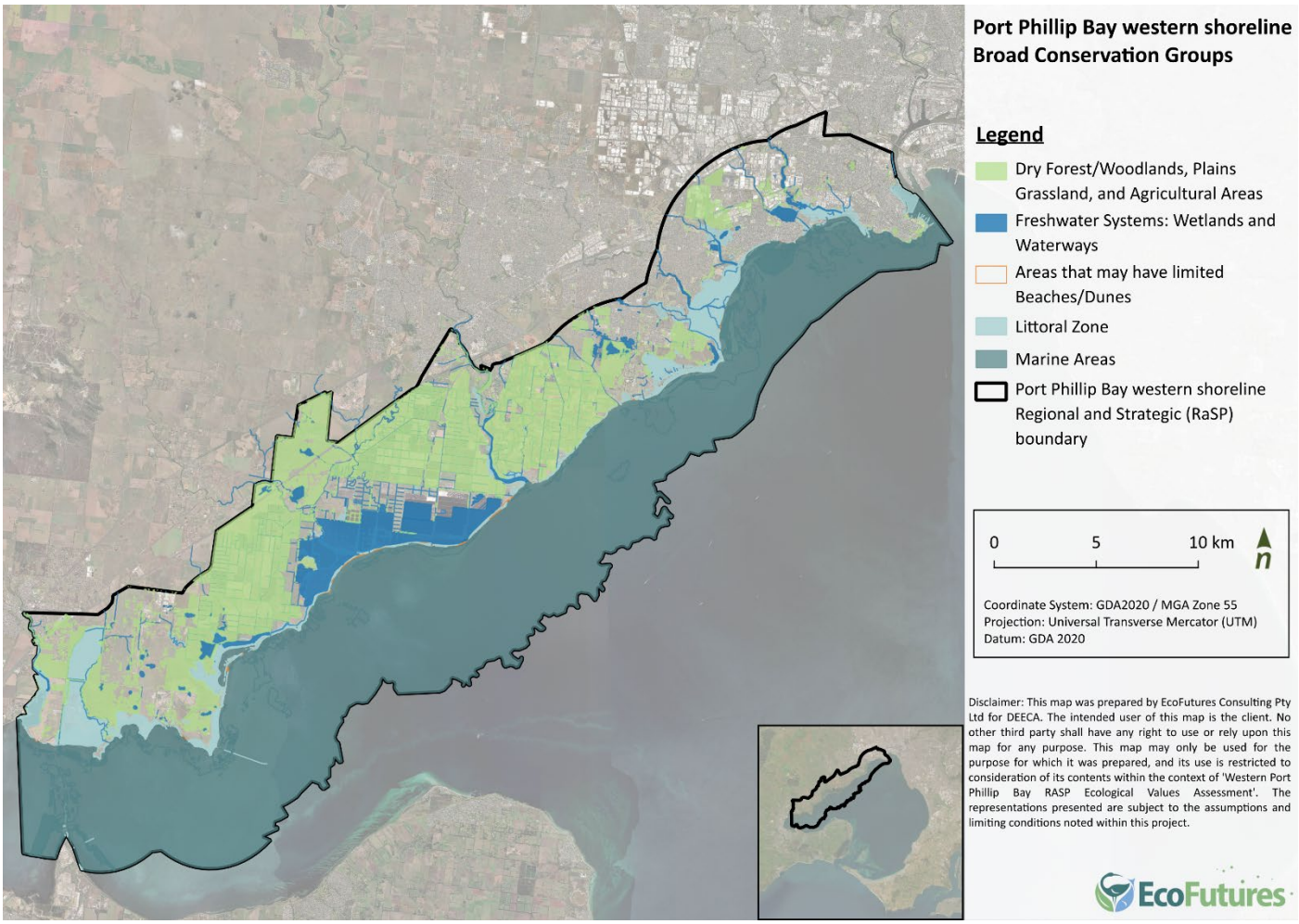


Figure 5. The location of the five Broad Conservation Groups within the study area

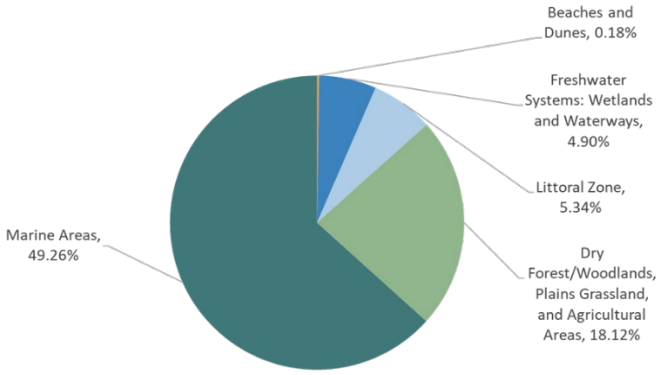


Figure 6. Broad Conservation Group area as a percentage of the total area within the study area boundary

Breaking these Broad Conservation Groups into Habitat Groups, Agricultural Areas are the dominant Habitat Group within the Dry Forest/Woodlands, Plains Grassland, and Agricultural Areas (78.79%), Saltmarsh are the dominant Habitat Group within the Littoral Zone (38.73%), and Soft Sediment constitutes 86.42% of the Marine Areas.

Table 4 Habitat Group area as a percentage of their respective Broad Conservation Group area.

Broad Conservation Group (BCG)	Habitat Group	Area (km sq)	Total BCG area (km sq)	% of Habitat Group area of BCG area
Dry Forest/Woodlands, Plains Grassland, and Agricultural Areas	Dry Forest/Woodlands	2.08	107.37	1.94%
	Plains Grassland	20.70		19.28%
	Agricultural Areas	84.60		78.79%
Freshwater Systems: Wetlands and Waterways	Freshwater Systems: Wetlands and Waterways	28.70	28.70	100%
Beaches and Dunes	Beaches and Dunes	1.03	1.03	100%
Littoral Zone	Estuarine Waterbodies	11.46	45.35	25.26%
	Mangrove	0.86		1.89%
	Other Coastal Habitats	6.99		15.42%
	Rocky Reef	0.28		0.62%
	Saltmarsh	17.56		38.73%
	Saltpan	5.62		12.39%
	Seagrass	0.09		0.19%
	Soft Sediment	2.49		5.50%
Marine Areas	Rocky Reef	16.47	295.87	5.57%
	Seagrass	23.53		7.95%
	Saltmarsh	0.18		0.06%
	Soft sediment	255.69		86.42%

3.2.1 Dry Forest/Woodland, Plains Grassland, and Agricultural Areas

This Broad Conservation Group includes all terrestrial habitat within the study area. Its Habitat Groups are:

- Dry Forest/Woodlands
- Plains Grassland
- Agricultural Areas

Dry Forest/Woodlands

Dry Forest/Woodlands span two Victorian Bioregions – Otway Plain and Victorian Volcanic Plain. Creekline Grassy Woodland (EVC 68), Floodplain Riparian Woodland (EVC 56), Plains Grassland/Plains Grassy Woodland Mosaic (897), Plains Grassy Woodland (EVC 55), Riparian Woodland (641) are the most common EVCs in this Habitat Group, though all of them are listed as 'Endangered' within their respective bioregion. Dry Forest/Woodlands support a range of species including birds in the Temperate Woodland Bird Community (e.g. Powerful Owl (*Ninox strenua*) and Swft Parrot (*Lathamus discolor*)).

Dry Forest/Woodlands nested asset examples

Swift Parrot. Image source: Mick Roderick, Birdlife Australia.

Powerful Owl. Image source: Geoff Sloane, Birdlife Australia.

Riparian Woodland. Image source: Ecology Australia 2018, Western Treatment Plant Biodiversity Conservation and Ramsar Management Plan.

Plains Grassland

This Habitat Group is named after the Plains Grassland Ecological Vegetation Class (EVC 132) in the Victorian Volcanic Plain bioregion, within the study area this Habitat Group consists of remnant and derived native grassland. Within this bioregion, the extent of Plains Grassland has experienced widespread decline across Victoria, making this Habitat Group ecologically significant and critical habitat for protection (Ecology Australia, 2018). Plains Grassland is typically dominated by tussock-forming species such as Wallaby Grass (*Rytidosperma* spp.), Kangaroo Grass (*Themeda triandra*), Common Tussock-grass (*Poa labillardiere*). Indigenous sedge species (e.g., *Bolboschoenus* spp. and *Schoenoplectus* spp.), and significant species such as Spiny Rice-flower (*Pimelea spinescens*) are also known to occur within the Plains Grassland. This Habitat Group also supports vertebrate and invertebrate species, including the Striped Legless Lizard (*Delma impar*), Golden Sun Moth (*Synemon plana*), and Altona Skipper Butterfly (*Hesperilla flavescens*).

Plains Grassland nested asset examples

Latham's Snipe. Image source: Nik Mulconray, eBird 2023.

Golden Sun Moth. Image source: Meredith Dairy, SWIFFT.

Plains Grassland at Lake Borrie Grassland. Image source: Ecology Australia, 2018.

Agricultural Areas

Although modified landscapes, Agricultural Areas support a range of ecological values and are therefore included in this assessment. Within the Western Treatment Plant, Agricultural Areas include improved pasture and crops, which form part of the terrestrial margin. These Agricultural Areas provide foraging habitat for birds such as ibis, while grazing waterfowl like the Black Swan (*Cygnus atratus*) and Australian Shelduck (*Tadorna tadornoides*) are also known to use some of these Agricultural Areas in large numbers (Ecology Australia, 2018). Agricultural areas outside of Western Treatement Plant are found to have vertebrates such as Tussock Skink (*Pseudemoia pagenstecheri*) or Striped Legless Lizard.

Agricultural areas nested asset examples

*Straw-necked Ibis (*Threskiornis spinicollis*). Image source: Julie Clark, eBird 2018.*

Striped Legless Lizard. Image source: DEECA.

Wallaby Grass. Image source: A J Brown, Agriculture Victoria.

Table 5 Dry Forest/Woodlands, Plains Grassland, and Agricultural Areas Broad Conservation Group - Habitat Groups and their example nested assets.

Habitat	Nested assets	
Agricultural Areas	Avian	Ibis, Cape Barren Goose, Whiskered Tern, Latham's Snipe (*Gallinago hardwickii*), Black Swan (*Cygnus atratus)*, and Australian Shelduck (*Tadorna tadornoides*) Birds of prey: White-bellied Sea Eagle (*Haliaeetus leucogaster*), Black Falcon (*Falco subniger*), Brown Falcon (*Falco berigora*), Black-shouldered Kite (*Elanus axillaris*), Orange-bellied Parrot (*Neophema chrysogaster*) Nesting, roosting, feeding sites Shorebird sites Other common birds from VBA records
	Non-avian	Striped Legless Lizard (*Delma impar*) Ground dwelling mammals: e.g., Fat-tailed Dunnart *Sminthopsis crassicaudata* Golden Sun Moth populations (*Synemon plana*) Tussock Skink (*Pseudemoia pagenstecheri*) Insect Species (e.g., Altona Skipper Butterfly) Delma Food Source Growling Grass Frog (in drains)
	Vegetation	Tussock forming species: spear-grasses (*Austrostipa* spp.), wallaby-grasses (*Rytidosperma* spp.), Kangaroo Grass (*Themeda triandra*), Rigid Panic (*Walwhalleya proluta*), Red-leg Grass (*Bothriochloa macra*), Common Tussock-grass (*Poa labillardierei*), and Common Grass-sedge (*Carex breviculmis*) Indigenous sedge species: club-sedges (*Bolboschoenus* spp., *Schoenoplectus* spp.), halophytes (e.g., Beaded Glasswort *Salicornia quinqueflora* and other saltmarsh shrubs), and freshwater forbs (e.g., Small Loosestrife (*Lythrum hyssopifolia*) Spiny Rice-flower (*Pimelea spinescens*) Tough Scurf-pea (*Cullen tenax*)
Plains Grassland	Avian	Ibis species, Cape Barren Goose (*Cereopsis novaehollandiae*), Whiskered Tern (*Chlidonias hybrida*), Latham's Snipe, Black Swan, and Australian Shelduck Birds of prey: White-bellied Sea Eagle, Black falcon, Brown falcon, Black-shouldered kite Nesting, roosting, feeding sites Shorebird sites Other common birds from VBA records Orange-bellied Parrot
	Non-avian	Striped Legless Lizards *(Delma impar*) Ground dwelling mammals (Fat-tailed Dunnart *Sminthopsis crassicaudata*) Golden Sun Moths populations (*Synemon plana*) Tussock Skink

Habitat	Nested assets	
		Insect Species (Altona Skipper Butterfly) Delma Food Source Growling Grass Frog (in drains)
	Vegetation	Tussock forming species e.g., spear-grasses Austrostipa spp., wallaby-grasses *Rytidosperma spp.*, Kangaroo Grass *Themeda triandra*, Rigid Panic *Walwhalleya proluta*, Red-leg Grass *Bothriochloa macra*, Common Tussock-grass *Poa labillardierei* and Common Grass-sedge *Carex breviculmis* Indigenous sedge species (e.g., club-sedges Bolboschoenus spp., Schoenoplectus spp.), halophytes (e.g., Beaded Glasswort *Salicornia quinqueflora* and other saltmarsh shrubs) and freshwater forbs (e.g., Small Loosestrife *Lythrum hyssopifolia)* Spiny Rice-flower *(Pimelea spinescens)* Tough Scurf-pea *(Cullen tenax)*
Dry Forest/ Woodlands	**Avian**	Nesting, roosting, feeding Shorebird sites Other common birds from VBA records Woodland bird species
	Non-avian	Growling Grass Frog Fat-tailed Dunnart Golden Sun Moth Bats
	Vegetation	Threatened flora such as Pimelea EVCS: Grassy Woodland EVC175, Plains Grassy Woodland EVC55, Creekline Grassy Woodland EVC68, Floodplain Riparian Woodland EVC56

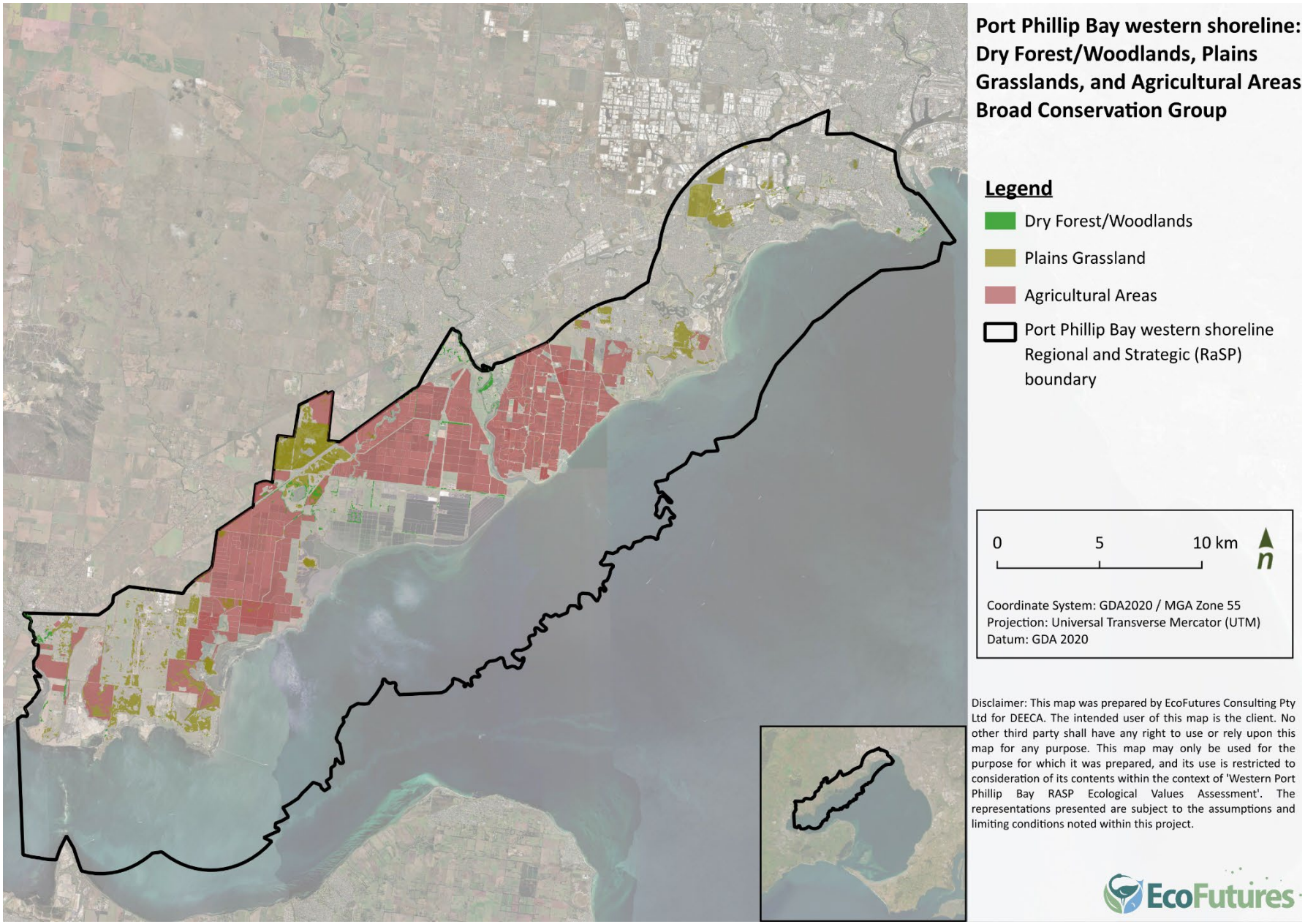


Figure 7. Dry Forest / Woodlands, Plains Grassland, and Agricultural Areas

3.2.2 Freshwater Systems: Wetlands and Waterways

This Broad Conservation Group encompasses all freshwater waterways and wetlands within the study area. Major waterways and creeks identified in this group are Hovells Creek, Werribee River, Skeleton Creek, Lollypop Creek, Little River, Cherry Creek, Laverton Creek and Kororoit Creek. Significant wetlands are Paul and Belfrages Swamp and Ryan's Swamp within the Western Treatment Plant (WTP).

This Broad Conservation Group includes threatened EVCs such as Cane Grass Wetland (EVC 291), Plains Sedgy Wetlands (EVC 647), Lignum Swamp (EVC 104), Plains Grassy Wetlands (EVC 125). It supports a large range of waders, birds of prey, threatened bird species such as Australasian Bittern (*Botaurus poiciloptilus)*, as well as non-avian species such as Growling Grass Frog (*Litoria raniformis*), Australian Grayling (*Prototroctes maraena*), Rakali (*Hydromys chrysogaster*) and Platypus (*Ornithorhynchus anatinus*). Since the entire WTP is located within the study area, the assessment also includes the natural settling ponds and drainage systems where the Growling Grass Frog have been observed, despite these being modified systems. The WTP supports one of the largest metapopulations of the Growling Grass Frog, which is listed as vulnerable under the EPBC Act. Wetlands and waterways within WTP, such as T-Section and Western Lagoons, provide critical habitats for the Growling Grass Frog (Ecology Australia, 2018; DEECA, 2018).

Freshwater Systems nested asset examples

Latham's Snipe. Image source: Nik Mulconray, eBird 2023.

Australian Grayling. Image source: Tarmo A Raadik, Threatened Species Link.

Tangled Lignum. Image source: Russel Best, Ecolinc.

Table 6 Freshwater Systems Broad Conservation Group nested assets.

Habitat	Nested assets	
Freshwater systems: Wetlands and Waterways	**Avian**	Wetland birds: Eurasian Coot, Purple Swamphen, Black Swan, Latham's Snipe, Brolga, Cape Barren Goose, Magpie Goose, Swamp Harrier, Australasian Shoveler, Australasian Bittern, Australian Painted-snipe, Lewin's Rail, Little Bittern, Baillon's Crake. Ducks: Blue-billed Duck, Pink-eared Duck, Pacific Black Duck, Chestnut Teal, Musk Duck, Freckled Duck. Birds of prey: White-bellied Sea Eagle, Black Falcon, Brown Falcon, Black-shouldered Kite Nesting, roosting, feeding sites Shorebird sites Other common birds from VBA records Orange-bellied Parrot Waterfowl
	Non-avian	Fish: Australian Grayling, River Blackfish, Yarra Pygmy Perch. Frogs: Growling Grass Frog, Eastern Banjo Frog (*Limnodynastes dumerilii*), Eastern Dwarf Tree frog (*Litoria fallax*), Striped Marsh Frog (*Limnodynastes peronii*), Common Spadefoot Toad (*Pelobates fuscus*). Mammals: Rakali, Platypus, Fat-tailed Dunnart, Micro-bats. Insects: Golden Sun Moth.
	Vegetation	Threatened EVCs and flora species: Cane Grass Wetland EVC 291, Plains Sedgy Wetland EVC 647, Shallow Freshwater Wetland EVC 200, Lignum Swamp EVC 104, Plains Grassy Wetland EVC 125. Threatened flora species: Southern Cane Grass, River Swamp Wallaby-grass, Sea Water-mat, Australian Grass Wrack, Spiny Rice-flower (Pimelea), Tangled Lignum.

Habitat	Nested assets	
	Other	WTP settling ponds, waterways, and riverbeds.

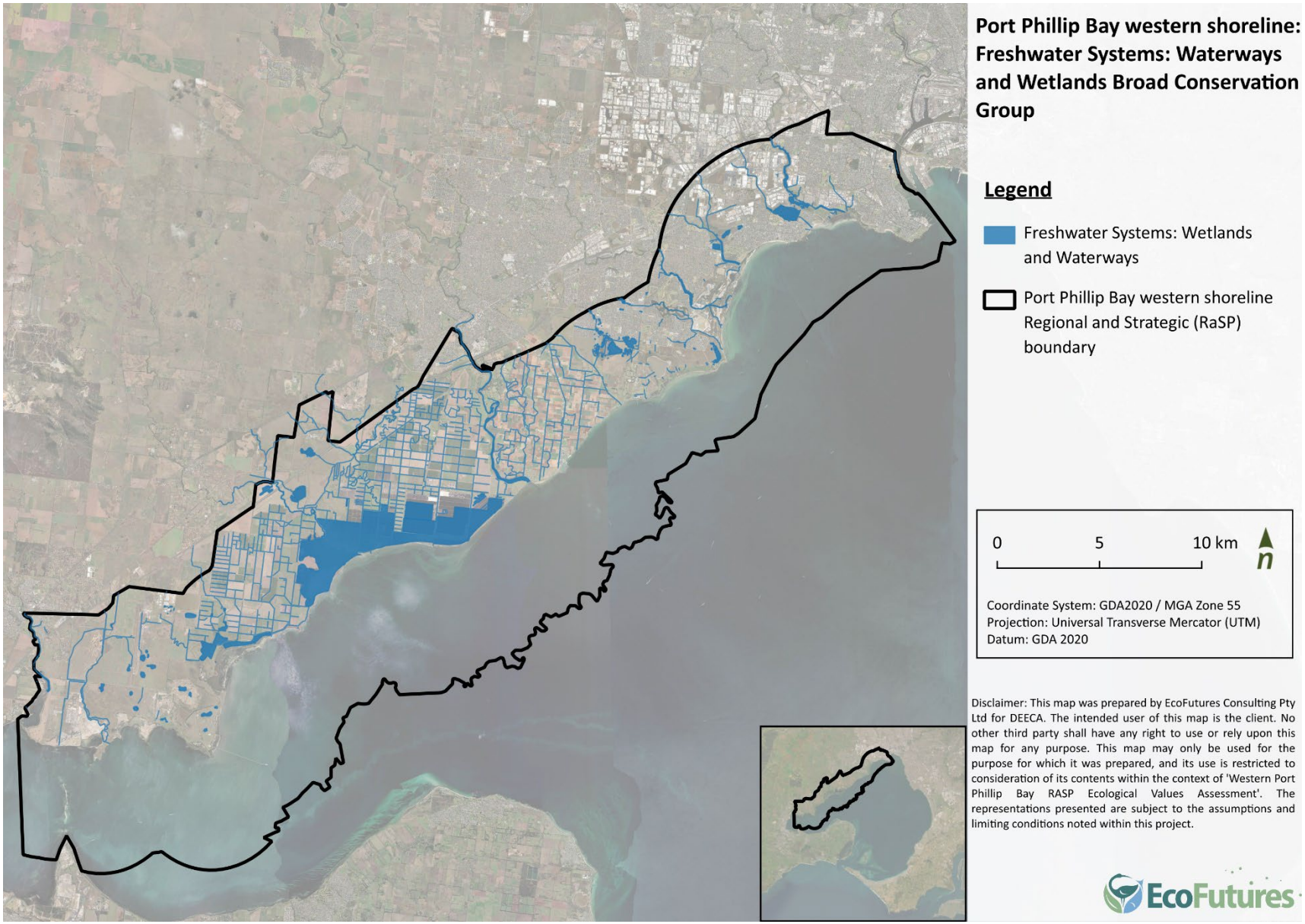


Figure 8. Port Phillip Bay western shoreline Freshwater Systems Broad Conservation Group including wetlands and waterways.

3.2.3 Beaches and Dunes

Coastal dunes and beaches are dynamic systems formed from the unconsolidated sand of coastal bluffs, watersheds and offshore sources, that are shaped by a myriad of marine and terrestrial processes. Material exchange across the dune-beach interface involves sand, groundwater, salt spray, and organic materials, all of which are influenced by climatic conditions. These dynamic factors contribute to the complex ecosystem interactions of coastal dune environments (Liebowitz et al. 2016). Within the study site, Beaches and Dunes are dominated by rare and depleted EVCs and species, such as Coastal Tussock Grassland (EVC 163), Coastal Tussock-grass (*Poa poiformis*) and Common Blown-grass (*Lachnagrotis filiformis*).

Beaches and Dunes are limited in extent across the study area, potentially occurring in certain parts of the WTP, along Point Cook, Altona, and Avalon Coastal Reserve. These habitats are often disturbed due to the modified landscape, which can reduce its capacity to support high biodiversity and ecological values. However, in some areas they, provide critical shelter, food, and nesting sites for small birds and animals such as the Red-capped Plover (*Charadrius ruficapillus*) and Sooty Oystercatcher (*Haematopus fuliginosus*). They may also contain wrack that supports invertebrates and provides foraging opportunities for shorebirds (EcoFutures, 2023; Parks Victoria, 2007).

Beaches and Dunes nested asset examples

Red-capped Plover. Image source: Steven Pratt, eBird 2018.

White-lipped Snake. Image source: Alex Dudley, Department of Natural Resources and Environment Tasmania.

Beaded Glasswort. Image source: A J Brown, Agriculture Victoria.

Table 7 Beaches and Dunes Broad Conservation Group nested assets.

Habitat	Nested assets	
Beaches and Dunes	**Avian**	Shorebirds and seabirds: Red-capped Plover, Sooty Oystercatcher, Pied Oyster Catcher (*Haematopus longirostris),* Migratory Shorebirds, Fairy Tern (*Sternula nereis*), Little Tern (*Sternula albifrons*), Silver Gull (*Chroicocephalus novaehollandiae*), Pacific Gull (*Larus pacificus*), Wood Sandpiper (*Tringa glareola)*, Crested Tern (*Thalasseus bergii*), Pied Cormorant (*Phalacrocorax varius*), Double-banded Plover (*Charadrius bicinctus*), Curlew Sandpiper (*Calidris ferruginea*), Red-necked Stint (*Calidris ruficollis*). Migratory shorebird high-tide roosting Nesting, roosting, feeding sites for shorebirds, seabirds and waterfowl Orange-bellied Parrot Other common birds from VBA records (e.g., Superb Fairy-wren, White-browed Scrub-wren)
	Non-avian	*Herpetofauna: White's Skink (Egernia whitii), White-lipped Snake (Drysdalia coronoides), Little Whip Snake (Suta flagellum), Eastern Three-lined Skink (Acritoscincus duperreyi)*
	Vegetation	Rare and depleted EVCs and flora species: Coastal Tussock Grassland (EVC), Coast Tussock-grass (*Poa poiformis*), Common blown-grass (*Lachnagrotis filiformis*), Prickly Speargrass (*Austrostipa stipoides*), Australian Saltgrass (*Distichlis distichophylla*), Beaded Glasswort (*Sarcornia quinqueflora*)
	Other	Dune formations: stabilising vegetation coverage Wrack: Habitat for invertebrates, foraging shorebirds, seabirds, and organic input (productivity)

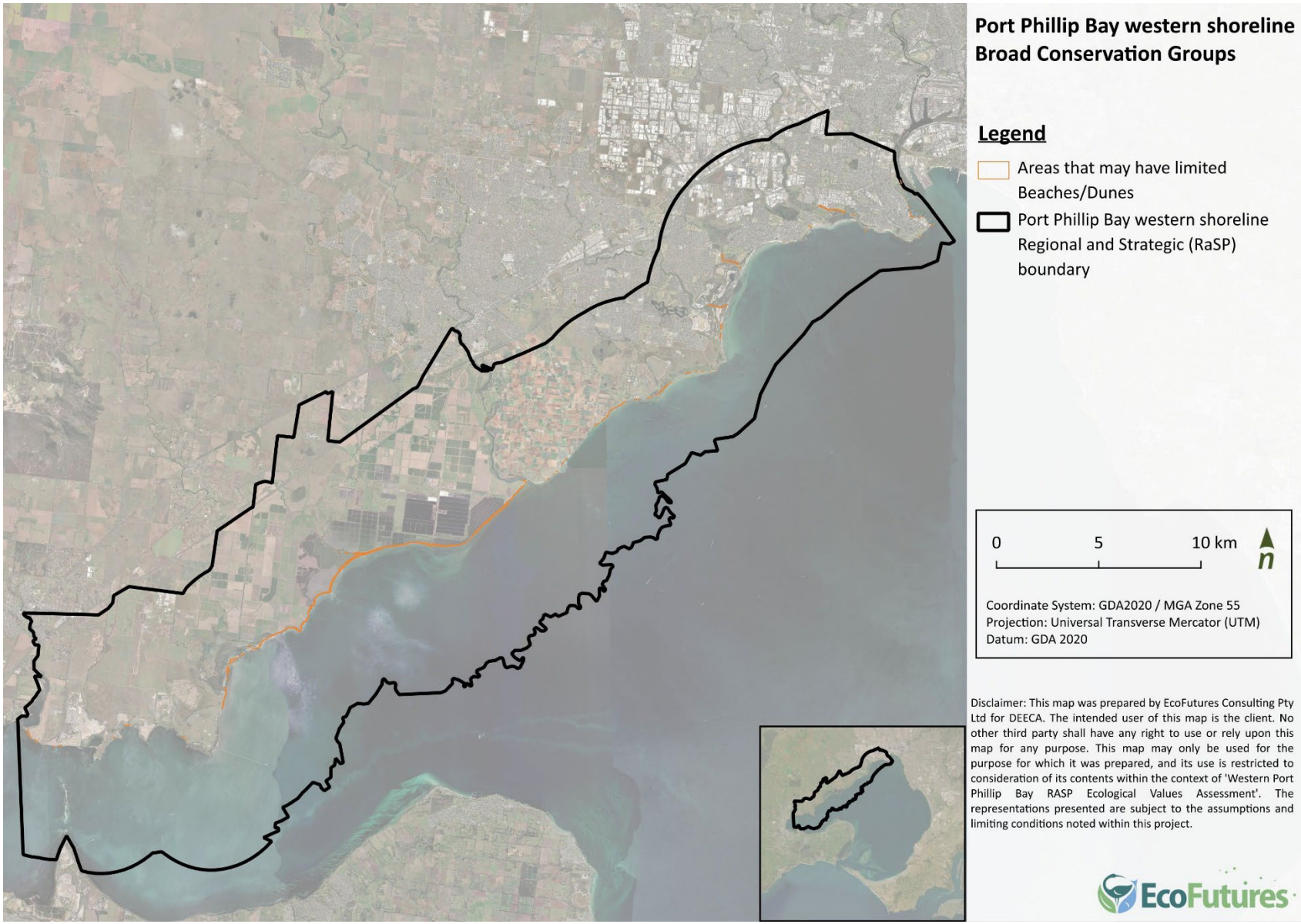


Figure 9. Port Phillip Bay western shoreline Beaches and Dunes Broad Conservation Group

3.2.4 Littoral Zone

The Littoral Zone is delineated to represent all habitats within the intertidal zone. The intertidal zone extent was identified using the Seamap Benthic habitat layer (University of Tasmania, 2024) for spatial data delineation. This Broad Conservation Group contains eight Habitat Groups:

- Estuarine Waterbodies
- Mangroves
- Saltmarsh
- Saltpan
- Seagrass
- Rocky Reefs
- Soft Sediment
- Other Coastal Habitats

Littoral Zone: Estuarine Waterbodies

Estuarine wetlands, estuaries, and lagoons are areas of waterbodies and waterways with both saltwater from the sea and freshwater from the catchment. These habitats depend on both sources for a healthy environment. These serve as critical habitats for many fauna species (e.g., snapper, Fairy Tern (*Sternula nereis*), gannets, and cormorants). Fringing and submerged vegetation includes temporary saline marshes and meadows as well as saline aquatic meadow communities.

Littoral Zone: Estuarine Waterbodies nested asset examples

Australian Fairy Tern. Image source: Christopher Stephens, eBird 2017.

White-lipped Snake. Image source: Alex Dudley, Department of Natural Resources and Environment Tasmania.

Beaded Glasswort. Image source: A J Brown, Agriculture Victoria.

Table 8 Littoral Zone: Estuarine Waterbodies - Habitat Group nested assets.

Habitat	Nested assets	
Estuarine Waterbodies	**Avian**	Fairy and Little Terns, Gannets, Cormorants, Great Crested Grebe (*Podiceps cristatus*), Little Penguin (*Eudyptula minor*), Spoonbill species, Red-capped Plover, Double-banded Plover, Crested Tern, White-faced Storm Petrel (*Pelagodroma marina*), Lewin's Rail (*Lewinia pectoralis*), Banded Stilt (*Cladorhynchus leucocephalus*)
		Migratory bird high tide roosting
		Nesting, roosting, feeding sites
		Shorebird sites
		Other common birds from VBA records
		Orange-bellied Parrot
	Non-avian	Reptile and amphibian species (e.g., Growling Grass Frog)
		Rakali
		Aquatic species: Crustaceans, Fish nursery
	Vegetation	White Mangrove (most southern population), Moonah, Coastal Wirilda, saltmarsh species - glassworts
		Temporary saline marshes and meadows, saline aquatic meadow
	Other	Estuary wetland, temporary saline lakes, other wetlands and estuaries.

Littoral Zone: Mangroves

Mangroves occur along the soft sediments on the tidal flats of sheltered estuaries, inlets, or bays, typically between the low and high tide levels. They are adapted to highly saline water and require regular tidal inundation. Mangroves play an important role in stabilising foreshore areas by trapping sediment with their trunks, twisted roots, and pneumatophores – a specialised physiological adaptation root structure that emerges above the soil to facilitate gas exchange (EcoFutures, 2023).

Mangroves are also recognised for sequestering carbon and are considered one of the ecosystems for 'blue carbon' sinks (Parks Victoria, 2021). In Port Phillip Bay, there is only one species – the White Mangrove (*Avicennia marina* var. *australasica*). Due to the low temperatures and frosts, mangroves are limited in extent within the bay, occurring in the Avalon Conservation Reserve / Limeburners Lagoon, Jawbone Marine Sanctuary, coastlines of Point Cook and Cheetham Wetlands.

Mangroves provide roosting and foraging opportunities for birds such as Little Pied Cormorant (*Phalacrocorax melanoleucos*), White-faced Heron (*Ardea novahollandae*). They also provide habitat for other fauna including bats, crabs, snails, worms, and insects.

Mangroves may encroach into other areas of vegetation such as saltmarsh communities and mudflats if sedimentation increases and retention rates of mangroves seeds and seedlings are high (Rogers, et al. 2005). This study does not consider the invasiveness of mangroves and impacts of competition or encroachment – this has been highlighted in Section 4.4.

Littoral Zone: Mangrove nested asset examples

Semaphore Crab. Image source: Dr Isobel Bennett, Australian Museum

Little Pied Cormorant. Image source: Julie Clarke, eBird 2017

White Mangrove. Image source: A J Brown, Agriculture Victoria.

Table 9 Littoral Zone: Mangroves - Habitat Group nested assets.

Habitat	Nested assets	
Mangroves	Avian	Spoonbill species, Red-capped Plover, Double-banded Plover, Crested Tern, White-faced Storm Petrel, Lewins Rail, Banded Stilt Migratory high tide roosting Nesting, roosting, feeding sites Shorebird sites Other common birds from VBA records Orange-bellied Parrot
	Non-avian	Reptile and amphibian species Mammals: Rakali Australian Grayling Crustaceans
	Vegetation	White mangrove (most southern population), Moonah, Coastal Wirilda EVCs: Mangrove Shrubland EVC140, Coastal Saltmarsh/Mangrove Shrubland Mosaic EVC302, Mangrove Shrubland/Coastal Saltmarsh/Berm Grassy Shrubland/Estuarine Flats Grassland Mosaic EVC692.

Littoral Zone: Saltmarsh

Saltmarsh vegetation communities are found in low-gradient marine and estuarine plains in sheltered coastal regions, such as bays and tidal flats, where freshwater and saltwater meet (Saintilan, 2009). This Habitat Group is strongly influenced by tidal patterns, associated landforms, and the complex interactions between freshwater inputs and coastal waters, creating a mosaic of floristic communities and microhabitats.

The saltmarsh supports a coastal ecosystem that thrives in saline conditions. Common saltmarsh floristic communities within the study area are Coastal Saltmarsh (EVC 9), Coastal Alkaline Scrub (EVC 858), Wet Saltmarsh Herbland (EVC A107), Wet Saltmarsh Shrubland (EVC 10), Berm Grassy Shrubland (EVC 311). Coastal Hypersaline Saltmarsh (EVC A111) and Coastal Tussock Saltmarsh (EVC A112) also occur extensively at The Spit Nature Conservation Reserve (Ecology Australia, 2018).

The Saltmarsh provides critical habitat for both terrestrial and marine species. These habitats offer shelter for fish during high tides and serve as feeding and roosting grounds for migratory wading birds, such as the Sharp-tailed Sandpiper (*Calidris acuminata*), Marsh Sandpiper (*Tringa stagnatilis*), Orange-bellied Parrot (*Neophema chrysogaster*), and Blue-winged Parrot (*Neophema chrysostoma*), as well as saltmarsh specialists like the White-fronted Chat (*Epthianura albifrons*). Non-avian species, including the Swamp Skink (*lissolepis coventryi*) and native rats, also inhabit this Habitat Group. Like mangroves, the Saltmarsh can absorb and store atmospheric carbon, making them important carbon sinks.

Coastal development has led to the significant loss of Saltmarsh habitat throughout coastal Victoria, particularly in Port Phillip, making remnant Saltmarsh areas within the study area of high ecological value (EcoFutures, 2023).

Littoral Zone: Saltmarsh – Habitat Group nested asset examples

Orange-bellied Parrot. Image source: John Barkla, Birdlife Australia.

Australian Spotted Crake. Image source: Indra Bone, eBird 2018.

Western Port Phillip Bay saltmarsh. Image source: EcoFutures 2023.

Table 10 Littoral Zone: Saltmarsh - Habitat Group nested assets.

Habitat	Nested assets	
Saltmarsh	**Avian**	Migratory Parrots e.g., Orange-bellied Parrot, Blue-winged Parrot Wetland birds and waders: Little Egret (*Egretta garzetta*), Brolga (*Grus rubicunda*), Hardhead (*Aythya australis*), Lewin's Rail, Pacific Golden Plover (*Pluvialis fulva*), Marsh Sandpiper (*Tringa stagnatilis*), Plumed Egret (*Ardea plumifera*), Sharp-tailed Sandpiper Non-water birds: Superb Fairy Wren (*Malurus cyaneus*), White-browed Scrub-Wren (*Sericornis frontalis*), Golden-headed Cisticola (*Cisticola exilis*), Striated Field-Wren (*Calamanthus fuliginosus*) Key shorebirds: Wood Sandpiper, Double-banded Plover, Curlew Sandpiper, Red-necked Stint High tide roosting sites for migratory birds Nesting, roosting, feeding sites for shorebird, resident and migratory birds Shorebird sites Other common birds from VBA records Waterbird foraging areas
	Non-avian	Saltmarsh invertebrates and grazers: Nitrogen fixers, sediment accretion, carbon storage, unique set of invertebrates and grazers in each saltmarsh type (e.g., tussock, saltbush, etc)

Habitat	Nested assets	
	Vegetation	Saltmarsh flora: Beaded Glasswort, Shrubby Glasswort, Salt LaWrencia, Marsh Saltbush, Wet and dry saltmarsh vegetation types EVCs: Coastal Saltmarsh EVC 9, Coastal Alkaline Scrub EVC 858, Wet Saltmarsh Herbland EVC A107, Wet Saltmarsh Shrubland EVC 10, Berm Grassy Shrubland EVC 311, Coastal Saline Grassland EVC A109, Coastal Dry Saltmarsh EVC A110, Brackish Lignum Shrubland EVC 947, Estuarine Flats Grassland EVC 914, Coastal Tussock Saltmarsh EVC A112, Coastal Hypersaline Shrubland EVC A111, Seasonally Inundated Sub-saline Herbland EVC 196, Spoil EVC 990, Coastal Saltmarsh Aggregate EVC 9.

Littoral Zone: Saltpan

Saltpan habitats are unique anthropogenic wetland habitats arising from past salt production use. There are only two saltpan habitats along the western shoreline of Port Phillip Bay found at Avalon Coastal Reserve and Cheetham Wetlands. These habitats include a series of interconnected shallow ponds and are characterised by their high salinity levels and flat, salt-crusted surfaces which actively contribute to both terrestrial and aquatic ecosystems. Saltpan habitat benefits from a pumped hydrological scheme to maintain habitat quality for shorebirds, with management required. This may or may not be occurring across all saltpan habitats in Port Phillip Bay.

The saltpan habitats support unique biological systems where planktonic and benthic communities develop in extreme saline conditions, hosting a diverse array of micro and macro-organisms (EcoFutures, 2023). These macro- and micro-organisms greatly contribute to nutrient cycling and are the foundation of saltpan ecosystems (Wasserman et al., 2022).

Migratory shorebirds favour saltpan habitats as their crucial feeding, roosting and nesting grounds due to the large extent of brine shrimp and algae. Shorebirds that feed on intertidal areas may move to adjacent saltpans to continue foraging at high tide. Saltpans are generally devoid of any vegetation cover and the natural predation barrier from shallow saline ponds mean that it is ideal high-tide roost and nesting grounds for specialised species.

Littoral Zone: Saltpan – Habitat Group nested asset examples

Banded Stilt. Image source: Luke Seitz, eBird 2016.

Red-necked Stint. Image source: Neil Hayward, eBird 2017.

Avalon saltpans & Fairy Tern nesting sites. Image source: EcoFutures 2023.

Table 11 Littoral Zone: Saltpan - Habitat Group nested assets.

Habitat	Nested assets	
Saltpan	**Avian**	Key threatened migratory shorebirds: Red-necked stint, Sharp-tailed sandpiper, Curlew Sandpiper, Double-banded Sandpiper Iconic birds at high tide: Banded Stilts and Red-necked Avocets, Small white terns (e.g., Fairy Terns and Little Terns) Resident shorebirds: Red-capped Plover, Masked Lapwing, Pied Oystercatcher Waterbird foraging Migratory high tide roosting Nesting, roosting, feeding sites Shorebird sites Other common birds from VBA records

Habitat	Nested assets	
	Non-avian	Growling Grass Frog
		Invertebrates

Littoral Zone: Seagrass

Seagrass meadows are complex and extremely productive environments which stabilise the sediment and capture sunlight to produce food, playing a vital role in supporting food chains (Stewart and Fairfull, 2007). While typically found in subtidal areas, spatial analysis identified a limited scattering of seagrass the deeper parts of intertidal zones.

Seagrass meadows provide habitat for epiphytic algae, diatoms, sponges, and grazing invertebrates such as molluscs. The organic matter from decaying seagrass leaves is a major food source for many crustaceans like crabs, shrimp, and burrowing worms. Seagrasses also offer shelter and protection for juvenile fish, making them important nursery areas for many species including Pipefish (*Syngnathinae spp.)*, Yellow Eye Mullet (*Aldrichetta forsteri*), Leatherjackets (*Oligoplites saurus*), and King George Whiting (*Sillaginodes punctatus*). Additionally, they provide crucial foraging grounds for shorebirds, waterbirds and waders. Many of the fauna associated with seagrasses rely heavily on the extent and cover of dominant species like Eelgrass (*Zostera muelleri)*. Beyond their role as habitats, seagrasses also sequester carbon, further emphasising the need for their continued conservation.

Littoral Zone: Seagrass – Habitat Group nested asset examples

Black Swan. Image source: Terence Alexander, eBird 2018.

Eastern Fiddler Ray. Image source: Richard Ling, Australian Museum.

Seagrass. Image source: Jacqui Geux 2020.

Table 12 Littoral Zone: Seagrass - Habitat Group nested assets.

Habitat	Nested assets	
Seagrass	**Avian**	Nesting, roosting, feeding sites
		Shorebird sites
		Other common birds from VBA records
		Orange-bellied Parrot
		Black Swan
	Non-avian	Invertebrates: Crabs, Worms, local seagrass habitat patches of fine sediment with more benthic diversity.
		Fish: Grazing species community, Sygnathids (seahorse family – listed), Banjo Sharks / Fiddler Rays. Nurseries for important species (ecological, commercial/recreational) e.g., King George Whiting, Flathead, Flounder.
	Other	Intertidal seagrass species (*Zostera meulleri*)
		Epiphytic algae

Littoral Zone: Rocky Reefs

Rocky Reefs in the Littoral Zone are found in rocky areas regularly exposed to both marine and terrestrial conditions and heavily influenced by wave energy within Port Phillip Bay. These reefs are typically structured around boulders, rock and reef platforms, rock walls, and breakwaters. In the study area, this Habitat Group is restricted to Point Cooke Marine sanctuary, Wyndham Harbour, Avalon Coastal Reserve, and Point Wilson. Intertidal reefs often experience rapid and extreme changes in environmental conditions, including temperature, salinity, and air exposure, which can lead to desiccation stress (EcoFutures, 2023). Rocky Reefs support highly diverse communities, including Neptune's Necklace (*Hormosira banksia*) and macroinvertebrates such as limpets, herbivorous snails, whelks, starfish, anemones, ascidians (including Cunjevoi) and shore crabs. Various fish species also use the reef during higher tide, while shorebirds such as Oystercatchers (*Haematopus* spp.), Cormorants (*Phalacrocoracidae* spp.), and Shearwaters (*Procellariidae* spp.) feed and roost on intertidal reefs during low tide.

Littoral Zone: Rocky Reefs – Habitat Group nested asset examples

Ruddy Turnstone. Image source: Jay McGowan, eBird 2015.

Tasmanian Blenny (also found in Victoria). Image source: Julian Finn, Museum Victoria.

Neptune's Necklace. Image source: Mark Norman, Museum Victoria.

Table 13 Littoral Zone: Rocky Reefs - Habitat Group nested assets.

Habitat	Nested assets	
Rocky Reefs	Avian	Migratory and resident shorebirds: Pied and Sooty Oystercatchers, Ruddy Turnstone (*Arenaria interpres*), Pacific Golden Plover
		Large Waders: egrets, cormorants, herons
		Seabirds: terns, gulls, gannets
		Orange-bellied Parrot
		High tide roosting for migratory birds
		Nesting, roosting, feeding sites for migratory and shorebirds
		Shorebird sites
		Other common birds from VBA records
		Orange-bellied Parrot
	Non-avian	Habitat forming species: Neptune's necklace, Tube worms, Little Black Horse Mussel, Macroalgae
		Intertidal fauna: Limpets, herbivorous snails, Whelks, Starfish, Anemones, Cunjevoi, Shore Crabs, Blenny
		Rockpool communities

Littoral Zone: Soft Sediment

Soft Sediments in the Littoral Zone are composed of the intertidal mudflats frequently exposed at low tide. These areas often coexist with seagrass and surrounding saltmarsh vegetation communities. Soft Sediments are often nutrient rich, particularly in the WTP, where areas have been enriched by effluent discharges for a long time (Ecology Australia, 2018). These habitats support a high biomass of benthic fauna, comprised of large gastropods, crustaceans, bivalves, especially in the WTP. Micro-algae, polychaete worms, and other amphipods also inhabit these sediments. At low tides, these habitats provide highly productive foraging environments for waterbirds and shorebirds (Rogers et al., 2011), with large numbers of foraging shorebirds observed within the WTP (Ecology Australia, 2018). Besides avian species, these habitats

serve as excellent feeding areas for fish, including stingarees, globefish, flounder, flathead, and whiting (Parks Victoria, 2007).

Littoral Zone: Soft Sediment – Habitat Group nested asset examples

Bar-tailed Godwit. Image source: Ian Davies, eBird 2015.

Red-capped Plover. Image source: Steven Pratt, eBird 2018.

Eastern Fiddler Ray. Image source: Richard Ling, Australian Museum.

Table 14 Littoral Zone: Soft Sediment - Habitat Group nested assets.

Habitat	Nested assets	
Soft Sediment	**Avian**	Shorebird and Waterbird foraging areas: Bar-tailed Godwit, Common Greenshank, Common Sandpiper, Curlew Sandpiper, Eastern Curlew, Grey-tailed Tattler, Hardhead, Lesser Sand Plover, Plumed Egret, Red Knot, Ruddy Turnstone, Double-banded Plover, Red-capped Plover, Sooty and Pied Oystercatcher, Wood sandpiper, Red-necked stint Seabirds: Little Tern, Fairy Tern, Crested Tern, Caspian Tern, Gannets Migratory high tide roosting Nesting, roosting feeding sites Shorebird sites Other common birds from VBA records Orange-bellied Parrot
	Non-avian	Growling Grass Frog Seaweed and Seagrass wrack: Habitat for invertebrates, foraging, organic deposition Characteristics invertebrate communities (Bivalves, crustaceans, insects, worms, windblown insects (resource for shorebird foraging) Habitat forming invertebrates: Burrowing shrimp, large bivalves, gas exchange and nutrient cycling Fish species (Rays, flathead)

Littoral Zone: Other Coastal Habitats

Other Coastal Habitats refers to a diversity floristic communities not classified in the other Habitat Groups. This includes Coastal Saline Grassland (EVC A109), Brackish Lignum Shrubland (EVC 947), Estuarine Flats Grassland (EVC 914), Seasonally Inundated Sub-Saline Herbland (EVC 196) and Coastal Alkaline Scrub (EVC 858). Coastal Saline Grassland is dominated by rhizomatous grasses, usually occurring in the upper zones of coastal saltmarsh. Estuarine Flats Grassland are tussock grassland of low-lying coastal sites beyond the zone of normal tidal inundation but can be subject to seasonal inundation. These habitats support migratory shorebirds for high tide roosting and are important nesting, shelter, roosting and feeding grounds for many other birds.

Littoral Zone: Other Coastal Habitats and their nested asset examples.

Common Greenshank. Image source: Marco Valentini, eBird 2017.

Curlew Sandpiper. Image source: Khemthong Tonsakulrungruang, eBird 2015.

Table 15 Littoral Zone: Other Coastal Habitats and their nested assets.

Habitat	Nested assets	
Other coastal	Avian	Migratory high tide roosting Nesting, roosting, feeding sites Shorebird sites Other common birds from VBA records
	Non-avian	Growling Grass Frog
	Vegetation	Coastal Saline Grassland EVC A109 Brackish Lignum Shrubland EVC 947 Estuarine Flats Grassland EVC914 Seasonally Inundated Sub-saline Herbland EVC196 Coastal Alkaline Scrub EVC 858

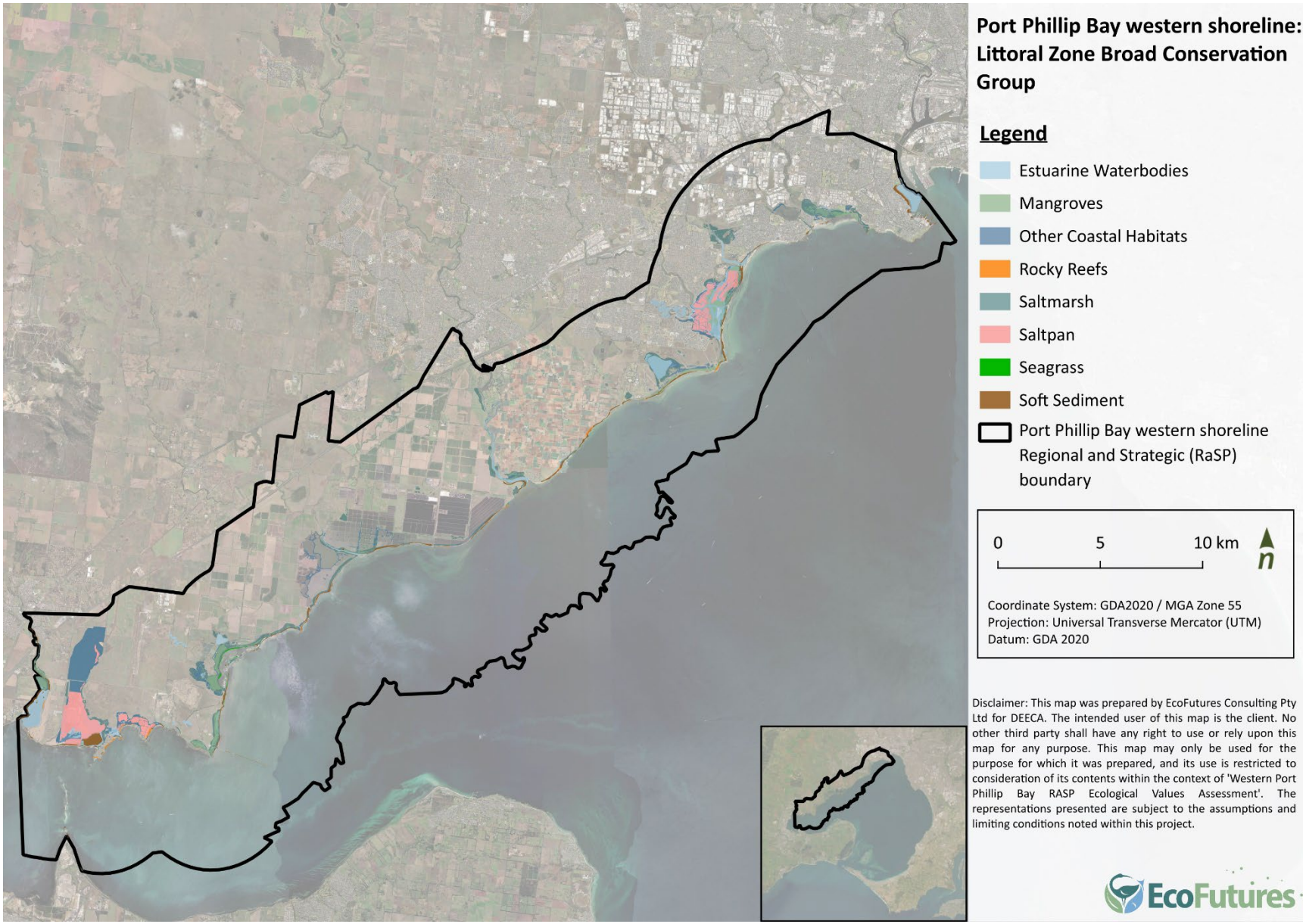


Figure 10. Port Phillip Bay western shoreline Littoral Zone Broad Conservation Group.

3.2.5 Marine Areas

Marine Areas have been delineated based on the benthic depth of the Seamap's Benthic Habitat layers (University Tasmania, 2024). This Broad Conservation Group includes all habitat within the circalittoral, infralittoral and sublittoral zones. This Broad Conservation Group contains four Habitat Groups:

- Seagrass
- Saltmarsh
- Rocky Reefs
- Soft Sediment

Marine Areas: Seagrass

As described in Section 3.2.4, seagrass meadows are an important marine habitat in Port Phillip Bay waters. Whilst seagrass meadows are found in the Littoral Zone, these highly productive ecosystems are also found in deeper waters of the study area. The predominant species in Victoria's sheltered bays and inlets are in the family Zosteraceae. *Zostera nigricaulis* is the dominant seagrass species in sublittoral zones, inhabiting shallow subtidal areas to 15m depth (DEECA, 2018).

Seagrass meadows provide habitat for epiphytic algae, diatoms, sponges, and grazing invertebrates including many molluscs, whilst organic matter formed from decaying leaves is a major food source for many crustaceans like crabs and shrimp as well as burrowing worms. Seagrasses provide shelter and protection for juvenile fish and are important nursery areas for many fish including Pipefish (*Syngnathinae* spp.), Yellow Eye Mullet (*Aldrichetta forsteri*), Leatherjackets (*Oligoplites saurus*), and King George Whiting (*Sillaginodes punctatus*). They are also important foraging habitat for shorebirds and waders. Most fauna associated with seagrass are heavily reliant on the extent and cover of the predominant marine seagrass species, such as Eelgrass (*Zostera muelleri*). In addition to the habitat they provide, the ability of Seagrass to reduce atmospheric carbon concentrations is an important consideration for their continued conservation.

Marine Areas: Seagrass nested asset examples

Black Swan. Image source: Terence Alexander, eBird 2018.

Eastern Fiddler Ray. Image source: Richard Ling, Australian Museum.

Eelgrass. Image source: Jacqui Geux 2020.

Table 16 Marine Areas: Seagrass - Habitat Group nested assets.

Habitat	Nested assets	
Seagrass	Avian	Nesting, roosting, feeding sites Shorebirds Other common birds from VBA records
	Non-avian	Fish: Sygnathids (seahorse family – listed), Fiddler Rays, Nurseries for important species (ecological, commercial/recreational) e.g., King George Whiting, Flathead, Flounder. Invertebrate communities: Grazing species community, Crabs, Worms.
	Other	Subtidal seagrass species (*Zostera nigricaulus, Zostera tasmanicus, Halophila australis*), epiphytic algae, local seagrass habitat patches of fine sediment with more benthic diversity.

Habitat	Nested assets	
		Protecting against erosion, improving water quality, carbon sequestration, oxygenation.

Marine Areas: Saltmarsh

Saltmarsh is an intertidal vegetation type and found generally within the Littoral Zone, however in delineating the habitat between Littoral Zone and Marine Areas, there was a limited distribution of Saltmarsh mapped beyond the Littoral Zone along the Spit Nature Conservation Reserve. Although saltmarsh can migrate with changing tidal conditions, and might persist temporarily in shallow marine areas, it cannot persist long-term in subtidal conditions. As we rely on static spatial boundaries from the habitat mapping datasets, saltmarsh occurring in the marine zone may be a mapping error. It may not account for the dynamic environment in reality (See Section 2.4 on data assumptions and limitation). As described in Section 3.2.4, Saltmarsh supports littoral / coastal ecosystems that thrive in saline conditions.

Common saltmarsh floristic communities within the study area are Coastal Saltmarsh (EVC9), Coastal Alkaline Scrub (EVC 858), Wet Saltmarsh Herbland (EVC 9), Wet Saltmarsh Shrubland (EVC 10), Berm Grassy Shrubland (EVC 311). Coastal Hypersaline Saltmarsh and Coastal Tussock Saltmarsh are also found to occur extensively at The Spit Nature Conservation Reserve (Ecology Australia, 2018).

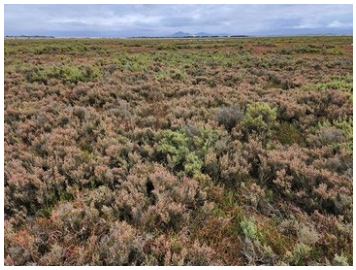
The Saltmarsh provides critical habitat for both terrestrial and marine species. They offer shelter for fish during high tides and serve as feeding and roosting grounds for migratory wading birds, such as the Sharp-tailed Sandpiper (*Calidris acuminata*), Marsh Sandpiper (*Tringa stagnatilis*), Orange-bellied Parrot (*Neophema chrysogaster*), and Blue-winged Parrots (*Neophema chrysostoma*), as well as saltmarsh specialists like the White-fronted Chat (*Epthianura albifrons*). Non-avian species, including the Swamp Skink (*lissolepis coventryi*) and native rats, also inhabit this Habitat Group. Like mangroves, the Saltmarsh can absorb and store atmospheric carbon, making them important carbon sinks.

Coastal development has led to the significant loss of Saltmarsh habitat throughout coastal Victoria, particularly in Port Phillip, making remnant Saltmarsh areas within the study area of high ecological value (EcoFutures, 2023).

Marine Areas: Saltmarsh nested asset examples

Orange-bellied Parrot. Image source: John Barkla, Birdlife Australia.

Australian Spotted Crake. Image source: Indra Bone, eBird 2018.



Coastal hypersaline saltmarsh, The Spit Lagoon. Image source: EcoFutures 2023.

Table 17 Marine Areas: Saltmarsh - Habitat Group nested assets.

Habitat	Nested assets	
Saltmarsh	Avian	Migratory Parrots: Orange-bellied Parrot, Blue-winged Parrot
		Wetland birds and waders: Little Egret, Brolga, Hardhead, Lewin's Rail, Pacific Golden Plover, Marsh Sandpiper, Plumed Egret, Sharp-tailed Sandpiper
		Non-water birds: Superb Fairy Wren, White-browed Scrub-Wren, Golden-headed Cisticola, Striated Field-Wren
		Nesting, roosting, feeding sites
		Shorebird sites
		Other common birds from VBA records

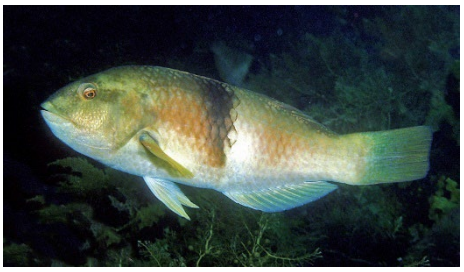
Habitat	Nested assets	
	Non-avian	Herpetofauna Saltmarsh invertebrates and grazers: Nitrogen fixers, sediment accretion, carbon storage, unique set of invertebrates and grazers in each saltmarsh type (e.g., tussock, saltbush, etc)
	Other	Ecological processes (Carbon sequestration, protecting coast storm surge and erosion)

Marine Areas: Rocky Reefs

Subtidal Reefs are located at depths greater than 2 metres below sea level, this includes shallow reefs (i.e. 2-20 metres) and deep reefs (up to 100 metres). This Habitat Group is found across the study area, with large areas found in deeper waters off Altona-Point Cook shores. Habitat quality and community and species composition varies across the study area. Habitat-forming macroalgae (e.g., filamentous brown algae *Ectocarpales* spp.), sponges, encrusting coralline algae, and hard coral (*Plesiastrea versipora*) (Hart et al. 2003; Parks Victoria, 2007) grow on these reefs. This supports diverse invertebrate communities consisting of starfish, urchins, crabs, lobsters, molluscs, marine worms, and cnidarians. In turn, these invertebrates support diverse fish assemblages, including Morwong (*Cheilodactylidae* spp.), Leatherjacket, Southern Hulafish (*Trachinops caudimaculatus*), and Blue-throat Wrasse (*Notolabrus tetricus*).

Rocky Reef nested asset examples

Sooty Oystercatcher. Image source: Adam Fry, eBird 2015.



Blue Throat Wrasse. Image source: Rudie H. Kuiter, Aquatic Photographics.

Neptune's Necklace. Image source: Mark Norman, Museum Victoria.

Table 18 Marine Areas: Rocky Reef - Habitat Group nested assets.

Habitat	Nested assets	
Rocky Reefs	Avian	Migratory and resident shorebirds: Pied and Sooty Oystercatchers, Ruddy turnstones, Pacific Golden Plover Large Waders: Egrets, Cormorants, Herons Seabirds: Terns, Gulls, Gannets Nesting, roosting feeding sites Shorebird sites Other common birds from VBA records
	Non-avian	Habitat forming species: Neptune's Necklace, Tube Worms, Little Black Horse Mussel, Macroalgae Reef fish (subtidal): Blenny, Triplefin, Wrasse Reef invertebrates (subtidal): Abalone, Molluscs, Starfish, Urchins Rockpool communities

Marine Areas: Soft Sediment

Soft Sediment occurs largely within this Marine Areas Broad Conservation Group and are common in Port Philip Bay and elsewhere along the Victorian coast. These habitats support the process of denitrification where nitrate is converted into nitrogen gas and released into the atmosphere. Soft Sediments are diverse and nutrient rich habitat and the spaces between sediments provide habitat for small organisms such as nematodes and copepods. Invertebrate communities are often associated with the upper layers of sediment with larger animals such as benthic fish, and starfish forage on the sediment surfaces (Parks Victoria, 2007).

Soft Sediment nested asset examples

Pacific Golden Plover. Image source: Sharif Uddin, eBird 2019.

Eastern Fiddler Ray. Image source: Richard Ling, Australian Museum.

Eight-armed Cushion Star. Image source: Museum Victoria.

Table 19 Marine Areas: Soft Sediment - Habitat Group nested assets.

Habitat	Nested assets	
Soft Sediment	Avian	Waterbird foraging areas: Black Swan, Plumed Egret Seabirds: Little Tern, Fairy Tern, Crested Tern, Caspian Tern, Gannets Nesting, roosting, feeding sites Shorebird sites Other common birds from VBA records
	Non-avian	Characteristics invertebrate communities (Bivalves, crustaceans, insects, worms, windblown insects (resource for shorebird foraging) Habitat forming invertebrates: Burrowing shrimp, large bivalves, gas exchange and nutrient cycling Fish species (Rays, flathead)
	Other	Seaweed and Seagrass wrack: Habitat for invertebrates, foraging, organic deposition

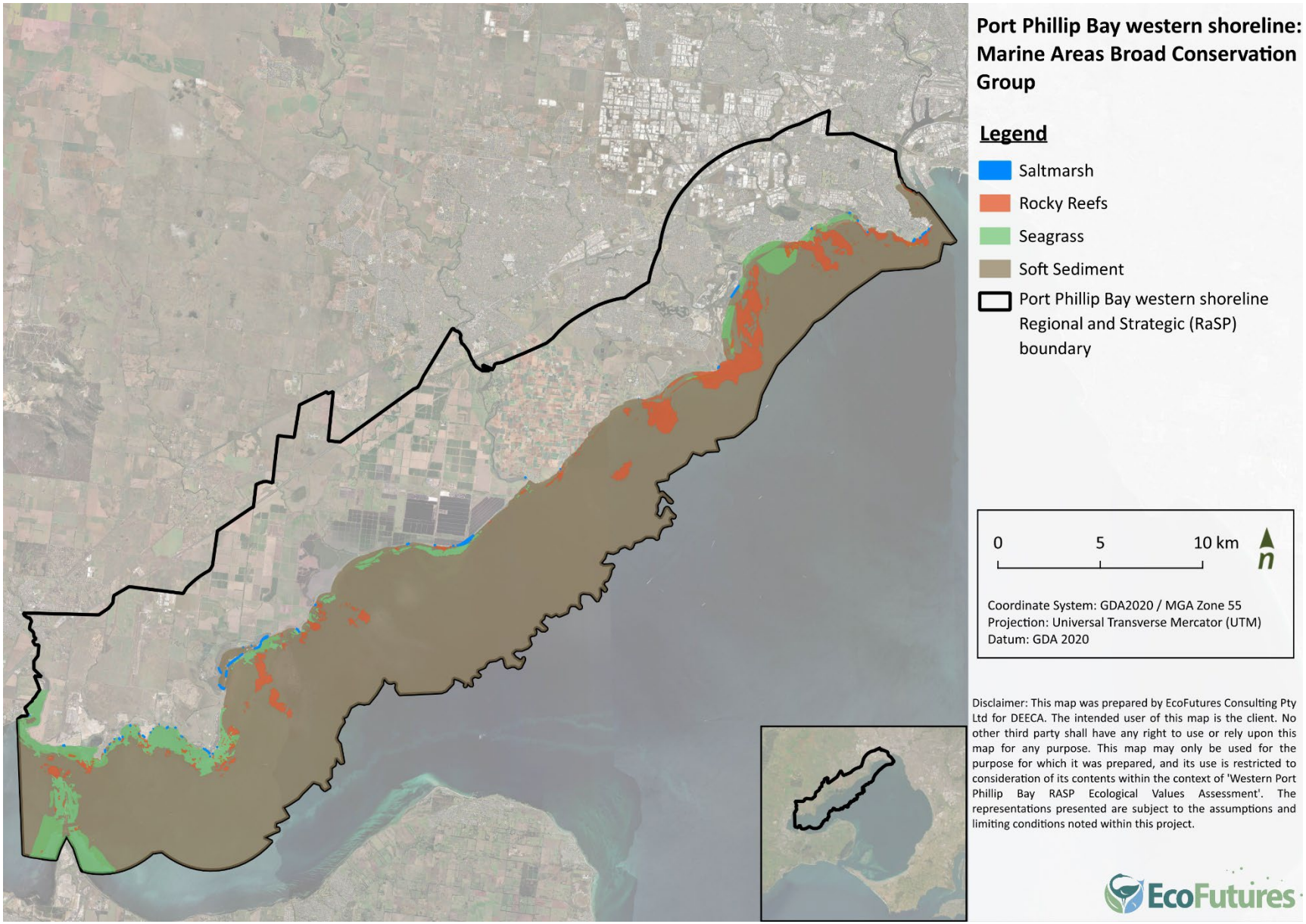


Figure 11. Port Phillip Bay western shoreline Marine Areas Broad Conservation Groups.

4 Vulnerability assessment

This section outlines an indicative vulnerability assessment based on best available information on existing ecological values and their vulnerabilities to potential coastal impacts. Vulnerability assessment has been developed through consultations with the Project Working Group, Specialist Advisory Group, DEECA and in-house ecologists to provide best available outcomes. This section describes the process and outcome of the vulnerability assessment.

4.1 What is vulnerability?

Section 4.3 of the technical guidelines 'Victoria's Resilient Coast – Adapting for 2100+' (DEECA, 2023) defines vulnerability as a function of a coastline's exposure, sensitivity and adaptive capacity to coastal hazards. The definitions of exposure, sensitivity and adaptive capacity are:

- **Exposure:** the degree to which a system is exposed to a given hazard
- **Sensitivity:** in the context of a vulnerability assessment, the term sensitivity refers to the degree to which a system is affected by, or responsive to, a hazard
- **Adaptive capacity:** the ability of systems, institutions, humans and other organisms to adjust following a hazard, to take advantage of emerging opportunities, or to respond to consequences.

In this study, we adapted the vulnerability definition from VRC framework to be suitable for specifically assessing the vulnerability of ecological assets to coastal hazards. Specifically, we defined vulnerabilities as:

- **Exposure:** the degree to which an ecosystem or asset is exposed to a given hazard
- **Level of tolerance to coastal hazard impacts:** the degree to which an ecosystem is affected by a hazard
- **Adaptive capacity:** the ability of ecosystem or habitat to adjust and response to changes

In addition to the above three definitions (i.e. Exposure, Level of tolerance to coastal hazard impacts and adaptive capacity), we introduced an additional parameter, **Irreplaceability**, into this vulnerability assessment.

Irreplaceability

Irreplaceability is considered an independent function that does not consider impacts of coastal hazards on ecological values. Rather, it is the degree of rarity of ecosystem, habitat and associated ecological values and how difficult it is to replace if it is lost (Margules and Pressey, 2000).

Irreplaceability is a common measure in systematic conservation planning where it is used to measure the uneven distribution of biodiversity across a landscape and the options available for conservation management decision. In the context of this vulnerability assessment, irreplaceability does not change with exposure, and it scales with the vulnerability of individuals to a population level. In the context of the study area, Irreplaceability feeds into the vulnerability assessment by providing information about the scale of vulnerability into the context of the western shoreline of Port Phillip Bay. In other words, if individual species are extremely unique and only occurring in this area, it is unlikely to be replaced with the same individual species if it is damaged or lost and therefore has a very high irreplaceability.

The tailored vulnerability assessment framework is shown in Figure 12.

These aspects of vulnerability identify the characteristics of an ecosystem or asset to impacts of each coastal hazard. This framework was used to assess the vulnerability for each coastal hazard type and determine how these Broad Conservation Groups and their nested assets would be impacted under temporary change and permanent change.

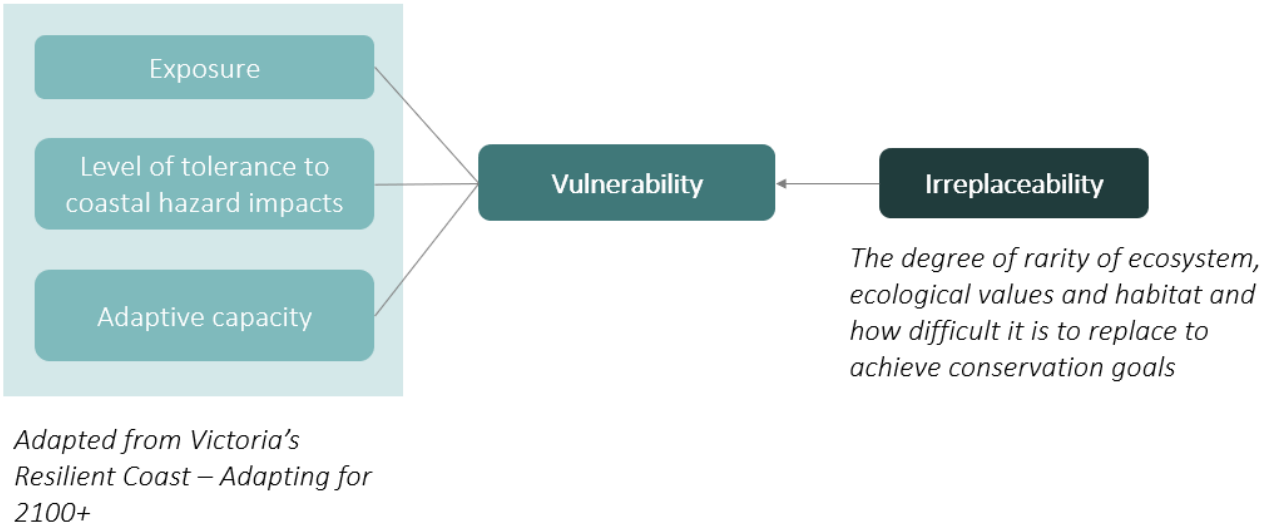


Figure 12. Vulnerability assessment framework developed based on Victoria's Resilient Coast – Adapting for 2100+ technical guidelines.

4.2 Alignment of the vulnerability assessment with the next phase of coastal hazard risk assessment

The vulnerability assessment has been set up in preparation for further quantification of vulnerability/risk in the next Stage (Stage 4) of the Adapt West adaptation planning process.

In the next stage, quantitative assessments will consider the Likelihood and Consequence (= Risk) of coastal hazard impacts to a diversity of values and assets across the Adapt West study area, based on Victoria's Resilient Coast framework and guidelines (2023).

The vulnerability assessment from this study will provide the 'Consequence' component for ecosystem values. The coastal hazard exposure will be the 'Likelihood' component of risk, based on the event-based mapping for relevant hazards.

The qualitative assessment of vulnerability in this study assumes habitat vulnerability if exposed to coastal hazards. Figure 13 illustrates how the ecological value assessment components from this study are intended to feed into quantitative risk assessments in the next stages of Adapt West planning.

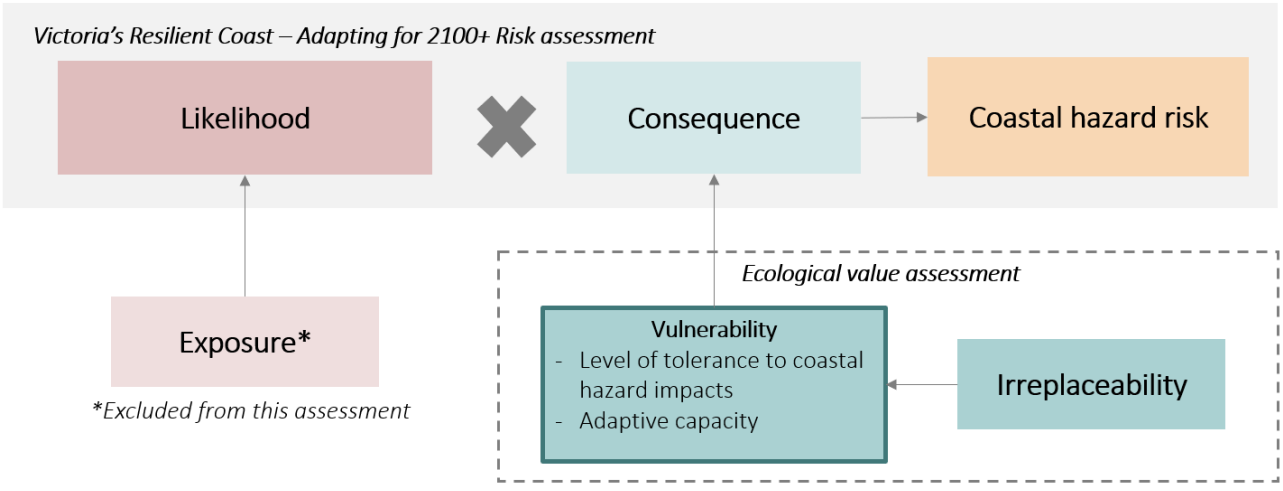


Figure 13. Alignment of ecological vulnerability assessment framework with Stage 4 of 'Victoria's Resilient Coast' technical guidelines

4.3 Vulnerability and irreplaceability criteria

Vulnerability of each asset was scored using a 5-point scale for both vulnerability and irreplaceability each with a ranking of Very low, Low, Medium, High and Very high (Table and Table).

Vulnerability criteria

As described in Section 4.1 and 4.2, vulnerability criteria consider the level of tolerance to coastal hazards and adaptive capacity. Exposure was excluded from this part of the assessment as it forms part of the likelihood assessment in the later phase of the Adapt West program. The vulnerability criteria are scored between very low (1) to very high (5).

Table 20. Vulnerability criteria and ranking

Scores	Ranking	Criteria
1	Very low	The value is highly tolerable to coastal hazards, so has very high adaptive capacity.
2	Low	The value is tolerant to coastal hazards, so has high adaptive capacity.
3	Medium	The value can tolerate impacts of coastal hazards temporarily, so has medium adaptive capacity.
4	High	The value cannot tolerate prolonged impacts of coastal hazards for prolonged period of time and so has low adaptive capacity.
5	Very high	The value is not tolerant of impacts of coastal hazards and so has no adaptive capacity.

Irreplaceability criteria

The irreplaceability criteria consider the distribution of habitat, ecosystem types and nested assets within the study area, within Port Phillip Bay and across Victoria. These are informed by the threatened status of nested assets, and expert opinion on the habitat in a particular region. The distribution of these ecological values is an effective way of understanding how rare the ecosystems / values are within the study area, compared to the broader landscape. The Irreplaceability criteria are scored between very low (1) to very high (5).

Table 21. Irreplaceability criteria and ranking

Scores	Ranking	Criteria
1	Very low	Very common in the project area and across Victoria
2	Low	Common in the project area and within Port Phillip Bay
3	Medium	Common in the project area but less common in Port Phillip Bay
4	High	Rare or unique, with many important representations within the project area
5	Very high	Rare or unique, restricted to local area within the project area

Application

These criteria are applied to all Broad Conservation Groups, except for Littoral Zone and Marine Areas where the habitat characteristics are distinct and require separate analysis for each Habitat Group.

Criteria are scored based on expert opinions, literature and the two workshops with the SAG (held in October 2024). The scores are then applied to the spatial layers for the next phase of the Adapt West program. The outcome of the vulnerability and irreplaceability scores for Broad Conservation Groups and Habitat Groups are summarised in Section 4.6.

4.4 Assumptions and limitations to the vulnerability assessment

There are several assumptions and limitations driving the vulnerability assessment. These were identified through workshops and consultations with the Specialist Advisory Group and the Project Working Group.

- Insufficient information about the speed of change – The speed of change relates to the speed of response of ecosystems to impacts of coastal hazards and whether the impacts would be a gradual change or a rapid change. This assessment does not have sufficient information about the speed of change unless specific threat modelling were to be undertaken in detail. As such, we have only assessed the vulnerabilities based on current status of response based on best available information.
- Intensity and frequency of coastal hazard events were not considered fully in the assessment – Certain coastal hazard types, such as storm tide inundation, do not have a defined intensity level that can be used for this assessment. Some ecosystems can tolerate event-based coastal hazards and can recover following an event. However, if the intensity of an event becomes too extreme, vulnerable/sensitive ecosystems and habitats may fail to recover, leading to long-term damage. If event-based hazards occur more frequently, ecosystems that typically tolerate and recover from disturbances may struggle to adapt, resulting in changes to their composition, structure, functions, and processes. It is important to recognise that the response to disturbances varies based on the ecosystem's resilience and the intensity of the events. This study cannot predict event intensity without specific modelling; instead, it offers a qualitative assessment of how increasing frequency or intensity of events could affect habitats and ecological values under these scenarios.
- Limited information about the adaptive capacity of nested assets – Some nested assets have extensive information available about the effects coastal hazards as well as their responses and recovery (e.g., seagrass). However, lesser-known nested assets (e.g., invertebrates and certain plant species) lack information on their adaptive capacity in response to coastal hazards. Consequently, this assessment draws on various different sources (e.g., expert opinion) and evaluates vulnerabilities at the Broad Conservation Group and Habitat Group levels.
- Assessment was conducted based on the current condition of the ecosystems and habitats – This assessment was undertaken using the best available information on the current condition of the ecosystems and habitats across western Port Phillip Bay. However, it does not consider the future conditions of ecosystems as there is insufficient information to predict how ecosystems might behave under modelled future environmental conditions. There are also many other confounding factors that influence environmental conditions beyond the coastal hazard impacts considered here. More sophisticated ecosystem and species distribution modelling is required to understand the future trajectory of these ecosystems beyond the scope of this assessment.
- Impacts of climate change factors beyond coastal hazard impacts were not considered – Climate change is one of the biggest threats to ecosystems across Victoria and the coastal hazard impacts assessed in this project are a subset of the full range of climate change impacts. It is likely that ecosystems will be vulnerable to the full effects of climate change beyond the coastal hazard perspective provided through this assessment. Some of these broader climate change impacts are increased water temperatures, higher air temperatures, ocean acidification, greater chance of frosting, higher carbon emissions, increased effect of wind, and increased catchment derived run-off. These factors were not included in this study.
- Other ecological threats were not considered in the study – Other ecological threats beyond the coastal hazards were not incorporated in this assessment. Examples of other threats include competition with other vegetation communities, invasive species, catchment management, land use changes (e.g., urban development, port development), and stormwater runoff. These are factors that will greatly affect the resilience, functional roles, and overall health of ecosystems. For instance, catchment impacts are likely to result in coastal squeeze for sensitive coastal ecosystems, as these threats degrade the condition and health of these remnant habitats. The assessment also does not consider invasive species and competition impacts. To illustrate, while mangroves provide numerous ecological benefits to birds and invertebrate species, they can also encroach on and extend landward into other vital vegetation communities, such as saltmarsh. The competition for space between ecological communities has not been considered in this assessment due to the limited scope of the project.

4.5 Application of the criteria: Case studies

This section presents several case studies of the application of the vulnerability and irreplaceability criteria to a few specific habitats, as examples on how these criteria and scores were allocated for each habitat and why it has been scored. As it is not possible to display the vulnerability scoring spatially for all Habitat Groups, this section highlights two specific Habitat Groups – Saltpan and Seagrass as case studies. The outcomes of the assessment are summarised in Section 4.6. The spatial layers are available in the data package.

4.5.1 Vulnerability assessment: Saltpan Habitat Group

The Saltpan habitats at the Avalon Coastal Reserve and Cheetham Wetlands have been identified as a significant area for specialised shorebirds. Saltpan habitats within Port Phillip Bay are rare (Cheetham, Avalon and Point Henry). The importance of Saltpans for migratory shorebirds is increasingly recognised (EcoFutures, 2023). Shorebirds that depend on intertidal areas for feeding may move to adjacent Saltpans to continue foraging and roosting at high tide and these areas are also important nesting grounds for specialised species that require spare vegetation cover and a natural predation barrier from the shallow saline ponds.

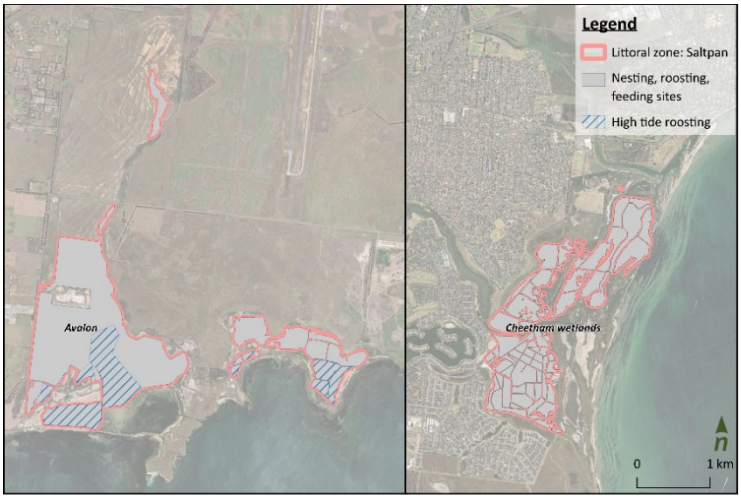


Figure 14. Littoral zone Saltpan Habitat Group in Avalon (left) and Cheetham wetlands and nested assets.

Saltpans in the saltworks have a variable and dynamic water regime controlled by artificial means (e.g., pumping) and they provide a mosaic of reliable feeding and roosting habitats within close proximity to each other, available every year and throughout the tide cycle. It is noted that the pumping regimes across the remaining saltpans in Port Phillip Bay may or may not be functioning. The saltworks levees and associated shallow sheltered areas provide roosting and nesting opportunities, with large expanses of water and lack of tall vegetation to allow the shorebirds sightlines for predator surveillance (Purnell et al. 2015).

There are two Australasian species of shorebird (Banded Stilt, Double-banded Plover) and three migratory shorebird species (Curlew Sandpiper, Sharp-tailed Sandpiper, Red-necked Stint) that occur in numbers of international significance (1% of global population) in the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site, and these species rely on the high-tide roost and forage habitats of the saltpans (EcoFutures, 2023). Shorebirds are known to forage and move across habitat, between Cheetham Wetlands, Conservation Ponds in WTP and Saltpans of Avalon (Rogers, 2022).

Irreplaceability scores are therefore rated as 'Very high'.

Irreplaceability score	Justification
Very high (5)	There is very limited saltpan habitat within the project area, and they are unique habitat arising from historic anthropogenic use. This habitat supports key threatened migratory birds and has a variety of resources for waterbirds.

Impact of storm tide inundation and permanent inundation to Saltpan habitats and associated ecological values

Storm tide inundation refers to the abnormal elevation of storm surges, which occur beyond high tide levels. Saltpans are tolerant of occasional flooding from storm tide inundation due to the regularity of tidal inundation experienced.

Additionally, throughout the study site, the presence of artificial levees and the artificial water regime means that there are opportunities to pump water off some saltpans and not pose a threat to the habitats of shorebirds in the short-term (Lei, 2021).

However, the Bellarine Peninsula – Corio Bay Local Coastal Hazard Assessment (Cardno, 2015) indicated that the levee fronting does not form a consistent barrier for storm tide inundation and under high sea level rise scenarios there could be inundation in some salt pans. If storm tide inundation events were to increase in frequency and size (magnitude), over time this could see the loss of saltpan habitat due to intrusion of saltmarsh communities currently present on the adjacent bunds of the saltpans.

Under the permanent inundation scenario, water inundation is assumed to cover the entire saltpan habitat. While there is insufficient information within the scope of this assessment on the likely levels of inundation and when it is likely to occur, saltpan habitat under permanent inundation will lose the filling-drying water regime and may be transformed into a Marine Areas. This habitat will likely be lost to inundation (become permanently inundated) and there will be a direct removal (loss) of high tide roosting, foraging and nesting areas for internationally listed threatened birds and migratory shorebirds.

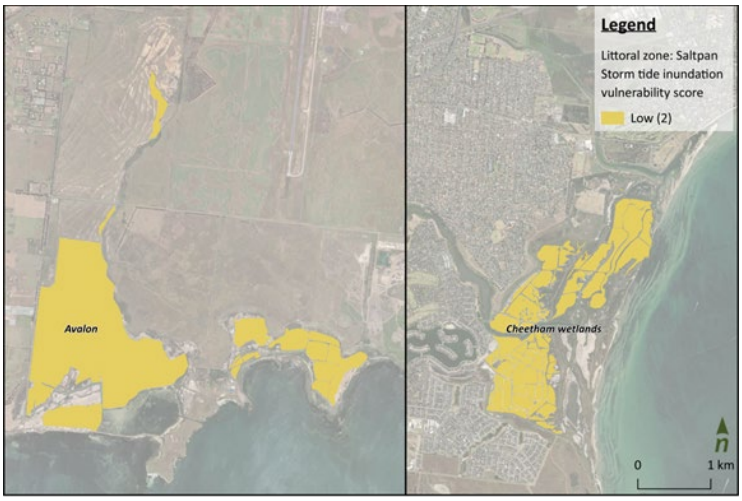


Figure 15 Littoral zone Saltpan Habitat Group storm tide inundation vulnerability score. Figure 16 Littoral zone Saltpan Habitat Group storm tide inundation vulnerability score.

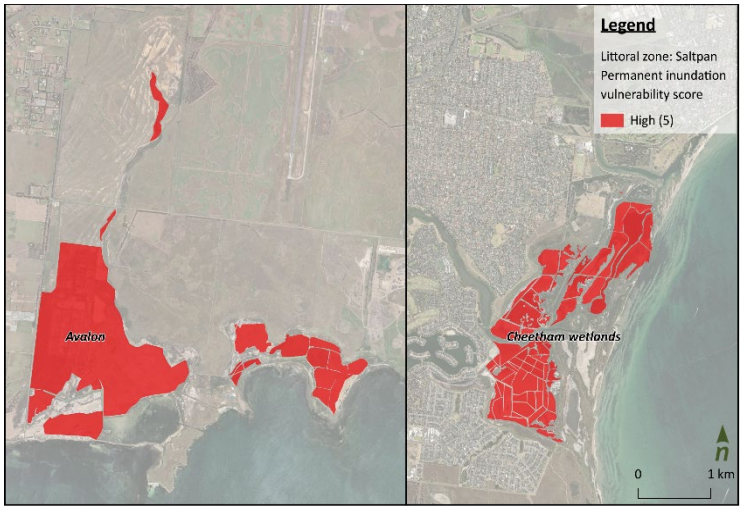


Figure 17 Littoral Zone Saltpan Habitat Group permanent inundation vulnerability score. Figure 18 Littoral Zone Saltpan Habitat Group permanent inundation vulnerability score.

Coastal hazard types	Vulnerability score	Justification
Storm tide inundation	Low (2)	Saltpan is generally tolerant of storm tide inundation and have almost negligible effect on the existing populations of shorebirds. However, if storm tide inundation keeps increasing, it may be lost to saltmarsh over a long period of time.
Permanent inundation	Very high (5)	Saltpan habitats would be transformed to Marine Areas with permanent inundation.

4.5.2 Vulnerability assessment: Seagrass

Seagrass meadows are found along the deeper waters of the study area, with mostly one species *Zostera nigricaulis* that occurs only in subtidal areas where exposure to the air is limited (DEECA, 2018). Seagrass meadows are found in several areas across Port Phillip Bay, Westernport and South-East of Victoria. Seagrass meadows provide habitat for a diverse range of species including grazing invertebrates, crustaceans, commercial and recreationally important fish, shorebirds and waders. In many areas, seagrasses are in healthy condition (Parks Victoria, 2021).

Irreplaceability score	Justification
Low (2)	There are many seagrass meadows across the Port Phillip Bay. Seagrasses are also commonly found across Western Port and south-east of Victoria.

Impact of offshore sediment dynamics on Seagrass habitats and associated ecological values

One of the key threatening processes for Seagrass communities are changes in the sediment deposition patterns and water flows. Offshore sediment dynamics increases movement of sediment across the marine beds which can increase nutrient levels and reduce light availability. Zabarte-Maeztu et al. (2021) summarised three stressors where sediments and organic matter could affect seagrass:

1. Seagrass require sufficient light to grow and are vulnerable to fine sediment suspended in water columns that reduces light penetration.
2. Fine sediment can settle on Seagrass, smothering leaf surfaces and preventing photosynthesis.
3. Fine sediment can intrude Seagrass substrate pore space and decrease permeability for oxygen availability. This could potentially lead to anerobic conditions.

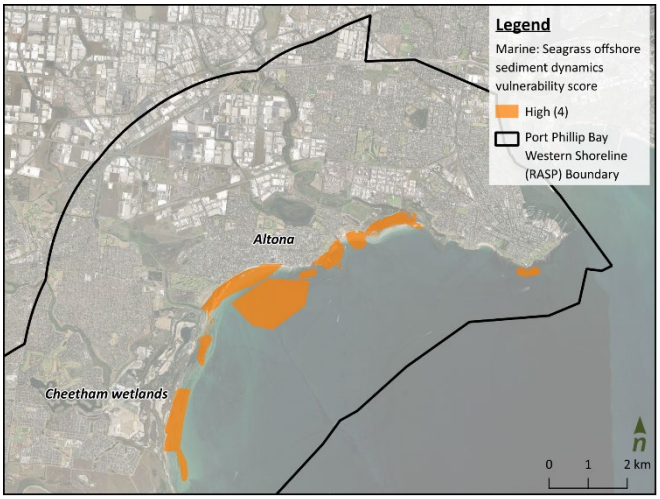


Figure 19 Marine Seagrass Habitat offshore sediment dynamics vulnerability score.

Offshore sediment dynamics can also have adverse impacts on important Seagrass nursery areas and reduce establishment rates of Seagrass. It also reduces connectivity between tidal entrances to deeper Marine Areas due to changes in the sedimentation in the marine beds. Therefore, the vulnerability score is high.

Coastal hazard types	Vulnerability score	Justification
Offshore sediment dynamics	High (4)	Seagrass is periodically eroded or buried in localised areas, often offset by other areas not/less affected. However offshore sediments can have impacts on important nursery areas and connectivity from shallow estuaries to deeper Marine Areas (Zabarte-Maeztu et al., 2021; de Boer, 2007).

4.6 Vulnerability assessment outcomes

The outcomes of the vulnerability assessment are described in the following sections for each Broad Conservation Group and Habitat Groups, with the justification for scoring the irreplaceability and vulnerability to each coastal hazard. These justifications were summarised based on experts from Specialist Advisory Group (SAG), EcoFutures' ecologists and DEECA for their expert understanding of the study area, ecological knowledge and current condition of the existing conditions. Some literature has also been included in the justifications. The scores are applied to the spatial layers and are available in the associated data package for this report.

4.6.1 Dry Forest/Woodland, Plains Grassland and Agricultural Areas

Table 22. Irreplaceability and vulnerability scoring for Port Phillip Bay western shoreline Dry Forest Broad Conservation Group.

Coastal hazard types	Irreplaceability scores	Vulnerability scores	Justification
Storm tide inundation	Medium (3)	Low (2)	Terrestrial vegetation is the most common habitat type in the project area and within PPB, however, some nested assets have important populations (e.g. native grasslands). While inundation itself, if short-term, is assessed as low, the increased salinity this would bring to the habitat would have a higher impact. There are predicted losses and damages to conservation and Agricultural Areas and their profits in Victoria due to sea level rise and storm surges (Kompas et al 2022), which will likely impact the species depending upon these areas as habitats.
Permanent inundation		Very high (5)	Very high vulnerability as these habitats cannot tolerate prolonged impacts of permanent inundation and this will affect terrestrial flora and fauna that require drier conditions (e.g., Stripped Legless Lizard and Spiny Rice-flower). There are predicted losses and damages to conservation and Agricultural Areas as well as their profits in Victoria due to sea level rise and storm surges (Kompas et al 2022), which will likely impact the species depending upon these areas as habitats.
Short-term erosion		Very low (1)	Dry Forest/Woodlands may be tolerant to short-term erosion driven by ocean/wave action, overland flow/drainage, due to the vegetation being anchored by extensive root systems.
Long-term erosion		High (4)	Long-term erosion will cause loss of habitat and reduce the quality of the remaining habitat.
Salinity		Very high (5)	These habitats do not tolerate changes in salinity in the short or long-term. Increased salinity will damage vegetation and result in a transition to salt tolerant vegetation types. This will also affect freshwater aquifers / groundwater and likely to result in a dieback of sensitive tree species and cause changes in the habitat type (salt tolerant vegetation will likely persist in this new landscape).
Groundwater		Very high (5)	Changes to water table depth (increasing) is likely to increase hydrological connectivity with surface water. A higher water table is likely to provide moisture to grasslands over prolonged period of time. Terrestrial species would not be able to survive under a prolonged wet environment.

4.6.2 Freshwater Systems: Wetlands and Waterways

Table 23. Irreplaceability and vulnerability scoring for Port Phillip Bay western shoreline Freshwater Systems Broad Conservation Group.

Coastal hazard types	Irreplaceability scores	Vulnerability scores	Justification
Storm tide inundation	Low (2)	Medium (3)	Effects of storm tide inundation is unlikely to greatly affect freshwater rivers and wetlands due to its capacity to withstand temporary disturbance.
Permanent inundation		High (4)	Freshwater wetlands and waterways cannot tolerate prolonged conditions of permanent inundation as they need a variety of water levels (for wetlands) for waterbird feeding and roosting habitat (DELWP, 2017). In rivers, higher water levels could mean dieback of instream vegetation and the lack of pulses/freshes would mean less sediment and nutrient cycling for maintaining habitat for a variety of species. Permanent inundation by seawater would eliminate habitat conditions for Growling Grass Frogs, Platypus, and rakali.
Short-term erosion		Medium (3)	Freshwater Systems would withstand short-term erosion temporarily.
Long-term erosion		High (4)	Retreat of shoreline would mean erosion to riverbanks and wetland banks and would increase chance of channel incision and increased sediment inputs into the river system.
Salinity		Very high (5)	Salinity is a major concern for Freshwater Systems, in particular most sensitive species such as Growling Grass Frogs are intolerant of prolonged high level of salinity (DELWP 2017). Waterbirds tolerate salinity in varying degree by species, which would change the composition of birds using these habitats. Nielson et al (2003) highlights the transition towards more salt-tolerant species of vegetation and invertebrates in these ecosystems as well as the loss of less salt-tolerant species.
Groundwater		Very high (5)	Depending on the salinity of the groundwater table/aquifers, when shallow groundwater becomes freshwater, Freshwater Systems have adapted to this hydrological connectivity. However, the effect could be variable depending on the salinity of the groundwater table. If it is saline, Freshwater System may not be able to cope with shallow saltwater and risk losing sensitive species as this change will be completely irreversible. Nielson et al (2003) highlights the transition towards more salt-tolerant species of vegetation and invertebrates in these ecosystems as well as the loss of less salt-tolerant species.

4.6.3 Beaches and Dunes

Table 24. Irreplaceability and vulnerability scoring for Port Phillip Bay western shoreline Beaches and Dunes Broad Conservation Group.

Coastal hazard types	Irreplaceability scores	Vulnerability scores	Justification
Storm tide inundation	High (4)	Medium (3)	There are very few Beaches and Dunes within western shoreline of Port Phillip Bay with some areas may have potential beaches and dunes present. They are still a preferred high tide roosting site for many birds across several families, therefore, the irreplaceability is high. These habitats can withstand storm tide inundation impacts for short periods.
Permanent inundation		Very high (5)	Complete loss of habitat as the shoreline is retreated and habitat will be completely inundated.
Short-term erosion		High (4)	There are very few beaches on the western shoreline of Port Phillip Bay, and they are highly vulnerable to erosion, particularly due to storm events and rising sea level (Bird 2006). It has a low adaptive capacity to move because there is lack of space inland for the beach and dune habitat to move and re-form when coastal hazard is occurring.
Long-term erosion		Very high (5)	There are very few beaches on the western shoreline of Port Phillip Bay, and they are highly vulnerable to erosion, particularly due to storm events and rising sea level (Bird 2006). Long-term erosion will result in the permanent loss of habitat for dune vegetation as well as habitat for shorebird and seabirds.
Salinity		Medium (3)	Beaches and Dunes vegetation tap into groundwater for freshwater (for some dunes).
Groundwater		Medium (3)	Beaches and Dunes vegetation tap into groundwater for freshwater (for some dunes).

4.6.4 Littoral Zone

Table 25. Irreplaceability and vulnerability scoring for Mangroves and Estuarine Waterbodies within the Port Phillip Bay western shoreline Littoral Zone Broad Conservation Group.

Habitat	Mangroves			Estuarine Waterbodies		
Coastal hazard types	Irreplaceability scores	Vulnerability scores	Justification	Irreplaceability scores	Vulnerability scores	Justification
Storm tide inundation	Low (2)	Very low (1)	Mangroves are tolerant to storm tide inundation as they are adapted to a constantly changing environment. Mangroves protect coastal foreshores by absorbing the energy of wind and wave action and providing a buffer that helps minimise erosion.	Very low (1)	Low (2)	Estuaries and wetlands are common across project area and in Victoria. Saline wetlands can withstand short-term storm tide inundation. However, considering local topography especially bunds of the former saltworks, there could be unintended consequences of seawater pooling in saltmarsh area if residence time is long enough. This effect is likely to be localised, hence the vulnerability is scored as 2.
Permanent inundation		High (4)	Mangroves are tolerant to storm tide inundation as they are adapted to a constantly changing environment. Mangroves protect coastal foreshores by absorbing the energy of wind and wave action and providing a buffer that helps minimise erosion.		Medium (3)	Estuary mouths are fertile feeding areas and provide sheltered roosting areas. Erosion and increased tidal ingress (presuming retention of levies) reduces sheltered roosting opportunities. Permanent inundation would change the habitat within the estuary, from brackish water to marine. Estuaries are highly productive due to the mixing of fresh and saltwater - which would become marine under permanent inundation. This would change the composition of species using these areas, from estuary specialists to marine species.
Short-term erosion		Very low (1)	The seaward limit of mangroves is generally aligned with mean sea level. With permanent inundation, the extent of mangrove will change. Permanent inundation may pose threats to the root systems, preventing gas exchange, which needs to happen in the air - eventually killing mangroves if the sea does not recede.		Medium (3)	Saline wetlands and estuaries could be tolerant of short-term erosion, but any large-scale erosion event (even if it's short-term) would likely to lead to habitat loss.
Long-term erosion		Medium (3)	Mangroves protect coastal foreshores by absorbing the energy of wind and wave action and providing a buffer that helps minimise erosion.		High (4)	Saline wetlands and estuaries could temporarily be tolerant of short-term erosion, but any large-scale erosion event (even if it's short-term) would likely to lead to habitat loss.
Salinity		High (4)	Increased salinity can cause stress to mangroves.		High (4)	Estuaries and saline wetlands are adapted to saline conditions, but increased salinity would transform the habitat from brackish mixed fresh and salt water with high productivity to a marine environment - which would no longer provide for estuarine specialists. Nielson et al (2003) highlights the transition towards more salt-tolerant species of vegetation and invertebrates in these ecosystems as well as the loss of less salt-tolerant species.
Groundwater		Very low (1)	Decrease in rainfall can lead to contractions in mangrove forests.		Medium (3)	While these habitats are adapted to saline conditions, groundwater intrusion could increase chance of hypersaline in the system and may change the composition of vegetation towards more salt tolerant species. Nielson et al (2003) highlights the transition towards more salt-tolerant species of vegetation and invertebrates in these ecosystems as well as the loss of less salt-tolerant species.

Table 26. Irreplaceability and vulnerability scoring for Saltmarsh and Saltpan within the Port Phillip Bay western shoreline Littoral Zone Broad Conservation Group

Habitat	Saltmarsh			Saltpan		
Coastal hazard types	Irreplaceability scores	Vulnerability scores	Justification	Irreplaceability scores	Vulnerability scores	Justification
Storm tide inundation	High (4)	Very low (1)	Saltmarsh is found in limited areas of the project area and supports many intertidal vegetation species and threatened migratory shorebirds. These are normally found in protected areas therefore the irreplaceability is high. Saltmarsh is tolerant to storm tide inundation as they are adapted to a constantly changing environment. Saltmarsh protects coastal foreshores by absorbing the energy of wind and wave action and providing a buffer that helps minimise erosion. Ecology Australia, Western Treatment Plant Biodiversity Conservation and Ramsar Management Plan: Part A, 2018 (pg. 65-66) states that inundation can reduce the extent and quality of shorebird, marsh birds, waterfowl and Orange-bellied Parrot foraging habitat and limit supratidal roosting habitat, affecting vegetation and amphibians.	Very high (5)	Low (2)	There is very limited Saltpan habitat within the study area, and it is a unique habitat arising from historic anthropogenic use. This habitat supports key threatened migratory birds and has a variety of resources for waterbirds (see Lei et al. 2021). Saltpan is tolerant of storm tide inundation, with negligible effects. However, if storm tide inundation keeps increasing, then it might lose to saltmarsh.
Permanent inundation		High (4)	Saltmarsh cannot tolerate permanent inundation as some saltmarsh species prefer drier conditions. Some of the saltmarsh types can tolerate almost permanent inundation, but those that are adapted to very little inundation would transition - and eventually all saltmarsh would be lost to Marine Areas. Ecology Australia, *Western Treatment Plant Biodiversity Conservation and Ramsar Management Plan: Part A*, 2018 (pg. 65-66) states that inundation can reduce the extent and quality of shorebird, marsh birds, waterfowl & Orange-bellied Parrot foraging habitat and limit supratidal roosting habitat, affects vegetation and amphibians		Very high (5)	There is very limited Saltpan habitat within the study area, and it is a unique habitat arising from historic anthropogenic use. This habitat supports key threatened migratory birds and has a variety of resources for waterbirds (see Lei et al. 2021). Saltpan habitats would be transformed to marine habitat with permanent inundation.
Short-term erosion		Low (2)	Short-term erosion can be tolerated by saltmarsh. Ecology Australia (2018) states that decreased sedimentation and deposition of effluent in conjunction with increased erosion impacts the productivity of the intertidal environment and affects the invertebrate community, structure and biomass, particularly around Lake Borrie Outfall and The Spit. It will also result in a decline in abundance and density of benthic invertebrates, and a significant reduction in the diversity of taxonomic groups and decline in species richness, undoubtedly impacting the species that feed on them. Between 2009 and 2013, species richness declined from 150 to less than 40 due to erosion impacts.		Very low (1)	There is very limited Saltpan habitat within the study area, and it is a unique habitat arising from historic anthropogenic use. This habitat supports key threatened migratory birds and has a variety of resources for waterbirds (see Lei et al. 2021). Saltpan habitats can tolerate short-term erosion, however some larger saltmarsh species such as shrubby glasswort can be killed by hypersalinity. This habitat is important for Orange-bellied Parrot, and therefore the vulnerability score should be high.

Habitat	Saltmarsh			Saltpan		
Long-term erosion		High (4)	A retreat of shoreline could mean the loss of habitat or potential intrusion of mangroves into the existing extent of saltmarsh. Ecology Australia (2018) states that decreased sedimentation and deposition of effluent in conjunction with increased erosion impacts the productivity of the intertidal environment and affects the invertebrate community, structure and biomass, particularly around Lake Borrie Outfall and The Spit. It will also result in a decline in abundance and density of benthic invertebrates, and a significant reduction in the diversity of taxonomic groups and decline in species richness, undoubtedly impacting the species that feed on them. Between 2009 and 2013, species richness declined from 150 to less than 40 due to erosion impacts.		Low (2)	There is very limited Saltpan habitat within the study area, and it is a unique habitat arising from historic anthropogenic use. This habitat supports key threatened migratory birds and has a variety of resources for waterbirds (see Lei et al. 2021). If the bunds containing the saltpans are eroded, these habitats could be exposed to tidal input and transformed into saltmarsh/other habitats.
Salinity		Low (2)	Saltmarsh can adapt to hypersaline conditions so it is insensitive to increasing salinity, although saltmarsh types less tolerant to hypersaline conditions would be lost		High (4)	There is very limited Saltpan habitat within the study area, and it is a unique habitat arising from historic anthropogenic use. This habitat supports key threatened migratory birds and has a variety of resources for waterbirds (see Lei et al. 2021). Saltpans are tolerant of high salinity, although at the extreme end, they provide for fewer species, and favour those that tolerate hypersaline conditions.
Groundwater		Very low (1)	While these habitats are adapted to saline conditions, groundwater intrusion could increase the chance of hypersalinity in the system and may change the composition of vegetation towards more salt tolerant species		Very low (1)	There is very limited Saltpan habitat within the study area, and it is a unique habitat arising from historic anthropogenic use. This habitat supports key threatened migratory birds and has a variety of resources for waterbirds (see Lei et al. 2021). Saltpan habitats may benefit from groundwater input if it resulted in shallow inundation followed by evaporation, but permanent inundation would transform these habitats.

Table 27. Irreplaceability and vulnerability scoring for Seagrass and Other Coastal Habitats within the Port Phillip Bay western shoreline Littoral Zone Broad Conservation Group

Habitat	Seagrass			Other Coastal Habitats		
Coastal hazard types	Irreplaceability scores	Vulnerability scores	Justification	Irreplaceability scores	Vulnerability scores	Justification
Storm tide inundation	Very low (2)	Very low (1)	Seagrass is common in the PPB and project area. Seagrass is not vulnerable to storm tide inundation as they can tolerate poor conditions for a short period of time.	Very high (4)	High (4)	Other Coastal Habitat such as coastal saline grassland and estuarine flats grassland are vulnerable to storm surges as the storm tide can wash and drown these vegetation communities.
Permanent inundation		Medium (3)	Vulnerable to increasing water depth and poor water clarity, but dynamics unable to migrate landward over time. All the Seagrass will be impacted by permanent inundation - impacting their ability to recover/be replaced.		Very high (5)	EVCs in this habitat are all threatened, any permanent inundation will remove the entire habitat. Ecology Australia (2018) states that coastal vegetation in intertidal regions is highly vulnerable and will suffer complete loss to inundation and its associated impacts such as coastal erosion and retreat and saline intrusion.
Short-term erosion		High (4)	Seagrass is sensitive to changes in water quality. Seagrass is periodically eroded or buried in localised areas, often offset by other areas not affected. This could potentially have impacts on important seagrass nursery areas. Potential effects of short-term erosion could also increase sediment load and nutrient inputs into the habitat. Ability to replace it is dependent on the frequency of events.		Medium (3)	Depending on the frequency of the short-term erosion - high tide is higher than before - more frequent events. Coastal saline grassland - interface between ocean and land will be severely impacted. EVCs in this habitat are all threatened.
Long-term erosion		Very high (5)	Seagrass is sensitive to changes in water quality. Walker & McComb (1992) also state that increasing wave energy and sedimentary erosion can lead to the fragmentation of seagrass beds and loss of rhizome mats. This is a direct removal of the habitat; hence vulnerability is scored as very high.		Very high (5)	Permanent retreat of shoreline - no ability to migrate inland, high ecological niche. EVCs in this habitat are all threatened. Ecology Australia (2018) states that coastal vegetation in intertidal regions is highly vulnerable and will suffer complete loss to inundation and its associated impacts such as coastal erosion and retreat and saline intrusion.
Salinity		Very low (1)	Seagrass is not vulnerable to changes in saline conditions as they are located underwater in saline condition.		Very low (1)	These vegetation communities are saline tolerant and can tolerant saltwater. EVCs in this habitat are all threatened

Habitat	Seagrass			Other Coastal Habitats		
Groundwater		Very low (1)	Seagrass is not vulnerable to changes in groundwater depth as increasing groundwater depth does not impact on the viability of seagrass.		High (4)	EVCs in this habitat are all threatened vegetation communities and they prefer drier conditions. Ecology Australia (2018) states that coastal vegetation in intertidal regions is highly vulnerable and will suffer complete loss to inundation and its associated impacts such as coastal erosion and retreat and saline intrusion. If groundwater depth increases and potentially saltwater influenced, there is possibility that these vegetation communities will likely turn into perennial wetlands as increasing groundwater depth would modify the soil condition ideal for these vegetation communities.

Table 28. Irreplaceability and vulnerability scoring for Rocky Reefs and Soft Sediment within the Port Phillip Bay western shoreline Littoral Zone Broad Conservation Group

Habitat	Rocky Reefs			Soft Sediment		
Coastal hazard types	Irreplaceability scores	Vulnerability scores	Justification	Irreplaceability scores	Vulnerability scores	Justification
Storm tide inundation	High (4)	Medium (3)	It can temporarily withstand storm tide inundation; however, this will likely mobilise sediments which may bury species.	High (4)	Medium (3)	Soft Sediments and mudflats in the Littoral Zone are not sensitive to storm tide inundation as they can withstand temporary disturbances. However, this will impact on the exposure time for shorebirds feeding on the intertidal mudflats.
Permanent inundation		High (4)	Intertidal reefs are vulnerable to permanent inundation as they cannot tolerate prolonged periods of inundation due to its importance in providing habitat for invertebrates and intertidal fauna. Inundation will reduce the extent of these habitat. Composition of intertidal habitat will change to subtidal rock/reef habitat though function will not change.		High (4)	Soft Sediments and mudflats in the Littoral Zone are tolerant to permanent inundation, however permanent inundation will reduce the duration of exposure time for shorebird feeding on intertidal mudflats and the area that they can feed on. Therefore, the vulnerability score is high (EcoFutures 2023). It is more vulnerable to permanent inundation than other coastlines at is very low-lying, and inundation may contribute to long-term erosion and landward recession (DEECA 2022).
Short-term erosion		Medium (3)	Intertidal reefs and rocks are crucial habitat for habitat forming species and intertidal fauna. Impacts to its habitat extent such as erosion and causing loss of habitat would mean a loss to these species (and a loss of food resource for birds). Habitat can be at risk from mobile sediments.		Medium (3)	Soft Sediments and mudflats within the Littoral Zones and intertidal zones are sensitive to erosion, be it short-term erosion or long-term erosion. However, they are naturally dynamic habitat and can rebound from short-term erosions.
Long-term erosion		Medium (3)	Retreat of shoreline would mean increase in wave energy which may lose some habitat, and long-term erosion would lead to sediment inputs that would bury species and habitat living in the intertidal reefs and rocks, similar to short-term erosion.		High (4)	Soft Sediments and mudflats within the Littoral Zones and intertidal zones are more sensitive to long-term erosion and may take a long time to recover as it is limited by the available sand in nearshore areas or being moved along the coast (DEECA 2022). The loss of sediments would mean loss of habitat for benthic invertebrates and reduced area available for shorebird feeding (EcoFutures 2023).
Salinity		Very low (1)	Intertidal reefs and rocks are not vulnerable to increased salinity as they are adapted to these conditions.		Very low (1)	Soft Sediments are not vulnerable to salinity as they are adapted to saline conditions.
Groundwater		Very low (1)	Intertidal reefs and rocks are not vulnerable to increased salinity as they are adapted to these conditions.		Very low (1)	Soft Sediments are not vulnerable to changes to groundwater depth as they can adapt to saline conditions.

4.6.5 Marine Areas

Table 29. Irreplaceability and vulnerability scoring for Saltmarsh and Seagrass within the Port Phillip Bay western shoreline Marine Areas Broad Conservation Group.

Habitat	Saltmarsh			Seagrass		
Coastal hazard types	Irreplaceability scores	Vulnerability scores	Justification	Irreplaceability scores	Vulnerability scores	Justification
Storm tide inundation	High (4)	Medium (3)	Saltmarsh is found in limited areas of the project area and supports many intertidal vegetation species and threatened migratory shorebirds. These are normally found in protected areas therefore the irreplaceability is high. Saltmarsh is tolerant to storm tide inundation as they are adapted to a constantly changing environment. Saltmarsh protects coastal foreshores by absorbing the energy of wind and wave action and providing a buffer that helps minimise erosion.	Low (2)	Low (2)	There are many seagrass meadows across the Port Phillip Bay. Temporary damage has been observed after big storm events where seagrass was washed ashore. However, seagrass is not generally vulnerable to storm tide inundation as they are adapted to such events, assuming there is no increasing storm intensity. Given there are many seagrass meadows across the Bay, the relative impact of storm tide inundation will be low.
Permanent inundation		Very high (5)	Saltmarsh cannot tolerate permanent inundation as some saltmarsh species prefer drier conditions. Ecology Australia (2018) states that coastal vegetation and saltmarshes in intertidal regions are highly vulnerable and will suffer complete loss to inundation and its associated impacts such as coastal erosion and retreat and saline intrusion.		Medium (3)	Seagrass has a medium vulnerability to permanent inundation. Permanent inundation can result in change in water quality with depth, especially in the deeper waters. This secondary impact will affect the viability of existing seagrass populations
Short-term erosion		Low (2)	Saltmarsh beyond the subtidal zones is behind the high energy areas, this means they're unlikely to be vulnerable to the secondary impacts arising from short-term erosion.		Medium (3)	Seagrass is sensitive to changes in water quality. Potential effects of short-term erosion could increase sediment load and nutrient inputs into the habitat.
Long-term erosion		High (4)	A retreat of shoreline could mean the loss of habitat or potential intrusion of mangroves into the existing extent of saltmarsh. Secondary impact of long-term erosion is less protection of the habitat. Ecology Australia (2018) states that coastal vegetation and saltmarshes in intertidal regions are highly vulnerable and will suffer complete loss to inundation and its associated impacts such as coastal erosion and retreat and saline intrusion.		Very high (5)	Seagrass is sensitive to changes in water quality. Potential effects of long-term erosion could increase sediment load and nutrient inputs into the habitat.
Salinity		Very low (1)	Saltmarsh can adapt to hypersaline conditions, so it is insensitive to increasing salinity.		Very low (1)	Seagrass is not vulnerable to changes in saline conditions as they are located underwater in saline condition.

Habitat	Saltmarsh			Seagrass		
Groundwater		Very low (1)	Groundwater intrusion or changes to groundwater depth is unlikely to cause any effects on saltmarsh as they are adapted to saline to hypersaline conditions.		Very low (1)	Seagrass is not vulnerable to changes in groundwater depth as they are in marine environment.
Offshore sediment dynamics		Very low (1)	Saltmarsh beyond subtidal zones is behind high energy areas and is tolerant to movements of sediments.		High (4)	Seagrass is periodically eroded or buried in localised areas, often offset by other areas not/less affected. However, this can have impacts on important nursery areas and connectivity from shallow estuaries to deeper Marine Areas (Zabarte-Maeztu et al 2021; de Boer 2007).

Table 30. Irreplaceability and vulnerability scoring for Rocky Reef and Soft Sediment within the Port Phillip Bay western shoreline Marine Areas Broad Conservation Group

Habitat	Rocky Reef			Soft Sediment		
Coastal hazard types	Irreplaceability scores	Vulnerability scores	Justification	Irreplaceability scores	Vulnerability scores	Justification
Storm tide inundation	Low (2)	Very low (1)	Subtidal reefs are not vulnerable to storm tide inundation.	Very low (1)	Very low (1)	Soft Sediments and mudflats are commonly found in PPB and across Victoria. In the Marine Areas, Soft Sediments are located outside of the intertidal zone and therefore not impacted by storm tide inundation.
Permanent inundation		Very low (1)	Subtidal reefs are not vulnerable to permanent inundation.		Very low (1)	Soft Sediments and mudflats are commonly found in PPB and across Victoria. In the Marine Areas, Soft Sediments are located outside of the intertidal zone and therefore not impacted by permanent inundation.
Short-term erosion		Medium (3)	Subtidal reefs and rocks provide crucial habitat for reef-building species and other subtidal fauna assemblages. Erosion would result in both habitat and biodiversity loss of many reef-building species and the species that depend on them Habitat can also be at risk from mobile sediments.		Low (2)	Soft Sediments and mudflats in the Marine Areas are outside of the intertidal zone. Changes in deposition and sediment dynamics can also cause issues with communities that use Soft Sediments. This habitat and their associated nested assets are naturally adjusted to the dynamic habitat conditions and therefore will be able to rebound quite quickly from erosion.
Long-term erosion		Medium (3)	Retreat of shoreline would mean increase in wave energy which may lose some habitat, and long-term erosion would lead to sediment inputs that would bury species and habitat living in the intertidal reefs and rocks - same as short-term erosion.	Very low (1)	High (4)	Soft Sediments and mudflats in the Marine Areas are outside of the intertidal zone. Changes in deposition and sediment dynamics can cause issues with communities that use Soft Sediments.
Salinity		Very low (1)	Subtidal reefs are not vulnerable to changes in salinity.		Very low (1)	Soft Sediments and mudflats in the Marine Areas are outside of the intertidal zone, therefore it is not impacted by changes in salinity.
Groundwater		Very low (1)	Subtidal reefs are not vulnerable to changes in groundwater depth.		Very low (1)	Soft Sediments and mudflats in the Marine Areas are outside of the intertidal zone, therefore it is not impacted by changes to groundwater depth.
Offshore sediment dynamics		High (4)	Subtidal reefs are vulnerable to offshore sediment dynamics. Shifting of sediments and sediment inputs in some areas would likely to smother rocky reefs communities (Wernberg et al 2009).		Low (2)	Soft Sediment and mudflats in the Marine Areas have adaptative capacity to adjust to offshore sediment dynamics as they are used to the mobile condition of the environment (Bainbridge et al 2018).

5 Spatial data library outputs

This assessment produced a suite of spatial products for the next phase of the Adapt West program. This consists of:

- The spatial extent of the Broad Conservation Groups, Habitat Groups, with associated vulnerability and irreplaceability scoring.
- The spatial extent of nested assets for each Broad Conservation Group.
- Contextual information regarding protected areas for consideration in future projects.

An excerpt of the spatial outputs of the ecological values study are presented below in Figure 20. A detailed list of the Broad Conservation Groups and their corresponding Habitat Groups and nested assets spatial data outputs are detailed in Appendix A: Spatial data register, Table 32.

Figure 20. Example GIS workspace highlighting the spatial outputs for the ecological values assessment, including broad conservation groups, with associated habitats and nested assets. Example illustrates all spatial outputs associated with the Dry Forests Broad Conservation Group.

Each spatial data set has a corresponding attribute table which provides detailed information on features such as scoring, habitat type, individual species, etc. Broadly spatial data outputs were grouped into three categories: broad conservation groups, habitats and nested assets. A description of each category and an example attribute table are presented below.

Broad Conservation Groups

Broad Conservation Group spatial layers represent the merged and dissolved spatial extent of habitats found within each respective group. These layers include vulnerability and irreplaceability scoring associated with each habitat, which are to be used in future stages of the *Adapt West - Shaping Our Shores* program. An example of the Littoral Zone Broad Conservation Group attribute table is presented in Figure .

	BroadCons	Habitat	STI_Irr	STI_Vul	PI_Irr	PI_Vul	STE_Irr	STE_Vul	LTE_Irr	LTE_Vul	SAL_Irr	SAL_Vul	GWD_Irr	GWD_Vul
1	Littoral zone	Estuarine water...	1	2	1	3	1	3	1	4	1	4	1	3
2	Littoral zone	Mangrove	2	1	2	4	2	1	2	3	2	4	2	1
3	Littoral zone	Other coastal	4	4	4	5	4	3	4	5	4	1	4	4
4	Littoral zone	Rocky reef	4	3	4	4	4	3	4	4	4	1	4	1
5	Littoral zone	Saltmarsh	4	1	4	4	4	2	4	4	4	2	4	1
6	Littoral zone	Saltpan	5	2	5	5	5	1	5	2	5	4	5	1
7	Littoral zone	Seagrass	2	1	2	3	2	4	2	5	2	1	2	1
8	Littoral zone	Soft sediment	1	1	1	2	1	4	1	4	1	1	1	1

Figure 21. Example attribute table of the Littoral Zone Habitat Groups and their associated vulnerability and irreplaceability scoring.

Habitat Groups

Habitat spatial layers represent individual habitats considered in this assessment, for example mangroves. The habitat layer includes merged data from a variety of spatial and report sources to create a combined layer representing one unique habitat across the study area. An example of the Littoral Zone Mangrove Habitat attribute table is presented in Figure 22.

Note: Habitat Group layers do not have associated vulnerability and irreplaceability scorings within their attribute table.

	)ESC	BIOREGION	EVC_CODE	EVCBCSSRC	VEG_CODE	BIOEVC	BIOREGCODE	HECTARES	EVC_GP	EVC_SUBGP	X_EVCNAME	AREASQM	XGROUPNAME	XSUBGGROUP	Source	Source_url	Layer_Name
1		NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	CoastKit	https://mapsha...	Habitats
2		NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	CoastKit	https://mapsha...	Habitats
3		NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	CoastKit	https://mapsha...	Habitats
4		NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	CoastKit	https://mapsha...	Habitats
5		NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	CoastKit	https://mapsha...	Habitats
6		NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	CoastKit	https://mapsha...	Habitats
7		NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	NULL	CoastKit	https://mapsha...	Habitats
8		Victorian Volca...	0140	3	VVP_0140	3.1 140	VVP_	0.71	19	19.1000000000...	Mangrove Shru...	7060.86999999...	Salt-tolerant an...	Coastal	DEECA	https://discover...	NV2005_EVCBCS
9		Victorian Volca...	0140	3	VVP_0140	3.1 140	VVP_	0	19	19.1000000000...	Mangrove Shru...	43.2100000000...	Salt-tolerant an...	Coastal	DEECA	https://discover...	NV2005_EVCBCS

Figure 22. Example of Littoral Zone Mangrove Habitat Group attribute table.

Nested assets

Nested assets represent key species (flora and fauna) found within each habitat. Each nested asset has been included merged data from a variety of spatial and report sources to create a combined layer representing one unique species. An example of the Orange Bellied Parrot attribute table is presented in Figure 23. ***Note the nested asset layers do not have associated vulnerability and irreplaceability scorings within their attribute table.***

	id	Nes_cat	Nes_asset	BroadCons	Habitat	Source
1	NULL	Birds	Orange Bellied Parrot	Littoral zone	Estuarine waterbodies	Digitised from Melbourne Water WTP significant species PDF
2	NULL	Birds	Orange Bellied Parrot	Littoral zone	Estuarine waterbodies	Digitised from Melbourne Water WTP significant species PDF
3	NULL	Birds	Orange Bellied Parrot	Littoral zone	Mangrove	Digitised from Melbourne Water WTP significant species PDF
4	NULL	Birds	Orange Bellied Parrot	Littoral zone	Mangrove	Digitised from Melbourne Water WTP significant species PDF
5	NULL	Birds	Orange Bellied Parrot	Littoral zone	Other coastal	Digitised from Melbourne Water WTP significant species PDF
6	NULL	Birds	Orange Bellied Parrot	Littoral zone	Other coastal	Digitised from Melbourne Water WTP significant species PDF
7	NULL	Birds	Orange Bellied Parrot	Littoral zone	Rocky reef	Digitised from Melbourne Water WTP significant species PDF
8	NULL	Birds	Orange Bellied Parrot	Littoral zone	Saltmarsh	Digitised from Melbourne Water WTP significant species PDF
9	NULL	Birds	Orange Bellied Parrot	Littoral zone	Saltmarsh	Digitised from Melbourne Water WTP significant species PDF
10	NULL	Birds	Orange Bellied Parrot	Littoral zone	Seagrass	Digitised from Melbourne Water WTP significant species PDF
11	NULL	Birds	Orange Bellied Parrot	Littoral zone	Soft sediment	Digitised from Melbourne Water WTP significant species PDF
12	NULL	Birds	Orange Bellied Parrot	Littoral zone	Soft sediment	Digitised from Melbourne Water WTP significant species PDF

Figure 23. Example of Orange Bellied Parrot attribute table.

6 Summary

6.1 Outputs

6.1.1 Significance of project outcomes for Adapt West adaptation planning

The project outcomes identified and classified a suite of habitat and ecological values into landscape-scale groups pertaining to the terrestrial, riparian, coastal and marine environment. These layers and associated information could then be used for the broad landscape planning to prioritise different 'landscapes' for decision making and conservation planning. In the context of the coastal hazard and adaptation planning for *Adapt West - Shaping our Shores*, these ecological themes could provide information on the environmental values at an appropriate level of detail for managing landscapes for adaptation planning.

The vulnerability assessment provides a deeper understanding on how habitats and ecosystems respond under different coastal hazards in different environments. The assessment highlighted the variability in the vulnerabilities of each Habitat Group which reflects on the dynamic nature of ecosystems present in the study area. This study provides the basis for assessing the consequence in the Stage 4 of the coastal hazard risk assessment which informs the risk of coastal hazard impacts to ecological values. Its irreplaceability parameter provides a complete picture of the vulnerability of ecosystems beyond coastal hazards but is critical in its use for considering the importance of ecological values in the landscape.

6.2 Additional research

The study provides an indicative vulnerability assessment for each Broad Conservation Group and their associated nested ecological values. There were some guiding assumptions to the assessment during the filtering of spatial data, developing vulnerability and irreplaceability criteria and assessing coastal hazard impacts to the ecological values. With the limited scope of the study to provide a more comprehensive assessment of the vulnerability of ecological values, the study recommends the following next steps for future studies:

- Develop detailed conceptual models of each coastal hazard impact on all habitats to identify specific pathways of threatened processes and specific threats to ecosystem functions and processes. While some coastal hazard impacts on certain habitat (e.g., seagrass) are well understood, such understanding is varied across habitats and their associated values.
- Develop a Resist-Adapt-Direct framework for critical habitats to understand the adaptive capacity and future trajectory of species under different climate scenarios. Some of the nested assets are very well studied e.g., shorebirds, however the adaptive capacity of vegetation species and communities and other non-avian species e.g., crustaceans and invertebrates are understudied and presents a knowledge gap about their potential recovery from coastal hazards.
- The potential for habitats to migrate in future is critical for coastal adaptation planning and management. This study does not undertake any species or community modelling to understand where likely habitats are going to be shifted in future, and any barriers to movement of habitats (e.g., human built environment along coastlines). Understanding the potential distribution, and any barriers to this distribution, would provide crucial information for management decisions such as using nature-based solutions to enhance these ecosystems or identifying new opportunities to establish new extent of the habitats.
- This study can be extended to investigate future climate change impacts for these coastal and inland habitats to identify the overall vulnerabilities of these ecological values. Other factors such as frost, increased temperatures and extreme weather are factors that drive the conditions of ecosystems in future.
- In alignment with the VRC framework, vulnerability results and findings produced in this comprehensive body of work are to be incorporated into Stage 4 of the *Adapt West – Shaping Our Shores* program. It is recommended that the

consequences assigned to environmental assets in the Stage 4 risk assessment are to align with vulnerability scorings for each coastal hazard derived for habitats in this assessment.

- Targeted discussion/workshop to apply ecological values outcomes in technical work. As part of progressing next steps of the adaptation planning, we recommend that DEECA and the project working group consider holding a workshop with those undertaking the vulnerability and risk assessment (Stage 4) to demonstrate how to best use the data; application of the vulnerability and irreplaceability scorings within the spatial data sets; and how that is embedded in the consequence assignment and application. We note that this is it beyond the current project scope.

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Appendices

Appendix **A**

Spatial datasets and references used

A.1. Spatial data quality assurance and quality control procedures

It is important to understand the quality, spatial coverage and suitability of data before it is used for vulnerability assessments. Quality assurance and quality control procedures allow for data to be assessed and reviewed in a systematic way. The use of quality assurance and quality control supports:

- The identification of data gaps, erroneous or problematic data
- An assessment of data quality (e.g., spatial coverage, creation date, resolution)
- Decisions regarding the suitability and/or limitations of data use for vulnerability analysis
- Providing decision makers with the information needed to report on the robustness and accuracy of vulnerability scoring.

Definitions

Quality assurance (QA) involves ensuring the reliability and accuracy of the data used for modelling. This includes systematic planning and implementation of activities to verify data quality, such as checking for completeness, consistency, and reliability.

Quality control (QC) focuses on the operational techniques and activities used to verify the quality of the data. This includes checks for errors, outliers, and missing values, as well as validation against known benchmarks or standards. QC ensures the data used for modelling is of high quality and suitable.

While QA and QC are often used interchangeably, they mean different things. QA refers to **defect prevention**, whereas QC refers to **defect detection**. Example applications of these approaches to the Our Coast Our Future exposure and risk modelling are provided in Table .

Table 31. QA and QC conducted for the ecological vulnerability assessment.

Quality assurance (defect prevention)	Conducting a systematic screening of environmental and species spatial datasets, examining when they were produced, resolution, spatial coverage and suitability to be included in the assessment.
	Conducting a systematic review of environmental and species spatial datasets, ensuring data completeness, accuracy and consistency from the outset.
	Implementing data validation rules and automated checks during data entry to prevent the introduction of errors or inconsistencies.
	Establishing quality standards and protocols for data collection, storage, and management to maintain data integrity throughout the vulnerability analysis process.
	Establishing quality standards and protocols for data selection ensuring digitised and existing spatial data recently produced, of a higher resolution, and/or with greater coverage were prioritised for inclusion.
Quality control (defect detection)	Performing data validation procedures to ensure merging of data is consistent, complete and no errors have occurred.
	Performing data cleaning procedures to create habitats to ensure no overlapping features.

A.2. Spatial data register

A detailed description of the spatial data used in the ecological values vulnerbaility and irreplaceability assessment is presented in Table 32. A detailed list of the all spatial datasets and reports considered in the context of this work are presented in Table 33 and Table 34.

Detialed descriptions of the vulnerability and irreplaceability scoring has been assigned to the Broad Conservation Groups. It is recommended that the "Habitat Groups" outputs for each Broad Conservation Group are to be used in Stages 3 and 4 of the *Adapt West – Shape Our Shores program*.

Table 32. Spatial data register of Broad Conservation Groups, Habitat Groups and nested assets considered in the ecological values vulnerability and irreplaceability assessment.

Folder	Sub folder(s)	Layer name	File type	Projection	Source	Source URL	Original file name	Description
Conversation Group		1_DryForest_BroadConsGroup	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55				Broad habitat conservation group representing dry forest, woodland, plains grasslands and agricultural areas. Includes a dissolved spatial extent of habitats and nested assets found within this broad conservation group. A description of habitats and nested assets within this broad conservation group are described in the 1_Habitat folder and 1_NestedAseets folder.
		2_Freshwater_BroadConsGroup	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55				Broad habitat conservation group representing freshwater areas. Includes a dissolved spatial extent of habitats and nested assets found within this broad conservation group. A description of habitats and nested assets within this broad conservation group are described in the 2_Habitat folder and 2_NestedAseets folder.
		3_LittoralZone_BroadConsGroup	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55				Broad habitat conservation group representing the littoral zone. Includes a dissolved spatial extent of habitats and nested assets found within this broad conservation group. A description of habitats and nested assets within this broad conservation group are described in the 3_Habitat folder and 3_NestedAseets folder.
		4_Beaches_BroadConsGroup	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55				Broad habitat conservation group representing beach areas. Includes a dissolved spatial extent of habitats and nested assets found within this broad conservation group. A description of habitats and nested assets within this broad conservation group are described in the 4_Habitat folder and 4_NestedAseets folder.
		5_Marine_Habitat_BroadConsGroup	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55				Broad habitat conservation group representing marine areas. Includes a dissolved spatial extent of habitats and nested assets found within this broad conservation group. A description of habitats and nested assets within this broad conservation group are described in the 5_Habitat folder and 5_NestedAseets folder.
1_DryForest_Broad ConsGroup	1_Habitats	1_DryForest_Woodlands	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/native-vegetation-modelled-2005-ecological-vegetation-classes-with-bioregional-conservation-sta	NV2005_EVCBCS	EVC classes included: Creekline Grassy Woodland, Floodplain Riparian Woodland, Plains Grassland/Plains Grassy Woodland Mosaic, Plains Grassy Woodland, Riparian Woodland
					Boon et al., 2011 (via DEECA GIS data handover)		intertidal_evc_final_v2_vg94	Includes areas identified as woodland
					Melbourne Water data handover - WTP data		ARI_2010_Ramsar_EVC_Final_Extract_AOI_PolygonsMerged	EVC classes included: Escarpment Shrubland, Floodplain Riparian Woodland, Plains Grassy Woodland, Riparian Woodland
		1_DryForest_Grassland	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/native-vegetation-modelled-2005-ecological-vegetation-classes-with-bioregional-conservation-sta	NV2005_EVCBCS	EVC classes included: Plains Grassland
					DEECA	https://discover.data.vic.gov.au/dataset/marine-and-coastal-feature-atlas-polygons	MARINE_FEATURE_ATLAS_POLY	Habitats included: Coastal environment. Specifically, tussock grasslands.
					Melbourne Water data handover - WTP data		ARI_2010_Ramsar_EVC_Final_Extract_AOI_PolygonsMerged	EVC classes included: Plains Grassland
		1_DryForest_AgriculturalAreas	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/victorian-land-use-information-system-2016-2017	LANDUSE_2017	Land uses considered: Mixed Farming and Grazing, Market Garden - Vegetables, Poultry (broiler production), Mixed farming and grazing (generally more than 20 ha), Livestock Grazing.
					Melbourne Water data handover - WTP data		New_AgriculturalLeaseAreaBoundary	
	1_NestedAssets / 1_Avian	1_DryForest_bird_orange_bellied_parrot	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	Digitised from Melbourne Water WTP significant species PDF			Orange bellied parrot habitat across woodland, grassland and agricultural areas
		1_DryForest_bird_shorebird_sites	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/east-asian-australasian-flyway-shorebird-sites-in-victoria	SHOREBIRD_SITES	Shorebirds roosting habitats with usage detailed

Folder	Sub folder(s)		Layer name	File type	Projection	Source	Source URL	Original file name	Description
			1_DryForest_bird_VBAFauna	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/victorian-biodiversity-atlas-fauna-records-unrestricted-for-sites-with-high-spatial-accuracy	VBA_FAUNA25	Fauna taxa records from the Victorian Biodiversity Atlas (VBA) (including most threatened taxa)
			1_DryForest_bird_nesting_feeding_roosting	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/coastal-bird-habitats-on-the-victorian-coast	COASTAL_BIRD_HABITAT	This layer identifies bird habitats in the Victorian coastal region. The layer is a polygon coverage with the polygon areas representing the main area of the respective bird habitats. Sites were identified from a broad range of published and unpublished sources of information and from personal communications made by experts in the field. In 2015 some additional locations were added with data from Birdlife Australia Shorebird 2020 Data. This dataset was formerly known as SHOREBIRD HABITAT but was renamed as it contains sites for seabirds and other birds.
						DEECA (data handover)		ShorebirdFeedingRoosting2009	Shorebird feeding and roosting sites
		1_Non-Avian	1_DryForest_GoldenSunMoth	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	Melbourne Water data handover		Golden Sun Moth Habitat digitised from Melbourne Water 10157 Fig2 GSM Habitat - EHP report	Golden sun moth habitat
						DEECA	https://discover.data.vic.gov.au/dataset/victorian-biodiversity-atlas-fauna-records-unrestricted-for-sites-with-high-spatial-accuracy	VBA_FAUNA25	Golden sun moth locations digitised into a polygon
			1_DryForest_FatTailedDunnart	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	Digitised from Melbourne Water WTP significant species PDF			Fat Tailed Dunnart habitat
			1_DryForest_GrowlingGrassFrog	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	Melbourne Water (digitised from GGF species records and WTP significant species PDF)			Growling grass frog species records used include: EHP14513_GGF_Results_2020to2021_Monitoring EHP15803_GGF_Results_2021to2022_Monitoring EHP16675_GGF_IncidentalRecords_2022to2023_Monitoring
			1_DryForest_nonbird_VBAFauna	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/victorian-biodiversity-atlas-fauna-records-unrestricted-for-sites-with-high-spatial-accuracy	VBA_FAUNA25	Fauna taxa records from the Victorian Biodiversity Atlas (VBA) (including most threatened taxa)
			1_DryForest_Bat	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	Digitised from Melbourne Water Gration 2008 WTP PDF			Digitised bat survey data
		1_Flora	1_DryForest_WTP_TreeInventory	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	Melbourne Water data handover		WTP_Tree_Inventory_20180620_GHD	Tree inventory
			1_DryForest_VBAFlora	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/victorian-biodiversity-atlas-flora-records-unrestricted-for-sites-with-high-spatial-accuracy	VBA_FLORA25	Flora taxa records from the Victorian Biodiversity Atlas (VBA) (including most threatened taxa)
			1_DryForest_Pimelea	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	Digitised from Melbourne Water WTP significant species PDF			Pimela habitat across woodland, grassland and agricultural areas
2_Freshwater_BroadConsGroup	2_Habitats		2_Freshwater_systems	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/native-vegetation-modelled-2005-ecological-vegetation-classes-with-bioregional-conservation-sta	NV2005_EVCBCS	EVC classes included: Swamp Scrub, Shallow Freshwater Marsh, Plains Sedgy Wetland, Plains Grassy Wetland, Lignum Swamp, Cane Grass Wetland, Aquatic Herbland.
						Boon et al., 2011 (via DEECA GIS data handover)		intertidal_evc_final_v2_vg94	Includes are identified as wetlands
						DEECA	https://discover.data.vic.gov.au/dataset/victorian-wetland-inventory-current	WETLAND_CURRENT	Wetland types included: Temporary freshwater lakes, Permanent freshwater lakes, Temporary freshwater swamps, Temporary freshwater marshes and meadows.
						DEECA	https://discover.data.vic.gov.au/dataset/vicmap-hydro-watercourse-line	HY_WATERCOURSE	Waterways with a 5 metre buffer applied
						Melbourne Water data handover		WTP_natural_waterways	Waterways within the Western Treatment Plant with a 5 m buffer applied
						Melbourne Water data handover - WTP data		ARI_2010_Ramsar_EVC_Final_Extract_AOI_PolygonsMerged	EVC classes included: Tall Marsh, Plains Sedgy Wetland, Open, Lignum Swamp, Cane Grass Wetland.
						DEECA	https://discover.data.vic.gov.au/dataset/vicmap-features-geomark-polygon	GEOMARK_POLYGON	Rivers within the study area represented as a polygon.

Folder	Sub folder(s)		Layer name	File type	Projection	Source	Source URL	Original file name	Description
						DEECA	https://discover.data.vic.gov.au/dataset/2010-index-of-stream-condition-bank-full-width-reach-polygon-features	ISC2010_BANKFULL_WIDTH_R	Rivers within the study area represented as a polygon. Polygon features represent the width between the top of the lowest bank and the corresponding height on the opposite bank for each River Reach.
			2_Freshwater_bird_orange_bellied_parrot	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	Digitised from Melbourne Water WTP significant species PDF			Orange bellied parrot habitat across freshwater areas
			2_Freshwater_bird_nesting_feeding_roosting	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/coastal-bird-habitats-on-the-victorian-coast	COASTAL_BIRD_HABITAT	This layer identifies bird habitats in the Victorian coastal region. The layer is a polygon coverage with the polygon areas representing the main area of the respective bird habitats. Sites were identified from a broad range of published and unpublished sources of information and from personal communications made by experts in the field. In 2015 some additional locations were added with data from Birdlife Australia Shorebird 2020 Data. This dataset was formerly known as SHOREBIRD HABITAT but was renamed as it contains sites for seabirds and other birds.
				Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA (data handover)		ShorebirdFeedingRoosting2009	Shorebird feeding and roosting sites
			2_Freshwater_bird_shorebird_sites	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/east-asian-australasian-flyway-shorebird-sites-in-victoria	SHOREBIRD_SITES	Shorebirds roosting habitats with usage detailed
		2_Non-Avian	2_Freshwater_Bat	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	Digitised from Melbourne Water Gration 2008 WTP PDF			Digitised bat survey data
			2_Freshwater_nonbird_VBAFauna	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/victorian-biodiversity-atlas-fauna-records-unrestricted-for-sites-with-high-spatial-accuracy	VBA_FAUNA25	Fauna taxa records from the Victorian Biodiversity Atlas (VBA) (including most threatened taxa)
			2_Freshwater_GrowlingGrassFrog	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	Melbourne Water (digitised from GGF species records and WTP significant species PDF)			Growling grass frog species records used include: EHP14513_GGF_Results_2020to2021_Monitoring EHP15803_GGF_Results_2021to2022_Monitoring EHP16675_GGF_IncidentalRecords_2022to2023_Monitoring
			2_Freshwater_GoldenSunMoth	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	Melbourne Water data handover		Golden Sun Moth Habitat digitised from Melbourne Water 10157 Fig2 GSM Habitat - EHP report	Golden sun moth habitat
						DEECA	https://discover.data.vic.gov.au/dataset/victorian-biodiversity-atlas-fauna-records-unrestricted-for-sites-with-high-spatial-accuracy	VBA_FAUNA25	Golden sun moth locations digitised into a polygon
			2_Freshwater_FatTailedDunnart	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	Digitised from Melbourne Water WTP significant species PDF			Fat Tailed Dunnart habitat
		2_Flora	2_Freshwater_WTP_TreeInventory	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	Melbourne Water data handover		WTP_Tree_Inventory_20180620_GHD	Tree inventory
			2_Freshwater_VBAFlora	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/victorian-biodiversity-atlas-flora-records-unrestricted-for-sites-with-high-spatial-accuracy	VBA_FLORA25	Flora taxa records from the Victorian Biodiversity Atlas (VBA) (including most threatened taxa)
3_Littoral_Zone_BroadConsGroup_V3	3_Habitats		3_Littoral_Estuarine_Waterbodies	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/estuaries	ESTUARIES	Permanently open estuaries
						DEECA	https://discover.data.vic.gov.au/dataset/victorian-wetland-inventory-current	WETLAND_CURRENT	Wetland types included: Estuary, Temporary saline marshes and meadows and Temporary saline lakes
						DEECA	https://discover.data.vic.gov.au/dataset/native-vegetation-modelled-2005-ecological-vegetation-classes-with-bioregional-conservation-sta	NV2005_EVCBCS	EVC classes included: Water body - salt
						Boon et al., 2011 (via DEECA GIS data handover)		intertidal_evc_final_v2_vg94	
						CoastKit	https://mapshare.vic.gov.au/coastkit/	Water Bodies	Saline water bodies

Folder	Sub folder(s)		Layer name	File type	Projection	Source	Source URL	Original file name	Description
			3_Littoral_Mangroves	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	SeamapAus	https://seamapaustralia.org/map/	SeamapAus_National_Benthic_Habitat_LayerPolygon	Mangrove habitat
						DEECA	https://discover.data.vic.gov.au/dataset/native-vegetation-modelled-2005-ecological-vegetation-classes-with-bioregional-conservation-sta	NV2005_EVCBCS	EVC classes included: Mangrove Shrubland, Mangrove Shrubland/Coastal Saltmarsh/Berm Grassy Shrubland/Estuarine Flats Grassland Mosaic
						CoastKit	https://mapshare.vic.gov.au/coastkit/	Habitats	Mangrove habitat
			3_Littoral_OtherCoastal	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	Boon et al., 2011 (via DEECA GIS data handover)		intertidal_evc_final_v2_vg94	
						DEECA	https://discover.data.vic.gov.au/dataset/native-vegetation-modelled-2005-ecological-vegetation-classes-with-bioregional-conservation-sta	NV2005_EVCBCS	EVC classes included: Coastal Alkaline Scrub
			3_Littoral_RockyReef	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	SeamapAus	https://seamapaustralia.org/map/	SeamapAus_National_Benthic_Habitat_LayerPolygon	High energy infralittoral rock, Low energy infralittoral rock, Rocky Reef
			3_Littoral_Saltmarsh	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	SeamapAus	https://seamapaustralia.org/map/	SeamapAus_National_Benthic_Habitat_LayerPolygon	Saltmarsh and saltflat habitat
						Boon et al., 2011 (via DEECA GIS data handover)		intertidal_evc_final_v2_vg94	
						Melbourne Water data handover - WTP data		EA_Saltmarsh_Plus_Boon_Extract_CoastalSaltHab_EVCs_MERGED	
						DEECA (data handover)		Jawbone_saltmarsh_poly2011	
						DEECA (data handover)		TheSpit_saltmarsh_poly_2011	
						CoastKit	https://mapshare.vic.gov.au/coastkit/	Existing Habitat	
						CoastKit	https://mapshare.vic.gov.au/coastkit/	Habitat condition	
			3_Littoral_Saltpan	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	Boon et al., 2011 (via DEECA GIS data handover)		intertidal_evc_final_v2_vg94	Saltpan habitat
						Avalon Conservation Action Plan		Key Fairy Terns	Key sites where Fairy Terns have been identified
			3_Littoral_Seagrass	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	SeamapAus	https://seamapaustralia.org/map/	SeamapAus_National_Benthic_Habitat_LayerPolygon	Sublittoral seaweed on sediment
			3_Littoral_SoftSediment	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	SeamapAus	https://seamapaustralia.org/map/	SeamapAus_National_Benthic_Habitat_LayerPolygon	Intertidal flats, central basin's, littoral mud and sublittoral sand and muddy sand habitats
	3_NestedAssets	3_Avian	3_Littoral_bird_orange_bellied_parrot	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	Digitised from Melbourne Water WTP significant species PDF			Orange bellied parrot habitat within the littoral zone
			3_Littoral_bird_VBAFauna	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/victorian-biodiversity-atlas-fauna-records-unrestricted-for-sites-with-high-spatial-accuracy	VBA_FAUNA25	Fauna taxa records from the Victorian Biodiversity Atlas (VBA) (including most threatened taxa)
			3_Littoral_bird_nesting_feeding_roosting	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/coastal-bird-habitats-on-the-victorian-coast	COASTAL_BIRD_HABITAT	This layer identifies bird habitats in the Victorian coastal region. The layer is a polygon coverage with the polygon areas representing the main area of the respective bird habitats. Sites were identified from a broad range of published and unpublished sources of information and from personal communications made by experts in the field. In 2015 some additional locations were added with data from Birdlife Australia Shorebird 2020 Data. This dataset was formerly known as SHOREBIRD HABITAT but was renamed as it contains sites for seabirds and other birds.
						DEECA (data handover)		ShorebirdFeedingRoosting2009	Shorebird feeding and roosting sites
			3_Littoral_bird_shorebird_sites	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/east-asian-australasian-flyway-shorebird-sites-in-victoria	SHOREBIRD_SITES	Shorebirds roosting habitats with usage detailed
			3_Littoral_bird_hightide_roosting	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	Avalon Conservation Action Plan		Location of waterbirds	
						Avalon Conservation Action Plan		Migratory birds	

Folder	Sub folder(s)		Layer name	File type	Projection	Source	Source URL	Original file name	Description
		3_Non-Avian	3_Littoral_nonbird_VBAFauna	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/victorian-biodiversity-atlas-fauna-records-unrestricted-for-sites-with-high-spatial-accuracy	VBA_FAUNA25	Fauna taxa records from the Victorian Biodiversity Atlas (VBA) (including most threatened taxa)
			3_Littoral_GrowlingGrassFrog	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	Melbourne Water (digitised from GGF species records and WTP significant species PDF)			Growling grass frog species records used include: EHP14513_GGF_Results_2020to2021_Monitoring EHP15803_GGF_Results_2021to2022_Monitoring EHP16675_GGF_IncidentalRecords_2022to2023_Monitoring
			3_Littoral_GoldenSunMoth	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/victorian-biodiversity-atlas-fauna-records-unrestricted-for-sites-with-high-spatial-accuracy	VBA_FAUNA25	Golden sun moth locations digitised into a polygon
		3_Flora	3_Littoral_VBAFlora	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/victorian-biodiversity-atlas-flora-records-unrestricted-for-sites-with-high-spatial-accuracy	VBA_FLORA25	Flora taxa records from the Victorian Biodiversity Atlas (VBA) (including most threatened taxa)
			3_Littoral_WTP_TreeInventory	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	Melbourne Water data handover		WTP_Tree_Inventory_20180620_GHD	Tree inventory
4_Beaches_BroadConsGroup	4_Habitats		4_Beaches	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	SeamapAus	https://seamapaustralia.org/map/	SeamapAus_National_Benthic_Habitat_LayerPolygon	Littoral sand
						Boon et al., 2011 (via DEECA GIS data handover)		intertidal_evc_final_v2_vg94	Includes are identified as sandy bank or berm grassy shrubland
						Melbourne Water data handover - WTP data		ARI_2010_Ramsar_EVC_Final_Extract_AOI_PolygonsMerged	EVC classes included: Berm Grassy Shrubland and Coastal Dune Grassland
						Melbourne Water data handover - WTP data		EVC_Dissolve_20220927	EVC class included: Berm Grassy Shrubland
	4_NestedAssets	4_Avian	4_Beaches_bird_VBAFauna	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/victorian-biodiversity-atlas-fauna-records-unrestricted-for-sites-with-high-spatial-accuracy	VBA_FAUNA25	Fauna taxa records from the Victorian Biodiversity Atlas (VBA) (including most threatened taxa)
			4_Beaches_bird_hightide_roosting	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	Avalon Conservation Action Plan		Location of waterbirds	
			4_Beaches_bird_orange_bellied_parrot	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	Digitised from Melbourne Water WTP significant species PDF			Orange bellied parrot habitat across beaches
			4_Beaches_bird_shorebird_sites	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/east-asian-australasian-flyway-shorebird-sites-in-victoria	SHOREBIRD_SITES	Shorebirds roosting habitats with usage detailed
			4_Beaches_bird_nesting_feeding_roosting	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/coastal-bird-habitats-on-the-victorian-coast	COASTAL_BIRD_HABITAT	This layer identifies bird habitats in the Victorian coastal region. The layer is a polygon coverage with the polygon areas representing the main area of the respective bird habitats. Sites were identified from a broad range of published and unpublished sources of information and from personal communications made by experts in the field. In 2015 some additional locations were added with data from Birdlife Australia Shorebird 2020 Data. This dataset was formerly known as SHOREBIRD HABITAT but was renamed as it contains sites for seabirds and other birds.
		4_Flora	4_Beaches_VBAFlora	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/victorian-biodiversity-atlas-flora-records-unrestricted-for-sites-with-high-spatial-accuracy	VBA_FLORA25	Flora taxa records from the Victorian Biodiversity Atlas (VBA) (including most threatened taxa)
5_Marine_Habitat_BroadConsGroup	5_Habitats		5_Marine_Seagrass	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	CoastKit	https://mapshare.vic.gov.au/coastkit/	Habitats	Seagrass habitat
						CoastKit	https://mapshare.vic.gov.au/coastkit/	Existing Habitat	
						SeamapAus	https://seamapaustralia.org/map/	SeamapAus_National_Benthic_Habitat_LayerPolygon	
						CoastKit	https://mapshare.vic.gov.au/coastkit/	Seagrass - Collapsed condition	
			5_Marine_Saltmarsh	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	SeamapAus	https://seamapaustralia.org/map/	SeamapAus_National_Benthic_Habitat_LayerPolygon	Saltmarsh and consolidated hard substrata
			5_Marine_Reef	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	SeamapAus	https://seamapaustralia.org/map/	SeamapAus_National_Benthic_Habitat_LayerPolygon	Rocky reef habitat including: High energy infralittoral rock, Low energy infralittoral rock, Low energy littoral rock, Moderate energy

Folder	Sub folder(s)		Layer name	File type	Projection	Source	Source URL	Original file name	Description
									infralittoral rock, Rocky Reef, Sublittoral biogenic reefs
			5_Marine_SoftSediment	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	SeamapAus	https://seamapaustralia.org/map/	SeamapAus_National_Benthic_Habitat_LayerPolygon	Marine soft sediment habitats including: Central Basin, Littoral mud, Littoral sand, non-reef sediment epibenthos, Sublittoral coarse sediment, Sublittoral mixed sediments, Sublittoral mud, Sublittoral sand and muddy sand, Sublittoral seaweed on sediment.
	5_NestedAssets	5_Avian	5_Marine_bird_VBAFauna	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/victorian-biodiversity-atlas-fauna-records-unrestricted-for-sites-with-high-spatial-accuracy	VBA_FAUNA25	Fauna taxa records from the Victorian Biodiversity Atlas (VBA) (including most threatened taxa)
			5_Marine_bird_orange_bellied_parrot	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	Digitised from Melbourne Water WTP significant species PDF			Orange bellied parrot habitat within marine areas
			5_Marine_bird_shorebird_sites	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/east-asian-australasian-flyway-shorebird-sites-in-victoria	SHOREBIRD_SITES	Shorebirds roosting habitats with usage detailed
			5_Marine_bird_nesting_feeding_roosting	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/coastal-bird-habitats-on-the-victorian-coast	COASTAL_BIRD_HABITAT	This layer identifies bird habitats in the Victorian coastal region. The layer is a polygon coverage with the polygon areas representing the main area of the respective bird habitats. Sites were identified from a broad range of published and unpublished sources of information and from personal communications made by experts in the field. In 2015 some additional locations were added with data from Birdlife Australia Shorebird 2020 Data. This dataset was formerly known as SHOREBIRD HABITAT but was renamed as it contains sites for seabirds and other birds.
						DEECA (data handover)		ShorebirdFeedingRoosting2009	Shorebird feeding and roosting sites
		5_Non-Avian	5_Marine_nonbird_VBAFauna	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/victorian-biodiversity-atlas-fauna-records-unrestricted-for-sites-with-high-spatial-accuracy	VBA_FAUNA25	Fauna taxa records from the Victorian Biodiversity Atlas (VBA) (including most threatened taxa)
			5_Marine_Invertebrates	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/marine-and-coastal-feature-atlas-points	MARINE_FEATURE_ATLAS_POINT	Invertebrates within marine areas
		5_Flora	5_Marine_VBAFlora	Shapefile	EPSG:7855 - GDA2020 / MGA zone 55	DEECA	https://discover.data.vic.gov.au/dataset/victorian-biodiversity-atlas-flora-records-unrestricted-for-sites-with-high-spatial-accuracy	VBA_FLORA25	Flora taxa records from the Victorian Biodiversity Atlas (VBA) (including most threatened taxa)

Table 33. Spatial data register including all datasets considered in the scope of the ecological values assessment.

Category	Original File Name		Original file type	Geometry	Description	Source	Link to dataset (if applicable)
Spatial data	ARI_2010_Ramsar_EVC_Final_Extract_AOI_PolygonsMerged	gpkg	Polygon	EVIC classes across the study area		Melbourne Water data handover - WTP data	
Spatial data	Biologically Important Areas	Shapefile	Polygon	Biologically Important Area data are spatially defined areas where aggregations of individuals of a regionally significant species are known to display biologically important behaviours such as breeding, foraging, resting or migration. This layer was originally produced by the Commonwealth of Australia (Department of Agriculture, Water and the Environment, 2015), and has been cropped to Victoria's state boundaries, and queried for temperate east marine regions (SEMR- south east marine region).		DEECA	https://discover.data.vic.gov.au/dataset/biologically-important-areas
Spatial data	Biotic Component	Shapefile	Polygon	Marine/coastal habitats e.g. saltmarsh, sublittoral sand etc		CoastKit	https://mapshare.vic.gov.au/coastkit/
Spatial data	Birds (area)	Shapefile	Polygon	Sightings of bird species		CoastKit	https://mapshare.vic.gov.au/coastkit/
Spatial data	Birds (sites)	Shapefile	Point	Sightings of bird species		CoastKit	https://mapshare.vic.gov.au/coastkit/
Spatial data	CAPAD marine	Shapefile	Polygon	Collaborative Australian Protected Areas Database (CAPAD). Nation-wide perspective on marine protected areas, with insight into their conservation and biodiversity. Contains Commonwealth MPAs **Data folder contains table showing permitted activities in each zone: https://alluvium.sharepoint.com/:b:/s/MarineSpatialPlanninginVictoria/EZnimxHFb-xFp9vcOhvJEqEBe6Ht8rN-m0UmeMBYclkpUQ?e=aakFpb Consistent with the Australian Government's commitment to develop a National Representative System of Marine Protected Areas, networks of marine parks have been proclaimed for Commonwealth waters across the North, North-west, South-west, Temperate East and Coral Sea Marine Regions and, most recently, in the Indian Ocean Territories. These networks build on previous marine protected area proclamations, including the South-east Marine Parks Network declared in 2007. This data contains spatial and contextual information about Australian Marine Parks proclaimed under the Commonwealth Government's Environment Protection and Biodiversity Conservation Act 1999, which are managed by Parks Australia, with the addition of Heard Island and McDonald Islands Marine Reserve, which is managed by the Australian Antarctic Division	DCCEEW	https://www.environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7BAF4EE98E-7F09-4172-B95E-067AB8FA10FC%7D
Spatial data	CAPAD terrestrial	Shapefile	Polygon	Attribution for names, alias, class, direction, locality, unique feature identification, suburb/locality. Includes alternate names. Collaborative Australian Protected Areas Database (CAPAD). Nation-wide perspective on terrestrial (land) protected areas, with insight into their conservation and biodiversity.		DCCEEW	https://www.environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7B4448CACD-9DA8-43D1-A48F-48149FD5FCFD%7D
Spatial data	COASTAL_BIRD_HABITAT	Shapefile	Polygon	This layer identifies bird habitats in the Victorian coastal region. The layer is a polygon coverage with the polygon areas representing the main area of the respective bird habitats. Sites were identified from a broad range of published and unpublished sources of information and from personal communications made by experts in the field. In 2015 some additional locations were added with data from Birdlife Australia Shorebird 2020 Data. This dataset was formerly known as SHOREBIRD HABITAT but was renamed as it contains sites for seabirds and other birds.		DEECA	https://discover.data.vic.gov.au/dataset/coastal-bird-habitats-on-the-victorian-coast
Spatial data	EA_Saltmarsh_Plus_Boon_Extract_CoastalSaltHab_EVCs_MERGED	gpkg				Melbourne Water data handover - WTP data	
Spatial data	ECC special management areas	Shapefile	Polygon	Areas of marine special management		CoastKit	https://mapshare.vic.gov.au/coastkit/
Spatial data	EHP14513_GGF_Results_2020to2021_Monitoring	Shapefile	Point	Growling grass frog monitoring sites		Melbourne Water data handover	
Spatial data	EHP15803_GGF_Results_2021to2022_Monitoring	Shapefile	Point	Growling grass frog monitoring sites		Melbourne Water data handover	
Spatial data	EHP16675_GGF_IncidentalRecords_2022to2023_Monitoring	Shapefile	Point	Growling grass frog monitoring sites		Melbourne Water data handover	
Spatial data	ESTUARIES	Shapefile	Polygon	Areas of estuarine waters derived and updated by the Index of Estuary Condition funded by the Department Environment, Land, Water and Planning. Underlying estuarine areas were produced by Deakin University as part of the projects: "Linking catchments to the sea: Understanding how human activities impact on Victorian estuaries" funded by the National Heritage Trust (Barton et al., 2008) and the Department of Sustainability and Environment and the Trial Implementation of the Index of Estuary Condition, funded by the Department of Sustainability and Environment and Deakin University (Pope et al., 2015).		DEECA	https://discover.data.vic.gov.au/dataset/estuaries
Spatial data	EVC_Dissolve_20220927	gpkg		EVC class included: Berm Grassy Shrubland		Melbourne Water data handover - WTP data	
Spatial data	Existing Habitat	Shapefile	Polygon	Blue carbon seagrass habitats		CoastKit	https://mapshare.vic.gov.au/coastkit/
Spatial data	FFG Act	Shapefile	Polygon	Listed and threatened species and communities, San Remo Marine community, Entrance deep canyon Marine community, Western port bryozoan reef community		CoastKit	https://mapshare.vic.gov.au/coastkit/
Spatial data	GEOMARK_POLYGON	Shapefile	Polygon	Rivers within the study area represented as a polygon.		DEECA	https://discover.data.vic.gov.au/dataset/vicmap-features-geomark-polygon
Spatial data	Melbourne Water 10157 Fig2 GSM Habitat - EHP report	PDF	Digitised polygon	Golden sun moth habitat		Melbourne Water data handover	
Spatial data	Gration 2008 WTP PDF	PDF	Digitised polygon	Bat sightings digitised		Melbourne Water data handover	
Spatial data	Habitat and Marine Life	Shapefile	Polygon	Large data set with habitats both terrestrial and marine		CoastKit	https://mapshare.vic.gov.au/coastkit/
Spatial data	Habitat condition	Shapefile	Polygon	Blue carbon seagrass habitats with their condition noted		CoastKit	https://mapshare.vic.gov.au/coastkit/
Spatial data	Habitat of important - area	Shapefile	Polygon	All important coastline habitats, with descriptions and species found		CoastKit	https://mapshare.vic.gov.au/coastkit/

Category	Original File Name		Original file type	Geometry	Description	Source	Link to dataset (if applicable)
Spatial data	Habitat of important - sites	Shapefile	Point		All important coastline habitats, with descriptions and species found, no points in clip	CoastKit	https://mapshare.vic.gov.au/coastkit/
Spatial data	Habitats	Shapefile	Point		Blue carbon seagrass habitats	CoastKit	https://mapshare.vic.gov.au/coastkit/
Spatial data	HY_WATERCOURSE	Shapefile	Line		Waterways with a 5 metre buffer applied	DEECA	https://discover.data.vic.gov.au/dataset/vicmap-hydro-watercourse-line
Spatial data	intertidal_evc_final_v2_vg94	Shapefile	Polygon		Intertidal areas with descriptions in shorthand e.g. MS, WSS, CS	Boon et al., 2011 (via DEECA GIS data handover)	
Spatial data	Invasive species	Shapefile	Point		Sightings of invasive species (marine)	CoastKit	https://mapshare.vic.gov.au/coastkit/
Spatial data	Invertebrates (area)	Shapefile	Polygon		Sightings of Invertebrate species (marine)	CoastKit	https://mapshare.vic.gov.au/coastkit/
Spatial data	Invertebrates (sites)	Shapefile	Point		Sightings of Invertebrate species (marine)	CoastKit	https://mapshare.vic.gov.au/coastkit/
Spatial data	ISC2010_BANKFULL_WIDTH_R	Shapefile	Polygon		Rivers within the study area represented as a polygon. Polygon features represent the width between the top of the lowest bank and the corresponding height on the opposite bank for each River Reach.	DEECA	https://discover.data.vic.gov.au/dataset/2010-index-of-stream-condition-bank-full-width-reach-polygon-features
Spatial data	Jawbone_saltmarsh_poly2011	Shapefile	Polygon		Saltmarsh area at jawbone - one attribute in clip	DEECA (data handover)	
Spatial data	Key Fairy Terns	Shapefile	Polygon			Avalon Conservation Action Plan	
Spatial data	LANDUSE_2017	Shapefile	Polygon		Land uses considered: Mixed Farming and Grazing, Market Garden - Vegetables, Poultry (broiler production), Mixed farming and grazing (generally more than 20 ha), Livestock Grazing.	DEECA	https://discover.data.vic.gov.au/dataset/victorian-land-use-information-system-2016-2017
Spatial data	Location of waterbirds	Shapefile	Polygon			Avalon Conservation Action Plan	
Spatial data	Major River entrances	Shapefile	Polygon		Entrances to major watercourses along the Victorian coastline.	DEECA	https://discover.data.vic.gov.au/dataset/primary-watercourse-entrances-along-the-victorian-coastline
Spatial data	Marine Assets	Shapefile	Polygon		Descriptions of marine habitats for species with details	DEECA (Marine Spatial Planning MSP-NOV-2021 data handover (from UTAS))	
Spatial data	Marine mammals (area)	Shapefile	Polygon		Sightings of mammal species	CoastKit	https://mapshare.vic.gov.au/coastkit/
Spatial data	Marine mammals (sites)	Shapefile	Point		Sightings of mammal species	CoastKit	https://mapshare.vic.gov.au/coastkit/
Spatial data	MARINE_FEATURE_ATLAS_POINT	Shapefile	Point		This layer contains marine and coastal features across Victoria. This data consists of conservation and protection zones, cultural and heritage areas, energy and resource extraction sites, defence and national security areas, locations of ports and shipping channels, fishing and aquaculture areas, species and areas of natural environment and biodiversity importance.	DEECA	https://discover.data.vic.gov.au/dataset/marine-and-coastal-feature-atlas-points
Spatial data	MARINE_FEATURE_ATLAS_POLY	Shapefile	Polygon		This layer contains marine and coastal features across Victoria. This data consists of conservation and protection zones, cultural and heritage areas, energy and resource extraction sites, defence and national security areas, locations of ports and shipping channels, fishing and aquaculture areas, and areas of natural environment and biodiversity importance. Specifically focused on Tussock grasslands	DEECA	https://discover.data.vic.gov.au/dataset/marine-and-coastal-feature-atlas-polygons
Spatial data	Melbourne Water WTP significant species PDF	PDF	Digitised polygon		Digitised polygons including orange bellied parrot, fat tailed dunnart, growling grass frog and pimelea habitats	Melbourne Water	
Spatial data	Migratory birds	Shapefile	Polygon			Avalon Conservation Action Plan	
Spatial data	NaturePrint v4.0 Biodiversity Values	Raster			Raster valuing terrestrial biodiversity from 1-100	DEECA	https://discover.data.vic.gov.au/dataset/natureprint-v4-0-strategic-biodiversity-values25
Spatial data	New_AgriculturalLeaseAreaBoundary	gpkg				Melbourne Water data handover - WTP data	
Spatial data	NV2005_EVCBCS	Shapefile	Polygon		Ecological Vegetation Classes within the study area. This is a derived dataset that delineates the Bioregional Conservation Status of EVCs.	DEECA	https://discover.data.vic.gov.au/dataset/native-vegetation-modelled-2005-ecological-vegetation-classes-with-bioregional-conservation-sta
Spatial data	PARKRES	Shapefile	Polygon		Areas under the National Parks Act 1975, conservation reserves and metropolitan open space parks under the policy control of the Land Management Policy Branch. This dataset replaced PK_PARKRES in April 2013.	DEECA	https://discover.data.vic.gov.au/dataset/parks-and-conservation-reserves-parkres2
Spatial data	Pimelea report final_site_coordinates	Excel			Coordinates of Pimelea sites	Melbourne Water data handover	
Spatial data	PPB_shorebird_habitat	Shapefile	Polygon		Shorebird feeding sites	DEECA (data handover)	
Spatial data	RAMSAR25	Shapefile	Polygon		Polygons defining Ramsar wetland areas in Victoria. The Ramsar Convention of Wetlands of International Importance, to which Australia is a signatory, requires contracting parties to designate wetlands of international significance within their territory for listing under the convention. Precision to 1:25 000.	DEECA	https://discover.data.vic.gov.au/dataset/ramsar-wetland-areas-in-victoria-at-1-25-0002
Spatial data	RECFISHHABITAT	Shapefile	Polygon		Scientific review and dataset on developing criteria for identifying key fish habitat locations and focussed on major Victorian bays and inlets (Port Philip Bay, Western Port, Corner Inlet and Gippsland Lakes). The recreational marine fish species habitat in the dataset are King George whiting, snapper, sand flathead, calamari, black bream and gummy shark. Commissioned by the Victorian Fisheries Authority (VFA) and later digitised by DELWP, the consultancy report was produced by the University of Melbourne. Kalu. Commissioned by VFA. developing criteria for identifying key fish habitat locations	DEECA	https://discover.data.vic.gov.au/dataset/recreational-fish-habitat
Spatial data	Seagrass - Collapsed condition	Shapefile	Polygon		Blue carbon seagrass habitats with their collapsed condition noted	CoastKit	https://mapshare.vic.gov.au/coastkit/
Spatial data	SeamapAus_National_Benthic_Habitat_LayerPolygon	Shapefile	Polygon		Coastal habitat areas detailing sediments, vegetation and type of habitat	SeamapAus	https://seamapaustralia.org/map/

Category	Original File Name	Original file type	Geometry	Description	Source	Link to dataset (if applicable)
Spatial data	SHOREBIRD_SITES	Shapefile	Polygon	Polygons defining the East Asian-Australasian Flyway Shorebird Sites in Victoria. The East Asian-Australasian Flyway extends from the Arctic Circle through Eastern and South East Asia to Australia and New Zealand and encompasses 22 countries. The East Asian-Australasian Shorebird Site Network was launched in 1996. It is now known as the East Asian-Australasian Flyway Site Network. Corner Inlet was listed as a shorebird site at the launch of the East Asian-Australasian Shorebird Site Network in 1996. In 2000, two other Victorian sites joined the network: Western Port, Port Phillip Bay (Western Shoreline) and Bellarine Peninsula. In 2006, Shallow Inlet Marine and Coastal Park and Discovery Bay Coastal Park were added. Adding these sites to the network provides recognition for Victoria's most important shorebird sites.	DEECA	https://discover.data.vic.gov.au/dataset/east-asian-australasian-flyway-shorebird-sites-in-victoria
Spatial data	ShorebirdFeedingRoosting2009	Shapefile	Polygon	Shorebird feeding and roosting sites	DEECA (data handover)	
Spatial data	TheSpit_saltmarsh_poly_2011	Shapefile	Polygon	Saltmarsh area at the spit- one attribute in clip	DEECA (data handover)	
Spatial data	VBA Fauna Grid 1M	Shapefile	Point	This layer summarises VBA fauna records against a standard grid of 1 degree longitude/latitude (GDA94). Any VBA taxa record with its centre in a cell is counted as a record for that cell.	DEECA	https://discover.data.vic.gov.au/dataset/victorian-biodiversity-atlas-fauna-1-minute-grid-summary
Spatial data	VBA Flora Grid 1M	Shapefile	Point	This layer summarises VBA flora records against a standard grid of 1 degree longitude/latitude (GDA94). Any VBA taxa record with its centre in a cell is counted as a record for that cell.	DEECA	https://discover.data.vic.gov.au/dataset/victorian-biodiversity-atlas-flora-1-minute-grid-summary
Spatial data	VBA_FAUNA25	Shapefile	Point	Fauna taxa records from the Victorian Biodiversity Atlas (VBA) (including most threatened taxa)	DEECA	https://discover.data.vic.gov.au/dataset/victorian-biodiversity-atlas-fauna-records-unrestricted-for-sites-with-high-spatial-accuracy
Spatial data	VBA_FLORA25	Shapefile	Point	Flora taxa records from the Victorian Biodiversity Atlas (VBA) (including most threatened taxa)	DEECA	https://discover.data.vic.gov.au/dataset/victorian-biodiversity-atlas-flora-records-unrestricted-for-sites-with-high-spatial-accuracy
Spatial data	Water Bodies	Shapefile	Polygon	All waterbodies on coastline	CoastKit	https://mapshare.vic.gov.au/coastkit/
Spatial data	WETLAND_CURRENT	Shapefile	Polygon	Polygons showing the extent and types of wetlands in Victoria. WETLAND_CURRENT was created in 2013 and was derived from WETLAND_1994 (the state's first wetland geospatial inventory) and several local and regional wetland datasets. Wetlands were classified (according to the new classification framework) into primary categories based on wetland system type, salinity regime, water regime, water source, dominant vegetation and wetland origin. Two data updates have been completed (in 2013 and 2017), which have expanded the wetlands inventory to include Tootgarook Swamp, Alpine Bogs, Mitchell River Floodplain Wetlands, Melbourne Water Billabongs and Mallee CMA Wetlands. The dataset currently consists of 38,799 polygons totalling 784,120 ha.	DEECA	https://discover.data.vic.gov.au/dataset/victorian-wetland-inventory-current
Spatial data	WTP_natural_waterways	Shapefile	Polygon	Waterways within the Western Treatment Plant with a 5 m buffer applied	Melbourne Water data handover	
Spatial data	WTP_Tree_Inventory_20180620_GHD	Shapefile	Polygon	Tree inventory	Melbourne Water data handover	
Spatial data	SMP_Delma-impar_Striped-Legless-Lizard_12159	Raster		Stripped Lizard distributions	Melbourne Water data handover	
Spatial data	SMP_Litoria-raniformis_Growling-Grass-Frog_13207	Raster		Growling Grass Frog distributions	Melbourne Water data handover	
Spatial data	SMP_Neophema-chrysogaster_Orange-bellied-Parrot_10305	Raster		Orange bellied parrot distributions	Melbourne Water data handover	
Spatial data	SMP_Sminthopsis-crassicaudata_Fat-tailed-Dunnart_11072	Raster		Fat-tailed Dunnart distributions	Melbourne Water data handover	
Spatial data	pre-1750_intertidal_evc__v2_vg94	Shapefile	Polygon	Intertidal areas with descriptions in shorthand e.g. MS, WSS, CS	Boon et al., 2011 (via DEECA GIS data handover)	

Table 34. Document register including all reports considered in the scope of the ecological values assessment.

Category	Original File Name	Source	Link to report (if applicable)	Date of publication
Report	Wadawurrung Country Plan	Wadawurrung Traditional Owners		2020
Report	Hydrodynamic assessment of tidal restoration options for Avalon Coastal Reserve	Deakin University, Blue Carbon Lab		2022
Report	Vegetation mapping of the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site	Arthur Rylah Institute for Environmental Research		2010
Report	Shorebirds of Avalon Salt fields: 1980-2016	Arthur Rylah Institute for Environmental Research		2016
Report	Surveys of benthic invertebrates in habitats potentially used by shorebirds in the Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site	Arthur Rylah Institute for Environmental Research		2011
Report	Port Phillip Bay (Western Shoreline) site pest plant and animal management plan	Parks Victoria		2011
Report	Marine Natural Values Study Vol 2: Marine Protected Areas of the Victorian Embayment's Bioregion Part 1 Port Phillip Bay	Parks Victoria		2012
Report	Port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site management plan	Victoria State Gov.		2018
Report	Conservation values of Avalon for waterbirds	Unknown		
Report	Point Cooke Marine Sanctuary management plan	Parks Victoria		2007
Report	Local movements of shorebirds and high-resolution mapping of shorebird habitat in the port Phillip Bay (Western Shoreline) and Bellarine Peninsula Ramsar Site	Arthur Rylah Institute for Environmental Research		2010
Report	Jawbone marine sanctuary management plan	Parks Victoria		2007
Report	Estimating the potential blue carbon gains from tidal marsh rehabilitation	Various		2020
Report	Bellarine peninsula, Corio Bay local coastal hazard assessment, inundation report	City of Greater Geelong		2015
Report	Barwon Heads climate coastal risk overview	City of Greater Geelong		
Report	Corangamite regional catchment strategy - Geelong City (Coast and Marine)	Corangamite CMA	https://corangamite.rcs.vic.gov.au/local-areas/local-area-8/	2024
Report	Port Phillip and Western port regional catchment strategy (Coasts)	Melbourne Water	https://portphillipwesternport.rcs.vic.gov.au/themes/coasts/	2024