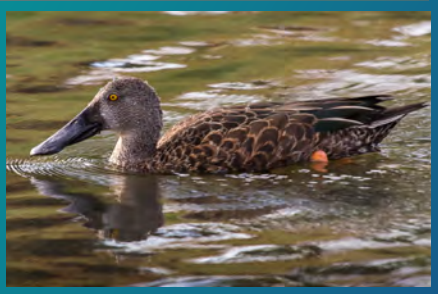
GOVERNMENT OF WESTERN AUSTRALIA

Department of **Biodiversity, Conservation and Attractions**
Department of **Primary Industries and Regional Development**
Department of **Water and Environmental Regulation**

Draft Vasse Wonnerup Operational Plan: guidance for managers 2019

Draft for public comment



Revitalising Geographe Waterways

VASSE taskFORCE

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Front cover photos
Top: Aerial view of the Vasse-Wonnerup wetland system. Photo – DWER
Below (from left to right):
Black swan cygnets. Photo - Kim Williams/DBCA
Red-necked stint (International migratory waterbird). Photo - Kim Williams/DBCA
Australasian shoveler (Australian resident waterbird). Photo - Kim Williams/DBCA

Back cover photo
Malbup Creek bird hide. Photo - Kim Williams/DBCA

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Acknowledgments

The Department of Biodiversity, Conservation and Attractions prepared this draft operational plan as part of the Revitalising Geographe Waterways program. The Planning Team, consisting of Grace Patorniti, Kelly Gillen, Bob Hagan, Wayne Elliott, Kim Williams and Jim Lane (Department of Biodiversity, Conservation and Attractions) and Kath Lynch (Department of Water and Environmental Regulation) coordinated the development of the draft operational plan.

The Planning Team would like to thank the other departmental staff and the Vasse Wonnerup wetlands partnership (i.e. representatives from the Department of Biodiversity, Conservation and Attractions, Department of Water and Environmental Regulation, Department of Primary Industries and Regional Development, the City of Busselton and Water Corporation) who contributed to the preparation of the draft operational plan.

Thank you to the many individuals, community groups, organisations and government agencies who made valuable contributions to the development of this draft operational plan.

Thank you also to the members of the Vasse Wonnerup wetlands Collaboration Group for providing valuable input to the draft operational plan, in particular the vision, management objectives and actions, through their attendance at workshops.

The traditional owners of the plan area, the Wardandi people, are acknowledged. The importance of the cultural heritage values of the plan area and the important and valuable knowledge that Wardandi people hold are recognised. Particular thanks and acknowledgement to the South West Aboriginal Land and Sea Council, and the South West Boojarah Native Title Working Party and Harris Family for their contribution and assistance, and for the sharing of cultural knowledge; and to Brad Goode and Associates for the work with traditional owners and for documenting the cultural knowledge.

The term ‘Noongar’, which refers to Aboriginal people who live in the south-west corner of Western Australia between Jurien Bay and Esperance, is used in the draft operational plan. The word ‘Noongar’ can be spelt in different ways and spelling in this form should also be seen to encompass the Nyoongar, Nyungar, Noongah and Nyungah spellings.

Preface

Revitalising Geographe Waterways is a State Government initiative to improve water quality in the Geographe Bay catchment encompassing, 30 projects across five integrated work areas.

Revitalising Geographe Waterways is overseen by the Vasse Taskforce, a multi-agency committee with representation from local government, government agencies, water service providers and catchment groups. Taskforce partners led the implementation of the 30 projects in partnership with industry, local farmers and the community. Taskforce partner, the Department of Biodiversity, Conservation and Attractions is the lead agency for the development of an operational plan for the Vasse-Wonnerup wetland system, lower Vasse River wetlands and adjacent Crown land.

The operational plan aims to protect the conservation, cultural heritage, social and economic values of the Vasse-Wonnerup wetland system and the lower Vasse River wetlands. The operational plan cannot address all of the management issues facing the wetland system and lower Vasse River wetlands, especially those which are whole of catchment issues. Initiatives of integrated catchment management will also need to continue to minimise the effects of nutrients entering the wetland system.

This operational plan is a non-statutory plan, therefore it requires the commitment from government agencies, local government and other organisations to work together to implement the operational plan.

The Vasse Wonnerup wetlands partnership will coordinate the implementation of the operational plan with support from catchment groups. The Department of Biodiversity, Conservation and Attractions will continue to manage the areas vested in the Conservation and Parks Commission and also prioritise the transfer of unallocated Crown land (e.g. Vasse-Wonnerup wetlands) and unmanaged Crown land (e.g. lower Vasse River wetlands) into conservation estate over the life of the plan.

List of Abbreviations

BC Act	*Biodiversity Conservation Act 2016* (WA)
CALM Act	*Conservation and Land Management Act 1984* (WA)
the City	City of Busselton
the Commission	Conservation and Parks Commission
DBCA	Department of Biodiversity, Conservation and Attractions
DEE	Department of the Environment and Energy (Commonwealth)
DFES	Department of Fire and Emergency Services, Western Australia
DMIRS	Department of Mines, Industry Regulation and Safety
DoH	Department of Health
DoT	Department of Transport
DPIRD	Department of Primary Industries and Regional Development
DPLH	Department of Planning, Lands and Heritage
DWER	Department of Water and Environmental Regulation
EPA	Environmental Protection Authority, Western Australia (supported by DWER)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
GeoCatch	Geographe Catchment Council
IBA	Important Bird and Biodiversity Area
SWCC	South West Catchments Council
SWALSC	South West Aboriginal Land and Sea Council
VWWP	Vasse Wonnerup wetlands partnership (DBCA, DWER, DPIRD, WC, City)
WA	Western Australia
WAPC	Western Australian Planning Commission (supported by DPLH)
WC	Water Corporation

Contents

1. Introduction

The preparation of the Vasse Wonnerup Operational Plan (the operational plan) is part of the Revitalising Geographe Waterways program. The program is a State Government initiative to improve water quality, health and management of waterways and wetlands in the Geographe Catchment (the catchment), which also incorporates recommendations from the independent review of the management of water-related assets in the catchment by Professor Hart (2014). The Revitalising Geographe Waterways program consists of 30 separate projects, one of which is the development of an operational plan for the Vasse-Wonnerup wetland system, lower Vasse River wetlands (also known as the Vasse River Delta wetlands) and adjacent Crown land.

The South West's Vasse-Wonnerup wetland system comprises the Vasse and Wonnerup[1] estuaries (also known as the Vasse-Wonnerup wetlands), Swan Lake (informal name), Vasse and Wonnerup exit channels, Wonnerup Inlet, the Deadwater (connected to the Wonnerup Inlet) and Malbup Creek (the seasonal connection between the estuaries). Upstream of, and adjacent to, the wetland system are the lower Vasse River wetlands (Ford Road to the check structure at the Old Butter factory) and Tuart Forest National Park.

The Vasse-Wonnerup wetland system is a unique and significant natural area contained within the Busselton[2] local government area. The vast expanse of the Vasse-Wonnerup wetland system is internationally important for thousands of waterbirds, with the wetlands and adjacent dryland supporting a rich biodiversity of native plants, native animals and ecological communities. The area is also culturally significant to the traditional owners (Wardandi people) and there is a long history of use for pathways and burial sites. The wetland system faces significant management issues, such as nutrient enrichment and encroachment from surrounding agricultural lands and urban development.

Since European settlement of the Busselton townsite in the 1830s, the wetlands and waterways in the catchment have been extensively modified to establish agricultural industries, such as grazing of beef cattle and dairy farming (Jennings 1983). Modifications include diversion of waterways to the ocean (Geographe Bay), a network of small drains to remove water from farmland and in 1908 floodgates (now referred to as surge barriers) were installed on the exit channels of the Vasse and Wonnerup Estuaries to regulate flow, exclude summer seawater intrusion and to protect the settlement area and agricultural lands from winter flooding and ocean tidal surges.

Substantial planning has already occurred for the catchment, including the Vasse-Wonnerup wetland system. Management plans and other guiding documents are currently being implemented for the wetland system and surrounding Crown land. This operational plan is a subsidiary document that complements the relevant management strategies and actions of these existing management plans and guiding documents. Further, the operational plan includes critical information such as the roles and responsibilities for the ongoing management of the wetland system and the lower Vasse River wetlands, and comprehensive strategies/actions to conserve and enhance the key values of the operational plan's study area.

[1] Wonnerup – *Wonnerup* is a Noongar placename, which means the place of the woman's digging stick (*Wonner*) boodjar.sis.uwa.edu.au/index.htm

[2] Busselton - *Undalup* is the Noongar word for Busselton.

1.1. Plan area

The operational plan's study area covers the water within the Vasse-Wonnerup wetland system (Swan Lake to Ford Road) and the lower Vasse River wetlands (Ford Road to the check structure at the Old Butter Factory) and adjacent lands. These adjacent lands comprise Crown land vested in the Conservation and Parks Commission (the Commission) or the City of Busselton (the City), unallocated Crown land (UCL) and unmanaged Crown land. The water and lands total about 1,600 hectares and are collectively referred to as 'the plan area' (see Maps 1a and b; Appendix 1).

The Wonnerup coastal reserves within the plan area are vested in, and managed by, the City. The management of these reserves: R22952 (Captain Baudin Reserve), R5217 (Wunda Buri Reserve), R385 (Lesueur Reserve), R39193 and R44330 (James Richardson Park) is mainly directed by the *Wonnerup Coastal Reserves Management Plan*[3] (City of Busselton 2016a). For direction in the management of these reserves the City's management plan should be referred to in the first instance.

Upstream of the check structure at the Old Butter Factory (i.e. western end of the plan area) is the lower Vasse River. Management of this waterway and adjacent Crown land is covered by the City's *Lower Vasse River draft water management plan* (*in preparation*). This waterway and the check structure are managed by the City.

Land tenure and reservation process

The Department of Biodiversity, Conservation and Attractions (DBCA, the department) manages the Crown land vested in the Commission; and for UCL outside of townsites DBCA has responsibility for on-ground management functions for the purpose of fire prevention and the control of weeds and pest animals only, through an arrangement with the Department of Planning, Lands and Heritage (DPLH).

DBCA cannot manage areas of UCL or unmanaged Crown land under the *Conservation and Land Management Act 1984* (CALM Act) until finalisation of the reservation process and the lands are vested in the Commission. It is important that these areas be officially reserved, so that the functions of the CALM Act and associated regulations[4] can be applied and investments in management actions can be secured. The creation of a CALM Act conservation reserve will enable Aboriginal people to continue their customary activities. The reservation process will include consultation with the City, Wardandi people and other key stakeholders.

DBCA will prioritise the addition of UCL (e.g. Vasse-Wonnerup wetlands) and unmanaged Crown land (e.g. lower Vasse River wetlands) to the conservation reserve system with vesting in the Commission and management by the department. The *Swan Coastal Plain South management plan 2016* (DPaW 2016) provides the initial direction for the lands that are to be reserved into the conservation estate and has brought together recommendations from a range of planning documents including the *Red Book status report (1993)* (EPA 1993), the *Busselton Wetlands Conservation Strategy* (WAPC 2005) and the *Forest Management Plan 2014-2023* (Conservation Commission 2013).

[3] The City of Busselton's reserve management plans can be accessed at: busselton.wa.gov.au/Environment-Waste/Environmental-Planning/Reserves-Management/Reserve-Management-Plans and the areas covered by reserve management plans can be viewed in the City's online mapping tool, IntraMaps: maps.busselton.wa.gov.au/IM80/default.htm

[4] Conservation and Land Management Regulations 2002 (CALM Act Regulations)

In addition to progressing the reservation of UCL and unmanaged Crown land within the plan area, expanding the conservation area around the Vasse-Wonnerup wetland system (e.g. unused road reserves or Crown land close to wetlands) would improve and protect the conservation and cultural heritage values of the area. Any future additions into the conservation estate that are within or adjoining the plan area will be managed in accordance with the operational plan, and applicable management plans and legislation.

South West Native Title Settlement

The lands of the plan area have underlying native title issues and will be subject to the South West Native Title Settlement (the SWNT Settlement) - the six individual Indigenous Land Use Agreements for the resolution of native title across the South West of Western Australia (WA), which includes the native title claims: South West Boojarah #2 (WC06/04) and Harris Family (WC96/41) – South West Boojarah #2 Indigenous Land Use Agreement.

The SWNT Settlement's package of benefits includes co-operative and joint management over parts of the conservation estate in the South West and up to 320,000 hectares of development and cultural land to become Noongar Land Estate held by the Noongar Boodja Trust. UCL and unmanaged Crown land of the plan area may be identified, following a government consultation process, for inclusion into Noongar Land Estate.

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
1. Progress the addition of the unallocated Crown land and unmanaged Crown land to the conservation reserve system.	1.1. Progress the proposed reservation of unallocated Crown land and unmanaged Crown land into conservation estate with vesting in the Conservation and Parks Commission, in consultation with native title parties and other relevant stakeholders. (**DBCA**, DPLH, key stakeholders) 1.2. Manage any future additions that are vested in the Conservation and Parks Commission in accordance with the operational plan, and applicable management plans and legislation. (**DBCA**)
2. Opportunities for Noongar people to be trained and employed in conservation and land management activities relevant to the reserves.	2.1. Identify opportunities to provide employment, business and training for Noongar people to assist in maintaining connection to country. (**Key stakeholders**) 2.2. Ensure employment arrangements for Aboriginal employees provide an avenue for them to discuss culturally sensitive matters relating to their employment with their elders. (**Key stakeholders**)

1.2. Key values and management issues

This operational plan focuses on the protection of the conservation, cultural heritage, social (i.e. community and recreation) and economic (i.e. commercial and tourism operations) values of the plan area. The key values and the major management issues are listed below[5], and explained in the background text in each section. The major management issues and the potential impacts to the key values are also addressed by the management strategies/actions presented throughout the plan (Note: the management objectives and strategies/actions are also all listed under Appendix 7).

Key values

The key values of the plan area include:

Conservation values

- Internationally significant wetlands (i.e. Ramsar site, and Important Bird and Biodiversity Area (IBA)), which provide feeding habitat, migration stopover and drought refuge for thousands of waterbirds, and a breeding ground for hundreds of swans.
- Part of internationally and nationally recognised biodiversity hotspots.
- A rich assembly of wetland and upland (or dryland) ecosystems.
    - The wetland ecosystem includes an *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) listed threatened ecological community (i.e. coastal saltmarsh community), and important habitat for bird and fish populations.
    - The upland ecosystem includes a priority ecological community (i.e. the WA Priority 1 community - *Eucalyptus cornuta*, *Agonis flexuosa* and *Eucalyptus decipiens* forest on deep yellow-brown siliceous sands over limestone), important habitat for threatened species (such as western ringtail possum, southern brush-tailed phascogale and Carnaby's cockatoo) and a remnant stand of tuart woodland.

Cultural heritage values

- Noongar culture and heritage - sites of mythological, ceremonial, cultural and spiritual significance.
- Other Australian cultural heritage - places associated with early settlement and the agricultural industry.

Social and economic values

- Opportunities for nature-based visitor experiences and increased community awareness, engagement and enjoyment.
- Opportunities for commercial activities (e.g. commercial operators and commercial fishing).
- Ocean storm and tidal surge protection, and river floodwater mitigation.

Management issues

The major management issues that have the potential to significantly impact the key values of the plan area include (in no particular order of importance):

- Impacts from climate change (e.g. changes in the pattern of rainfall; increasing temperatures/warming climate; and rising sea levels that increases vulnerability to flooding and coastal erosion).
- Impacts to water quality from nutrient run-off into the wetland system and the lower Vasse River wetlands from surrounding land-uses (current and historical uses) and accumulation of nutrients in sediments of the wetlands.

[5] The key values and management issues of the plan area were identified through workshops with the Vasse-Wonnerup wetlands Collaboration group (see section **2.4. Community involvement**).

- Altered hydrological regimes, such as changes to the natural drainage system, river diversions and flood protection through the installation and operation of surge barriers and seasonal openings of the sand bar.
- Impacts from changes of land-use from rural to urban development, intensifying agriculture and habitat fragmentation from vegetation clearing in the surrounding landscape (current and historical).
- A need for increased protection of the wetland system and the lower Vasse River wetlands with security of tenure (i.e. transfer of vesting of UCL and unmanaged Crown land into the conservation estate).
- Impacts to community health from problem animals (e.g. mosquitoes) and phytoplankton (e.g. toxic blue-green algae); and impacts to community wellbeing (particularly midges, odours and aesthetics).
- Weed invasion (particularly kikuyu, divided sedge and arum lily), and predation and competition from introduced animals (particularly foxes and cats).
- Potential of fire risk to human life, community assets and biodiversity.
- Unauthorised and inappropriate recreational access and inappropriate recreational activities.
- Limited opportunities for passive recreation and tourism, and limited provision of information/interpretive signs (e.g. park signs and information bays) to communicate the values of the plan area.
- A need for increased understanding of the various activities (e.g. commercial and recreational fishing) undertaken within the plan area and any possible conflicts between these activities and the key values of the plan area.
- A need for ongoing engagement and education of the local community to increase the community's knowledge and appreciation of the wetland system and the lower Vasse River wetlands.
- A need for increased knowledge and understanding of the ecosystems' interactions and function through ongoing research and monitoring.

1.3. Ecological characteristics of the Ramsar site

The Vasse-Wonnerup wetlands provide habitat for thousands of waterbirds every year and as such were included on the List of Wetlands of International Importance under the Ramsar Convention in 1990 (the original 750 hectare site was extended by 365 hectares in 2000). The Ramsar Convention is an intergovernmental environmental treaty that provides the framework for national action and international cooperation to promote the conservation and wise use of wetlands.

The 1,115 hectares Vasse–Wonnerup System Ramsar site[6] is located in the City of Busselton and is wholly covered by this operational plan (Figure 1). The Ramsar site comprises the Vasse-Wonnerup wetland system (excluding the Deadwater), the seasonally inundated floodplains, the lower reaches of the Sabina and Ludlow rivers and part of the Tuart Forest National Park, including the lower reaches of the Abba River. There have been preliminary discussions to possibly extend the Ramsar site boundary and area to include other wetland areas within the Busselton wetlands complex.

[6] The full description of the Vasse–Wonnerup System Ramsar site is available in the Ramsar wetlands information sheet 2009–2014 version: environment.gov.au/water/topics/wetlands/database/pubs/38-ris.pdf.

Figure 1: Vasse-Wonnerup System Ramsar site: Ramsar site (blue shaded area) and plan area boundary (black line)

The Vasse–Wonnerup System Ramsar site consists mostly of extensive, nutrient-enriched, shallow seasonally drying wetlands. It has widely varying salinities of freshwater to hypersaline and is intermittently open to the ocean. The Ramsar site supports peak numbers of 25,000 to 30,000 waterbirds in most years and the most significant regular breeding colony of black swans (*Cygnus atratus*) in WA. The only estuary in WA to support bigger numbers of waterbirds is the Peel–Harvey Estuary, which is approximately 13 times the size of the Vasse–Wonnerup System Ramsar site.

Ramsar criteria for listing

To be included on the List of Wetlands of International Importance, a wetland ecosystem must satisfy at least one of the Ramsar Convention's nine criteria (Ramsar Convention 2005). The Vasse–Wonnerup System Ramsar site meets the following three Ramsar criteria:

- **Criterion 5:** *A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.*

More than 33,000 waterbirds were counted in January 1986 and waterbird data indicate that more than 20,000 waterbirds use the wetlands each year. In the 1998 to 2000 survey over 37,000 waterbirds from 68 species were found to use the wetlands (Lane 2009).

- **Criterion 6:** *A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.*

At least 1% of the Australian population of black-winged stilt (*Himantopus himantopus*) and at least 1% of the world population of red-necked avocet (*Recurvirostra novaehollandiae*) use the Vasse-Wonnerup wetland system in most years. The 1998 to 2000 surveys also found that the Australian shelduck (*Tadorna tadornoides*) and Australasian shoveler (*Anas rhynchotis*) were also in numbers greater than 1% of the population (Lane 2009).

The Vasse-Wonnerup wetland system potentially supports eight of the 35 species of migratory shorebirds contained in the *Wildlife Conservation Plan for Migratory Shorebirds* (Commonwealth of Australia 2015), developed under the EPBC Act. This plan was adopted by the State Government as an Interim Recovery Plan[7] for the threatened migratory shorebirds visiting WA.

Ecological character description

The ecological character of the Vasse–Wonnerup System Ramsar site has been described in the report, *Ecological Character Description for the Vasse-Wonnerup Wetlands Ramsar site in South-west Western Australia* (WRM 2007) and a summary is provided in Table 1.

Table 1: Summary of the ecological character of the Vasse–Wonnerup System Ramsar site, as described in WRM (2007, p28).

Component	Component Type	Description
Physical form	Geomorphology/Estuary morphology	• Broad, shallow basin, large seasonal variation in area of inundation • Seasonally closed estuary
	Soil type	• Sandy, poor nutrient retention, acid sulfate soils • Sedimentation and erosion
	Hydrology and hydrogeology	• Seasonal freshwater inflows
Water quality	Nutrients	• Eutrophication
	Salinity	• Seasonal salinity regime
	Dissolved oxygen	• Summer anoxia/hypoxia
	Turbidity / Water Clarity	-
Biological	Phytoplankton and aquatic macrophytes	• Microalgae, macroalgae, seagrasses
	Fringing vegetation	• Samphires, sedges and reeds, remnant eucalypts, paperbarks
	Habitat connectivity	• Tuart National Park and Geographe Bay
	Aquatic invertebrates	• Zooplankton, benthic macroinvertebrates
	Fish community	• Freshwater, estuarine and marine fishes
	Waterbirds	• International migratory species • Australian resident species

DBCA is the lead agency for implementation of the Ramsar Convention in WA. Part of the responsibility involves reporting to the Commonwealth Department of the Environment and Energy (DEE) if the ecological character of the Ramsar site has changed, is changing or is likely to change. To assist with this, 'limits of acceptable change' and 'interim limits of acceptable change' were set out in the *Ecological Character Description for the Vasse-Wonnerup Wetlands Ramsar site in South-west Western Australia* by WRM 2007, but these will need to be reviewed as new information is gained from present and future monitoring. To ensure that 'limits of acceptable change' are not exceeded, operational limits may need to be identified as early warning triggers. Where an operational limit is reached, management should intervene to determine whether the change is detrimental and, if required, prevent further deterioration.

[7] The Interim Recovery Plan is available on DBCA's Parks and Wildlife Service website: dbca.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-animals

Ongoing research and monitoring in the Vasse-Wonnerup wetlands (see section **6. Research and monitoring**) will enable the 'limits of acceptable change' and operational limits to be reviewed for the critical components and processes of the wetlands.

An officer (e.g. ranger) employed long term in a combined community liaison (e.g. communication of the values and management issues) and on-ground operations role for the plan area will be considered during the term of the operational plan.

Management objective	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
1. To maintain Ramsar wetland status and values.	1.1. Regularly monitor for bird numbers against the Ramsar criteria and the 'Limits of Acceptable Change' (WRM 2007). (**DBCA**) 1.2. Identify specific seasonal threats to the Ramsar values (i.e. meeting the Ramsar criteria to qualify for the Ramsar list) to inform future management actions. (**DBCA**) 1.3. Continue to seek opportunities to undertake research and increase knowledge relating to the retention of the Ramsar values. (**DBCA**, Science community) 1.4. Review and update the Vasse-Wonnerup System Ramsar site's 'Limits of Acceptable Change' and the Ramsar Information Sheet. (**DBCA**, DEE) 1.5. Develop a 'trigger and response' framework to monitor 'limits of acceptable change' of the ecological character of the wetlands. (**Science community**, DBCA) 1.6. Seek funding for a ranger covering the plan area. (**DBCA**)

2. Management directions and purpose

This operational plan aims to conserve the key values of the plan area in the long-term.

The plan area includes nature reserves, including Sabina Nature Reserve and Wonnerup Estuary Nature Reserve. Nature reserves are terrestrial areas with high conservation values set aside for the conservation of native plants and animals. These reserves are managed to protect and restore natural environments, and to promote the study and appreciation of nature. Recreational activities that are compatible with this purpose are permitted; such activities include bushwalking, nature appreciation and bird watching.

The plan area also includes part of Tuart Forest National Park. National parks have outstanding natural values and national significance for scenic, cultural or biological values. The park is managed to conserve plants and animals and to preserve features of archaeological, historical or scientific interest, and for sustainable tourism and recreation that maintains these natural and cultural values.

Management of the CALM Act lands shall be also carried out in a manner that 'protects and conserves the value of the land to the culture and heritage of Aboriginal persons', as described in section 33(2) of the CALM Act.

The *Swan Coastal Plain South management plan 2016* (DPaW 2016) gives broad direction for the management of 82 parks and reserves that are vested in the Commission and several proposed additions. Some of these reserves and proposed additions are located within the operational plan's study area.

The *Tuart Forest National Park management plan 2014* (DPaW 2014) gives direction for the management of Tuart Forest National Park (Reserves 40250, 40251 and 43059) that is vested in the Commission and several proposed additions (including Ludlow State Forest and Reserve 868). Of these reserves, part Reserve 40250 and Lot 2 on Plan 3280 are located within the operational plan's study area.

These two management plans provide guidance and direction for the operational plan, which is a subsidiary management document.

2.1. Vision and guiding principles

Vision

A resilient and healthy ecosystem that's valued and supported through shared custodianship.

The vision statement was derived from stakeholder input through workshops with the Vasse-Wonnerup wetlands Collaboration group (see section **2.4. Community involvement**).

Guiding principles

Guiding principles (Figure 2) will provide broad direction for management and are key themes covered by the draft operational plan. These principles reflect the importance, complexity and multi-faceted approach to management of the Vasse-Wonnerup wetland system, lower Vasse River wetlands and adjacent Crown land.

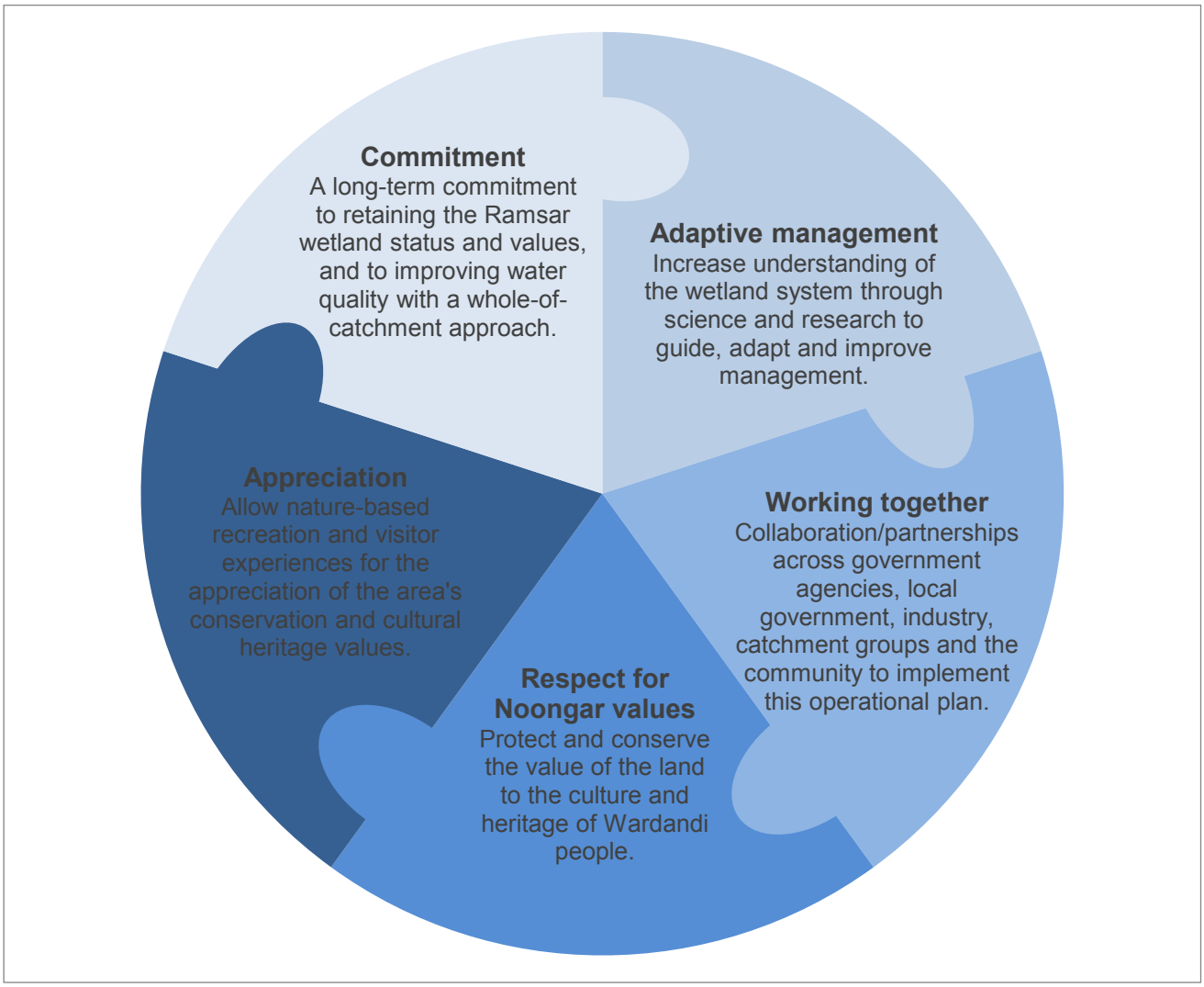


Figure 2: Guiding principles that provide broad direction for management.

2.2. Management arrangements

Government agencies and local government associated with the Vasse Wonnerup wetlands partnership (VWWP; formerly the Vasse Estuary Technical Working Group - VETWG) have important management roles associated with the Vasse-Wonnerup wetland system. This includes roles to mitigate the risk of fish kills in the Vasse-Wonnerup wetlands as described in the *Memorandum of Understanding* (MOU) *for Implementation of Fish Kill Strategy and Response Plan*.

These current VWWP management roles as outlined in the MOU, which are to be reviewed during the term of the operational plan, are summarised as follows (Note: Pending resolution of the long-term governance for the lands of the plan area and the reservation process, the management roles stated in the MOU will continue to apply):

- Water Corporation owns, operates and maintains the Vasse Estuary and Wonnerup Estuary surge barriers and therefore controls water levels in the Vasse-Wonnerup wetlands for the protection of lands upstream of the surge barriers from storm surges and winter flooding. Water Corporation also owns, operates and maintains the automated water level, water temperature and salinity monitoring equipment at the surge barriers.
- DBCA has an important role in ensuring that water levels in the Vasse-Wonnerup wetlands are, to the extent possible without causing unacceptable impacts on other parties, managed to maintain and ideally enhance the Ramsar and other conservation values of the Vasse-Wonnerup wetlands.
- Department of Water and Environmental Regulation (DWER) has delegated responsibility for responding to fish kills in inland and estuarine waters including the Vasse-Wonnerup wetlands. DWER also has the lead role in fish kill mitigation and related water quality and microalgae monitoring and to reduce nutrient inputs to the Vasse-Wonnerup wetlands.
- Department of Primary Industries and Regional Development (DPIRD) has responsibility for the management of fish stocks and regulates commercial and recreational fishing that occurs within the Vasse-Wonnerup wetlands.
- The City has the lead role in cleaning up after fish kills in the Vasse-Wonnerup wetlands. The City also undertakes mosquito breeding control operations on the Vasse-Wonnerup wetlands' saltmarshes with advice and assistance from the Department of Health (DoH) (see section **3.5. Public health and wellbeing**).

2.3. Legislation and policy framework

DBCA manages reserves within the plan area that are vested in the Commission in accordance with the provisions of the CALM Act, *Biodiversity Conservation Act 2016*[8] (BC Act) and other environmental legislation and departmental policies[9].

The BC Act received Assent on 21 September 2016 and was partially proclaimed on 3 December 2016. The Biodiversity Conservation Regulations 2018 were published in the Government Gazette on 14 September 2018, along with a second proclamation for the remaining provisions of the Act. The Regulations and remaining provisions of the Act came into operation on 1 January 2019 and fully replace the *Wildlife Conservation Act 1950* and *Sandalwood Act 1929* and their regulations.

Management of the plan area will also require consideration of the ongoing commitment to the following international conservation agreements to which Australia is a signatory:

- Convention on Wetlands of International Importance especially as Waterfowl Habitat 1971 (Ramsar Convention)
- China-Australia Migratory Bird Agreement (CAMBA)
- Japan-Australia Migratory Bird Agreement (JAMBA)
- Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA)
- Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).

[8] Western Australian legislation is available on the State Law Publisher's website: slp.wa.gov.au/Index.html
[9] Departmental policies are available on DBCA's Parks and Wildlife Service website: dbca.wa.gov.au/about-us/36-policies-and-legislation

The EPBC Act, administered by the Australian Government, relates to the protection of matters of national environmental significance such as wetlands of international importance (listed under the Ramsar Convention), nationally threatened species and ecological communities, migratory species (species protected under international conservation agreements) and heritage places. The EPBC Act, through the Environment Protection and Biodiversity Conservation Regulations 2000, also regulates the reporting of sites in Australia that are listed under the Ramsar Convention.

Actions that have, or are likely to have, a significant impact on a matter of national environmental significance require approval from the Australian Government environment minister in addition to any approval that may be needed in WA.

The Vasse-Wonnerup wetland system and lower Vasse River wetlands are also protected under the State's *Environmental Protection (Swan Coastal Plain Lakes) Policy (EPP) 1992*. Wetlands identified under this Policy are protected from land uses that will impact on their conservation values. Any development which is deemed to potentially adversely affect an EPP Lake is likely to require formal assessment by WA's Environmental Protection Authority (EPA).

2.4. Community involvement

A Vasse-Wonnerup wetlands Collaboration group (comprising stakeholders, i.e. scientists, multi-agency and local government staff, and community members) was formed in 2016 and since early 2016 there have been a number of facilitated workshops with the group. The workshops provided an opportunity for stakeholders to come together to share knowledge, exchange ideas and to assist in the development of the draft operational plan, in particular the vision, management objectives and management strategies/actions.

At the onset of the workshops in 2016, the Collaboration group worked together to co-define a dilemma statement for the Vasse Wonnerup wetland system, as follows:

"How do we achieve a resilient, healthy Vasse Wonnerup ecosystem balancing social, cultural, ecological and economic values supported by adaptive, well-resourced and coordinated management fostering shared community custodianship for future generations?"

The dilemma statement was a starting point for developing the vision for the wetland system (i.e. what did we want to achieve in the future). At a workshop in July 2018, the Collaboration group worked together to finalise the vision statement.

It will be important to maintain relationships with all stakeholders (e.g. traditional owners, community members and local government) with an interest in implementing the operational plan and/or protecting key values of the plan area. The department will identify opportunities to develop partnerships with key stakeholders, such as undertaking joint projects. There may be opportunities for joint projects with the existing, committed organisations and community groups working in areas such as water quality monitoring, Aboriginal interests, catchment rehabilitation, species protection and education.

The community can have a significant contribution to wetland protection and management on public lands through participation in on-ground and wetland management planning activities. The department and stakeholders recognise the importance of community involvement in wetland management, which is often necessary for government to achieve successful, long-term implementation of management strategies and actions.

Various reserves of the plan area have active volunteer groups to assist in the on-ground management. These groups include: Friends of Captain Baudin Reserve, Friends of the

Busselton Wetlands, the Wonnerup Foreshore Reserve Friends and the Ludlow Tuart Forest Restoration Group. DBCA is committed to establishing and supporting a Vasse-Wonnerup wetlands Friends Group.

Information, interpretation and education

There has been an increasing interest from the community and organisations in the Vasse-Wonnerup wetlands; however knowledge of the wetlands has remained relatively low. Also, there has been a limited understanding of the full range of issues involved in management of the wetlands. To increase community awareness and understanding, quality information and educational material needs to be updated and developed. The need to interact with and inform the community is ongoing, particularly in the case of the Vasse-Wonnerup wetlands where the local community is rapidly growing with new residents seeking explanations and information about the wetlands.

The ongoing provision of consistent and accurate information to the community and visitors allows land managers to communicate the values of the plan area and to explain how to protect it. Information about the plan area will be provided through a range of media, including park signage, printed material, electronic media (e.g. the Revitalising Geographe Waterways website) and social networking. Information is also available from agency staff, the City, conservation groups and volunteers.

The Revitalising Geographe Waterways website[10] will continue to be the main portal for engaging with the community and communicating information related to the operational plan and the other projects of the Revitalising Geographe Waterways program.

2.5. Implementing the operational plan

VWWP will coordinate the implementation of the operational plan. Each of the management strategies/actions presented throughout the operational plan identifies the relevant lead and support agencies/organisations responsible for implementing that particular management strategy/action. These responsibilities may be reviewed during the term of the operational plan.

Reporting requirements

Progress towards achieving the objectives of this operational plan will be demonstrated by regular monitoring and evaluation to investigate the effectiveness of the management strategies/actions and to identify opportunities for improvement through ongoing research and monitoring. This ongoing review and revision of the strategies/actions, and research and monitoring are important to guide adaptive management of the plan area.

Regular reports and updates to the community will be provided through GeoCatch and/or through DBCA (consideration for an annual report card or similar to be prepared) and publicly available on the Revitalising Geographe Waterways website.

Term of the plan

The operational plan will guide management of the plan area for a period of 10 years from the date that the final operational plan is publicly released. During this 10-year period, the operational plan may be reviewed and updates to the operational plan may be made. If a significant update is necessary, relevant stakeholders will be notified of the proposed changes and invited to provide comment.

[10] The Revitalising Geographe Waterways website can be accessed at: rgw.dwer.wa.gov.au/

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
1. Seek to increase community awareness, understanding and stewardship of the key values and management issues of the wetland system.	1.1. Ongoing engagement through the Revitalising Geographe Waterways website. (**GeoCatch,** DBCA) 1.2. Prepare and install interpretative and other signage at appropriate sites around the plan area. (**DBCA, City**) 1.3. Prepare, and make available to the community, brochures/fact sheets on the key values and management issues of the wetland system. (**DBCA, City**, GeoCatch, SWCC, DWER) 1.4. Encourage opportunities for citizen science to enhance appreciation, knowledge and understanding of the wetlands. (**DBCA, GeoCatch**, SWCC) 1.5. Establish and support a Vasse-Wonnerup wetlands Friends Group. (**DBCA**, City, GeoCatch)
2. Develop and maintain partnerships and collaboration with and between key stakeholders.	2.1. Coordinate the support and commitment of key agency partners through the Vasse Wonnerup wetlands partnership to deliver management strategies/actions under the operational plan. (**VWWP**) 2.2. DBCA will continue membership and support of the Geographe Catchment Council. (**DBCA**) 2.3. Identify opportunities to develop partnerships with key stakeholders. (DBCA, SWCC, DWER, GeoCatch, DPIRD, City) 2.4. Continue to collaborate with the Science community. (**DBCA, DWER**, Science community)
3. Clarify roles and responsibilities of government agencies involved in the management of the Vasse-Wonnerup wetlands.	3.1. Implement the operating guidelines for surge barrier operations and sand bar openings (updated Surge Barrier Operating Guidelines, *in preparation*) — Appendix 2. (**WC**, VWWP) 3.2. Review, update and implement the *MOU for Implementation of Fish Kill Strategy and Response Plan* and thereafter undertake a 5-year review or as required. (**VWWP**) 3.3. Implement the *Fish Kill Mitigation and Response Plan* process (outlined in the *Fish Kill Mitigation and Response flowchart*) — Appendix 3. (**VWWP**) 3.4. Prepare the *Science and Monitoring Plan* (*in preparation*) — Appendix 5. (**DWER**, DBCA, SWCC, Science community)

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
4. To ensure integrated and adaptive management of the plan area.	4.1. Implement the relevant management actions in the *Swan Coastal Plan South management plan 2016* and the *Tuart Forest National Park management plan 2014*. (**DBCA**) 4.2. Support implementation of the complementary strategies and actions in relevant plans, including: • *Busselton Wetlands Conservation Strategy* (WAPC 2005); (**Key stakeholders**) • *Vasse Wonnerup Wetlands and Geographe Bay Water Quality Improvement Plan* (WQIP) (*in preparation*); (**DWER**, GeoCatch, key stakeholders) • *Geographe Catchment Management Strategy* (*in preparation*). (**GeoCatch**, key stakeholders) 4.3. Continue to cooperate with the members of the science community to ensure up-to-date science is shared and applied to the management of the plan area. (**DBCA**, **DWER**, SWCC, DPIRD, Science community) 4.4. Review and report on the management strategies/actions and provide regular updates to the community. (**VWWP**, GeoCatch)

3. Managing the natural environment

3.1. Climate, geology and landscape

Climate

The plan area is within the Busselton area, which experiences a dry Mediterranean climate comprised of mild, wet winters and hot, dry summers. The mean maximum temperature (1997-2017) recorded at the Busselton Aero weather station (No. 009603) ranges from 30.2°C in January and February to 16.7°C in July and the mean minimum temperature (1997-2017) ranges from 14.6°C in February to 6.7°C in July (BoM 2018). The mean annual rainfall (1997-2017) recorded is approximately 684mm (the majority falling between May and September), with the highest mean rainfall during this period in July (135.4mm) (BoM 2018).

Australian average rainfall has been increasing since the 1970s, mainly due to an increase in wet season rain in northern Australia (CSIRO & Bureau of Meteorology 2015). During the cooler months, rainfall has declined in the southwest of the continent (CSIRO & Bureau of Meteorology 2015). In southern Australia, cool season (winter and spring) rainfall is projected to decrease (high confidence) (CSIRO & Bureau of Meteorology 2015). The cool season rainfall decline is driven by the southward movement of winter storm systems (CSIRO & Bureau of Meteorology 2015). The winter decline may be as great as 50% in south-western Australia by 2090 under a pathway representing a future with little curbing of emissions, with a CO_2 concentration continuing to rapidly rise (CSIRO & Bureau of Meteorology 2015).

The rainfall decline in southern Australia has been linked to circulation changes in the southern hemisphere that are influenced by increasing greenhouse gases and reductions in stratospheric ozone (CSIRO & Bureau of Meteorology 2015). Increasing greenhouse gases have also contributed to Australian average surface air temperature rise of 0.9°C since 1910 (CSIRO & Bureau of Meteorology 2015).

Professor Hart (2013, p.10) states that *"Climate change in the region appears to be increasing the occurrence of high intensity summer rainfall. This summer rainfall, with an inflow of nutrient-rich runoff, often occurs before fish kill events…" "The predicted increase in intensity of summer rainfall events associated with climate change will also need to be factored into any hydraulic assessment prior to any possible modification of the system"* (Hart 2014, p.26).

Geology, landform and soils

The plan area is located within an extensive low lying coastal plain, the southern end of the Swan Coastal Plain – also referred to as the Busselton Plain (Webb *et al.* 2009). The Swan Coastal Plain is characterised by a generally subdued topography formed almost entirely of river (fluvial) and windblown (aeolian) depositional material and arranged in a sequence of four parallel main geomorphic units: Quindalup Dune System, Spearwood Dune System, Bassendean Dune System and Pinjarra Plain (WAPC 2005).

The then Department of Agriculture's *Busselton - Margaret River - Augusta land capability study* (Tille & Lantzke 1990) mapped 15 land systems on the basis of topography, geology, soils and vegetation in the region. There are two land systems and associated soil types within the plan area, as follows:

- Quindalup Coast land system (youngest dune system) - three Quindalup soil types:
  - Quindalup Flats – flats and low rises with deep pale calcareous sand;
  - Quindalup Wet Flats - poorly drained flats around the edge of the Vasse Estuary and consist of dark calcareous sands and marine deposits; and

  - Quindalup Very Wet Saline Flats – Vasse-Wonnerup wetlands, being low-lying depressions which are often underwater in winter and saline in summer.

- Ludlow Plain land system older and inland of the Quindalup Dune System - two Ludlow soil types (closely align with Spearwood soils):
  - Ludlow Flats – flats and very low dunes characterised by deep yellow brown siliceous sands over limestone (i.e. Spearwood sands);
  - Ludlow Wet Rocky Flats – flats with high winter watertables and shallow brown and yellow sands over limestone (i.e. shallow Spearwood sands).

The plan area comprises mostly flat, shallow, seasonally brackish wetlands and floodplains (fringing vegetation and rich alluvial flats) with upland vegetation (tall tuart woodland). This upland vegetation of tuart woodland is part of the largest and most southern remnant of tall tuart woodland, which is the only remaining contiguous example of the uplands, wetlands and rivers of the Ludlow Plain Land System of the Spearwood Dune System (Keighery & Keighery 2002).

Most of the Vasse-Wonnerup wetlands are at high risk from acid sulfate soils or potential acid sulfate soils (WRM 2007). The peat sub-soil horizons in the wetlands are naturally rich in organic material and iron oxides and are also frequently low in oxygen due to bacterial decomposition of the abundant organic material (WRM 2007). When inundated, sulfate in the sea water mixes with wetland sediments to produce large quantities of iron sulfide minerals (e.g. pyrite) and if contained in a waterlogged, undisturbed environment are known as potential acid sulfate soils (WRM 2007). If these sulfides are subsequently exposed to air, by either natural or anthropogenic disturbance, they oxidise to form sulfuric acid, resulting in acid sulfate soils (WRM 2007).

3.2. Wetland and catchment management

Hydrology

The catchment includes a number of poorly drained flats, wetlands and 14 predominant waterways, including the Carbunup, Buayanup, Vasse, Sabina, Abba, Ludlow and Capel river systems. The catchment is underlain by the superficial aquifer, which is approximately 10m thick. Below this, lies confined aquifers, the Leederville aquifer and underneath the older and larger Yarragadee aquifer, which are recharged by direct infiltration of rainfall on the Blackwood Plateau. The Capel River is the only waterway that intersects the Leederville aquifer, which is the reason it is a perennial river system. All other waterways receive contributions only from the superficial aquifer and surface runoff.

European settlement has seen many changes to the catchment's hydrology, with the hydrological changes occurring from the 1880s until the 1950s. At the time of European settlement waterways flowed into an extensive chain of coastal wetlands and emptied into the Wonnerup or Vasse estuaries. The Wonnerup Estuary received freshwater via direct inflow from the Ludlow and Capel rivers. In the 1860s, the Capel River was diverted directly into Geographe Bay via Higgins Cut (WAPC 2005). The Ludlow River, although redirected and a bund constructed, still flows into the Wonnerup Estuary with Swan Lake forming on the eastern side of the bund.

The Vasse Estuary received direct flows from the Abba, Sabina and Vasse rivers; and indirect inflow from Iron Stone Gully, Buayanyup and Carbunup rivers and other creeks to the west, which discharged into the Broadwater-New River wetland system and then into the Vasse River and the Vasse Estuary (Hart 2014). In 1915 a cut was made to drain water from New River to Geographe Bay (WAPC 2005; WRM 2007).

Professor Hart (2014, p.13) states that *"during the 1920s extensive drainage networks were put in place throughout the catchment, increasing the river inflow to the system and resulting in more frequent flooding of low-lying coastal properties (including the Busselton townsite). In 1927 the Vasse Diversion drain was constructed to divert the upper Sabina River and most of the Vasse River to Geographe Bay. Approximately 60% of flow from the Sabina River and 90% of flow from the Vasse River is diverted to the Vasse Diversion Drain, which has cut off the Broadwater-New River wetland system from the Vasse-Wonnerup. The VW wetlands now receive around 20% of the pre-European freshwater inflows."*

Surge barriers

Two sets of timber surge barriers were constructed in 1908, replaced in 1929 and rebuilt with concrete and steel in 2004 in the exit channels that connect the Vasse and Wonnerup estuaries to the Wonnerup Inlet (Figure 3) (WAPC 2005; WRM 2007). The rebuilt surge barriers include a fish gate and propped gate to allow fish to move between the estuaries and the Wonnerup Inlet and to allow exchange of water between the two systems. The surge barriers are automatic one-way flow structures (i.e. when water levels are lower in Wonnerup Inlet, the surge barriers automatically open and water flows out from the estuary into Wonnerup Inlet).

The primary function of the surge barriers is to regulate water levels, exclude sea water and minimise flooding of the adjoining lands and Busselton township (Lane *et al.* 2011). The surge barriers maintain fresh–brackish water within the Vasse-Wonnerup wetlands for a longer period than would have occurred under 'natural' conditions. These barriers prevent flooding of the surrounding agricultural land during high river flows in winter and sea water inundation caused by storm surges (Lane *et al*. 1997). They have also enabled the Busselton townsite to expand into land that was previously inundated during winter. The barriers effectively transformed the estuaries into shallow, winter-fresh/summer-hypersaline lagoons, which is unique in WA. Large areas of the estuaries dry out during summer, though some water remains and provides important summer refuge habitat for thousands of waterbirds.

A natural sand bar across the mouth of the Wonnerup Inlet closes the estuaries to Geographe Bay for much of the year. The sand bar (and the surge barriers) is managed by the Water Corporation with support from VWWP.

Figure 3: Location of surge barriers (Reprinted with permission from DWER)

Managing water levels

Water Corporation manages the catchment's drainage network (known as the Busselton Drainage District) to protect the City from storm surges and flooding. As part of these obligations Water Corporation, with input from VWWP, manages the Vasse and Wonnerup surge barriers according to operating guidelines developed in 1990 (see **Appendix 2**). The 1990 operating guidelines specify water levels in the estuary that trigger management actions of opening the Wonnerup Inlet bar (to avoid flooding), installing check boards at the end of winter (to hold water back within the estuaries over spring) and to reduce the risk of fish kills (minimum water levels). During 2015-2018, interim operating guidelines have been adopted as part of the Vasse Estuary sea water inflow trial.

The 1990 operating guidelines are currently under review with new information being obtained from the Vasse Estuary sea water inflow trial, hydrodynamic modelling and research programs, and input from consultation with surrounding landholders, key stakeholders and the broader community. These updated operating principles will be applicable to the operations of the Vasse and Wonnerup surge barriers.

The updated surge barrier operating guidelines will aim to achieve a water-level regime necessary to improve summer water quality, reduce the risk of fish kills whilst maintaining the Ramsar values and the ecological processes of the wetlands, and to also support key life stages for focal species[11]and keystone species[12]. These include focal species such as black swans and international migratory shorebird (or 'waders') species, and keystone species such as samphire communities and macrophyte communities (see section **3.3. Biological environment).** Any water regime for the Vasse-Wonnerup wetlands is to also consider the receiving body, the Geographe Bay, which has one of the largest seagrass meadows on the WA coast.

It is important that any adopted water regime (water inputs and drying) ensures the long-term viability of existing aquatic macrophytes, including seagrasses. Macrophytes are important to the system as they are an important food source for many birds and invertebrates, and provide a variety of ecosystem services such as oxygenating the water, recycling nutrients and trapping and stabilising sediments. Changes in the water regime and water quality may result in a change of the aquatic macrophyte community.

Monitoring is important to support management decisions concerning surge barrier operation and to support ongoing research. It is important that the water levels be monitored continuously with real-time data availability. Water levels are continuously monitored by Water Corporation at the surge barriers, with the automatic water level loggers installed in 2004, and by DBCA within the wetland system.

Sand bar

The Vasse-Wonnerup wetlands connect to the Geographe Bay via the mouth of Wonnerup Inlet. This mouth may be partially or fully closed by the formation of a sand bar (or infrequently by a seaweed barrier) at any time of the year, depending upon winds, wave action, currents, astronomic and barometric tides, local sea level and river flows.

[11] *"Focal species are organisms used in planning and managing nature reserves because their requirements for survival represent factors important to maintaining ecological healthy conditions"* (Miller *et al.* 1998, p82) of a particular site.

[12] *"Keystone species enrich ecosystem function in a unique and significant manner through their activities…Their removal initiates changes in ecosystem structure and often a loss of diversity"* (Miller *et al.* 1998, p82).

The state of the mouth (closed, partially closed or open) is important in terms of: water quality in the Wonnerup Inlet and the Deadwater; fish movement between Vasse-Wonnerup wetlands and Geographe Bay; water level management in the Vasse-Wonnerup wetlands; and flood levels on surrounding lands.

If the mouth closes during periods of river flow (usually in winter or early spring) to a sand bar height greater than 0.7 metres above average sea level (i.e. +0.7m AHD) then flooding of adjoining land, including private land, may result. In this circumstance a channel may be excavated through the sand bar to drop water levels in Wonnerup Inlet allowing the surge barriers to open, to prevent or alleviate flooding of adjacent properties and roads.

If the mouth closes during late summer or autumn, then this will prevent maintenance of a minimum level of water in the Vasse Estuary (i.e. minimum level of -0.1m AHD) and the Wonnerup Estuary (i.e. minimum level of -0.4m AHD), and the water quality in the usually tidal Wonnerup Inlet and the Deadwater may deteriorate. In this circumstance the sand bar is opened and when required the smaller fish gates (part of the surge barrier structure) are opened to create two-way flow between the Vasse Estuary and Wonnerup Inlet to improve water quality and allow for fish movement.

Check structure

At the western end of the plan area is the check (or weir) structure at the Old Butter Factory (i.e. where the lower Vasse River flows through the lower Vasse River wetlands into the Vasse Estuary). The City manages the check structure, which includes installing check boards at the end of spring to retain water levels in the lower Vasse River. The lower Vasse River is ephemeral (i.e. only flows in winter months and after summer rains) with water levels artificially maintained over summer by manually installing the weir check boards, forming a still pool upstream of the check structure. The City is investigating options to replace or remove the old leaky check structure and boards, which was installed about 1933. Removing the check structure would return the lower Vasse River to a seasonally flowing river.

Swan Lake

At the eastern end of the plan area is Swan Lake (informal name). Swan Lake became a seasonal freshwater lake when an earth bund was constructed across Wonnerup Estuary to realign the Ludlow River. At the eastern end of the bund that separates Swan Lake from Wonnerup Estuary, there are three culverts with one-way flap valves (i.e. water flows from Swan Lake to Wonnerup Estuary) installed by the Water Corporation.

The flap valves are managed to ensure the lake's water levels benefit nesting activity by black swans (i.e. to operate the flap valves each winter-spring to retain water in the lake for a longer period to protect black swans from foxes during nesting activity). Historically, adjoining landowner Keith Forrest voluntarily operated the flap valves to benefit the black swans. Consequently, Swan Lake now supports the largest annually breeding black swan colony in WA of around 200 pairs. Since 2018, responsibility for operating the lake's flap valves was delegated to DBCA.

Swan Lake. Photo – Grace Patorniti/DBCA

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
1. To manage water levels to protect and support conservation values, especially waterbirds and their habitats, and to achieve flood protection for the Busselton area.	1.1. Implement the updated Surge Barrier Operating Guidelines (*in preparation*) to maintain the Ramsar values and ecological processes of the wetlands and to support key life stages for focal species. (**WC**, VWWP) 1.2. Identify and implement flood mitigation actions for the Busselton drainage area flood mitigation network. (**WC**, City) 1.3. Develop and implement operating guidelines for the flap valves controlling water levels in Swan Lake, to continue optimal conditions for breeding of swans. (**DBCA**, WC)
2. To monitor changes in hydrological regime (surface water and sea water intrusion) in the wetlands and catchment, to understand impacts on the wetlands.	2.1. Continue to monitor surface water flows on the rivers entering the wetlands. (**DWER**, DBCA, WC) 2.2. Continue to monitor water levels and investigate opportunities for the data to be publicly available online. (**WC**, DBCA)

Managing water quality

The Vasse-Wonnerup wetlands are nutrient-enriched and shallow, seasonally drying lagoons. Agricultural fertiliser losses and animal waste from the catchment and drainage from the Busselton townsite have contributed to high nutrient inputs to the Vasse-Wonnerup wetlands over the last 160 years (DoW 2010). Historically, cattle grazing had occurred on parts of the Vasse-Wonnerup wetlands and agricultural activity still occurs on adjacent lands, mostly within the floodplain area. Over the past few decades, substantial action has occurred to address these large catchment sources, including fertiliser management, dairy effluent upgrades, restoration of rivers and community awareness programs to reduce nutrient transport to the wetlands.

One of the water management goals is to continue to reduce the nutrients (in particular, total phosphorus and total nitrogen) within and entering the wetland system as higher nutrients favour phytoplankton and subsequently algal blooms.

The nutrient sources are mainly from surface water (i.e. through dairy milking sheds, cattle feedlots or fertiliser application), with nutrients from groundwater being negligible, as *"most nutrients delivered to the receiving water bodies* [including the Vasse-Wonnerup wetlands] *and the* [Geographe] *bay are from surface-water flows. However, there is likely to be a small portion of groundwater being discharged to the receiving water bodies (probably less than five per cent of the total nutrient load)…"* (DoW 2009, p.84).

The nutrient-enriched Vasse-Wonnerup wetland system experiences algal blooms from macroalgae (generally green algae such as *Cladophora* and *Rhizoclonium*) and microalgae (phytoplankton). Phytoplankton blooms are a regular occurrence in the Vasse Estuary exit channel where the phytoplankton growth consumes the available nutrients, peaks and then crashes (dies) when all the available nutrients are consumed. The decay of dead phytoplankton consumes oxygen from the water and can lead to hypoxic conditions (oxygen less than 2 mg/L). Hypoxic conditions can trigger the release of nutrients stored in the sediments and supplies the nutrients for the next cycle of phytoplankton growth.

DWER is preparing an updated Water Quality Improvement Plan (WQIP) for the Vasse-Wonnerup wetlands and Geographe Bay, which is due for completion in June 2019. The purpose of the WQIP is to guide management strategies to reduce the flow of nutrients to these important ecosystems. The WQIP brings together the best available scientific knowledge about the current water quality status of the Vasse-Wonnerup wetlands, Geographe Bay and the associated waterways for the purpose of nutrient management planning, such as identifying nutrient reduction targets for total phosphorus and total nitrogen entering the wetlands.

Sediments

Sediment characteristics have been found to be highly variable in the Vasse Wonnerup wetland system, influenced by variable inputs. Scientists from the University of Western Australia and DWER are investigating sedimentation accumulation rates and a source composition of organic matter is being investigated in a PhD thesis through Edith Cowan University (see section **6. Research and monitoring**).

In 2016 and 2017, a sediment investigation study for the Vasse Estuary exit channel was undertaken by scientists from DWER (i.e. *Sediment Investigations of the Vasse Estuary Exit Channel* report—*in preparation*). The study was initiated in response to concerns regarding the potential role of accumulated sediment as a contributing factor to poor water quality, unpleasant odour and mass fish kills within the Vasse Estuary exit channel. As part of the study, maps showing the depth and composition of nutrient-rich sediment in the Vasse

Estuary exit channel were produced with the deepest levels identified at Estuary View Drive and the western side (upstream) of the Vasse surge barrier.

Sediment/sludge (organic rich, sulfidic black ooze) build-up at the Vasse surge barrier has increased considerably since the major upgrade of the surge barrier in 2004 and is a contributing factor to poor water quality conditions at the barrier. Sediment build-up contributes to toxic algal blooms and the release of hydrogen sulphide gas, which greatly impacts on the visual amenity and produces unpleasant odours at the barrier. It is when the upper surface of the sludge is exposed during the annual minimum water levels (i.e. during late summer–autumn) that the strong odour is produced. In June 2017, Water Corporation commissioned the removal of a small volume (< 300m^3) of sediment from in front of the surge barrier to improve visual amenity and reduce odours. A suction pump mounted on a floating pontoon was used to pump sediment slurry into tankers for transport to the Busselton Wastewater Treatment plant. This sludge was last removed in 2004 when the surge barrier was upgraded and it is estimated that sludge removal may be required every 5-10 years.

Removal of accumulated organic material (i.e. floating macroalgae and macrophytes) at the gates is essential to prevent detrimental sediment conditions behind the surge barrier from developing faster than every 5-10 years. Continued monitoring of water quality, sediment accumulation, and community perceptions of odour in the Vasse Estuary exit channel are recommended so that management may be adjusted as these aspects change over time. In addition it is recommended that the existing water quality monitoring program is extended to Estuary View Drive where sulfidic black ooze has accumulated and causes unpleasant odours for nearby residents, and to investigate alternative options to reduce those odours.

Oxygenation trial

The Vasse Estuary is the most nutrient-enriched estuary in the South West of WA and periodically displays the symptoms typical of a eutrophic system including; macro and micro algal blooms, foul odours, low visual amenity and fish deaths. These symptoms are particularly evident in the Vasse Estuary exit channel, the stretch of estuary directly upstream of the Vasse surge barrier.

A key water quality parameter contributing to these symptoms is dissolved oxygen. Resetting the balance between oxygen supply and consumption is a challenging task for estuaries with heavily modified catchments. While broad scale approaches such as the reduction of nutrient loading are underway, water resource managers may look to engineered means, such as artificial oxygenation, to assist in maintaining aerobic conditions.

In 2015 and 2016 a mobile oxygenation plant was commissioned for the Vasse Estuary to trial the use of an artificial oxygenation plant upstream of the surge barrier. The goal of the plant was to maintain dissolved oxygen at concentrations above that which limit ecological function (defined as 4mg/L) and assess the ability of the plant to reduce the likelihood of fish kills. The land-based plant was operated in summer-autumn to remediate dissolved oxygen levels, to create aerobic conditions and minimise release of nutrients. The process works when the liquid oxygen stored in the plant is converted to gaseous oxygen, which is connected via a cable to two submersible pumps (oxygenators) in the estuary. Low oxygen water from the estuary is drawn into the pumps where gaseous oxygen is added to the water. The oxygen-rich water is then pumped back into the estuary.

Two years of trialling the oxygenation plant showed that regular use of the technology could contribute to long-term improved water quality; however, further investigation is required to determine the long-term effectiveness and cost of an oxygenation plant for the Vasse Estuary exit channel.

Fish kill events

In 1997, VETWG (a collaborative interagency group with representatives from State and Local Government, water service providers and catchment groups) was established after a major fish kill to reduce the severity and frequency of major fish kills in the Vasse Estuary. A report with recommendations prepared by VETWG in 1997 (Lane *et al.* 1997) established that there is a long history of mass fish deaths in the lower reaches of the Vasse and Wonnerup estuaries. Instances of fish kills are reported between 1905 and 1960 and "*in 1960, the entire Vasse-Wonnerup Estuary was opened up to net fishing in order to reduce the number of fish that might otherwise die in summer…Whilst net fishing does not prevent fish kills from occurring, it has certainly reduced the number of fish that have died mass death incidents*" (Elscot 2000, p.10). Since 1960, mass fish deaths have occurred in 1966, 1988, 1989 and 1997 in the Vasse Estuary exit channel or the Wonnerup Inlet and once in the Deadwater (Elscot 2000).

The report (Lane *et al.* 1997) suggests that the principal cause of summer (mostly February) mass fish deaths is temporary declines in dissolved oxygen concentrations due to night-time respiration by algal blooms, decay of algal blooms (and toxic product from decaying seaweed) and high water temperatures[13]. Measures used in the past to reduce the frequency and severity of fish kills have been the artificial opening of the sand bar; increased harvesting of fish by netting; and partial opening of the Vasse estuary floodgates to allow fish to escape and to raise water levels (Lane *et al.* 1997).

Between 1997 and 2013, only a small number of smaller fish kills occurred, with the exception of a mass fish kill in 2000 at the Vasse floodgates. This event was well-documented by Elscot (2000) due to an extensive monitoring program for the Vasse-Wonnerup wetland system in place at the time. In 2013, a major fish kill occurred in the Vasse Estuary and Wonnerup Inlet. The fish kill was a concern for the local community and as a result VETWG reviewed their operations and developed the *Fish Kill Mitigation and Response Plan* (the Mitigation Plan), adopting the Australian Inter-service Incident Management System (AIIMS) emergency response protocols. In 2014, a *MOU for the implementation of the Fish Kill Mitigation Strategy and Response Plan for the Vasse Wonnerup Wetlands* was signed.

The Mitigation Plan outlines the process to be undertaken by the five agencies involved in VETWG (renamed as the Vasse Wonnerup wetlands partnership in 2016) in the event of a fish kill. The Mitigation Plan includes a trigger and response flowchart with triggers based on water quality monitoring data and observations. Water quality monitoring is undertaken over the high risk fish kill period (November to April) by DWER. Two telemetered buoys in the Vasse Estuary exit channel provide continuous 'real-time' data that support the trigger and response framework. If a trigger to take preventative action occurs, then the *Fish Kill Mitigation and Response flowchart* identifies the appropriate level of response to be followed (see **Appendix 3**). The Mitigation Plan, which includes the flowchart, has been annually reviewed and implemented since the 2013/14 summer and this shall continue.

The most recent fish kill occurred in March 2017, where 3,000-5,000 introduced juvenile goldfish were killed as a result of rapid changes in salinity resulting from the surge barrier operations undertaken to maintain the water level at -0.1m and to manage a high risk algal

[13] General information on factors that contribute to fill kill events is available on the Department of Water and Environmental Regulation website: water.wa.gov.au/water-topics/waterways/threats-to-our-waterways/fish-kill-events

bloom. The most recent significant (>1,000 fish) fish kill of native fish occurred in February 2014 in the Vasse Estuary exit channel due to a toxic algal bloom and poor water quality.

Members of the public may report any sightings of a fish kill through the FishWatch hotline 1800 815 507 (24-hour service) or the nearest DPIRD's Fisheries office.

Stormwater management

The Vasse-Wonnerup wetland system is subject to pressures from the adjacent road network (e.g. Layman Road and Causeway Road) and the surrounding urban and agricultural activities. These pressures include potential pollution incidents (spillages) on the roadways and poor water quality from stormwater drains entering the wetland system.

Transport-related surfaces including roads represent a significant contributor of suspended solids, trace metals, polycyclic aromatic hydrocarbons and nutrients (DoW 2004–2007); therefore it is important to have a pollution preparedness plan. Stormwater runoff from urban areas is a source of nutrients into local waterbodies and future urban expansion will result in increasing nutrient run-off. It will be important to improve urban stormwater management through measures such as upgrading drains where necessary and undertaking routine drain maintenance. Urban planners and developers can assist by ensuring all new and infill urban developments apply water sensitive urban design principles.

GeoCatch, in partnership with DWER, the City and the Shire of Capel have been working on water quality projects across the catchment, such as the Water Sensitive Urban Design and the Urban Stormwater Treatment projects. These projects aim to deliver best practice urban water management to improve stormwater quality entering local waterways, wetlands and Geographe Bay.

Infill sewerage

In 2016, Water Corporation completed an infill sewerage project for the West Busselton area (i.e. Abbey and Broadwater). It is important to ensure septic tanks are disused and wastewater is directed to a treatment plant for processing and disposal. Septic tanks contribute to the phosphorus and nitrogen loads in the catchment and the removal of these nutrient loads would have an immediate and long-term positive effect.

Management objectives	Management strategies/actions (**Lead agency** [**in bold]** and support agency [not in bold])
1. To improve water quality within and entering the wetland system, to maintain and enhance conservation and social values.	1.1. Continue to monitor the nutrient load flowing into the Vasse-Wonnerup wetlands. (**DWER**, GeoCatch) 1.2. Investigate and establish environmental targets related to water quality regimes necessary to maintain the Ramsar values and ecological processes. (**DBCA**, DWER, Science community) 1.3. Implement the Vasse Wonnerup Wetlands and Geographe Bay WQIP (*in preparation*). (**DWER**, GeoCatch, key stakeholders) 1.4. Implement the Geographe Catchment Management Strategy (*in preparation*). (**GeoCatch**, key stakeholders) 1.5. Implement best management practices for drain management in urban and industrial areas, and to encourage the upgrade of drains where necessary and undertake ongoing drain maintenance. (**City**, **WC**, GeoCatch)

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
	1.6. Ensure a pollution preparedness plan is in place to manage pollution incidents (response and clean up) to minimise downstream impacts to the Vasse-Wonnerup wetland system. (**City**, DFES, DWER)
2. Manage salinities and salt load within the wetland system to maintain and enhance conservation values and avoid impact on adjoining lands.	2.1. Implement the updated Surge Barrier Operating Guidelines. (**WC**, VWWP) 2.2. Investigate the implications of accumulating salt loads and the extent of saline water in the wetlands system on the conservation values of the Vasse-Wonnerup wetlands and on adjoining lands. (**DBCA**, DWER)
3. Reduce the frequency and severity of toxic algal blooms and mass fish kills.	3.1. Implement recommendations of the *Sediment Investigations of the Vasse Estuary Exit Channel* report (*in preparation*) for the Vasse Estuary exit channel and identify funding opportunities for any associated costs. (**DWER**, DBCA, WC, City) 3.2. Continue to support the requirement for an Oxygenation Plant for the Vasse Estuary exit channel to reduce the risk of fish kills. (**VWWP**) 3.3. Implement the updated Surge Barrier Operating Guidelines. (**WC**, VWWP) 3.4. Annually review and implement the *Fish Kill Mitigation and Response Plan* process (outlined in the *Fish Kill Mitigation and Response flowchart*) — Appendix 3. (**VWWP**) 3.5. Continue monitoring water quality in the Vasse Estuary exit channel. (**DWER**, WC) 3.6. Remove accumulations of organic material (e.g. floating seagrass) from upstream of the surge barriers. (**WC**)
4. Reduce nutrient inputs at a local and catchment scale.	4.1. Undertake regular workshops and activities, which promote nutrient reduction, for the community and rural landowners. (**GeoCatch**, SWCC) 4.2. Implement the *Vasse Wonnerup Wetlands and Geographe Bay WQIP* (*in preparation*). (**DWER**, GeoCatch, key stakeholders) 4.3. Implement the *Geographe Catchment Management Strategy* (*in preparation*). (**GeoCatch**, key stakeholders)

3.3. Biological environment

For information on vegetation types, flora and fauna of the Wonnerup coastal reserves refer to the *Wonnerup Coastal Reserves Management Plan* (City of Busselton 2016a).

The Vasse-Wonnerup wetland system has high biodiversity and ecological values, despite the high levels of nutrients entering the system (Chambers *et al.* 2011, 2012 and Tweedley *et al.* 2012, 2013, as cited in Hart 2014).

Native plants and plant communities

The plan area is part of the South-West Australia biogeographic region, Australia's only internationally recognised biodiversity hotspot and one of 35 in the world; and part of the Busselton-Augusta hotspot, one of 15 of Australia's national biodiversity hotspots (DEE 2018; Conservation International 2018).

The vegetation of the Vasse-Wonnerup wetlands is described as:

- in the more shallow open waters: low samphire (*Sarcocornia quinquenervia, Tecticornia pergranulata* and *Suaeda australis*) and on the fringes taller mixed samphire (*T. halocnemoides*, *T. indica* and *T. syncarpa*), sea rush (*Juncus kraussii*) and sedges (*Lepidosperma leptostachyum*) and weed species e.g. divided sedge (*Carex divisa*) (WRM 2007; Webb *et al.* 2009);
- upslope from the samphire: areas of remnant paperbark (*Melaleuca rhaphiophylla, M. viminea* and *M. cuticularis*) woodlands with an understorey of mainly coast saw sedge (*Gahnia trifida*), bare twig rush (*Baumea juncea)* and pale rush (*Juncus pallidus*); and
- at higher elevation and along tributary rivers: eucalypt (*Eucalyptus rudis*) and peppermint (*Agonis flexuosa*) (WRM 2007; Webb *et al.* 2009).

The broad vegetation communities (identified by the dominant plant species) of the Vasse-Wonnerup wetland system are shown at Map 2.

The majority of the dunes between the Vasse-Wonnerup wetlands and Geographe Bay have been cleared or parkland cleared and are dominated by peppermints with an understorey of mainly couch grass (*Cynodon dactylon*) and weed species (WRM 2007; Webb *et al.* 2009). The dune extent between Captain Baudin Reserve and the Deadwater are relatively intact and characterized by peppermint over an understorey including *Spyridium globulosum*, *Hibbertia cuneiformis*, *Leucopogon parviflorus*, *Acacia littorea*, *A.cochlearis* and *Alyxia buxifolia* with the sedge *Lepidosperma gladiatum* and the native grass *Austrostipa flavescens* (WRM 2007; Webb *et al.* 2009). Annual weeds are widespread and coastal weeds dominate the foredune.

At the lower Vasse River wetlands' marsh areas and areas around Vasse Estuary, tall samphire that is seasonally covered by dense marsh club rush (*Bolboschoenus caldwellii*) occurs extensively (DEC 2009).

The vegetation of Tuart Forest National Park within the plan area consists of mature tall tuart woodland, with the area adjacent to the Vasse-Wonnerup wetlands comprising riparian habitat that includes occurrences of the Busselton yate ecological community (DPaW 2014) (see section **Ecological communities** under **3.3. Biological environment**).

Plants of conservation significance

The plant species of conservation significance that have been recorded within the plan area (NatureMap, data extracted 12 July 2018) are listed in Table 2.

Table 2: Plants of conservation significance

Common name (Scientific name)	Conservation status – State[14]
None recorded (*Puccinellia vassica*)	Priority one[15]
None recorded *(Cardamine paucijuga*)	Priority two
None recorded *(Lasiopetalum membranaceum)*	Priority three

Native animals and habitats

Animals of conservation significance

The animal species of conservation significance (apart from migratory birds) that have been recorded within the plan area (NatureMap, data extracted 12 July 2018) or are known within the plan area are listed in Table 3. A full list of migratory shorebirds (also known as 'waders') that have been recorded on the Vasse-Wonnerup wetlands and are listed under international conservation agreements is provided at Appendix 4.

Table 3: Animals of conservation significance (list of migratory shorebirds is provided at Appendix 4).

Common name (Scientific name)	Conservation status – State[16] (Commonwealth EPBC Act)
western ringtail possum or *Ngwayir* (*Pseudocheirus occidentalis*)	Critically endangered (Critically endangered)
Carnaby's cockatoo (*Calyptorhynchus latirostris*)	Endangered (Endangered)
Australian painted snipe (*Rostratula australis*)	Endangered (Endangered and marine)
forest red-tailed black cockatoo or *Karrak* (*Calyptorhynchus banksii* subsp. *naso*)	Vulnerable (Vulnerable)
Carter's freshwater mussel (*Westralunio carteri*),	Vulnerable (Vulnerable)
blue-billed duck (*Oxyura australis*)	Priority four
southwestern brown bandicoot or *Quenda* (*Isoodon obesulus fusciventer*)	Priority four
water-rat or *Rakali* (*Hydromys chrysogaster*)	Priority four
peregrine falcon (*Falco peregrinus*)	Other specially protected fauna

The western ringtail possum (*Pseudocheirus occidentalis*) had its conservation status upgraded from 'threatened' species to 'endangered' in 2014 and then in 2017 upgraded from 'endangered' to 'critically endangered' under the Wildlife Conservation Act. It is also listed as 'critically endangered' under the EPBC Act. The plan area comprises critical habitat for this species.

[14] Conservation codes explained and priority flora listed in the Threatened and Priority Flora List (dated 16 January 2018), which is available at: dbca.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-plants

[15] *P. vassica* is endemic to the outer edges of marine saltmarsh in the Leschenault Inlet (Bunbury) and was previously known in the Vasse-Wonnerup saltmarsh (Busselton), but is now extinct due to the reduced marine influence in the estuaries (Williams 2007).

[16] Threatened species as listed under the Wildlife Conservation (Specially Protected Fauna) Notice 2018 (dated 11 September 2018); and conservation codes explained and priority fauna listed in the Threatened and Priority Fauna List (last updated 11 September 2018). Available at: dbca.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-animals?view=categories&id=109. As of the 1 January 2019 the Specially Protected Fauna Notice published under the *Wildlife Conservation Act 1950* will transition to be the Threatened Fauna and Specially Protected Fauna listed under Part 2 of the *Biodiversity Conservation Act 2016*, until the next Notice is published.

The *Western Ringtail Possum National Recovery Plan* (DPaW 2017) identifies three key management zones in the south west of WA, including the Swan Coastal Plain management zone where the plan area is located. These management zones currently support or previously supported large populations of the western ringtail possum with the densest (up to 20 ringtail possums per hectare) determined in the Busselton peppermint stands.

Waterbirds including migratory shorebirds

The Busselton wetlands, which include the Vasse-Wonnerup wetland system, are one of 314 sites within Australia that have been identified as an IBA (Dutson *et al.* 2009) and a key biodiversity area (which is an extension of Birdlife Australia's IBA concept). This site is of international importance for bird conservation for resident waterbirds and migratory shorebirds (or 'waders'), and meets the Global IBA Criteria developed by Birdlife International (BirdLife International 2018; Dutson *et al*. 2009). The wetlands are also one of the most important waterbird habitats in Western Australia.

Bird monitoring has been occurring for many years at wetlands on the Swan Coastal Plain[17] (refer to Jaensch 1986, Storey *et al.* 1993, Lane *et al*. 2007). More than 33,000 waterbirds were counted in January 1986 and waterbird data indicates that more than 20,000 waterbirds use the Vasse-Wonnerup wetlands each year. In the 1998 to 2000 survey over 37,000 waterbirds from 68 species were found to use the wetlands (Lane 2009).

Banded stilt (Australian resident waterbird). Photo - Kim Williams/DBCA

The Vasse-Wonnerup wetland system regularly supports between 25,000 and 35,000 waterbirds annually, including 40 species that have priority conservation status at a state, national or international level (WRM 2007). The waterbird numbers are highly seasonal with the annual peak of about 35,000 historically occurring during December-February, due to the arrival of migratory shorebirds and ducks species from inland areas as waterways dry.

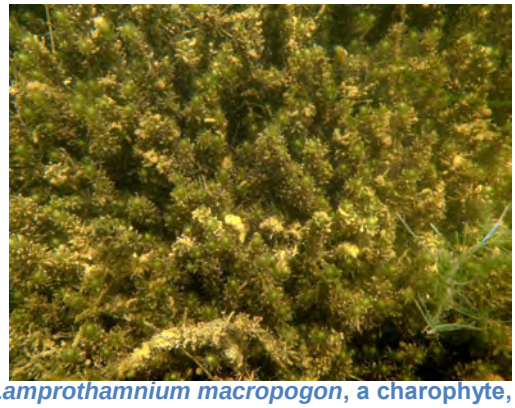
There are over 8 million shorebirds from 54 species that undertake annual migrations, travelling up to 25,000kms a year across the East Asian-Australasian Flyway (covers 23 countries including Australia, Japan China, Russia, and South Korea), which is one of the major flyways for migratory shorebirds and is one of the nine flyways recognised worldwide (WRM 2007; Bamford *et al.* 2008). A review of data for populations of these 54 species by Bamford *et al.* (2008) provided population estimates for 34 species, with population estimates later revised due to ongoing decline of many these species in Australia (Hansen *et al.* 2016) including at the Vasse-Wonnerup wetlands.

[17] An information sheet, *A list of waterbirds of the Vasse Wonnerup wetlands* (Lane 1997a), is available on GeoCatch's website: geocatch.asn.au/resource/list-waterbirds-vasse-wonnerup-wetlands/

The international migratory shorebird seasonal movement is typically the breeding period of May-August in the northern hemisphere including China and Siberia; then the southward migration for the non-breeding period of December-February in the southern hemisphere including south-east Asia, Australia (e.g. Vasse-Wonnerup wetlands) and New Zealand; and then the northward migration to complete the annual cycle (Lane 1990; WRM 2007; Bamford *et al.* 2008). Twenty-two species of these migratory shorebirds have been recorded at the Vasse-Wonnerup wetlands including: wood sandpiper (*Tringa glareola*), sharp-tailed sandpiper (*Calidris acuminata*), long-toed stint (*C. subminuta*), curlew sandpiper (*C. ferruginea*) and greenshank (*Tringa nebularia*) (Lane 1990; WRM 2007; Bamford *et al.* 2008).

"The diversity and abundance of waterbirds on which the Ramsar nomination for the VW wetlands is based, is dependent on phytoplankton, macroalgal and macrophyte (charophytes and aquatic angiosperms) communities. As such it is crucial that the quality of this food source be maintained if waterbirds are to be conserved on the wetlands" (Chambers *et al.* 2011, as cited in Hart 2014, p.15).

***Althenia cylindrocarpa*, a seagrass, in the Vasse Estuary. Photo – Jane Chambers/Murdoch University.**



***Lamprothamnium macropogon*, a charophyte, in the Wonnerup Estuary. Photo – Jane Chambers/Murdoch University.**

South West Catchments Council (SWCC)-led PhD research projects have been undertaken within the Vasse-Wonnerup wetland system, including understanding how waterbirds use the wetland system as part of their feeding habitat (SWCC 2018). This research investigated the food source for the waterbirds (creating a food web structure) with a focus on species for which the Ramsar nomination was awarded (i.e. black-winged stilt, red-neck avocet, Australian shelduck and Australasian shoveler). Little is known of how the wetland system functions ecologically and what food is crucial for sustaining wetland health for the birds and this research will enable the most important food sources of some waterbird species to be identified (see section **6. Research and monitoring**).

The lower Vasse River wetlands, which include unmanaged reserves, provide important habitat for waterbirds. During winter the lands are inundated, creating islands, which provide an ideal bird breeding area that is protected from predators such as foxes and cats.

Fish

Fish are an important component of the diet of some waterbirds. The Vasse-Wonnerup wetland system provides important habitat and nursery grounds for over thirty fish species, some of which are of commercial and recreational importance (Allen *et al.* 2013). In particular, the areas downstream of the surge barriers (i.e. the Deadwater and Wonnerup Inlet) provide a sheltered, food-rich environment for part or all of the life cycle of species such as mullet, mulloway and whiting, while also supporting substantial numbers of the highly-valued recreational species black bream (*Acanthopagrus butcheri*) (Allen *et al.* 2013).

In 2013, there was a significant fish kill event with the death of over 30,000 fish, mainly mullet and black bream (Tweedley *et al.* 2016). Black bream populations are particularly susceptible to fish kills as they undertake all of the life cycle within their natal estuarine environment therefore stocks cannot be replenished from the marine environment or from other estuaries (Tweedley *et al.* 2016). To investigate juvenile recruitment in the years following the fish kill, acoustic tracking of black bream and mullet was carried out by Murdoch University. Monitoring a year or two following the fish kill, showed very little of recruitment of black bream. Follow up monitoring in spring 2015 and summer 2016 in the Wonnerup Inlet and the Deadwater (the main breeding habitat for black bream) suggests that the recent poor recruitment was not due to a reduction in the number of sexually mature adult fish, but likely due to unfavourable environmental variables for the survival of the eggs and larvae (Tweedley *et al.* 2016). The report recommended continued monitoring to determine if the population is recovering and to explain factors related to the recruitment levels of black bream (Tweedley *et al.* 2016).

The Vasse-Wonnerup wetlands are also dominated by small-bodied fish species such as the hardyhead and goby (Allen *et al.* 2013). These species are found throughout estuaries in south-western Australia and are tolerant of the wide range of environmental conditions, particularity salinity, which occur throughout the year. Introduced freshwater fish species, mosquitofish (*Gambusia affinis*) and goldfish (*Carassius auratus*) have also been recorded in the wetlands (Allen *et al.* 2013).

Macroinvertebrates

Macroinvertebrates are organisms that are large (macro) enough to be seen with the naked eye and lack a backbone (invertebrate). Aquatic macroinvertebrates live all, or part, of their lives in the water and examples include dragonfly larvae, mosquito larvae, midge larvae, water fleas, snails and worms (DWER 2018).

Macroinvertebrates play an important role in freshwater and estuarine food webs (WRM 2007). They provide a food source for many waterbirds and fish, with a high biodiversity and abundance of aquatic benthic (bottom-dwelling) macroinvertebrates supporting large waterbird populations, and productive commercial and recreational fisheries (WRM 2007). They also contribute to nutrient recycling and the decomposition of organic matter (WRM 2007).

Low dissolved oxygen levels and toxins associated with algal blooms cause the death of invertebrates, particularly larger predatory macroinvertebrates (WRM 2007). Loss of these predators and subsequent changes in invertebrate functional feeding groups disrupts food chains and can lead to increases in nuisance species such as midges (WRM 2007). Decaying matter from algal blooms also provides an abundant food source for midge larvae and for amphipods (WRM 2007).

"Some of these [species] *are sensitive to pollution* [i.e. degraded conditions such as poor water quality] *whereas others can live in very polluted* [i.e. degraded] *waters. Because of this variability in sensitivity to pollution, macroinvertebrates make good biological indicators. By sampling macroinvertebrate communities and looking at both the types and numbers of animals present we can get an idea as to how healthy a waterway is"* (DWER 2018).

Macroinvertebrate sampling in the Vasse-Wonnerup wetlands is important to determine the density and diversity of the aquatic macroinvertebrate taxa within the wetlands. Macroinvertebrate surveys undertaken in February 2009/2010 and November 2009/2010 in the surface waters and sediments of the Vasse-Wonnerup wetlands found mostly taxa associated with nutrient enrichment. The dominant taxa (i.e. highest number of individuals) were Cyclopoida spp. (copepods – microcrustaceans), Oligochaeta spp. (dominant in the

sediments only) (segmented worms), *Ceinidae* sp. (amphipod), *Mytilocypris tasmanica chapmani* (ostrocod – seed shrimp), *Daphnia* spp. (water fleas), Calanoida spp. (copepods), Chironomidae spp. larvae (non-biting midge) and *Platicypris baueri* (ostracod) (Tweedley *et al.* 2011). Taxa that are typically present in reasonable densities in healthy waterways e.g. Chydoridae (water fleas), and larvae of Ephemeroptera (mayflies) and Odonata (dragonflies) were not found in the wetlands, and Trichoptera (caddisflies) was found in very low numbers (Tweedley *et al.* 2011).

Seasonal surveys of benthic macroinvertebrates undertaken from August 2012 to May 2013, as part of a sediment accumulation and resuspension study, in the Vasse-Wonnerup wetlands identified the dominant taxa to be mostly tolerant or very tolerant of degraded conditions (e.g. nutrient enrichment). These dominant taxa (i.e. highest number of individuals) were Nematoda spp. (roundworms), *Capitella capitata* (segmented worm) and Oligochaeta spp.; and other taxa tolerant of degradation included Chironomidae spp. larvae, *Mytilocypris tasmanica chapmani*, *Ceinidae* sp., *Perthidae* sp. (amphipod), and Culicidae spp. Larvae (mosquitoes) (Tweedley *et al.* 2013). The surveys found minimal diversity of taxa typically associated with less degradation; the taxa found include Calanoida spp. (copepods), *Daphnia* spp., *Potamopyrgus* sp. (freshwater snail) and Hydrophillidae sp. larvae (water scavenger beetle) (Tweedley *et al.* 2013).

There has been limited research of the characteristics of benthic macroinvertebrate communities within the Vasse-Wonnerup wetland system, but studies have revealed that characteristics change between seasons and sites (Tweedley *et al.* 2013; Tweedley and Cottingham 2017). Sampling in March 2017 of benthic macroinvertebrates within seven regions of the Vasse-Wonnerup wetland system (i.e. lower and upper Vasse-Wonnerup wetlands, Vasse Estuary exit channel, Wonnerup Inlet and the Deadwater) as part of an integrated ecological monitoring program[18] identified *a "marked difference in faunal composition in regions downstream (Wonnerup Inlet and the Deadwater) and upstream (Vasse and Wonnerup estuaries) of the surge barriers. Regions downstream of the surge barrier contained larger numbers of species and individuals and were in better ecological health (i.e. had higher taxonomic distinctness values) than those upstream of the barrier"* (Tweedley and Cottingham 2017, p.5). These preliminary findings are from the first of five seasons of data to be collected (Tweedley and Cottingham 2017) with the results from the integrated monitoring program due for release in 2019.

Ecological communities

The Vasse-Wonnerup wetland system supports the 'Subtropical and Temperate Coastal Saltmarsh' ecological community, which is a priority ecological community[19] (listed as priority 3) in WA and under the EPBC Act it is a threatened ecological community (TEC) (listed as Vulnerable[20]). This ecological community occurs within a relatively narrow margin of the Australian coastline, spanning across six states (DSEWPaC 2013). The vegetation unit, samphire shrublands dominated by *Tecticornia* or *Sarcocornia* species corresponds with the coastal saltmarsh that occurs at the Vasse-Wonnerup wetland system (DSEWPaC 2013).

[18] The integrated monitoring program is the seasonal monitoring of water quality, aquatic plants, benthic macroinvertebrates, and fish and waterbird communities in different regions within the Vasse-Wonnerup wetland system over a year.

[19] A list of priority ecological communities in WA is available on the department's website: dbca.wa.gov.au/plants-and-animals/threatened-species-and-communities/wa-s-threatened-ecological-communities.

[20] The full description of, and the Conservation advice for, the 'Subtropical and Temperate Coastal Saltmarsh' ecological community is available on DEE's Species Profile and Threats Database: environment.gov.au/cgi-bin/sprat/public/publicshowcommunity.pl?id=118.

The samphire shrublands provide important nesting material for swans, roosting habitat for shorebirds and may offer nursery habitat for fish (WRM 2007).

Samphire shrublands. Photo - Kim Williams/DBCA

Much of the area where the coastal saltmarsh occurs was grazed by cattle and horses prior to reservation as nature reserve. Removal of this livestock is likely to have resulted in an increase in the abundance of introduced pasture grasses such as saltwater couch (*Paspalum vaginatum*). Other weeds invading the grazed coastal saltmarsh include puccinellia (*Puccinellia ciliata*) and divided sedge (*Carex divisa*) (DSEWPaC 2013). The level of threat these weed species might pose requires further assessment.

The 'Tuart (*Eucalyptus gomphocephala*) woodlands and forests of the Swan Coastal Plain', which includes the tuart woodlands of Tuart Forest National Park, are being considered for listing as a TEC under the EPBC Act.

The Busselton Yate ecological community, which is described as yate (*Eucalyptus cornuta*), peppermint (*Agonis flexuosa*) and *Eucalyptus decipiens* forest on deep yellow-brown siliceous sands over limestone, is a priority ecological community (listed as priority 1), but may meet the criteria to be listed as a TEC.

Rehabilitation

DBCA will continue to support and work with stakeholders (e.g. SWCC, the City and GeoCatch) to plan and implement rehabilitation projects within and adjacent to the plan area.

It is important to protect and establish appropriate riparian vegetation around the Vasse-Wonnerup wetland system and the lower Vasse River wetlands, principally as habitat for waterbirds and other fauna. Rehabilitation of riparian vegetation and other areas of native vegetation within and adjacent to the plan area will also facilitate the retention and restoration of ecological linkages.

Ecological corridors

An ecological linkage can act as stepping stones of habitat which facilitate the maintenance of ecological processes and the movement of organisms within, and across, a landscape. The identification of existing and potential ecological corridors will guide future rehabilitation and land acquisition to strengthen local and regional linkages.

The wetlands, rivers and associated riparian vegetation provide a contiguous ecological linkage on a local and regional scale. One such significant ecological linkage is the reserves of the Vasse-Wonnerup wetland system with the New River wetland system and Broadwater Reserve (Webb *et al*. 2009).

WAPC (2005) supports action to improve linkages and/or wildlife corridors between Tuart Forest National Park and Wonnerup Estuary with controlled and managed public access.

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
1. Maintain and enhance the conservation values of the wetland system.	1.1. Identify and manage keystone species in the plan area. (**DBCA**, Science community) 1.2. Create and maintain and/or enhance as required functioning habitats for keystone species. (**DBCA**) 1.3. Identify focal species and their habitats/zones and the threats that are impacting them. (**DBCA**, Science community) 1.4. Identify and manage the major threats to the ecological communities in the plan area. (**DBCA**)
2. Maintain and where possible enhance the viability of populations of threatened flora and fauna, and threatened ecological communities.	2.1. Periodically review existing threatened flora, fauna and ecological communities recovery plans and update accordingly. (**DBCA**) 2.2. Develop and implement recovery plans for threatened fauna and flora where possible. (**DBCA**) 2.3. Verify location and boundaries of threatened and priority ecological communities. Determine and implement high priority management actions in occurrences as required e.g. design and establish regular monitoring of condition and threats, map and control priority weeds, and determine and implement appropriate fire regimes. (**DBCA**)
3. Manage fringing vegetation composition, structure and condition to provide functional habitat.	3.1. Identify and prioritise areas within the plan area for rehabilitation; and rehabilitate these areas with local native species, subject to funding availability. (**DBCA**, **City**, GeoCatch, SWCC) 3.2. Monitor fringing vegetation for potential impacts from changes in the hydrological regime. (**DBCA**) 3.3. Educate and encourage landowners to retain and protect native vegetation on properties adjoining the plan area. (**DBCA**, **City**, GeoCatch)
4. To identify, protect and enhance remnant vegetation and ecological corridors within the plan area and within adjacent areas.	4.1. Prepare a map showing existing and potential ecological corridors (including watercourses, native vegetation and bird flight paths) to guide future rehabilitation and land acquisition. (**DBCA**, SWCC, City) 4.2. Protect and enhance ecological corridors identified under Management Action No. 4.1 through land planning and other processes. (**DBCA, City**, DPLH) 4.3. Encourage the retention and protection of native vegetation on properties adjoining the plan area through land planning and other processes. (**DBCA, City**, DPLH)

3.4. Threatening processes

For information on the management issues for the Wonnerup coastal reserves refer to the *Wonnerup Coastal Reserves Management Plan* (City of Busselton 2016a).

Weeds

The priority weeds for the wetland areas are kikuyu grass (*Pennisetum clandestinum*) and divided sedge *(Carex divisa)*, with arum lily (*Zantedeschia aethiopica*) being prolific within Tuart Forest National Park and along the lower Abba and Sabina rivers. There are also areas of bulrush *(Typha orientalis)*, which if left unmanaged has the potential to rapidly colonise large areas of the Vasse Estuary resulting in loss of native plant species and loss of fauna habitat.

Preventing the introduction and spread of weeds is a more cost-effective option then weed control. Where weed species are detected in the plan area, the control of small manageable outbreaks is a priority.

There is currently minimum impact from the Mexican waterlily (*Nymphaea mexicana*) within the Vasse-Wonnerup wetlands, even though as described in Ottelia Ecology (2018) it covers a considerable area of the adjacent lower Vasse River. It is a highly invasive plant, therefore any existing and new infestations within the wetlands has a high priority for eradication. Within the lower Vasse River, the City proposes to prevent the further spread of Mexican waterlily through herbicide control and/or shading and to undertake strategic control of Mexican waterlily to progressively reclaim areas of open water, while minimising adverse impacts and preventing a return to algal blooms in the area as recommended by Ottelia Ecology (2018).

To coordinate weed management on a regional scale there is a regular meeting of the Regional Weed Network, which consists of representatives from DBCA, Nature Conservation Margaret River Region, Yallingup land conservation district committee, Lower Blackwood land conservation district committee, City of Busselton and Augusta-Margaret River Shire.

There also has been consideration to form a Recognised Biosecurity Group[21] for conservation areas and surrounding lands in the greater area (e.g. Margaret River and Busselton). A Recognised Biosecurity Group is a mechanism to enable landholders, community groups and agencies to work cooperatively, with support from DPIRD, to manage and control declared pests (plants and animal) under the *Biosecurity and Agriculture Management Act 2007*.

Introduced and other problem animals

The introduced red fox (*Vulpes vulpes*) is frequently observed on and near the Vasse-Wonnerup wetlands. Foxes are known predators of waterbirds, their eggs and young and possibly other wetland fauna. In the past, the department has implemented measures to reduce their numbers by baiting with poisonous ‘1080’ baits (sodium monofluoroacetate). As foxes continue to reinvade the Vasse-Wonnerup wetlands it is necessary for control measures to be ongoing in order to have lasting effect.

A predator-proof fence was previously proposed along the Layman Road reserve/Vasse Estuary boundary, to limit fox access to the estuary and to facilitate fox baiting within the

[21] Additional information on Recognised Biosecurity Groups is available on the DPIRD’s (Agriculture and Food Division) website: agric.wa.gov.au/bam/recognised-biosecurity-groups

Vasse Estuary area, which is close to residential areas. The funding for this project was associated with the development of the Port Geographe area and due to changes in ownership and governance relating to the development, the fence is no longer planned or funded.

Tuart Forest National Park is currently baited on a monthly basis for foxes as part of the department's Western Shield animal conservation program[22]. Expansion of the fox baiting program around the margin of the wetland system particularly during waterbird breeding season is desirable.

Rabbits are controlled with baiting, which is targeted at rehabilitation sites. Besides baiting, fences with rabbit-proof fence netting are usually installed to protect rehabilitation sites from rabbits as well as kangaroos.

A future Recognised Biosecurity Group for the region, including the plan area, will enable landholders, community groups and agencies to develop a coordinated approach to manage and control declared pests such as foxes, feral cats and rabbits.

Disease

The plant diseases known in the plan area are dieback disease caused by *Phytophthora* species and canker disease, which is usually caused by fungi (*Quambalaria coyrecup*) and is impacting marri trees (*Corymbia calophylla*) (Centre of Excellence for Climate Change Woodland & Forest Health 2013).

Myrtle rust (a fungus) is a potential threat to the plan area. To date, the fungus has not been detected in WA. There is one myrtle rust monitoring site within the plan area (i.e. section of Tuart Forest National Park) that is monitored quarterly.

Fire

DBCA is responsible for the prevention and preparedness aspects of fire management on lands managed under the CALM Act, and on UCL and unmanaged reserves that are outside of the Busselton townsite.

There is currently little prescribed burning undertaken around the wetlands. This area around the wetlands is considered to be a low fire risk area as a majority of the vegetation type is samphire, which is not considered to be bushfire prone vegetation. There is the occasional small human-caused fire. The operational focus is to maintain firebreaks for management and emergency access.

The application of standard firebreak requirements on lands not managed by DBCA may not be appropriate. In areas adjacent to the wetlands, changes to firebreak specifications to protect conservation values will require consultation with the City's bushfire officer to approve any proposed variation.

Other management issues

The plan area is subject to disturbance activities such as illegal dumping of car bodies; rubbish dumping of domestic, industrial and garden waste; illegal hunting; unauthorised off-road vehicle access and theft of management materials.

[22] Additional information on the Western Shield animal recovery program is available on the Parks and Wildlife website: dbca.wa.gov.au/management/pests-diseases/westernshield

There is an existing sand extraction operation in the Ludlow area, adjacent to the plan area and there is a proposal to extend the area of activity. The potential impact of the expansion on the adjacent wetland hydrology and in close proximity to the major swan breeding and roosting site is not known.

There is ongoing urban development on the north side of Layman Road, south of the Port Geographe Marina. It is expected that there will be increased pressure on the adjoining areas of the Vasse Estuary from domestic pets, increased noise and public recreational use. These all have the potential to disturb the feeding patterns and opportunities for migratory bird species to feed especially over the summer months.

Off-road driving

Off-road driving is not allowed within the plan area, except for limited beach driving within City-managed coastal reserves. The authorised beach areas are signposted[23]. Off-road driving can disturb waterbirds, damage sensitive areas (i.e. wetlands and fringing vegetation) and potentially spread weeds and disease.

Large expanses of the middle and upper reaches of the Vasse-Wonnerup wetlands dry during late summer-autumn, and remain dry until the wetlands fill during winter. Recreational vehicles such as four-wheel-drives and trail or quad bikes are regularly driven onto the flats when initially damp and as the water levels recede. This activity breaks the surface crust leaving ruts up to 1m deep, which after repeated use compress and compact the underlying soil leaving a permanent depression. Exposure of the underlying soils results in the drying and oxidation of the sulphate components of the soils and potentially forms highly acidic pools and acidic scum, which inhibits the growth of vegetation.

Effective closure of these wetland areas to recreational vehicles is required. Uncontrolled access in sections of the plan area exposes the Vasse Estuary to unauthorised off-road driving; options to close and secure these areas to exclude this activity should be investigated with the City.

Impacts to birds

Waterbirds may be impacted from disturbance activities such as some recreational activities. Watercraft activity on the broad expanses of the Vasse and Wonnerup estuaries can cause a great deal of disturbance, particularly when large numbers of waterbirds are present in late spring and summer.

Different waterbird species exhibit varying degrees of sensitivity and employ a range of response strategies when exposed to disturbance activities. Observational studies of disturbance distances for a selection of species found in the Vasse-Wonnerup wetlands were reported in 1995, with the distance to disturbance ranging from 25 – 500m. The frequency and type of disturbance is likely to be problematic at two crucial periods during the year: when birds are nesting during winter-spring; and for wader species, rebuilding body condition over summer months prior to migrating to the northern hemisphere.

There have been reported sightings of recreational drones in the vicinity of the wetlands - for information on the use of drones see section **Remotely piloted aircraft** under **5.2. Recreational activities and sites**. Disturbance caused by aircraft could potentially cause waterbirds to use energy needed for feeding, migration and breeding and may deter birds

[23] For information on off-road vehicle access within the City—managed Wonnerup coastal reserves refer to the *Wonnerup Coastal Reserves Management Plan* (City of Busselton 2016a).

away from the Vasse-Wonnerup wetlands. Drones disturbances are known to interfere with recreational bird watching and bird study activities.

Birds are also susceptible to bird strike from commercial aircraft, which has been recognised within the assessment of the Busselton-Margaret River Regional Airport expansion, requiring a minimum height requirement over wetlands and estuaries of the Vasse and Wonnerup areas. This height requirement is that "*All aircraft fly a minimum of 640 ft (AGL) over wetlands and estuaries of the Vasse and Wonnerup areas to avoid bird strike and disturbance of waterbird habitat*" (City of Busselton 2016b, p.20).

Straying stock

Stray cattle have been observed with the wetland area, resulting in damage to fringing vegetation and wetland soils. To address this issue, ongoing management and maintenance of boundary fences by adjacent landowners is necessary.

Fencing

Historically, parts of the Vasse and Wonnerup estuaries and Swan Lake were privately leased or owned and used for seasonal cattle grazing. Kilometres of fencing were erected, extending out across the wetland beds. Since discontinuation of grazing on the UCL and reserved portions of the wetlands, fences have been removed, partially removed, or fallen into disrepair. Some fencing wire remains and some of this is barbed, which presents a hazard to birds. The fence posts provide roosting spots for birds and are of historical interest and should be remain in situ, but all the fencing wire requires removal and disposal.

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
1. Minimise the impacts of weeds and introduced animals on the key values of the plan area.	1.1. Undertake periodical risk assessments to identify key threats to the wetland system's values. (**DBCA**, City, SWCC, GeoCatch) 1.2. Develop and implement control and monitoring programs for weeds and introduced animals. (**DBCA**, GeoCatch, City, SWCC) 1.3. Develop and implement community education programs on the impacts of weeds and introduced animals. (**DBCA, City**, GeoCatch, SWCC) 1.4. Integrate, where possible, ecosystem restoration in weed management programs. (**DBCA**, City, SWCC) 1.5. Establish cooperation and coordination between landowners and other parties to maintain and enhance, where possible, coverage of areas under fox, cat and rabbit baiting within and adjacent to the plan area. (**DBCA**, City, SWCC, DPIRD) 1.6. Seek funding to install a predator-proof fence around the Vasse-Wonnerup wetlands, where necessary. (**DBCA**, SWCC)

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
2. To protect the key values of the plan area from adverse impacts of fire and fire management activities.	2.1. In consultation with the City's bushfire officer review firebreak requirements in wetland areas not managed by the DBCA and consider alternative mitigation measures where necessary. (**DBCA**, City) 2.2. Prepare and implement a fire management plan/s for the plan area (including, but not limited to, access to and egress from the plan area). (**DBCA, City**)
3. Protect the plan area from disturbance activities.	3.1. Conduct regular inspections of the plan area to monitor for disturbance activities. (**DBCA, City**) 3.2. Consider establishing a database to record areas and incidences of disturbance and damage in the plan area, and use this information to coordinate and implement prevention and mitigation measures. (**DBCA, City**) 3.3. Identify areas requiring management of vehicle access to protect conservation and cultural heritage values, and explore options to close and secure these areas. (**DBCA**, City)
4. Minimise human-induced impacts on native flora and fauna.	4.1. Liaise with adjacent landowners to encourage fencing to exclude stock from wetland areas and areas of native vegetation. (**DBCA, GeoCatch**) 4.2. Remove fencing wire from unused fences within the estuaries (leave the wooden posts as they are roosting spots for birds). (**DBCA**)
5. To protect the key values of the plan area from adverse impacts of mining activities and urban development activities.	5.1. Implement mitigation measures (e.g. revegetation, vegetated buffers, habitat protection) to reduce the impact of any existing adjacent mining operations on the fringing vegetation and wetland hydrology where necessary. (**DBCA**, DMIRS) 5.2. Reduce the potential impact of existing or intensified adjacent urban development, including canal construction, on the key values of the plan area and consider mitigation measures (e.g. revegetation, vegetated buffers, habitat protection) where necessary. (**DBCA**, City, DPLH)

3.5. Public health and wellbeing

Mosquitoes

The City undertakes an annual mosquito control program[24], which is funded by DoH. The control program is managed to ensure non-target effects are minimised.

The mosquitoes, southern saltmarsh mosquito (*Aedes camptorhynchus*), summer saltmarsh mosquito (*Aedes vigilax*) and common banded mosquito (*Culex annulirostris*), that breed in the samphire saltmarshes of the Vasse-Wonnerup wetlands are known vectors of the disease-causing Ross River and Barmah Forest viruses. Mosquito breeding occurs primarily in spring and early summer, when the saltmarshes are flooded and water temperatures are rising. During these months, the City sprays (by helicopter) the samphire saltmarshes in order to limit mosquito breeding. In late summer-autumn, when water levels are lower, spraying of these marshes is not required as no breeding occurs.

The management of water levels can impact the levels of mosquito breeding. For example, higher levels in the Vasse Estuary in late summer – autumn is likely to result in additional flooding events in the samphire saltmarshes. This will result in a higher likelihood of additional mosquito breeding activity and consequential need for additional spraying.

Any management of the hydrology of the wetlands needs to take into account the potential impact on mosquitos. Managing estuary water levels to reduce water fluctuations in the samphire saltmarshes may reduce the number of opportunities for mosquitoes breeding. Further investigation into the relationship between mosquito breeding and water level management is needed.

The management of water levels in the Vasse-Wonnerup wetlands will require ongoing consultation with the City, to inform the City's annual mosquito control program.

Midges

The Vasse-Wonnerup wetlands produce very large numbers of non-biting, chironomid midges. Their larvae ('bloodworms') live in sediments of the wetlands and are likely to be an important food source for various species of waterbirds and fish.

Midges can be a nuisance for nearby residents as they are attracted to lights within and around houses. To date, this has not been a significant public issue and no midge control measures are undertaken by the City. The Port Geographe canals development incorporated design features to reduce the severity of midge nuisance potentially impacting residents, given its close proximity to the adjacent Vasse Estuary.

Options to mitigate impacts from midges include educating nearby residents of measures they can take to minimise attraction of midges and restoring riparian/fringing vegetation to reduce midge movement to nearby residences.

Amenity

The Vasse-Wonnerup wetlands have experienced severe problems including nuisance odours for many years caused by excessive amounts of nutrients entering them.

[24] Information on Mosquito Control Activities in the City of Busselton is available at: busselton.wa.gov.au/Environment-Waste/Environmental-Health/Mosquito-Control

"*Increased foul odour is often associated with drying wetland sediments*" (WRM 2007, p.76). The Vasse-Wonnerup wetlands contain sulfidic materials (soils and sediments enriched in sulfides, such as pyrite) and a risk associated with sulfidic materials is the generation of foul odours during drying events, when the loss of water cover increases the likelihood of sulphur gases in the sediments escaping to the atmosphere, causing a 'rotten egg' odour. This 'rotten egg' gas (hydrogen sulphide gas) and other pungent sulphur gases released from wetlands (volatile organic sulphur compounds) are produced by anaerobic sulfate-reducing bacteria (WRM 2007).

There have been community concerns with odours, such as those described in WRM (2007, p.101) *"An increase in the severity of repugnant odours emitted from drying sediments ("sludge") of the lower Vasse Estuary during…2005/06 and 2006/07* [as water levels declined over summer and autumn]. *Odours were particularly noxious along Estuary View Drive and down to the* [Vasse Estuary] *floodgates…"*

Another source of odour is decomposing seagrass wrack in Wonnerup Inlet. Vast amounts of seagrass from Geographe Bay occasionally enter the inlet during winter storms. The decomposing seagrass wrack produces hydrogen sulphide, which is highly toxic to fish, and strong unpleasant odours, and can also result in poor water quality from lower dissolved oxygen levels (Lane *et al.* 1997).

Domestic animals

Dogs are allowed in national parks or conservation parks only in designated areas, but are not allowed in nature reserves. The exception is approved assistance dogs (e.g. guide dogs) and specially trained dogs for search and rescue operations, security or educational purposes or feral animal control, which may be allowed in all areas.

Areas may be declared designated dog areas on some department-managed land where impacts are considered manageable and/or there has been a history of dog access in the area. Under the CALM Act Regulations, designated areas will be signposted where practical, with the conditions specified on the signs.

There are designated dog exercise areas on some City-managed lands; further information is provided on the City of Busselton website[25] and for the Wonnerup coastal reserves refer to the *Wonnerup Coastal Reserves Management Plan* (City of Busselton 2016a).

Domestic cats are excluded from all department-managed lands; there are no exceptions to this 'exclusion of cats' policy. The State Government's *Cat Act 2011* aims to encourage responsible pet ownership and reducing the number of unwanted cats; also the City has a local cat law (i.e. *City of Busselton Keeping and Control of Cats Local Law 2014*) to control the number of cats kept on premises in order to protect native fauna.

Some reserves of the plan area are baited for foxes with 1080 several times a year, which may pose a risk to domestic animals. Where baiting occurs, signage will be installed to notify and warn visitors of the risk.

[25] Additional information on the City's designated dog exercise areas is available on the City's website: busselton.wa.gov.au/Community-Services/Ranger-Services/Animal-Information/Dogs-on-Beaches

Snakes

Tiger snakes (*Notechis scutatus*), which are venomous, are particularly abundant on and around the Vasse-Wonnerup wetlands and can be encountered anywhere, including on-water and mid-estuary, at any time. All activities on the Vasse-Wonnerup wetlands need to be planned and conducted with consideration to personal safety, ensuring all reasonable and practical steps are taken to minimise the risk of being bitten by a snake. Signage and information on visitor safety at the Vasse-Wonnerup wetlands' public access points may be required.

Management objective	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
1. To manage the wetlands in order to promote the health and wellbeing of residents and visitors.	1.1. Maintain monitoring and management of mosquito populations in the wetlands and provide for minimal environmental impact mosquito control methods and programs. (**City, DoH**, DBCA) 1.2. Investigate the link between mosquito ecology, and changes in water levels and quality. (**VWWP**, Science community) 1.3. Develop and provide information on the significance of midges in food webs and on ways to minimise the attractiveness of adjoining residences to nuisance midges. (**City**, DBCA) 1.4. Provide information to the community prior to adverse changes in odours, mosquitos or midges, where practicable. (**City**, GeoCatch) 1.5. Identify the causes of strong unpleasant odours through continuing to investigate the link between sediments and odour with hydrogen sulphide monitoring and community surveys; and mitigate where practicable and environmentally beneficial. (**VWWP**) 1.6. Coordinate management of seagrass wrack on the Geographe Bay shoreline so as to minimise the amount entering Wonnerup Inlet, then decomposing and producing strong unpleasant odours and poor water quality. (**City, DPIRD**, WC)

4. Managing cultural heritage

For information on Aboriginal and European heritage of the Wonnerup coastal reserves refer to the *Wonnerup Coastal Reserves Management Plan* (City of Busselton 2016a).

4.1. Noongar culture and heritage

Management of the CALM Act land shall be carried out in a manner that *protects and conserves the value of the land to the culture and heritage of Aboriginal persons*, as described in s33(2) of the CALM Act.

It is acknowledged that the Wardandi people have had a long and continuing connection to the Vasse-Wonnerup wetlands. There is a long history of Aboriginal occupation of the South West, evidenced, for example, by cave deposits near Margaret River. These indicate that Aboriginal people have been present for at least 35,000 years.

The earliest recorded history of Aboriginal (Wardandi) people on the Vasse-Wonnerup wetlands comes from the Baudin expedition's visit to Geographe Bay in 1801. Shore parties documented their encounters with the local Aboriginal people, their activities, dwellings, fish traps and a possible 'spiritual site' on the east bank of Wonnerup Estuary. Published accounts of this expedition include sketches and paintings of some of these discoveries. Later explorers also documented Aboriginal activity on the Vasse-Wonnerup wetlands. Lieutenant H. W. Bunbury, for example, mentioned Aboriginal people in the 1830s wading across either estuary when water levels were low (Bunbury & Morrell 1930).

An ethnographic consultation was held in February 2018 with representatives of the South West Boojarah (SWB) and Harris Family native title claim groups to understand the Aboriginal cultural heritage values and significance of the Vasse-Wonnerup wetlands [and the lower Vasse River and Toby Inlet] (Brad Goode & Associates Pty Ltd 2018). The Noongar community consider that the Vasse-Wonnerup wetlands contain immense spiritual, environmental, customary and social significance as part of the broader cultural landscape of the Geographe Waterways (Brad Goode & Associates Pty Ltd 2018).

"Nyungar community consider all waterways to have mythological significance due to the belief that they were created by the Dreaming serpent called the Waugal and customary significance as a primary area of traditional, historical and contemporary uses" (Brad Goode & Associates Pty Ltd 2018, p.3). *''The Geographe Waterways are viewed by the Nyungar community consulted to be a part of a holistic system within a cultural landscape which connects with other waterways in the wider region, including through walk trails which were situated alongside the rivers. Little creeks feed the larger rivers and waterways which were likened by the SWB and Harris Family representatives to the veins in their mother's body"* (Brad Goode & Associates Pty Ltd 2018, p.72).

The representatives advised that *"songlines and walk trails followed the Vasse Wonnerup system on which old songs, law, burial grounds, camp grounds, fish traps and ceremonial sites are located. Traditional Nyungar burials were reported to have occurred along the southern side of the sand dunes along the coast whereby the deceased were buried facing east in a sitting position with their tools by their side to greet the sun as it rises"* (Brad Goode & Associates Pty Ltd 2018, p.4).

"SWB and Harris Family representatives advised that a partnership needs to be established where the Nyungar community is recognised as an equal stakeholder in regards to the joint management, protection and restoration of waterways and country. The SWB and Harris Family representatives advised that this joint management partnership is essential as the

Nyungar community have custodianship rights and responsibilities over the waterways, which includes maintaining the health of the water system. It is the belief of the Nyungar community that they can be punished for not looking after country. In addition, the SWB and Harris Family representatives advised that they hold intricate knowledge of the land and waterways and subsequently should be at the forefront of plans and projects. It was also requested that engagement include employment opportunities offered to Nyungar individuals and businesses to carry out rehabilitation and restoration works as part of management policies and practices" (Brad Goode & Associates Pty Ltd 2018, p.74).

Heritage sites and places

The Vasse-Wonnerup wetlands, the lower Vasse River and Toby Inlet are considered by the Noongar community to be part of one continuous water system, with requests being made by the community for the Geographe waterways to be assessed as one site in regards to the *Aboriginal Heritage Act 1972* (Brad Goode & Associates Pty Ltd 2018).

There are four registered heritage sites, including Korilya Stud and Sabina River; and four other heritage places including Wonnerup and Sabina River Camp Ground within or traversing the Vasse-Wonnerup wetland system (Brad Goode & Associates Pty Ltd 2018). There are also a number of additional sites and places that have not been reported for various reasons. As such, "*representatives advised that they should be re-consulted in regard to specific works which result from the [operational plan and water] management plans in order to help account for specific Aboriginal heritage sites and mitigate the impact that the plans could have upon such sites"* (Brad Goode & Associates Pty Ltd 2018, p.5).

Customary activities

Customary activities by Aboriginal people can include hunting for food, preparing medicine and engaging in artistic and ceremonial events[26]. These activities are an important part of Aboriginal culture, enabling maintenance of relationships with the land, water and fire; sharing of knowledge; engagement in traditional practices; and accessing and looking after places of significance. Access to the plan area for customary activities is important for traditional owners as it ensures the continuation of traditions, the transfer of knowledge to younger generations and the protection and conservation of cultural values. The creation of a CALM Act conservation reserve will enable Aboriginal people to continue their customary activities.

"…The wetlands hold cultural heritage values as a traditional and historical food source with one of the Nyungar informants advising that there used to be fish traps used in the wetlands as, before the artificial diversion drains were installed, the wetlands were a primary source of fish. In relation to the surge barrier (or floodgates) at the Vasse Estuary the SWB and Harris Family representatives advised that they are interfering with the natural flow of the river, however, if they improve the sediment levels of the waterways then they are acceptable" (Brad Goode & Associates Pty Ltd 2018, p.73).

4.2. Other Australian cultural heritage

The earliest recorded visit to Geographe Bay and the Vasse-Wonnerup wetlands by non-Aboriginal people was in 1801, by the French 'Baudin expedition'. A stranded shore-party camped for several days on the narrow strip of land between the Deadwater and Geographe

[26] Section 103A of the CALM Act and Division 3 of the BC Act provide for Aboriginal people to undertake customary activities. Customary activities include preparing or consuming food, preparing or using medicine, and engaging in ceremonial or other cultural activities customarily undertaken by Aboriginal people.

Bay and it is possible that some lost or discarded items remain undiscovered (in addition to their longboat). Later explorations (1820s onwards) by the British produced more comprehensive accounts of the Vasse-Wonnerup wetlands, such as Mr Collie & Lieutenant Preston in 1829 and Lieutenant Bunbury in 1836-37, as reported by Cross (1833), and Bunbury and Morrell (1930) (as cited in Lane *et al.* 1997).

The Swan River Colony of Western Australia was founded in 1829. Shortly after, the Augusta and then Vasse settlements were established (Jennings 1983). At Vasse (later named Busselton), John Bussell was the first to be granted land in 1832 and then later that year Captain Molloy, with the first actual settlement taking place 1834 (Jennings 1983). Early agricultural use was principally on the floodplains, but in places extended onto the beds of the estuaries. Significant agricultural use of the floodplains continues to the present day, in particular around the Wonnerup Estuary.

Remaining in-situ the physical evidence of Other Australian historical use of the Vasse-Wonnerup wetlands includes:

- remnant of the 1929 replacement floodgates on the Wonnerup Estuary exit channel;
- earth bund that separates 'Swan Lake' from the remainder of Wonnerup Estuary;
- diverted mouth of the Ludlow River;
- runnelling of parts of the floodplains and estuary saltmarshes (as evident in aerial photographs);
- fence posts (and some wire) still standing on the beds of the estuaries;
- substantial and probably pre-1930 wooden duck shooting 'blind' on the Wonnerup Estuary (duck hunting was permitted in parts of the Vasse-Wonnerup wetlands until 1930, after which it was banned on the waters of the Vasse River, Vasse Estuary and Wonnerup Estuary — as outlined in WRM 2007); and
- World War Two practice-bombing target on the nature reserve between Layman Road and Vasse Estuary.

Other areas of historical interest are Tuart Forest, one of the first areas to be gazetted as a State Forest in WA and had the first formal training school for forest managers in WA; and adjacent to the plan area the historical building Wonnerup House (WRM 2007), also listed on the State Register of Heritage Places.

Information on other heritage sites located within or near the plan area is available on the City's Municipal Heritage Inventory at: busselton.wa.gov.au/Community-Services/Cultural-Development/Heritage-List-and-Municipal-Heritage-Inventory .

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
1. Promote and increase community awareness and understanding of the Aboriginal cultural heritage values of the plan area.	1.1. Develop and install appropriate culturally sensitive interpretative signage concerning local Aboriginal heritage in ongoing consultation with relevant Wardandi people and other appropriate people. (**DBCA, City**, GeoCatch, SWCC, traditional owners, SWALSC)
2. To identify, protect and conserve cultural sites, and support the continuation and strengthening of connection to country and sharing of cultural knowledge (supported and consistent with DBCA's Customary Activities Policy and Guidelines).	2.1. Consult with relevant Wardandi and other appropriate people to identify culturally significant sites. (**DBCA**, City, SWCC, DPLH, traditional owners, SWALSC) 2.2. Promote and support culturally appropriate access and interpretation of cultural sites, where appropriate. (**DBCA**, City, traditional owners, SWALSC, GeoCatch, SWCC) 2.3. Protect cultural sites and artefacts, and liaise with traditional owners to determine which sites of high cultural sensitivity may require special management and/or access restrictions and implement as appropriate. (**DBCA**, traditional owners, key stakeholders) 2.4. Support the traditional owners to maintain their connection to, and responsibilities for, country by facilitating the conduct of customary activities (e.g. support on-country trips by younger and older generations of traditional owners to the plan area to ensure knowledge, stories and songs about country are passed on, and to undertake other customary activities). (**DBCA**, traditional owners, key stakeholders) 2.5. Facilitate access within the plan area for traditional owners for the purposes of carrying out customary practices, transferring knowledge to the younger generations and enjoying country. (**DBCA**, traditional owners, key stakeholders) 2.6. Assess factors that may inhibit the rights of traditional owners to enjoy country and maintain their customary practices, and explore/implement management interventions to address issues as necessary. (**DBCA**, traditional owners, key stakeholders)
3. Identify and conserve Other Australian culturally significant places and the history of the plan area.	3.1. Identify Other Australian culturally significant sites and structures. (**DBCA, City**, SWCC, DPLH) 3.2. Promote appropriate access and interpretation of Other Australian cultural sites. (**DBCA,** City, SWCC, DPLH, GeoCatch)

5. Managing recreation and visitor use

Providing opportunities for the public to interact with the wetlands through passive recreational activities (such as wildlife viewing and nature walks) and nature-based tourism opportunities could increase their awareness of, and connection to, the wetland system. The range of nature-based recreational opportunities will be consistent with protecting the plan area's conservation and cultural values.

Consideration of the conservation and Noongar cultural values of the plan area will be at the forefront of visitor planning. Any recreation area should be:

- low impact and compatible with the key values of the strategy area;
- consistent with the department's *Policy Statement No. 18 – Recreation, tourism and visitor services*; and
- adopt 'Leave No Trace' principles.

Implementation of a monitoring program to establish the number of visitors to the area and to identify any impacts to the plan area's conservation values will be considered during the term of the plan. Where impacts are identified, the department will work with the local community and stakeholders to restrict or prohibit these activities.

5.1. Visitor access

There is limited public vehicle access into and around the plan area, which helps to protect its conservation values. The plan area includes both department-managed tracks and City-managed public roads. Day-use sites and wildlife viewing sites within the plan area, outlined below, are accessible by two-wheel-drive vehicles.

Swan Lake has limited access to facilitate management activities and potential wildlife viewing sites. The department with support from other key agencies will explore options to secure access to the northern end of Swan Lake. There is also limited access for management purposes to the southern end of Swan Lake.

The construction of unmade Buttercup Road reserve will help provide access to conservation areas and will also provide a buffer between future residential development and conservation areas.

5.2. Recreational activities and sites

For information on recreational activities and sites within the Wonnerup coastal reserves refer to the *Wonnerup Coastal Reserves Management Plan* (City of Busselton 2016).

Day use sites

Established day-use sites include the Layman and adjacent Malbup day-use sites, and Membenup. The day-use sites are listed in Table 4 and shown at Map 3.

Management of day-use sites will focus on improving the quality of established sites, in combination with a better standard of access and interpretation for visitors.

There are no designated camp sites within the plan area.

Table 4: Existing day-use sites

Day-use site	Activity	Comments or proposals
Malbup	Bushwalking, interpretation and wildlife viewing	This site is the access point for the Possum Paths spotlight trail and Malbup bird hide (see **Table 6**). Facilities include interpretation panels, picnic tables and a car parking area.
Layman	Picnicking	Facilities include picnic tables, toilets and rubbish bins.
Membenup	Nature appreciation, bushwalking, picnicking and interpretation	This site is a popular area to view tall tuart trees. Facilities include interpretation signs and shelter, and picnic table.
Wonnerup coastal reserve day-use sites	-	Refer to the *Wonnerup Coastal Reserves Management Plan* (City of Busselton 2016).

Trails

The three established walk trails in the plan area are the Possum Paths Spotlight Trail, the Malbup bird hide access trail and the Wetland walk.

Two trails leading to new bird hides overlooking the Vasse-Wonnerup wetlands are proposed in the *Busselton Wetlands Trails Master Plan* (Shire of Busselton 2007). The department has indicated in-principle support for these trail concepts, but their development will be subject to assessment of social and environmental considerations and availability of resources for the design, construction and maintenance of the trails.

Although there is the potential for several trails within department-managed lands, the trails will depend on the availability of funding, outcomes of further trail assessment through the WA Trail Development Process and consultation with the local Wardandi people and other interest groups. Where trails are proposed along a wetland they should be set back from the edge of the fringing vegetation and only provide access to the wetland via a spur track to a discrete point.

A summary of the existing and potential trails within the plan area and their class are listed in Table 5 and existing trails are shown at Map 3. Other trails may be developed as demand increases after detailed planning and public consultation.

Information about existing trails within and adjacent to the plan area is also available from the Busselton Visitor Centre and includes the *Busselton Heritage Trail* guide book and the City's brochures, *Coastal and Wetland Trails in Wonnerup, Busselton* and *Wetland Walks and Trails, Busselton*.

Footpaths

Footpaths adjacent to urban areas will be considered, planned and installed in sympathy with the values of the wetlands.

Table 5: Existing and potential trails

Walk trail	Proposed class[1]	Comments or proposals
Possum Paths spotlight trail	3	A two kilometre walk trail popular for spotlighting of western ringtail and brushtail possums.
Malbup trail	1	A 400 metre walk trail (sections of limestone trail and wooden boardwalk) leading from the Possum Paths spotlight trail to the Malbup bird hide.
Wetland walk	-	A 400 metre Vasse River delta wetlands bird hide and interpretive trail[27] (bird hide is the Pioneer Cove bird hide, see **Table 6**). Managed by the City.
Malbup-Abba trail *(potential)*	3	A trail extending from the existing Possum Paths spotlight trail leading to a new bird hide (see **Table 6**). This trail concept is outlined in the *Tuart Forest National Park management plan 2014* (DPaW 2014).
Membenup trail *(potential)*	2	A trail and new bird hide (see **Table 6**). This trail concept is outlined in the *Tuart Forest National Park management plan 2014* (DPaW 2014).
Ludlow-Layman trail *(potential)*	3	A trail leading from the Ludlow settlement to the Membenup and Layman day-use sites. This trail concept is outlined in the *Tuart Forest National Park management plan 2014* (DPaW 2014). Consideration will be given to a dual-use path and linking it with the existing Busselton path network.
Wonnerup coastal reserve trails	-	Refer to the *Wonnerup Coastal Reserves Management Plan* (City of Busselton 2016).

[1] Walk trails are classified according to Australian Standard 2156.1: *Walking Tracks – Classification and Signage*. Variables taken into consideration include trail condition, gradient, signage, infrastructure and terrain. Classification ranges from 1 (least degree of difficulty) to 6 (most difficult).

Horse-riding

Horse-riding may be allowed in national parks or conservation parks, but is not allowed in nature reserves. Areas may be declared designated horse-riding areas on some department-managed land where impacts are considered manageable and/or the activity has been previously evaluated and permitted. Under the CALM Act Regulations, designated areas will be signposted where practical, with the conditions specified on the signs.

In regard to the plan area, there is no provision of bridle trails (except within particular areas of the Wonnerup coastal reserves[28]). Recreational riding is permitted in areas of Tuart Forest National Park outside of the plan area, on selected tracks and on undeveloped public road reserves (for further information see *Tuart Forest National Park management plan 2014*).

[27] A map of the Wetland walk - Vasse River Delta Wetlands Bird Hide and Interpretive Trail is available on the GeoCatch website at: geocatch.asn.au/wp-content/uploads/2017/09/City-of-Busselton-Wetland-Walks-and-Trails.pdf

[28] For information on horse-riding within the City—managed Wonnerup coastal reserves refer to the *Wonnerup Coastal Reserves Management Plan* (City of Busselton 2016a).

Cycling

Cycling is an increasingly popular activity and mountain biking is one of the world's fastest growing recreational, sport and tourism activities in WA.

The *Western Australian Mountain Bike Strategy 2015-2020* (WestCycle Incorporated 2015) sets out a series of strategies and recommendations for sustainable mountain biking. The *South West Mountain Bike Master Plan* (Common Ground Trails Pty Ltd 2015) provides a framework to create a high quality mountain bike trail network in the South West (from Bunbury down to Pemberton), and identifies and prioritises areas for trail development. The master plan has identified the Busselton area for potential future trail development, however has not identified any trail development sites within the plan area.

The City of Busselton has prepared a *Bike Plan*[29] (2010) as a guide for the development of a cycle network around Busselton and a *Walk-Cycle Brochure* (2014) that outlines cycling routes around the Busselton-Dunsborough area. There is also a shared use path/cycling path along Layman Road, which is part of the east-west primary route as proposed for the subregion's integrated cycling network under the draft *Leeuwin-Naturaliste 2050 Cycling Strategy* (Department of Transport 2018). The City (2018) has also released the *City of Busselton Draft Cycling and Shared Path Network Plan 2018-2022*, which shows existing cycling and path network and new potential pathways.

Wildlife viewing

The Vasse-Wonnerup wetland system is internationally recognised for the thousands of birds that feed, roost and nest in the area, and wildlife viewing sites around the wetlands[30] provide opportunities to enjoy this unique ecosystem. There are existing wildlife viewing sites provided and managed by the department and the City, as listed in Table 6 and shown at Map 3. The potential sites, as listed in Table 6, are planned so as to restrict access to minimise disturbance to sensitive waterbird areas, while providing the ideal observation points for bird-watching enthusiasts. These sites to be developed will depend on the availability of funding, outcomes of further planning and assessment and consultation with the local Wardandi people and other interest groups.

A wetland education centre and viewing tower was previously proposed and associated with the development of the Port Geographe area. Due to changes in ownership and governance relating to the development, these facilities are no longer planned or funded.

Table 6: Existing and potential bird hides and other wildlife viewing sites

Site	Comments or proposals
Pioneer Cove bird hide	A City managed facility.
Malbup bird hide	A DBCA-managed facility.
Malbup-Abba bird hide *(potential)*	A bird hide overlooking the Vasse Estuary.
Membenup bird hide *(potential)*	A bird hide overlooking the Wonnerup Estuary.
Swan Lake *(potential)*	Wildlife viewing site at the northern end of Swan Lake is sought should access and appropriate land be available.

[29] Additional information on the City's *Bike Plan* is available on the City's website: busselton.wa.gov.au/Leisure-Tourism/Leisure-and-Tourism-Sport

[30] An information sheet, *Where to Watch Waterbirds on the Vasse-Wonnerup Wetlands* (Lane 1997b), is available on GeoCatch's website: geocatch.asn.au/resource/watch-birds-vasse-wonnerup-wetlands/

Water-based activities

Changes in water levels and water quality must be taken into account when considering the suitability of water-based activities. Any water-based activities (e.g. canoeing and remote-controlled boats) will need to be monitored for impacts to birds and other fauna, and native vegetation.

Historically, watercraft activity on the broad open water of the Vasse-Wonnerup wetlands has been limited to commercial fisher, researchers and the occasional canoeist. This is mostly likely due to limited accessibility, mostly very shallow water depth and the dense macroalgae and seagrass during the warmer months. Wonnerup Inlet, the Deadwater and the Wonnerup Estuary exit channel are little used by watercraft such as canoes.

There is limited canoeing within the Vasse Estuary exit channel and Wonnerup Inlet and some limited canoeing within the open water of the estuary for the scientific and monitoring purposes. There is no existing or proposed formal canoe or kayak launch sites within the plan area.

Areas for watercraft use are necessarily limited to prevent disturbance of sensitive waterbird areas, such as the area of cormorants in the Vasse Estuary exit channel. Water-based activities are not encouraged on the wetlands due to the impact on waterbirds and potential contact with toxic algal blooms.

Recreational fishing

Recreational fishing (freshwater, estuarine and coastal) is managed by DPIRD's Sustainability and Biosecurity Division in accordance with the *Fish Resources Management Act 1994* and the forthcoming Aquatic Resources Management Act. In regard to the plan area, the key recreational fishing areas are the Deadwater and Wonnerup Inlet[31] - most of this fishing is conducted by rod and line from the shore, and restrictions apply to recreational net fishing[32]. The main catch is black bream.

Unmanaged, informal access to fishing sites does occur and can result in damage to fringing wetland vegetation and may disturb valuable waterbird nesting and roosting sites. Fisher access should be reviewed in consultation with key stakeholders and managed to minimise damage to fringing vegetation.

The minor impacts include discarded fishing gear, bait and unwanted fish, and the occasional accidental hooking of birds. Fishing off the surge barriers is not allowed, but does occur and may cause fouling of the barrier infrastructure.

Jetties

Any existing private jetties will need to be assessed according to the new tenure of the Vasse-Wonnerup wetlands (i.e. proposed nature reserve) and applicable legislation. Also, a jetty licence from Department of Transport (DoT) is required under the *Jetties Act 1926 (WA)*. DoT will ensure that the location of the jetty does not interfere with navigation and that safety is addressed through jetty design, construction and maintenance. A jetty licence does not provide any tenure over the structure or any part of the wetlands.

[31] For information on recreational fishing within the City-managed Wonnerup coastal reserves area (e.g. Deadwater and Wonnerup Inlet) refer to the *Wonnerup Coastal Reserves Management Plan* (City of Busselton 2016a).

[32] Information on the recreational net fishing restrictions is available at *Net fishing Recreational fishing guide 2017/18*: fish.wa.gov.au/About-Us/Publications/Recreational-Fishing/Pages/Recreational-Fishing-Guides.aspx

There is a presumption against the relocation, extension or construction of new private (domestic use) jetties.

DoT is responsible for safety and navigation in and on coastal waters of Geographe Bay, which is adjacent to the plan area.

Remotely piloted aircraft

Remotely piloted aircraft or drones, model aircraft and rockets are considered 'aircraft' under the Civil Aviation Safety Regulations 1998. The Civil Aviation Safety Authority (CASA) is responsible for regulating these aircraft and the Civil Aviation Safety Regulations apply to their use regardless of land tenure[33].

The areas where you're not allowed to fly drones are identified on the CASA website's 'Can I fly there?' drone safety app: casa.gov.au/aircraft/standard-page/can-i-fly-there-drone-safety-app.

The use of drones, model aircraft and rockets on and over the plan area is restricted due to safety, environmental, cultural, operational and amenity considerations.

As well as complying with CASA legislative and regulatory requirements, the use of remotely piloted aircraft within department-managed lands and/or waters must comply with all relevant State legislative and regulatory requirements, including the CALM Act and CALM Regulations, and the BC Act and Biodiversity Conservation Regulations[34].

5.3. Tourism operations

The Vasse-Wonnerup wetland system and adjacent Crown land are invaluable natural assets, providing breath-taking views of an array of wildlife. There are opportunities to enhance nature-based tourism within this area that is compatible with the key conservation and cultural values, and delivers a positive outcome to the region.

The department issues licences for commercial operations (businesses that deliver tourist, recreation or educational services for private benefit [profit] while on conservation estate). Licences allow commercial operators lawful access to and appropriate use of department-managed lands and waters. Licences are granted in consultation with the Commission and must be consistent with the purpose of the reserve, the protection of key values and with the objectives of this operational plan.

Currently, there are no licenced commercial operations for the areas of the Vasse-Wonnerup wetland system vested in the Commission. There are commercial operations licences to conduct activities within Tuart Forest National Park.

[33] Information on safety rules for flying drones in Australia is available at: casa.gov.au/aircraft/landing-page/flying-drones-australia

[34] Information on the use of remotely piloted aircraft within DBCA-managed lands and/or water is available on DBCA's Parks and Wildlife Service website: dbca.wa.gov.au/management/remotely-piloted-aircraft

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
1. Minimise disturbance impacts from recreational activities on conservation and cultural heritage values, and management activities.	1.1. Identify and develop appropriate recreational activities and sites, and commercial tourism opportunities, which are compatible with the conservation and cultural heritage values of the plan area. (**DBCA, GeoCatch**, City) 1.2. Develop recreational trails in accordance with Table 5, the WA Trail Development Process and DBCA policy. (**DBCA**) 1.3. Manage private jetties according to outcomes of assessments. (**DBCA**, DoT) 1.4. Explore options to secure public access to suitable viewing points, for example near the northern end of Swan Lake. (**DBCA**, DPLH) 1.5. Construct Buttercup Road to provide management access to the boundary of the conservation area, and a buffer between future development and the conservation area. (**City**)
2. Manage recreational fishing in the Vasse-Wonnerup wetland system to minimise the impacts on the conservation values.	2.1. Review recreational fisher access to the Vasse-Wetland wetland system, in consultation with Recfishwest and local recreational fishing groups, to minimise disturbance to native fringing vegetation and where necessary implement appropriate management measures. (**DPIRD**, DBCA, City)
3. Increase visitor appreciation, awareness and enjoyment of the conservation and cultural heritage values of the plan area.	3.1. Develop and facilitate education programs and interpretive resources in consultation with relevant stakeholders. (**DBCA, City**, GeoCatch, SWCC, traditional owners, SWALSC) 3.2. Explore and adopt options to improve the accessibility of, and information provided by, the Busselton Visitor Centre. (**City**) 3.3. Explore and consider options to provide accessible and wider circulation of, information on recreational opportunities for the local community and visitors. (**DBCA, City**) 3.4. Apply applicable commercial operator licence conditions to ensure culturally sensitive and appropriate visitation to cultural heritage sites. (**DBCA**)

6. Research and monitoring

6.1. Research

Research is critical to improving knowledge and helps inform future management decisions. The Vasse-Wonnerup wetlands have been the focus of considerable research and monitoring during the past 10 years. The Ecological Character Description by WRM (2007) identified several gaps in our scientific knowledge of the wetlands. Through considerable expansion in research effort these knowledge gaps are being addressed and include baseline fish and crayfish surveys, the ecology of the Black Bream and acoustic tracking projects, annual snapshot surveys by Murdoch University characterising the composition, distribution and abundance of aquatic macrophytes, phytoplankton and invertebrates and seawater trials by DWER in an effort to improve water quality and reduce algal blooms.

The bathymetry of the VW wetlands has been mapped (2008) and the hydrodynamics recently modelled by DWER, which is an important contribution to determining, for example, the extent of inundation of the wetlands and adjoining lands at various water levels.

In 2016 the Revitalising Geographe Waterways program provided funding for science, monitoring and modelling for the wetlands. To ensure a collaborative approach to improved science for the Revitalising Geographe Waterways program, a Vasse Wonnerup Science Advisory Group (the 'Science group') was formalised in 2016 to bring together scientists from agencies, catchment groups and universities. The Science group undertook priority research and monitoring projects outlined in the *Catchment to Coast science, modelling and monitoring plan 2016–2019* (DWER 2017) to inform the operational plan (see Appendix 5).

Research projects undertaken in the Vasse-Wonnerup wetlands as part of the *Catchment to Coast science, modelling and monitoring plan* include:

- Sediment removal feasibility study (DWER)
- Vasse Estuary oxygenation trial (DWER)
- Vasse Estuary sea water inflow trial (DWER)
- Fine scale vegetation mapping (DBCA)
- Hydrodynamic model (DWER)
- The integrated ecological monitoring program (DWER, DBCA, Murdoch University).

These studies have contributed to our knowledge of the system and of the relationship between water levels, water quality, sediments, aquatic macrophytes, macroinvertebrates, fish and waterbirds. The continuation of scientific research to improve on our understanding in this dynamic system is essential to the future management and protection of key values and the Ramsar status of the wetlands. We can use the knowledge from these research programs to help review and update the Vasse-Wonnerup System Ramsar site's 'Limits of Acceptable Change' and the Ramsar Information Sheet (Mgt action 1.4 under **1.3 Ecological characteristics of the Ramsar site**) and develop 'trigger and response' values for the Science and Monitoring plan (Mgt action 2.1 under **6. Research and monitoring**).

Additional research and monitoring projects have been carried out in the broader catchment in an effort to reduce nutrients entering our waterways and therefore reduce nutrient enrichment of the wetlands. GeoCatch and industry groups, along with farmers are working together to reduce nutrient runoff from farms. Projects have included soil amendment trials, dairy effluent management, fertiliser management, fencing and restoring native riparian vegetation. More information on these projects is available on the Revitalising Geographe Waterways website at: rgw.dwer.wa.gov.au.

Other research projects related to the Vasse-Wonnerup wetlands include three SWCC led research projects as are part of the South West Catchment Council Research Node (SWCC 2018) for the Vasse Wonnerup Wetlands. These projects explore:

- Composition of organic matter and nutrient sources contributing to the Vasse Wonnerup wetland system - 'where nutrients come from' (Edith Cowan University).
- A snapshot of the trophic relationships between key bird, fish and invertebrate species in the Vasse-Wonnerup wetland system - identifying 'who eats what in the system' by creating a predictive food web (Murdoch University).
- Further understanding of community values, perception and attitudes and adaptive management in the Vasse-Wonnerup wetland system - 'how the community values the Vasse-Wonnerup wetland system' (Murdoch University).

The department has provided support for the research projects outlined above and will continue to support future management-related research investigations. Research protocol for conducting research in the Vasse-Wonnerup wetlands, Wonnerup Inlet or lower Vasse River wetlands is provided under Appendix 6.

6.2. Monitoring

Historically, monitoring as part of scientific investigations on the Vasse-Wonnerup wetlands have had a strong evaluation and management focus. In the 1970s and 1980s waterbird monitoring surveys were conducted to determine the species that frequent the Vasse-Wonnerup wetlands, their numbers and breeding activity, and the seasonal changes, with the nomination of the Vasse-Wonnerup wetlands in 1990 as a Ramsar site being based on this data. In 1998-2000 waterbird monitoring was conducted to determine whether the Vasse-Wonnerup wetlands still met criteria for Ramsar listing. Monthly waterbird monitoring was conducted from January 2015 to December 2018 to evaluate the Vasse-Wonnerup wetlands' continuing accreditation for Ramsar status.

Continuous water level monitoring of the estuaries was commenced in 1992. Following a fish kill in February 1997, the history of management of the surge barriers, sand bar openings, water levels and fish kills was investigated and documented (Lane *et al.* 1997). One of the recommendations from the VETWG report (Lane *et al.* 1997) was implementing routine monitoring of water quality, microalgae and fish behaviour in the lower reaches of Vasse-Wonnerup wetlands, which was subsequently commenced in 1997-98.

Routine monitoring of water quality and phytoplankton by DWER is conducted at four sites within the Wonnerup Estuary, six sites within the Vasse estuary, and four sites within the Vasse Estuary exit channel and Wonnerup Inlet. Estuary sites are sampled monthly in winter and fortnightly in summer, while the exit channel and inlet sites are sampled more regularly, with sampling twice a week in summer. Water samples are collected for nutrient analysis and vertical profiles of physical parameters, including salinity and dissolved oxygen are also collected. Specific details of the monitoring program are provided in DWER's Sampling and Analysis Plan. At each site, water samples are also collected for phytoplankton identification and counting undertaken by DWER's Phytoplankton Ecology Unit. Data loggers monitoring salinity, temperature and dissolved oxygen are deployed and maintained by DWER at two locations in the Vasse Estuary exit channel upstream of the surge barrier (this data is available live on the DWER website) and one location downstream.

Annual surveys of submerged aquatic plants were commenced in 2006 by Murdoch University's Marine and Freshwater Research Laboratory in response to concerns of major macroalgal blooms over summer months. The annual snapshots have monitored aquatic plant species and biomass, phytoplankton, water quality and sediment characteristics (Chambers *et al.* 2009, 2010, 2011, 2013a, 2013b, 2014, 2015; Wilson *et al.* 2007, 2008).

Monitoring projects undertaken during 2016 – 2019 as part of the *Catchment to Coast science, modelling and monitoring plan* include:

- Integrated Ecological Monitoring Program (Science group)
- Monthly Waterbird Monitoring Program (DBCA)
- Fish Movement (Murdoch University)
- Fish passage through the Vasse surge barrier (Murdoch University)
- Black bream monitoring program (Murdoch University)
- Annual macrophytes monitoring (Murdoch University).

The future monitoring requirements for the Vasse-Wonnerup wetland system include monitoring for:

- key values, especially Ramsar values (waterbirds)
- key environmental/ecological parameters, principally water levels and salinities
- other environmental/ecological parameters, principally food supply, oxygen concentration and toxic algae
- potentially detrimental activities, principally water-based recreational activity.

The details of the requirements listed above will be included in the Science and Monitoring Plan (also to include science methodology, and defining ecological indicators and targets), which is under preparation — to replace Appendix 5 in the final operational plan. This science and monitoring plan will be implemented and periodically reviewed (every five years).

Monitoring water levels

The water levels of the Vasse-Wonnerup wetlands are actively managed and, together with salinity levels, are critically important in determining the suitability of the wetlands for waterbirds. The survival of fringing vegetation and the health of adjoining pastures are also dependent upon appropriate management of water levels and salinities in the wetlands. Water levels may change significantly in a matter of hours (e.g. due to strong winds) or days (due to flows). The wind direction and strength results in water tilting and water movement, which has an impact on water levels of the wetlands, salt on private property and changing conditions for waterbirds. At the moment DBCA monitors at one place; it would be ideal to install additional loggers at multi-points (e.g. north, south, west and east) to monitor the changes in water levels from water tilting and water movement.

The water level in the lower Vasse River wetlands (Ford Road to the check structure at the Old Butter Factory) is continuously monitored by DBCA by means of a low cost logger, with data downloaded at approximately six-monthly intervals. This monitoring was initiated in 1999 and still continues to maintain appropriate water levels for the survival of the melaleucas of the lower Vasse River wetlands and the suitability of this area for waterbird breeding. Upgrading this monitoring equipment to provide continuous real-time data availability will be considered during the term of the plan.

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
1. Undertake research projects to improve understanding of the wetland system and inform management.	1.1. Continue to undertake research to identify an optimal and achievable water level management regime for maintaining and enhancing Ramsar values of the wetland system. (**DBCA**, DWER, Science community) 1.2. Identify the potential risks of climate change to the wetland system. (**DBCA, DWER**, Science community) 1.3. Co-ordinate implementation of the access protocols for undertaking research in the Vasse-Wonnerup wetlands, Wonnerup Inlet or lower Vasse River wetlands — Appendix 6. (**DBCA**, DWER, Science community) 1.4. Implement monitoring recommendations of the *Sediment Investigations of the Vasse Estuary Exit Channel* report (*in preparation*) for the Vasse Estuary exit channel. (**DWER**, DBCA, WC, City)
2. Monitor the ecological health of the wetland system, through developing and maintaining effective monitoring programs.	2.1. Develop, implement and periodically review (every five years) the Science and Monitoring Plan for key values, management issues and water levels in the plan area. (**VWWP**, Science community)
3. To ensure the research and monitoring undertaken in the wetlands is integrated into future management actions.	3.1. Ensure science and monitoring findings are reported to key agency partners for discussion and action. (**VWWP**, DWER, DPIRD, City, WC) 3.2. Periodically review (every five years) management actions in the light of research and monitoring results. (**VWWP**, Science community) 3.3. Identify opportunities for funding on-going monitoring of the wetlands. (**VWWP**, GeoCatch) 3.4. Prepare the Vasse-Wonnerup System Ramsar report card [against the Ramsar criteria and the 'Limits of Acceptable Change'] every three years, and publish it on DBCA and Revitalising Geographe Waterways websites. (**DBCA**, key stakeholders) 3.5. Review the findings/recommendations of the three SWCC led research projects and review the operational plan's management actions in the light of the research results. (**SWCC**, DBCA, DWER) 3.6. Upload research and monitoring reports onto the Revitalising Geographe Waterways website and promote research findings to the community. (**GeoCatch**, DBCA, DWER, Science community)

7. Managing resource use and development

7.1. Mining and extraction of basic raw materials

Exploration, extraction and rehabilitation activities are approved and largely governed by other government agencies under legislation such as the *Environmental Protection Act 1986*, *Mining Act 1978* and state agreements. The Department of Mines, Industry Regulation and Safety is the State's lead agency for related assessment and approvals under the Mining Act.

Any proposed adjacent mining activities will require the establishment of adequate buffers and setbacks to the plan area in accordance with the *Busselton Wetlands Conservation Strategy* (WAPC 2005), *Guidance Statement No. 33: Environmental Guidance for Planning Development* (EPA 2008) and any future policies on buffer requirements.

There is one tenement issued under the Mining Act across the plan area and one active mine adjacent to the plan area (development approval for an extractive industry (limestone) and crushing facility at lot 3 (130) & lot 237 Ludlow Park Road, Wonnerup). Also, historically sections of the Wonnerup Coastal Reserves were mined for mineral sands (City of Busselton 2016a).

It is the department's preference that basic raw materials such as gravel, shale, clay, sand, limestone are sourced from outside of the plan area. When this is not feasible, the department will consider access to basic raw materials on the basis that it is for use within the boundary of the reserve/park. The department will ensure that all basic raw material removals from lands vested in the Commission will comply with relevant legislation, policies and guidelines.

7.2. Other resource use

Development

The population growth of the Busselton-Vasse urban area is projected to more than double by 2050 (City of Busselton 2016c). In line with this expected growth the housing supply will be sustained through infill development, development of existing zoned land and planned urban areas (i.e. Yalyalup East, Bovell and Ambergate North) (City of Busselton 2016c).

To assist strategic planning for the Busselton area's future transport needs and to identify forecast traffic congestion, the City commissioned a Busselton Traffic Study (Arup 2015). The project report identified several short and long term options for upgrades to the local road network upgrade[35], including duplication of Causeway Road and bridge, and development of Eastern Link and Ford Road. The road projects will likely require referral to the WA's EPA and Commonwealth DEE and formal assessment of the projects may be undertaken.

To protect the key values of the plan area, the department will provide advice on development proposals (including subdivisions and other development proposals) in relation to their potential adverse impacts to the plan area, such as impacts to: geological and hydrological features, soils, surface water movement and quality, and native vegetation and waterbird habitat. To further protect the key values, proposed adjacent developments require

[35] Information on the proposed local road network upgrades are available on the City's website: busselton.wa.gov.au/Developing-Busselton/Priority-Projects/Local-Road-Network-Upgrades

the establishment of adequate buffers and setbacks in accordance with the *Busselton Wetlands Conservation Strategy* (WAPC 2005), *Guidance Statement No. 33: Environmental Guidance for Planning Development* (EPA 2008) and any future policies on buffer requirements.

Agriculture

The catchment, including the Busselton area, has been extensively cleared and developed for agricultural activities such as grazing of beef cattle and dairy farming and horticulture, and is becoming rapidly more urbanised. Modelling of the catchment has showed that excessive amounts of nutrients are generated from the agricultural activities and urban areas and these nutrients are impacting the condition of downstream water assets such as the Vasse-Wonnerup wetland system and lower Vasse River.

Any changes of land use or land-use intensification in the catchment will require an assessment to identify and subsequently minimise any potential adverse impacts on the wetland system. One such change of land use has been the shift of from agriculture (e.g. beef and dairy farming) to horticulture (e.g. increase in avocado farms due to increasing demand).

It is expected that urban growth and agricultural intensification will continue in the future, and potentially increase nutrient loads and impact water quality. It is important to update or use planning tools (e.g. Urban Nutrient Decision Outcomes (UNDO) tool, water sensitive urban design approach, or nutrient and irrigation management plans) to assist in minimising nutrient increases from future development.

Commercial fishing

Commercial fishing occurs within the Vasse-Wonnerup wetland system[36] and all commercial fishers require a commercial fishing licence and fishing boat licence to operate. There are restrictions on the equipment that can be used and fishers are required to attend their nets at all times, to help prevent entanglement of waterbirds and other native animals.

Seven commercial fishers are currently able to fish from boats in the area (Fletcher and Santoro 2015). Beach-based commercial fishing also operates from City-managed Wonnerup coastal reserves and fishers are allowed access for this purpose (City of Busselton 2016a).

Access through department-managed lands is to be in accordance with the department's *Corporate Policy Statement No. 39: Access for commercial fishing* (2016), which states "*in general, the existing right of access will be maintained unless problems related to environmental degradation, unacceptable impacts to cultural heritage sites or values, or conflict with visitor access and use occur*".

Commercial fishing undertaken within the plan area is likely to result in a bycatch of native fauna and possible conflicts between the activity and the key values of the plan area. On the basis of the likely disturbance of the conservation values of the wetlands (in particular upstream of the surge barriers), the department considers that commercial fishing licences upstream of the Vasse and Wonnerup surge barriers should reviewed, and if possible restricted, at the first available opportunity.

[36] For information on commercial fishing within the City-managed Wonnerup coastal reserves area (e.g. Deadwater and Wonnerup Inlet) refer to the *Wonnerup Coastal Reserves Management Plan* (City of Busselton 2016a).

While commercial fishing licences remain in the plan area, as part of its responsibilities DPIRD undertakes regular compliance checks, enforcement, management, research, surveillance and education.

Beekeeping

There is one current apiary site, classified as 'highly constrained', within the plan area (i.e. Tuart Forest National Park). The site has been assessed in accordance with the department's *Corporate Policy Statement No. 41: Beekeeping on Crown land* (2017). The conditions placed on the permit may render the existing site unviable for use by commercial beekeepers and there are no suitable locations within the plan area to relocate sites. To address this, the department will negotiate with the beekeeper to identify replacement sites outside the plan area.

Utilities

Infrastructure such as electricity, water, gas and telecommunication lines is placed on road reserves, easements or underground in the plan area (e.g. Busselton Water's water main is located within the Ford Road reserve).

This plan provides for continuation of existing utility and service arrangements. The maintenance of existing infrastructure must consider sensitive sites such as TECs, fauna breeding areas and cultural significance. Access, particularly in low lying wetlands, can lead to the spread of weeds and disease; therefore appropriate hygiene practices must be employed.

Utility providers need permission from the relevant DBCA District Manager for access to department-managed land. This permission will include conditions of entry and operation for the maintenance of infrastructure, including during emergencies.

Any proposed utilities or services need to be located to minimise impacts on the plan area's key values, including visual amenity. To limit these impacts, the department prefers that utility infrastructure that is not servicing the plan area itself be located outside the plan area. When this is unavoidable, the use of already degraded areas, pre-existing corridors or co-location with existing infrastructure is preferred.

Management objectives	**Management strategies/actions** (**Lead agency** [**in bold]** and support agency [not in bold])
1. Identify and minimise any potential adverse impacts to the key values of the plan area from future development proposals, agricultural intensification, mining, and changes of land-uses on adjoining lands and in the catchment.	1.1. Assess future subdivision, mining and development proposals and ensure appropriate conditions (e.g. protection and retention of native vegetation, revegetation and wetland management plans) are applied to the proposals to minimise any adverse impacts on the wetland system. (**City**, DPLH, DBCA, DWER, DPIRD) 1.2. Work with agency partners to identify and minimise any potential adverse impacts on the wetland system from significant land use changes in the catchment. (**DBCA**, DWER, DPIRD, City)
2. Minimise the impacts of commercial fishing on the Vasse-Wonnerup wetland system.	2.1. Review current commercial fishing management arrangements with a view to implementing new management arrangements that will minimise the bycatch of native fauna, in consultation with agency partners and stakeholder groups. (**DPIRD**, DBCA)

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Map 1a - Plan area

Legend

- Plan area boundary
- Nature reserve
- CALM Act sections 5(1)(h) reserve
- National Park
- Unallocated Crown land
- Other Crown reserve
- Crown freehold - department interest
- Roads
- Major hydrography

N

0 2 4 6 8km

Scale

Geographe Bay

Buttercup Road (proposed)

ROAD

NORTH ROAD

Swan Lake

R 44838

Ludlow River

LUDLOW DRIVE

Wonnerup Estuary NR R 44838

BEACH

Wonnerup Estuary

5595

The Deadwater

R 31913

Inset D

R 385 Lot 93

FORREST

2

TUART

R 40373 Lot 95

R 385 Lot 94

Wonnerup surge barriers

R 40250 Tuart Forest NP

R 5217

ROAD

R 22952 Lot 72

R 41568

Vasse surge barriers

LAYMAN

R 40356 Lot 5541

Creek

HIGHWAY

Vasse Estuary exit channel

R 22952 Lot 112

LAYMAN

R 44330 Lot 96

Vasse Islands

Malbup

Inset B

Inset C

R 31188

R 40250 Tuart Forest NP

DRIVE

R 50270

RUABON ROAD

R 40250 Tuart Forest NP

UCL PIN 527032 1.4 ha

ROAD

BUSSELL

R 31188 Sabina NR

Vasse Estuary

TUART

R 50017 Vasse Estuary NR

LAYMAN

R 41568

R 49385 Vasse Estuary NR

R 41568

R 31188 Sabina NR

WONNERUP

BUSSELTON

PEEL TERRACE

R 31188 Sabina NR

Abba

CAUSEWAY

Inset A

BYPASS

River

SUES

SOUTH

Vasse

ROAD

VASSE HIGHWAY

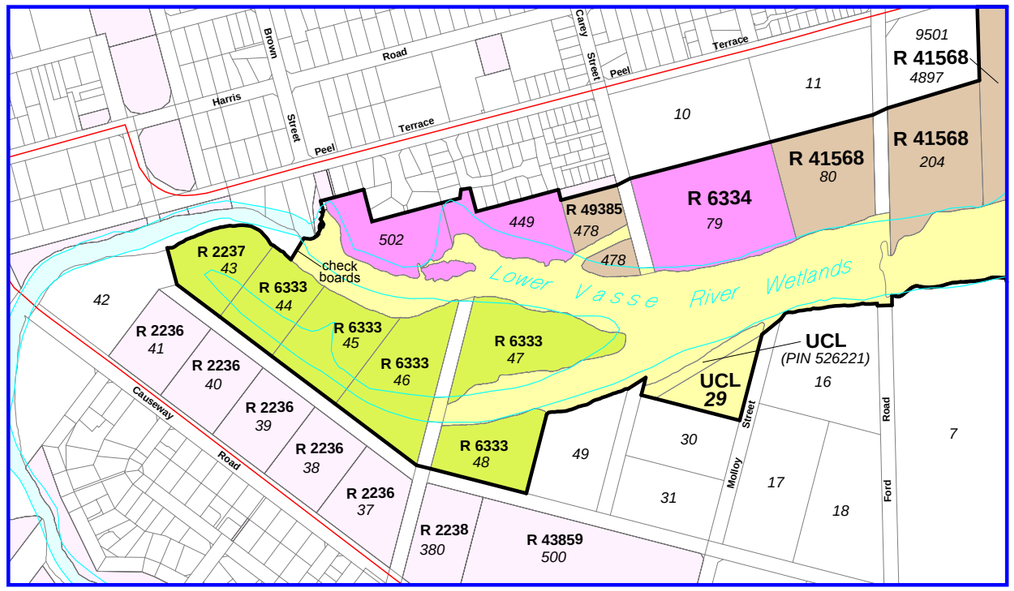
Sabina River

ROAD

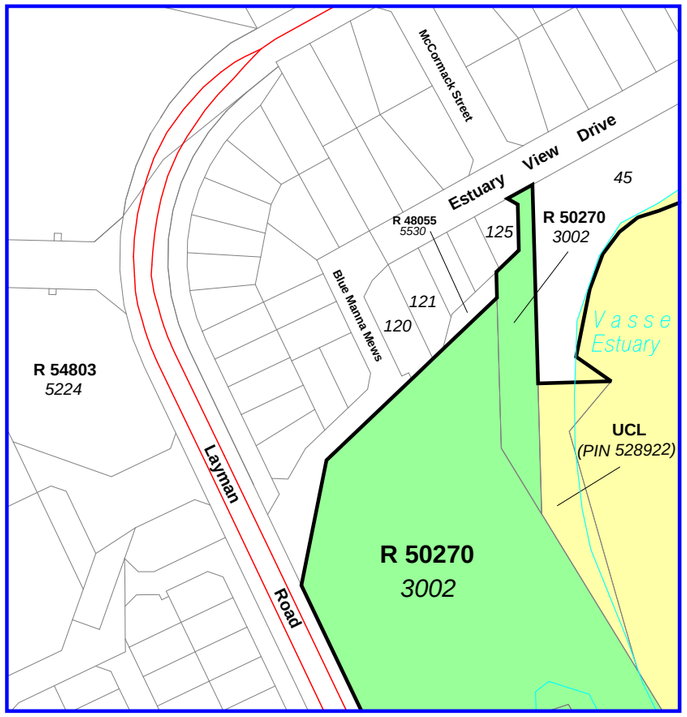
ROAD

BUSSELTON

River



Inset A



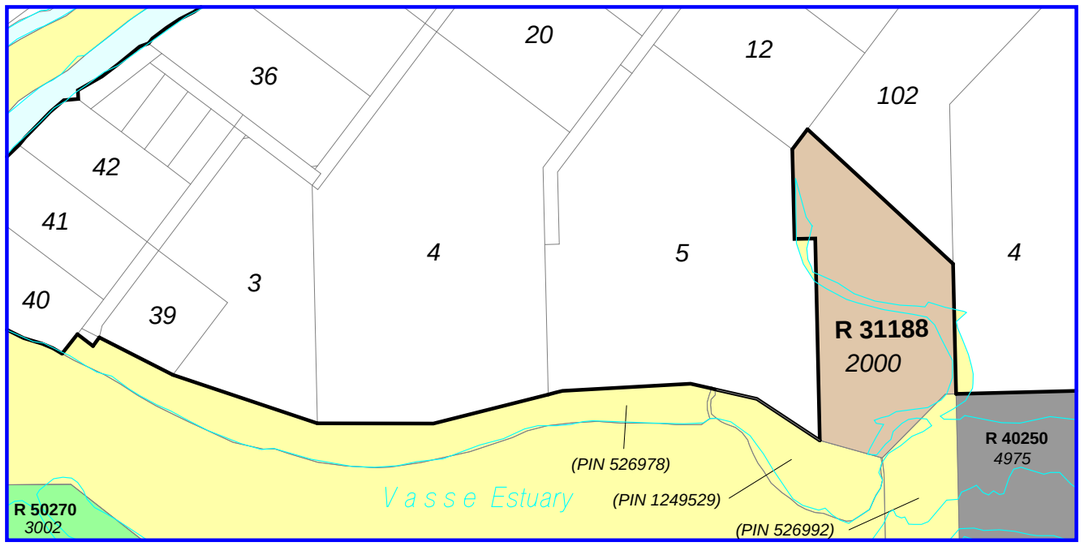
Inset B

Legend

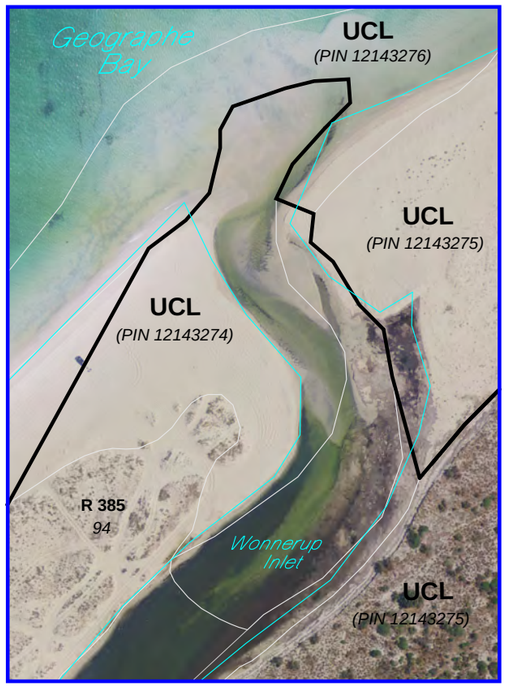
- Plan area boundary
- National Park
- Nature Reserve
- CALM Act section 5(1)(h) reserve
- Unallocated Crown land
- Crown reserve (LGA)
- Crown reserve (unmanaged)
- Major roads
- Major hydrography

Maps are not to scale

Inset C



Inset D



Map 2 - Vegetation communities

Legend

Plan area boundary

Vegetation communities* (vegetation types based on dominant species)

- Samphire shrublands: *Sarcocornia* dominated vegetation
- Samphire shrublands: *Tecticornia* dominated vegetation
- Typically *Sarcocornia* dominated vegetation, but has become weed invaded
- Dune plants: coastal health species associated with the Quindalup dune landform
- Flooded gum *(Eucalyptus rudis)*
- *Melaleuca* spp.: *M. rhaphiophylla, M. viminea* or *M. cuticularis*
- Peppermint *(Agonis flexuosa)*
- Sea rush *(Juncus krausii)*
- Tuart *(Eucalyptus gomphocephala)*
- Other vegetation: includes native species *Acacia saligna, Bolboschoenus caldwellii, Eucalyptus cornuta* and *Gahnia trifida;* weed species *Cares Divisa, Pennisetum clandestinum, Stenotaphrum secundatum* and *Typha orientalis*

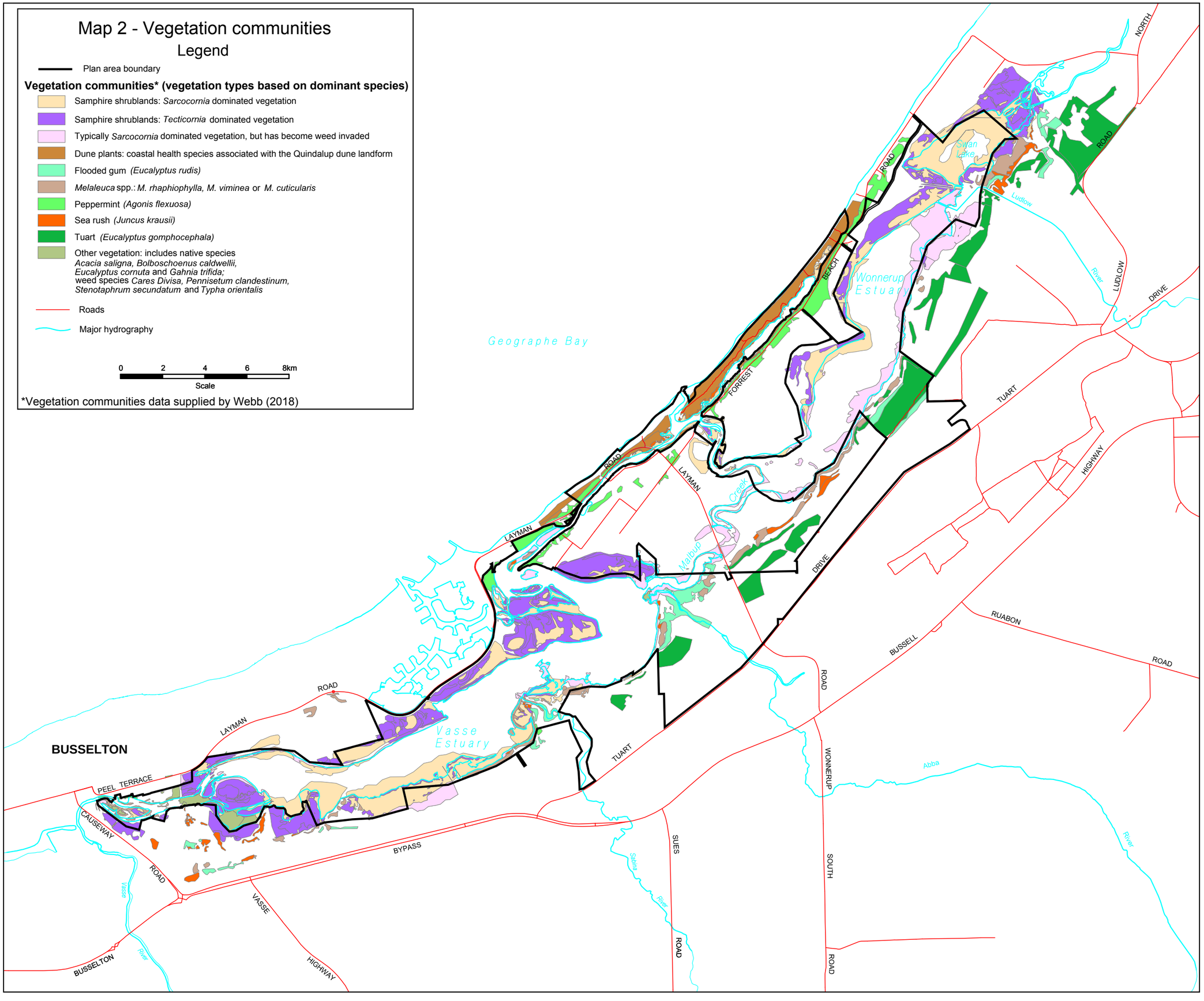
Roads

Major hydrography

0 2 4 6 8km

Scale

*Vegetation communities data supplied by Webb (2018)



Map 3 - Recreation sites and public access

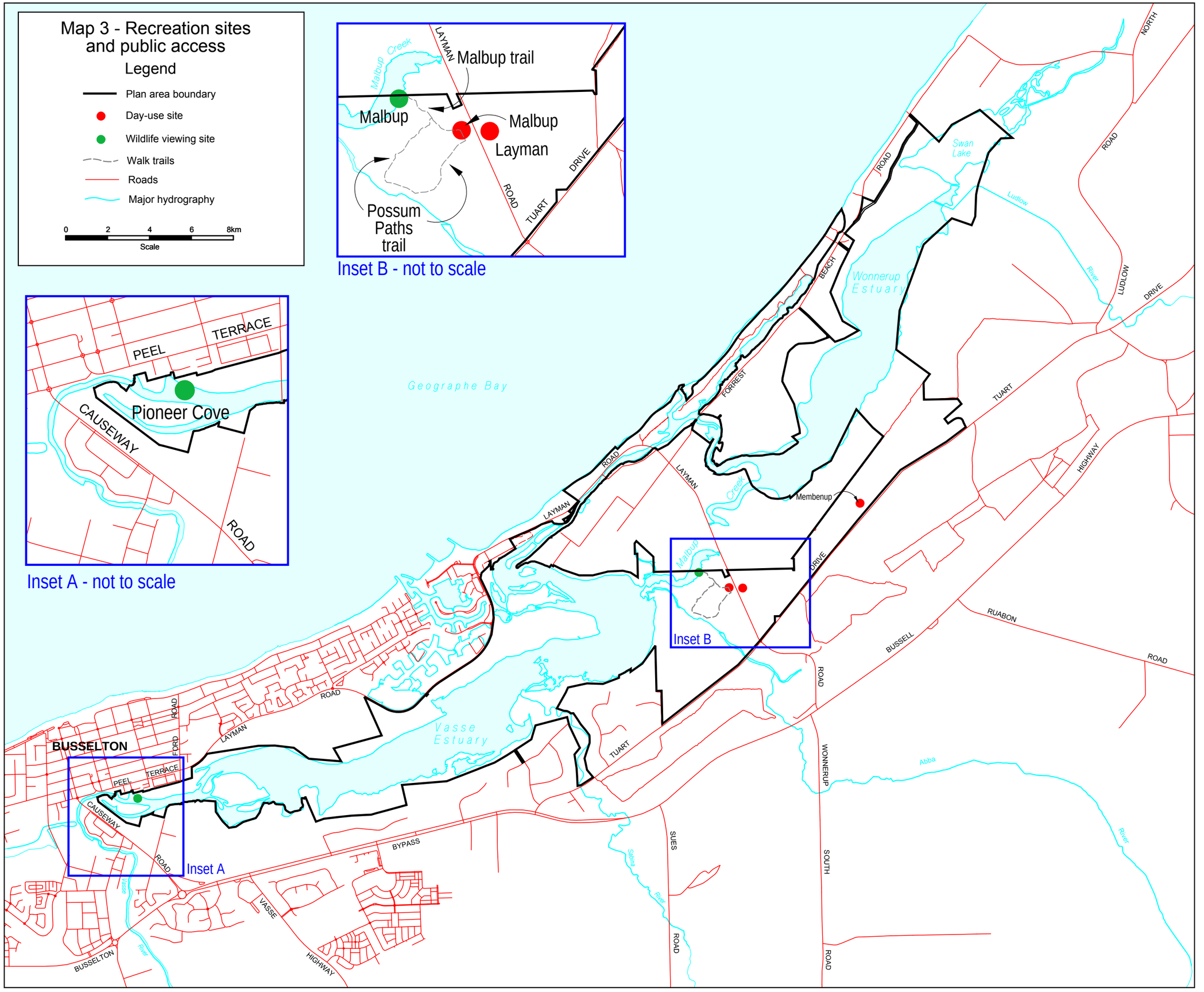
Legend

- Plan area boundary
- Day-use site
- Wildlife viewing site
- Walk trails
- Roads
- Major hydrography

0 2 4 6 8km
Scale

Inset B - not to scale

Inset A - not to scale



Appendices

Appendix 1: Existing lands of the plan area

Reserve name / tenure	Reserve number/ Identifier	Purpose	Vesting	Class ^	Area (ha)#
Unallocated Crown land (UCL) (part of the lower Vasse River wetlands - check structure at the Old Butter Factory to Ford Road)	Part PIN 11725413	Water feature	N/A	N/A	9
Crown Reserve (part of the lower Vasse River wetlands)	R 2237 (Lot 43)	Railway	Unvested - unmanaged	U	1
Crown Reserve (part of the lower Vasse River wetlands)	R 6333 (Lots 44-48)	Railway	Unvested - unmanaged	U	7
UCL	PIN 526221	N/A	N/A	N/A	0.3
UCL	PIN 526222 (Lot 29)	N/A	N/A	N/A	0.7
Crown Reserve	R 35490 (Lots 502 and 449)	Drainage and Public recreation	City of Busselton	U	1
Vasse Estuary Nature Reserve*	R 49385 (Lot 478)	Conservation of flora and fauna	Conservation and Parks Commission	U	1
Crown Reserve	R 6334 (Lot 79)	Water supply	City of Busselton	U	3
Vasse Estuary Nature Reserve*	R 50017 (Lot 80)	Conservation of flora and fauna	Conservation and Parks Commission	A	2
UCL[1] (Vasse & Wonnerup estuaries – waterbodies upstream of the surge barriers)	N/A	N/A	N/A	N/A	700
Wonnerup Nature Reserve*	R 41568 (Lots 204, 4897 and 3)	Conservation of flora and fauna	Conservation and Parks Commission	U	25
Un-named 5(1) (h) reserve	R50270 (Lots 3001, 3002, 5025, and 301)	Conservation	Conservation and Parks Commission	U	120
UCL	PIN 528922	N/A	N/A	N/A	0.3
Crown Reserve (James Richardson Park)	R 44330 (Lot 96)	Public recreation	City of Busselton	U	0.5
UCL	PIN 528953	N/A	N/A	N/A	0.1
UCL[1] (Vasse islands)	PIN 528963 PIN 528966 PIN 528967	N/A	N/A	N/A	6
Crown Reserve (Captain Baudin Park)	R 22952 (Lots 112 and 72)	Camping and Recreation	City of Busselton	C	5
UCL	PIN 1375180 PIN 1249530	N/A	N/A	N/A	0.4
UCL	PIN 528971	N/A	N/A	N/A	0.9

Reserve name / tenure	Reserve number/ Identifier	Purpose	Vesting	Class ^	Area (ha)#
Sabina Nature Reserve	R 31188 (Lots 126, 4564, 4646 and 5205)	Conservation of flora and fauna	Conservation and Parks Commission	A	115
UCL	PIN 527032	N/A	N/A	N/A	1
Tuart Forest National Park	Part R 40250 (Part Lot 4975)	National Park	Conservation and Parks Commission	A	311
Crown Freehold[1]	PIN 527052 (Lot 2 on Plan 3280)	N/A	N/A	N/A	40
UCL	PIN 526992	N/A	N/A	N/A	3
UCL	PIN 1249529	N/A	N/A	N/A	2
UCL	PIN 526978	N/A	N/A	N/A	5
Sabina Nature Reserve	R 31188 (Lot 2000)	Conservation of flora and fauna	Conservation and Parks Commission	A	8
Crown Reserve (Wunda Buri Reserve)	R 5217 (Lot 57)	Camping; Recreation	City of Busselton	A	10
Crown Reserve (Whalers Reach Reserve)	R 40373 (Lot 95)	Public recreation	City of Busselton	C	1
Crown Reserve (Lesueur Reserve)	R 385 (Lots 93 and 94)	Camping and Recreation	City of Busselton	A	21
Crown Reserve (Heirisson Reserve)	R 40356 (Lot 5541)	Public recreation	Unvested - unmanaged	N/A	1
UCL (Wonnerup Inlet - waterbody downstream of surge barriers to the coastline)	N/A	N/A	N/A	N/A	11
Crown Reserve (includes the Deadwater)	R 39193 (Lot 4805)	Recreation and Foreshore protection	City of Busselton	U	63
Wonnerup Estuary Nature Reserve*	R 44838 (Lot 8000)	Conservation of flora and fauna	Conservation and Parks Commission	U	20
Wonnerup Estuary Nature Reserve* (accessway)	R 44838 (Lot 8001)	Conservation of flora and fauna	Conservation and Parks Commission	U	0.4
Wonnerup Estuary Nature Reserve*	R 44838 (Lots 37, 5015 and 5907)	Conservation of flora and fauna	Conservation and Parks Commission	U	102
Road reserve (proposed Buttercup Road)	PIN 12103408	Public road	City of Busselton	N/A	3
Total					**1600.6**

*Provisional name.
^Class: U= Unclassified, A= class 'A' as defined in the *Land Administration Act 1997.*
#Approximate area.
[1]Proposed addition to conservation estate as recommended by *Forest Management Plan 2014–2023* (Conservation Commission 2013)

Appendix 2: Surge barrier operating guidelines

The 1990 guidelines for operating the floodgates and managing the sand bar (Lane *et al.* 1997, pages 39-40) - this document is currently under review (i.e. referred as the updated Surge Barrier Operating Guidelines).

The 1990 guidelines for operating the floodgates and managing the sand bar.

The Water Authority's "Update to Hand Book of Basic Data" (August 1990) reads as follows with respect to operation of the floodgates and management of the sand bar at the mouth of Wonnerup Inlet.

2.9 Vasse and Wonnerup Floodgates

2.9.1 General

"The Vasse and Wonnerup floodgates protect the low lying agricultural land surrounding the Vasse and Wonnerup Estuaries from flooding with sea water".

"They also have a check board facility on each flood-gate to allow fresh water to be retained at the end of winter to control the drop in water table on these flats. This is done to maintain water in the estuary system for as long as possible and to hold back any summer run-off".

"Due to high temperatures and low levels in the estuaries, there is a strong possibility that fish fatalities will occur in the Vasse estuary and between the floodgates if the bar is closed, with resultant criticism of the Authority".

"The Authority's major obligation is the interest of the drainage ratepayers and this will be the overriding consideration. It will however, be necessary to take action to facilitate better environmental management where the interest of the ratepayers can be protected".

2.9.2 Maintenance

"The gates must be lifted each year and scraped clear of marine growth and any corrosion on steel work protected. The structures should be annually sprayed for protection against white ants and fire".

2.9.3 Operation

2.9.3.1 WINTER

"Immediately after the first rains produce run-off, the boards can be removed. To prevent vandalism, these boards should be stored in the Depot."

"Due to the fact that the ocean outlet for these two structures will block easily, it may be necessary to open this bar by mechanical means on several occasions throughout the winter. Experience has shown that to attempt to open the bar without sufficient head is a waste of time, and the gauge board at the Vasse Floodgate should attain a reading of at least 0.7m AHD, or the attempt will probably fail (unless the sea is extremely quiet with low tides. This is unlikely at times when the bar is blocked and the Estuaries are between 0.4m and 0.7m AHD in height)".

"Before the run-off has finished for the season, it is necessary to fix the stopboards to a height of 0.40m AHD so that the fresh water is retained, to facilitate the breeding of waterfowl. (It is desirable - but difficult - to keep the water at 0.40m AHD)".

2.9.3.2 SUMMER

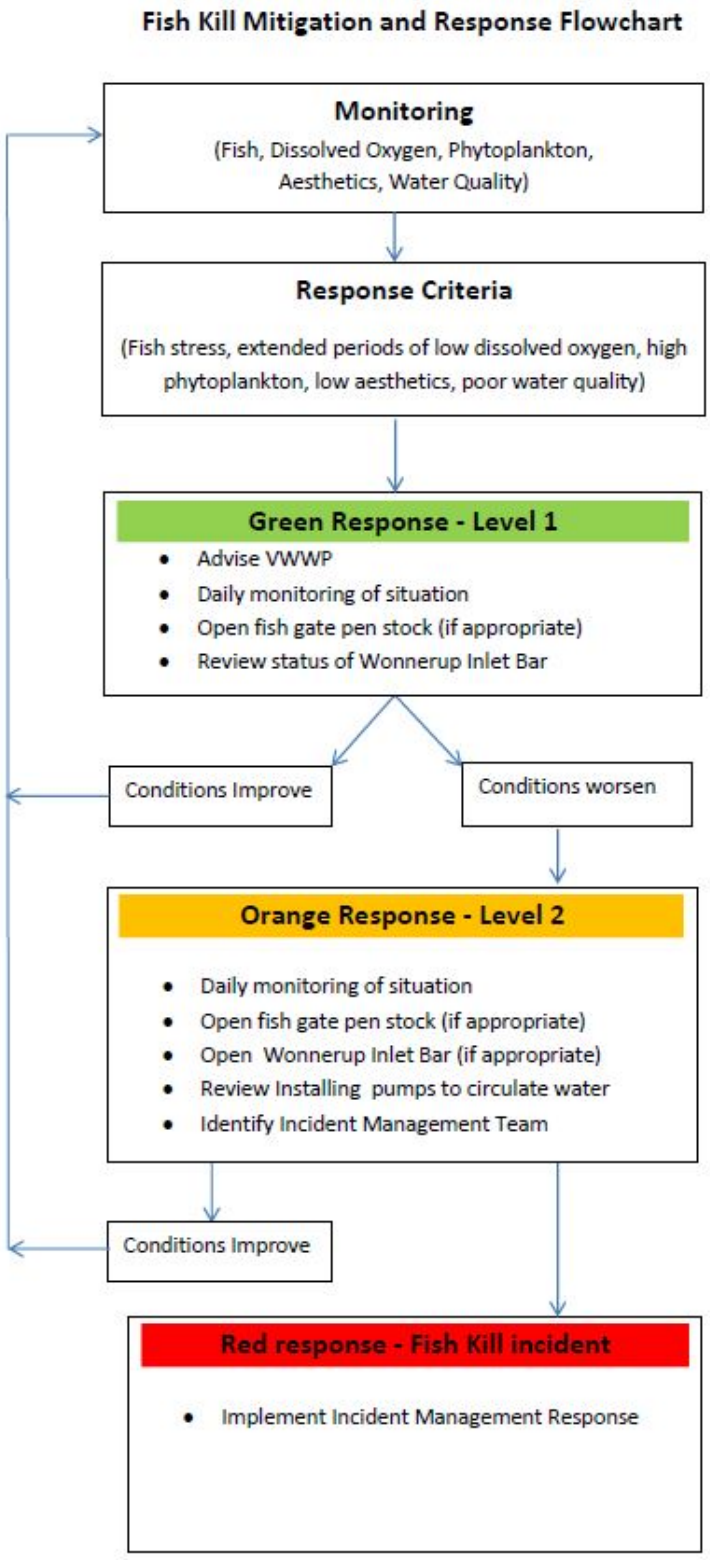
"The water levels should be monitored at the Vasse Floodgates on a minimum monthly basis until the level reaches 0.1m AHD and then on a minimum weekly basis. If three consecutive

days of temperatures in excess of 30 degrees occur, preparation should be made to allow fish to pass through the gates if they show any signs of stress (swimming on surface)".

"When the level reaches -0.1m AHD, farmers on the Vasse estuary should be notified and the gates opened to maintain the level at -0.1m AHD".

Appendix 3: Fish kill mitigation and response flowchart

The current fish kill mitigation and response plan process is outlined in the 'Fish kill mitigation and response flowchart'. This flowchart (or trigger and response procedure) is annually reviewed and revised to include new science information to improve the procedure and to reduce the incidence of fish kills.



Appendix 4: Migratory shorebirds and conservation status

Migratory shorebirds (also known as 'waders') that have been recorded on the Vasse-Wonnerup wetlands and are listed under international conservation agreements[37], and their conservation status.

Current Scientific Name (Listed Scientific Name)	Common Name	*Bonn	CAMBA	JAMBA	ROKAMBA	Conservation status – State[38] (Commonwealth EPBC Act)
Limnodromus semipalmatus	Asian dowitcher	A2H	Listed	Listed	Listed	Migratory (Marine; migratory)
Hirundo rustica	barn swallow		Listed	Listed	Listed	Migratory (Marine; migratory)
Limosa lapponica	bar-tailed godwit	A2H	Listed	Listed	Listed	Migratory (Marine; migratory)
Sterna sumatrana	black-naped tern		Listed	Listed		Migratory (Marine; migratory)
Limosa limosa	black-tailed godwit	A2H	Listed	Listed	Listed	Migratory (Marine; migratory)
Limicola falcinellus	broad-billed sandpiper	A2H	Listed	Listed	Listed	(Marine; migratory)
Hydroprogne caspia	Caspian tern			Listed		Migratory (Migratory)
Tringa nebularia	common greenshank, greenshank	A2H	Listed	Listed	Listed	Migratory (Marine; migratory)
Anous stolidus	common noddy		Listed	Listed		Migratory (Marine; migratory)
Tringa totanus	common redshank, redshank	A2H	Listed	Listed	Listed	Migratory (Marine; migratory)
Actitis hypoleucos	common sandpiper	A2H	Listed	Listed		Migratory (Marine; migratory)
Actitis hypoleucos (Tringa hypoleucos)	common sandpiper				Listed	Migratory (Migratory)
Sterna hirundo	common tern		Listed	Listed	Listed	Migratory (Marine; migratory)
Calidris ferruginea	curlew sandpiper	A2H	Listed	Listed	Listed	Migratory; Vulnerable (Marine; migratory; critically endangered)

[37] The species currently on the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) migratory species list. Available at: environment.gov.au/sprat (Accessed 25 September 2018).
[38] Threatened species and migratory birds protected under an international agreement as listed under the Wildlife Conservation (Specially Protected Fauna) Notice 2017 (dated 16 January 2018). Available at: dpaw.wa.gov.au/plants-and-animals/threatened-species-and-communities/threatened-animals?view=categories&id=109

Current Scientific Name (Listed Scientific Name)	Common Name	*Bonn	CAMBA	JAMBA	ROKAMBA	Conservation status – State[38] (Commonwealth EPBC Act)
Charadrius bicinctus	double-banded plover	A2H				Migratory (Marine; migratory)
Numenius madagascariensis	Eastern Curlew	A1	Listed	Listed	Listed	Migratory, Vulnerable (Marine; migratory; critically endangered)
Pandion cristatus (Pandion haliaetus)	eastern osprey	A2S				Migratory (Marine; migratory)
Apus pacificus	fork-tailed swift		Listed	Listed	Listed	Migratory (Marine; migratory)
Anas querquedula	garganey	A2H	Listed	Listed	Listed	Migratory (Marine; migratory)
Plegadis falcinellus	glossy ibis	A2S				Migratory (Marine; migratory)
Calidris tenuirostris	great knot	A2H	Listed	Listed	Listed	Migratory; Vulnerable (Marine; migratory; critically endangered)
Charadrius leschenaultii	greater sand plover, large sand plover	A2H	Listed	Listed	Listed	Migratory; Vulnerable (Marine; migratory; vulnerable)
Pluvialis squatarola	grey plover	A2H	Listed	Listed	Listed	Migratory (Marine; migratory)
Motacilla cinerea	grey wagtail		Listed	Listed	Listed	Migratory (Marine; migratory)
Tringa brevipes	grey-tailed tattler	A2H	Listed		Listed	Migratory (Migratory)
Tringa brevipes (Heteroscelus brevipes)	grey-tailed tattler			Listed		Migratory (Marine; migratory)
Gallinago hardwickii	Latham's snipe, Japanese snipe	A2H		Listed	Listed	Migratory (Marine; migratory)
Charadrius mongolus	lesser sand plover, Mongolian plover	A2H	Listed	Listed	Listed	Migratory; Endangered (Marine; migratory; endangered)
Numenius minutus	little curlew, little whimbrel	A2H	Listed	Listed	Listed	Migratory (Marine; migratory)
Charadrius dubius	little ringed plover		Listed	Listed	Listed	Migratory (Marine; migratory)
Sternula albifrons (Sterna albifrons)	little tern	A2S		Listed	Listed	Migratory (Marine; migratory)
Sternula albifrons	little tern		Listed			Migratory (Migratory)
Calidris subminuta	long-toed stint	A2H	Listed	Listed	Listed	Migratory (Marine; migratory)

Current Scientific Name (Listed Scientific Name)	Common Name	*Bonn	CAMBA	JAMBA	ROKAMBA	Conservation status – State[38] (Commonwealth EPBC Act)
Tringa stagnatilis	marsh sandpiper, little greenshank	A2H	Listed	Listed	Listed	Migratory (Marine; migratory)
Charadrius veredus	oriental plover, oriental dotterel	A2H	Listed	Listed	Listed	Migratory (Marine; migratory)
Glareola maldivarum	Oriental Pratincole		Listed	Listed	Listed	Migratory (Marine; migratory)
Acrocephalus orientalis	oriental reed-warbler	A2H	Listed	Listed		Migratory (Marine; migratory)
Pluvialis fulva	pacific golden plover	A2H	Listed	Listed	Listed	Migratory (Marine; migratory)
Calidris melanotos	pectoral sandpiper	A2H		Listed	Listed	Migratory (Marine; migratory)
Gallinago stenura	pin-tailed snipe	A2H	Listed	Listed	Listed	Migratory (Marine; migratory)
Calidris canutus	red knot, knot	A2H	Listed	Listed	Listed	Migratory (Marine; migratory; endangered)
Sula sula	red-footed booby		Listed	Listed		Migratory (Marine; migratory)
Phalaropus lobatus	red-necked phalarope	A2H	Listed	Listed	Listed	Migratory (Marine; migratory)
Calidris ruficollis	red-necked stint	A2H	Listed	Listed	Listed	Migratory (Marine; migratory)
Cecropis daurica (Hirundo daurica)	red-rumped swallow		Listed		Listed	Migratory (Marine; migratory)
Cecropis daurica	red-rumped swallow			Listed		Migratory (Migratory)
Sterna dougallii	roseate tern		Listed	Listed		Migratory (Marine; migratory)
Arenaria interpres	ruddy turnstone	A2H	Listed	Listed	Listed	Migratory (Marine; migratory)
Philomachus pugnax	ruff (reeve)	A2H	Listed	Listed	Listed	Migratory (Marine; migratory)
Calidris alba	sanderling	A2H	Listed	Listed		Migratory (Marine; migratory)
Calidris alba (Crocethia alba)	sanderling				Listed	Migratory (Migratory)
Calidris acuminata	sharp-tailed sandpiper	A2H	Listed	Listed	Listed	Migratory (Marine; migratory)
Ardenna tenuirostris (Puffinus tenuirostris)	short-tailed shearwater				Listed	Migratory (Marine; migratory)

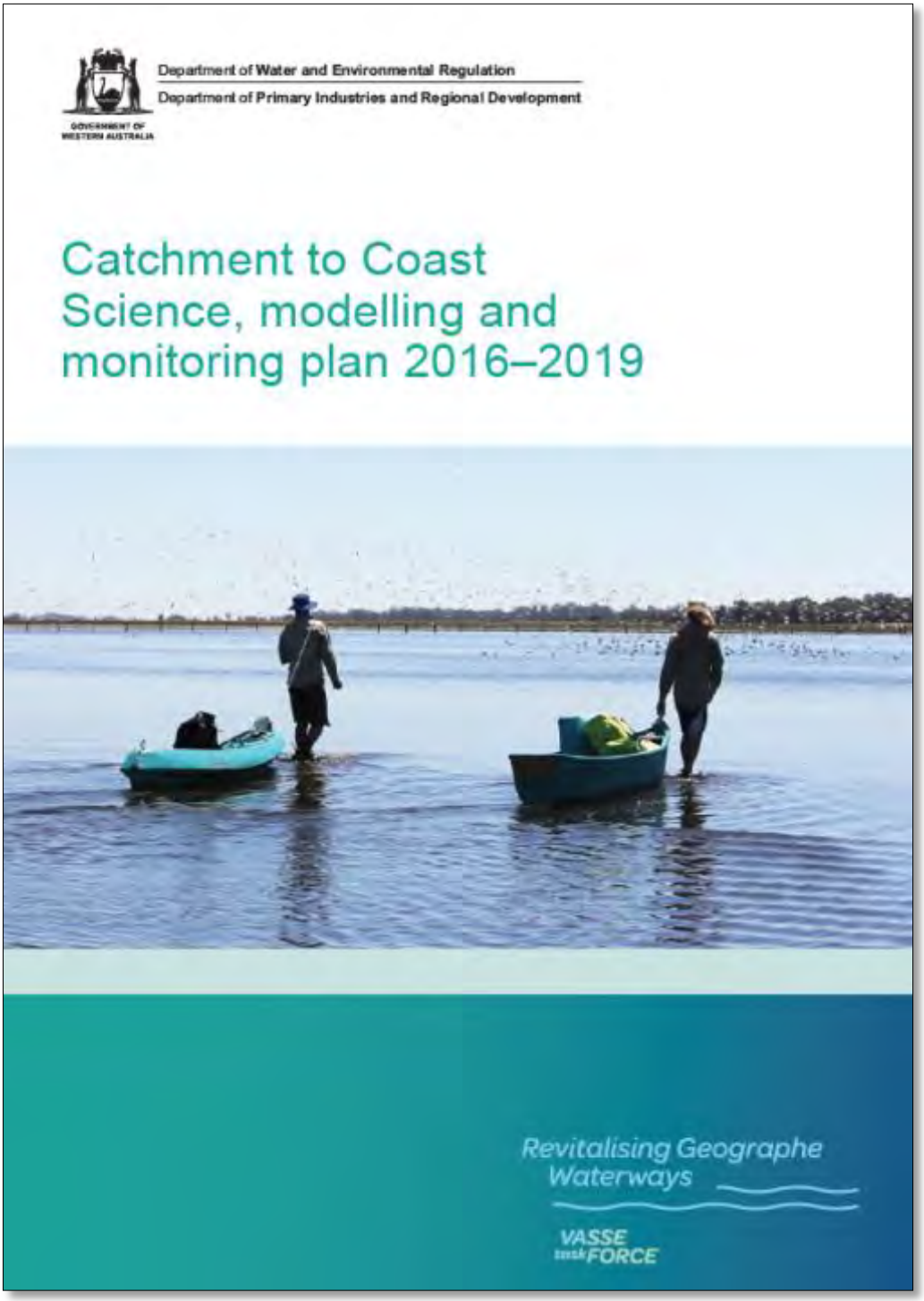
Current Scientific Name (Listed Scientific Name)	Common Name	*Bonn	CAMBA	JAMBA	ROKAMBA	Conservation status – State[38] (Commonwealth EPBC Act)
Ardenna tenuirostris	short-tailed shearwater		Listed	Listed		Migratory (Migratory)
Gallinago megala	Swinhoe's snipe	A2H	Listed	Listed	Listed	Migratory (Marine; migratory)
Xenus cinereus	Terek sandpiper	A2H	Listed	Listed	Listed	Migratory (Marine; migratory)
Tringa incana	wandering tattler	A2H		Listed		- (Migratory)
Numenius phaeopus	whimbrel	A2H	Listed	Listed	Listed	Migratory (Marine; migratory)
Hirundapus caudacutus	white-throated needletail		Listed	Listed		Migratory (Marine; migratory)
Hirundapus caudacutus (Chaetura caudacuta)	white-throated needletail				Listed	Migratory (Migratory)
Chlidonias leucopterus	white-winged tern, white-winged black tern		Listed	Listed		Migratory (Marine; migratory)
Chlidonias leucopterus (Chlidonias leucoptera)	white-winged tern, white-winged black tern				Listed	Migratory (Migratory)
Tringa glareola	wood sandpiper	A2H	Listed	Listed	Listed	(Marine; migratory)

* The following codes are used in the Bonn Convention appendices:

- A1: species listed explicitly in Appendix 1
- A2S: species listed explicitly in Appendix 2
- A2H: species is member of a family listed in Appendix 2.

Appendix 5: Science and monitoring plan

The *Catchment to Coast science, modelling and monitoring plan 2016–2019* (DWER 2017) cover is shown below and the document is available on the Revitalising Geographe Waterways website at: https://rgw.dwer.wa.gov.au/rgw-publications/. A future science and monitoring plan is under preparation and will be included under Appendix 4 in the final operational plan.



Appendix 6: Research protocol

Research Protocol for the Vasse-Wonnerup wetlands, Wonnerup Inlet and lower Vasse River wetlands

Purpose

This research protocol provides guidance to researchers wishing to conduct research on the Vasse-Wonnerup wetlands, Wonnerup Inlet or the lower Vasse River wetlands.

Prior, informed consent

Researchers should obtain, through the Department of Biodiversity, Conservation and Attractions (DBCA) prior informed consent of DBCA before conducting research.

The procedure for obtaining prior informed consent is:

1. The Researcher submits to DBCA a plain English summary of the research proposal including:
    - names and contact details of researchers, institutions and funding partners
    - ethics approval from an authorised ethics committee
    - project description (objectives, methods, significance)
    - sites to be visited on a topographical map that shows recognisable geographical features and detailed locations
    - project timeline and dates and times of planned trips
    - expected publications and outputs
    - intellectual property arrangements.

    The Researcher should submit their research proposal to DBCA allowing sufficient time for it to be considered.
2. The Researcher and DBCA reach agreement on how the research should proceed including methods and processes and timing for informing the community of progress of the research and reporting any interim results.
3. On completion of the research, copies of all results and publications should be submitted to DBCA.

DBCA will provide lawful authority in accordance with regulation 4 of the Conservation and Land Management Regulations 2002 once agreement on the conditions listed above are reached.

Other requirements

- Researchers should incorporate into the project any local research needs where possible.
- Ethics approval: Researchers should obtain approval from an appropriate ethnics committee before commencing the project.
- Methodology: Researchers should provide details of the methodology to be used in the proposed research.
- Access and storage: Researchers should ensure that appropriate procedures are in place for storage and access to the research.
- Professional standards: The Researcher should be a registered member of the relevant professional or industry body and should abide by professional and ethical standards pertaining to their discipline.

Appendix 7: Management objectives and strategies/actions.

1. Introduction - 1.1. Plan area

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
1.Progress the addition of the unallocated Crown land and unmanaged Crown land to the conservation reserve system.	1.1.Progress the proposed reservation of unallocated Crown land and unmanaged Crown land into conservation estate with vesting in the Conservation and Parks Commission, in consultation with native title parties and other relevant stakeholders. (**DBCA**, DPLH, key stakeholders) 1.2.Manage any future additions that are vested in the Conservation and Parks Commission in accordance with the operational plan, and applicable management plans and legislation. (**DBCA**)
2.Opportunities for Noongar people to be trained and employed in conservation and land management activities relevant to the reserves.	2.1.Identify opportunities to provide employment, business and training for Noongar people to assist in maintaining connection to country. (**Key stakeholders**) 2.2.Ensure employment arrangements for Aboriginal employees provide an avenue for them to discuss culturally sensitive matters relating to their employment with their elders. (**Key stakeholders**)

1. Introduction - 1.3. Ecological characteristics of the Ramsar site

Management objective	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
1.To maintain Ramsar wetland status and values.	1.1.Regularly monitor for bird numbers against the Ramsar criteria and the 'Limits of Acceptable Change' (WRM 2007). (**DBCA**) 1.2.Identify specific seasonal threats to the Ramsar values (i.e. meeting the Ramsar criteria to qualify for the Ramsar list) to inform future management actions. (**DBCA**) 1.3.Continue to seek opportunities to undertake research and increase knowledge relating to the retention of the Ramsar values. (**DBCA**, Science community) 1.4.Review and update the Vasse-Wonnerup System Ramsar site's 'Limits of Acceptable Change' and the Ramsar Information Sheet. (**DBCA**, DEE) 1.5. Develop a 'trigger and response' framework to monitor 'limits of acceptable change' of the ecological character of the wetlands. (**Science community**, DBCA) 1.6.Seek funding for a ranger covering the plan area. (**DBCA**)

2. Management directions and purpose

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
1. Seek to increase community awareness, understanding and stewardship of the key values and management issues of the wetland system.	1.1. Ongoing engagement through the Revitalising Geographe Waterways website. (**GeoCatch,** DBCA) 1.2. Prepare and install interpretative and other signage at appropriate sites around the plan area. (**DBCA, City**) 1.3. Prepare, and make available to the community, brochures/fact sheets on the key values and management issues of the wetland system. (**DBCA, City**, GeoCatch, SWCC, DWER) 1.4. Encourage opportunities for citizen science to enhance appreciation, knowledge and understanding of the wetlands. (**DBCA, GeoCatch**, SWCC) 1.5. Establish and support a Vasse-Wonnerup wetlands Friends Group. (**DBCA**, City, GeoCatch)
2. Develop and maintain partnerships and collaboration with and between key stakeholders.	2.1. Coordinate the support and commitment of key agency partners through the Vasse Wonnerup wetlands partnership to deliver management strategies/actions under the operational plan. (**VWWP**) 2.2. DBCA will continue membership and support of the Geographe Catchment Council. (**DBCA**) 2.3. Identify opportunities to develop partnerships with key stakeholders. (DBCA, SWCC, DWER, GeoCatch, DPIRD, City) 2.4. Continue to collaborate with the Science community. (**DBCA, DWER**, Science community)
3. Clarify roles and responsibilities of government agencies involved in the management of the Vasse-Wonnerup wetlands.	3.1. Implement the operating guidelines for surge barrier operations and sand bar openings (updated Surge Barrier Operating Guidelines, *in preparation*) — Appendix 2. (**WC**, VWWP) 3.2. Review, update and implement the *MOU for Implementation of Fish Kill Strategy and Response Plan* and thereafter undertake a 5-year review or as required. (**VWWP**) 3.3. Implement the *Fish Kill Mitigation and Response Plan* process (outlined in the *Fish Kill Mitigation and Response flowchart*) — Appendix 3. (**VWWP**) 3.4. Prepare the *Science and Monitoring Plan* (*in preparation*) — Appendix 5. (**DWER**, DBCA, SWCC, Science community)

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
4.To ensure integrated and adaptive management of the plan area.	4.1.Implement the relevant management actions in the *Swan Coastal Plan South management plan 2016* and the *Tuart Forest National Park management plan 2014*. (**DBCA**) 4.2.Support implementation of the complementary strategies and actions in relevant plans, including: • *Busselton Wetlands Conservation Strategy* (WAPC 2005); (**Key stakeholders**) • *Vasse Wonnerup Wetlands and Geographe Bay Water Quality Improvement Plan* (WQIP) (*in preparation*); (**DWER**, GeoCatch, key stakeholders) • *Geographe Catchment Management Strategy* (*in preparation*). (**GeoCatch**, key stakeholders) 4.3.Continue to cooperate with the members of the science community to ensure up-to-date science is shared and applied to the management of the plan area. (**DBCA**, **DWER**, SWCC, DPIRD, Science community) 4.4.Review and report on the management strategies/actions and provide regular updates to the community. (**VWWP**, GeoCatch)

3. Managing the natural environment – 3.2. Wetland and catchment management – Managing water levels

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
1.To manage water levels to protect and support conservation values, especially waterbirds and their habitats, and to achieve flood protection for the Busselton area.	1.1.Implement the updated Surge Barrier Operating Guidelines (*in preparation*) to maintain the Ramsar values and ecological processes of the wetlands and to support key life stages for focal species. (**WC**, VWWP) 1.2.Identify and implement flood mitigation actions for the Busselton drainage area flood mitigation network. (**WC**, City) 1.3.Develop and implement operating guidelines for the flap valves controlling water levels in Swan Lake, to continue optimal conditions for breeding of swans. (**DBCA**, WC)
2.To monitor changes in hydrological regime (surface water and sea water intrusion) in the wetlands and catchment, to understand impacts on the wetlands.	2.1.Continue to monitor surface water flows on the rivers entering the wetlands. (**DWER**, DBCA, WC) 2.2.Continue to monitor water levels and investigate opportunities for the data to be publicly available online. (**WC**, DBCA)

3. Managing the natural environment – 3.2. Wetland and catchment management – Managing water quality

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
1.To improve water quality within and entering the wetland system, to maintain and enhance conservation and social values.	1.1.Continue to monitor the nutrient load flowing into the Vasse-Wonnerup wetlands. (**DWER**, GeoCatch) 1.2.Investigate and establish environmental targets related to water quality regimes necessary to maintain the Ramsar values and ecological processes. (**DBCA**, DWER, Science community) 1.3.Implement the Vasse Wonnerup Wetlands and Geographe Bay WQIP (*in preparation*). (**DWER**, GeoCatch, key stakeholders) 1.4.Implement the Geographe Catchment Management Strategy (*in preparation*). (**GeoCatch**, key stakeholders) 1.5.Implement best management practices for drain management in urban and industrial areas, and to encourage the upgrade of drains where necessary and undertake ongoing drain maintenance. (**City**, **WC**, GeoCatch) 1.6.Ensure a pollution preparedness plan is in place to manage pollution incidents (response and clean up) to minimise downstream impacts to the Vasse-Wonnerup wetland system. (**City**, DFES, DWER)
2.Manage salinities and salt load within the wetland system to maintain and enhance conservation values and avoid impact on adjoining lands.	2.1.Implement the updated Surge Barrier Operating Guidelines. (**WC**, VWWP) 2.2.Investigate the implications of accumulating salt loads and the extent of saline water in the wetlands system on the conservation values of the Vasse-Wonnerup wetlands and on adjoining lands. (**DBCA**, DWER)
3.Reduce the frequency and severity of toxic algal blooms and mass fish kills.	3.1.Implement recommendations of the *Sediment Investigations of the Vasse Estuary Exit Channel* report (*in preparation*) for the Vasse Estuary exit channel and identify funding opportunities for any associated costs. (**DWER**, DBCA, WC, City) 3.2.Continue to support the requirement for an Oxygenation Plant for the Vasse Estuary exit channel to reduce the risk of fish kills. (**VWWP**) 3.3.Implement the updated Surge Barrier Operating Guidelines. (**WC**, VWWP) 3.4.Annually review and implement the *Fish Kill Mitigation and Response Plan* process (outlined in the *Fish Kill Mitigation and Response flowchart*) — Appendix 3. (**VWWP**) 3.5.Continue monitoring water quality in the Vasse Estuary exit channel. (**DWER**, WC)

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
	3.6. Remove accumulations of organic material (e.g. floating seagrass) from upstream of the surge barriers. (**WC**)
4. Reduce nutrient inputs at a local and catchment scale.	4.1. Undertake regular workshops and activities, which promote nutrient reduction, for the community and rural landowners. (**GeoCatch**, SWCC) 4.2. Implement the *Vasse Wonnerup Wetlands and Geographe Bay WQIP* (*in preparation*). (**DWER**, GeoCatch, key stakeholders) 4.3. Implement the *Geographe Catchment Management Strategy* (*in preparation*). (**GeoCatch**, key stakeholders)

3. Managing the natural environment – 3.3. Biological environment

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
1.Maintain and enhance the conservation values of the wetland system.	1.1.Identify and manage keystone species in the plan area. (**DBCA**, Science community) 1.2.Create and maintain and/or enhance as required functioning habitats for keystone species. (**DBCA**) 1.3.Identify focal species and their habitats/zones and the threats that are impacting them. (**DBCA**, Science community) 1.4.Identify and manage the major threats to the ecological communities in the plan area. (**DBCA**)
2.Maintain and where possible enhance the viability of populations of threatened flora and fauna, and threatened ecological communities.	2.1.Periodically review existing threatened flora, fauna and ecological communities recovery plans and update accordingly. (**DBCA**) 2.2.Develop and implement recovery plans for threatened fauna and flora where possible. (**DBCA**) 2.3.Verify location and boundaries of threatened and priority ecological communities. Determine and implement high priority management actions in occurrences as required e.g. design and establish regular monitoring of condition and threats, map and control priority weeds, and determine and implement appropriate fire regimes. (**DBCA**)
3.Manage fringing vegetation composition, structure and condition to provide functional habitat.	3.1.Identify and prioritise areas within the plan area for rehabilitation; and rehabilitate these areas with local native species, subject to funding availability. (**DBCA**, **City**, GeoCatch, SWCC) 3.2.Monitor fringing vegetation for potential impacts from changes in the hydrological regime. (**DBCA**) 3.3.Educate and encourage landowners to retain and protect native vegetation on properties adjoining the plan area. (**DBCA**, **City**, GeoCatch)
4.To identify, protect and enhance remnant vegetation and ecological corridors within the plan area and within adjacent areas.	4.1.Prepare a map showing existing and potential ecological corridors (including watercourses, native vegetation and bird flight paths) to guide future rehabilitation and land acquisition. (**DBCA**, SWCC, City) 4.2.Protect and enhance ecological corridors identified under Management Action No. 4.1 through land planning and other processes. (**DBCA, City**, DPLH) 4.3.Encourage the retention and protection of native vegetation on properties adjoining the plan area through land planning and other processes. (**DBCA, City**, DPLH)

3. Managing the natural environment – 3.4. Threatening processes

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
1.Minimise the impacts of weeds and introduced animals on the key values of the plan area.	1.1.Undertake periodical risk assessments to identify key threats to the wetland system's values. (**DBCA**, City, SWCC, GeoCatch) 1.2.Develop and implement control and monitoring programs for weeds and introduced animals. (**DBCA**, GeoCatch, City, SWCC) 1.3.Develop and implement community education programs on the impacts of weeds and introduced animals. (**DBCA, City**, GeoCatch, SWCC) 1.4.Integrate, where possible, ecosystem restoration in weed management programs. (**DBCA**, City, SWCC) 1.5.Establish cooperation and coordination between landowners and other parties to maintain and enhance, where possible, coverage of areas under fox, cat and rabbit baiting within and adjacent to the plan area. (**DBCA**, City, SWCC, DPIRD) 1.6.Seek funding to install a predator-proof fence around the Vasse-Wonnerup wetlands, where necessary. (**DBCA**, SWCC)
2.To protect the key values of the plan area from adverse impacts of fire and fire management activities.	2.1.In consultation with the City's bushfire officer review firebreak requirements in wetland areas not managed by the DBCA and consider alternative mitigation measures where necessary. (**DBCA**, City) 2.2.Prepare and implement a fire management plan/s for the plan area (including, but not limited to, access to and egress from the plan area). (**DBCA, City**)
3.Protect the plan area from disturbance activities.	3.1.Conduct regular inspections of the plan area to monitor for disturbance activities. (**DBCA, City**) 3.2.Consider establishing a database to record areas and incidences of disturbance and damage in the plan area, and use this information to coordinate and implement prevention and mitigation measures. (**DBCA, City**) 3.3.Identify areas requiring management of vehicle access to protect conservation and cultural heritage values, and explore options to close and secure these areas. (**DBCA**, City)
4.Minimise human-induced impacts on native flora and fauna.	4.1.Liaise with adjacent landowners to encourage fencing to exclude stock from wetland areas and areas of native vegetation. (**DBCA, GeoCatch**) 4.2.Remove fencing wire from unused fences within the estuaries (leave the wooden posts as they are roosting spots for birds). (**DBCA**)

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
5. To protect the key values of the plan area from adverse impacts of mining activities and urban development activities.	5.1. Implement mitigation measures (e.g. revegetation, vegetated buffers, habitat protection) to reduce the impact of any existing adjacent mining operations on the fringing vegetation and wetland hydrology where necessary. (**DBCA**, DMIRS) 5.2. Reduce the potential impact of existing or intensified adjacent urban development, including canal construction, on the key values of the plan area and consider mitigation measures (e.g. revegetation, vegetated buffers, habitat protection) where necessary. (**DBCA**, City, DPLH)

3. Managing the natural environment – 3.5. Public health and wellbeing

Management objective	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
1. To manage the wetlands in order to promote the health and wellbeing of residents and visitors.	1.1. Maintain monitoring and management of mosquito populations in the wetlands and provide for minimal environmental impact mosquito control methods and programs. (**City, DoH**, DBCA) 1.2. Investigate the link between mosquito ecology, and changes in water levels and quality. (**VWWP**, Science community) 1.3. Develop and provide information on the significance of midges in food webs and on ways to minimise the attractiveness of adjoining residences to nuisance midges. (**City**, DBCA) 1.4. Provide information to the community prior to adverse changes in odours, mosquitos or midges, where practicable. (**City**, GeoCatch) 1.5. Identify the causes of strong unpleasant odours through continuing to investigate the link between sediments and odour with hydrogen sulphide monitoring and community surveys; and mitigate where practicable and environmentally beneficial. (**VWWP**) 1.6. Coordinate management of seagrass wrack on the Geographe Bay shoreline so as to minimise the amount entering Wonnerup Inlet, then decomposing and producing strong unpleasant odours and poor water quality. (**City, DPIRD**, WC)

4. Managing cultural heritage

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
1. Promote and increase community awareness and understanding of the Aboriginal cultural heritage values of the plan area.	1.1. Develop and install appropriate culturally sensitive interpretative signage concerning local Aboriginal heritage in ongoing consultation with relevant Wardandi people and other appropriate people. (**DBCA, City**, GeoCatch, SWCC, traditional owners, SWALSC)
2. To identify, protect and conserve cultural sites, and support the continuation and strengthening of connection to country and sharing of cultural knowledge (supported and consistent with DBCA's Customary Activities Policy and Guidelines).	2.1. Consult with relevant Wardandi and other appropriate people to identify culturally significant sites. (**DBCA**, City, SWCC, DPLH, traditional owners, SWALSC) 2.2. Promote and support culturally appropriate access and interpretation of cultural sites, where appropriate. (**DBCA**, City, traditional owners, SWALSC, GeoCatch, SWCC) 2.3. Protect cultural sites and artefacts, and liaise with traditional owners to determine which sites of high cultural sensitivity may require special management and/or access restrictions and implement as appropriate. (**DBCA**, traditional owners, key stakeholders) 2.4. Support the traditional owners to maintain their connection to, and responsibilities for, country by facilitating the conduct of customary activities (e.g. support on-country trips by younger and older generations of traditional owners to the plan area to ensure knowledge, stories and songs about country are passed on, and to undertake other customary activities). (**DBCA**, traditional owners, key stakeholders) 2.5. Facilitate access within the plan area for traditional owners for the purposes of carrying out customary practices, transferring knowledge to the younger generations and enjoying country. (**DBCA**, traditional owners, key stakeholders) 2.6. Assess factors that may inhibit the rights of traditional owners to enjoy country and maintain their customary practices, and explore/implement management interventions to address issues as necessary. (**DBCA**, traditional owners, key stakeholders)
3. Identify and conserve Other Australian culturally significant places and the history of the plan area.	3.1. Identify Other Australian culturally significant sites and structures. (**DBCA, City**, SWCC, DPLH) 3.2. Promote appropriate access and interpretation of Other Australian cultural sites. (**DBCA,** City, SWCC, DPLH, GeoCatch)

5. Managing recreation and visitor use

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
1.Minimise disturbance impacts from recreational activities on conservation and cultural heritage values, and management activities.	1.1.Identify and develop appropriate recreational activities and sites, and commercial tourism opportunities, which are compatible with the conservation and cultural heritage values of the plan area. (**DBCA, GeoCatch**, City) 1.2.Develop recreational trails in accordance with Table 5, the WA Trail Development Process and DBCA policy. (**DBCA**) 1.3.Manage private jetties according to outcomes of assessments. (**DBCA**, DoT) 1.4.Explore options to secure public access to suitable viewing points, for example near the northern end of Swan Lake. (**DBCA**, DPLH) 1.5.Construct Buttercup Road to provide management access to the boundary of the conservation area, and a buffer between future development and the conservation area. (**City**)
2.Manage recreational fishing in the Vasse-Wonnerup wetland system to minimise the impacts on the conservation values.	2.1.Review recreational fisher access to the Vasse-Wetland wetland system, in consultation with Recfishwest and local recreational fishing groups, to minimise disturbance to native fringing vegetation and where necessary implement appropriate management measures. (**DPIRD**, DBCA, City)
3.Increase visitor appreciation, awareness and enjoyment of the conservation and cultural heritage values of the plan area.	3.1.Develop and facilitate education programs and interpretive resources in consultation with relevant stakeholders. (**DBCA, City**, GeoCatch, SWCC, traditional owners, SWALSC) 3.2.Explore and adopt options to improve the accessibility of, and information provided by, the Busselton Visitor Centre. (**City**) 3.3.Explore and consider options to provide accessible and wider circulation of, information on recreational opportunities for the local community and visitors. (**DBCA, City**) 3.4.Apply applicable commercial operator licence conditions to ensure culturally sensitive and appropriate visitation to cultural heritage sites. (**DBCA**)

6. Research and monitoring

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
1. Undertake research projects to improve understanding of the wetland system and inform management.	1.1. Continue to undertake research to identify an optimal and achievable water level management regime for maintaining and enhancing Ramsar values of the wetland system. (**DBCA**, DWER, Science community) 1.2. Identify the potential risks of climate change to the wetland system. (**DBCA, DWER**, Science community) 1.3. Co-ordinate implementation of the access protocols for undertaking research in the Vasse-Wonnerup wetlands, Wonnerup Inlet or lower Vasse River wetlands — Appendix 6. (**DBCA**, DWER, Science community) 1.4. Implement monitoring recommendations of the *Sediment Investigations of the Vasse Estuary Exit Channel* report (*in preparation*) for the Vasse Estuary exit channel. (**DWER**, DBCA, WC, City)
2. Monitor the ecological health of the wetland system, through developing and maintaining effective monitoring programs.	2.1. Develop, implement and periodically review (every five years) the Science and Monitoring Plan for key values, management issues and water levels in the plan area. (**VWWP**, Science community)
3. To ensure the research and monitoring undertaken in the wetlands is integrated into future management actions.	3.1. Ensure science and monitoring findings are reported to key agency partners for discussion and action. (**VWWP**, DWER, DPIRD, City, WC) 3.2. Periodically review (every five years) management actions in the light of research and monitoring results. (**VWWP**, Science community) 3.3. Identify opportunities for funding on-going monitoring of the wetlands. (**VWWP**, GeoCatch) 3.4. Prepare the Vasse-Wonnerup System Ramsar report card [against the Ramsar criteria and the 'Limits of Acceptable Change'] every three years, and publish it on DBCA and Revitalising Geographe Waterways websites. (**DBCA**, key stakeholders) 3.5. Review the findings/recommendations of the three SWCC led research projects and review the operational plan's management actions in the light of the research results. (**SWCC**, DBCA, DWER) 3.6. Upload research and monitoring reports onto the Revitalising Geographe Waterways website and promote research findings to the community. (**GeoCatch**, DBCA, DWER, Science community)

7. Managing resource use and development

Management objectives	Management strategies/actions (**Lead agency [in bold]** and support agency [not in bold])
1. Identify and minimise any potential adverse impacts to the key values of the plan area from future development proposals, agricultural intensification, mining, and changes of land-uses on adjoining lands and in the catchment.	1.1. Assess future subdivision, mining and development proposals and ensure appropriate conditions (e.g. protection and retention of native vegetation, revegetation and wetland management plans) are applied to the proposals to minimise any adverse impacts on the wetland system. (**City**, DPLH, DBCA, DWER, DPIRD) 1.2. Work with agency partners to identify and minimise any potential adverse impacts on the wetland system from significant land use changes in the catchment. (**DBCA**, DWER, DPIRD, City)
2. Minimise the impacts of commercial fishing on the Vasse-Wonnerup wetland system.	2.1. Review current commercial fishing management arrangements with a view to implementing new management arrangements that will minimise the bycatch of native fauna, in consultation with agency partners and stakeholder groups. (**DPIRD**, DBCA)