AdaptWest

Environment and Open Space Research Paper
28 November 2014

URPS in collaboration with SEED consulting and AECOM

AdaptWest Research Paper
Environment and Open Space

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Prepared for City of Port Adelaide Enfield
City of Charles Sturt
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1.0 Introduction

1.1. About AdaptWest

AdaptWest is a partner project between the Cities of Port Adelaide Enfield, Charles Sturt and West Torrens, the South Australian Government and the Australian Government to develop a Regional Climate Change Action Plan for Western Adelaide.

In 2013, an initial stage of work was completed comprising a social, economic and environmental profile of the Western Adelaide region, and collation of historical climate observations and future climate projections.[1]

The current stage of AdaptWest builds upon this previous work and is being delivered through three main tasks:

- **Preparing the evidence base** - Identifying regional values and key decisions with potential to be impacted by climate change, and gathering information to better understand these values, decisions and impacts;
- **Undertaking the Integrated Vulnerability Assessment (IVA)** – Assessing the exposure, sensitivity, and adaptive capacity of the region to understand vulnerabilities and opportunities presented by climate change; and
- **Preparing the Adaptation Plan** – Identifying priority areas of focus and adaptation options, developing adaptation pathway maps, and determining key actions, roles and responsibilities, and implementation costs.

AdaptWest has adopted five themes through which to consider the region and its vulnerability to climate change. These themes are:

- Assets, infrastructure and economy;
- Coastal management;
- Environment and open space;
- Social and community resilience and health; and
- Urban planning and development.

The project's methodology embeds the active participation of key stakeholders from the Western Adelaide region associated with each of the five themes. Specifically, this involves interactive stakeholder workshops associated with each project task, and direct stakeholder input to key project decisions relating to the focus of the project, the assessment of vulnerability, and preferred adaptation responses.

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[1]SKM (2013) *Western Adelaide Region Climate Change Adaptation Plan – Stage 1*, City of Port Adelaide Enfield

1.2. Values and key decisions

Two important aspects of the AdaptWest project's approach to vulnerability assessment and adaptation planning are the consideration of regional values, and key decision lifetimes.

Stakeholder input has driven the development of seven Western Adelaide regional values which will be used to focus the project toward those features or aspects of particular importance to the region, namely:

- Amenity and quality of life;
- A strong and connected community;
- Coastal and riverine water quality;
- Coastal environment;
- Infrastructure and essential services;
- Management and use of stormwater; and
- Regional productivity and economic contribution to the state.

These values and the process of their development are described further in Section 2.4, and the values provide a point of reference throughout this research paper.

An important aspect of planning for regional adaptation is to understand the relationship over time between key decisions the region's stakeholders will make, and climate change impacts. In this context, a decision lifetime is the time taken to make a decision (lead time) plus the duration of that decision's implications (consequence time).[2]

Some decisions made by individuals or organisations have lifetimes that are shorter than the timeframes over which the major effects of climate change will occur (e.g. < 10 years). In contrast, there are decisions made today that have longer lifetimes (e.g. > 70-80 years) that will converge with the expected timing of some of the more significant projected impacts of climate change.

Early stakeholder input to the AdaptWest project has led to development of Figure 1.1, which summarises key decisions to be made amongst various stakeholder organisations and the region as a whole, and their lifetimes. Several of these decisions will be relevant across multiple project themes and regional values.

Consideration of key decision lifetimes will occur throughout the AdaptWest project, particularly in development of the **Adaptation Plan**.

[2] Stafford Smith *et al.* (2011) *Rethinking adaptation for a 4°C world*, Philosophical Transactions of the Royal Society A, p.197

Figure 1.1: Western Adelaide key decision and decision lifetimes identified by stakeholders

1.3. Purpose of the research papers

A research paper has been prepared for each of the five AdaptWest themes as part of the task of **preparing the evidence base**.

The papers are intended to be a resource to support completion of the **IVA** and development of the **Adaptation Plan**.

Each paper provides **targeted** information about the region in relation to the theme topic and regional values and responds to the following IVA considerations:

- The current state of the region, in the context of regional values (Section 2.0);
- Exposure to climate hazards (Section 3.0);
- Sensitivity to climate hazards (Section 4.0); and
- The region's adaptive capacity (Section 5.0).

Development of the research papers has primarily drawn upon the *Western Adelaide Region Climate Change Adaptation Plan – Stage 1* report[3] and additional relevant literature and interviews with key informants associated with the research paper theme where appropriate.

[3] SKM (2013)

2.0 Environment and open space in the Western Adelaide region

2.1. Overview

The Western Adelaide region's environment and open space areas are comprised of two distinct natural landscapes: plains and coasts. The plains landscape is characterised by low rainfall areas where the majority of the land has been cleared to make way for urban settlements. The coast landscape is the land area adjacent to the ocean which contains a mixture of beach, dune, mudflat, wetland, and estuary environments, some of which are heavily modified and disturbed; coast landscapes as used here also include the near-shore marine areas, including sea grass beds.

Environment and open space are fundamentally important components for the Western Adelaide region, underpinning the region's liveability and economic prosperity by providing critical conservation, human health, community, aesthetic, and tourism services.

The terms "environment" and "open space" are defined as follows for the purpose of this report:

- **Environment:** as used here has a focus on biodiversity and conservation services, and refers to all living elements (excluding people) within the region, specifically native and introduced flora and fauna species, ecological communities, and significant natural places (i.e. listed national estates and reserves). Environment is also used here to describe water resources (i.e. surface and ground water); and
- **Open Space:** refers to water bodies and vegetated areas (predominantly grassed and/or with managed gardens) which we categorise here as: marine, aquatic, or terrestrial. Our definition of open space tends to refer to areas which predominantly offer recreational and aesthetic services, though biodiversity services may also be provided in some cases. Accordingly, elements of the "environment" may be included in some "open space" categories (e.g. a threatened ecological community listed in "environment" may be incorporated in a "terrestrial reserves" category listed under open space).

Section 2.3 briefly describes each of these elements in relation to Western Adelaide currently.

2.2. Key stakeholders

Key stakeholders in Western Adelaide with an interest in environment and open space are:

- **Local governments** that provide services and facilities. For example, maintaining and managing environment and open space areas for multi-use purposes, such as conservation, recreation and erosion control (e.g. of waterways and coastal

dunes). Local governments are also often responsible for planning and designing the type and location of open spaces in community developments;

- **State government agencies**, particularly the Department of Water and Natural Resources (DEWNR), who provide services and facilities, lead on climate change adaptation, and regulate the conservation of threatened species and environmental values through the administration of relevant regulatory acts (i.e. *National Parks and Wildlife Act 1972*, *Adelaide Dolphin Sanctuary Act 2005*, *Coast Protection Act 1972*; *Fisheries Management Act 2007*);
- **Commonwealth government and agencies**, particularly the Department of Environment, who set strategic policies in relation to climate change adaptation and coastal management, and administer relevant regulatory legislations (e.g. *Environment Protection and Biodiversity Conservation Act 1999*) on the protection and management of nationally and internationally significant flora and fauna species, ecological communities, and places. The Department of Planning, Transport and Infrastructure and Primary Industries and Regions South Australia are also responsible (together with the City of Charles Sturt local government) for management and permit issuing of the Boating Lake at West Lakes (City of Charles Sturt). The Commonwealth Government is also a provider of funding and investment for adaptation and environmental management;
- **Not for profit organisations** that are concerned with conservation and environment, such as Ridley Grove Community Garden Inc. and Surf Life Saving South Australia who have branches at North Haven, Semaphore, Grange, Henley, and West Beach;
- **Community groups and clubs** that provide services and facilities located in open space areas and/or use those services and facilities provided by governments or commercial operators. For example residents associations and local environmental groups (e.g. Port Adelaide Residents Environment Protection Group, Tennyson Dunes Group, Friends of Patawalonga Creek, and Friends of Dry Creek Trail) and sports clubs (e.g. Kilburn Football Club, South Australian Rowing Association, Port Adelaide Rowing Club, Softball South Australia); and
- **Households and individuals,** including visitors and residents in the region who benefit from and use services and facilities located within environment and open space areas.

2.3. Existing conditions - environment

2.3.1. Significant species, ecological communities and natural places

The following section outlines significant species, ecological communities and natural places recorded as occurring within the region. Records of species and ecological communities may be from direct observations (known to occur), or derived due to suitable habitat occurring (may or likely to occur). Significant native species are those listed as threatened (rare, vulnerable, endangered, critically

endangered) at Federal, State, regional, or local levels, as well as those listed under Federal legislation as marine species and/or migratory species. Marine species, although not necessarily formally threatened, are listed at the Federal level to identify their formal protection within Commonwealth waters. Migratory species include national migrants as well as international migrants protected under international agreements. Significant non-native species are those formally listed as pest species under Federal and State legislations. Significant natural places are those identified under Federal legislation as being of significant ecological and/or historical cultural value – only those providing ecological services are included here (i.e. listed historical buildings are not included).

The following legislations, agreements, reports, and databases were considered:

- **Federal legislation:**
    - *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act);
- **State legislation:**
    - *National Parks and Wildlife Act 1972* (NPW Act);
    - *Natural Resource Management Act 2004* (NRM Act);
    - *Adelaide Dolphin Sanctuary Act 2005* (ADS Act); and
    - *Fisheries Management Act 2007* (FM Act);
- **International agreements:**
    - Japan-Australia Migratory Bird Agreement (JAMBA);
    - China-Australia Migratory Bird Agreement (CAMBA);
    - Republic of Korea-Australia Migratory Bird Agreement (ROKAMBA);
    - Convention on the Conservation of Migratory Species of Wild Animals (Bonn); and
    - Agreement on the Conservation of Albatrosses and Petrels (ACAP);
- **Reports:**
    - Western Adelaide Region Climate Change Adaptation Plan – Stage 1;[4]
    - Metropolitan Adelaide and Northern Coastal Action Plan;[5]
    - Adelaide and Mount Lofty Ranges NRM Region Regional Species Conservation Assessment Project. Phase 1: Regional Species Status Assessments;[6]
    - City of Port Adelaide Enfield State of the Environment Report 2012;[7]

[4] SKM (2013)
[5] Caton *et al.* (2009) *Metropolitan Adelaide and Northern Coastal Action Plan* 2009. Volume 2., AMLR NRM Board and DEH
[6] Gillam and Urban (2014) *Adelaide and Mount Lofty Ranges NRM Region Regional Species Conservation Assessment Project. Phase 1: Regional Species Status Assessments*, Department of Environment Water and Natural Resources (DEWNR)
[7] City of Port Adelaide Enfield (2012) *State of the Environment Report 2012*, City of Port Adelaide Enfield

  - City of Port Adelaide Enfield Biodiversity Management Plan 2009-2014;[8]
  - The Determination of Weeds of National Significance;[9]
  - Environmental Management Plan: Mutton Cove, South Australia;[10]
  - Ecological Implications for Freshwater Fishes Arising from Specific Hydrological Changes to the Lower River Torrens, Adelaide;[11]
  - Marine Habitats in the Adelaide and Mount Lofty Ranges NRM Region;[12] and
  - Action Plan for South Australian Fishes 2009;[13]

- **Databases:**

  - Atlas of Living Australia (ALA);[14] and
  - EPBC Act Protected Matters Search Tool.[15]

At least 170 **significant native fauna species** listed at Federal, State, and/or regional/local levels (Table 2.1) were identified within the region, with 115 of these species known to occur[16] (Appendix A)**.** These include:

- 24 species listed as threatened at the Federal level (17 birds, 3 mammals, 3 reptiles, 1 shark);
- 100 species listed as marine or migratory at the Federal level (58 birds, 11 mammals, 3 reptiles, 2 sharks; 26 fishes);
- 70 species listed as threatened at the State level (60 birds, 7 mammals; 3 reptiles); and
- 96 species listed as threatened at regional/local levels (85 birds, 5 mammals, 5 reptiles, 1 invertebrate).

[8] Port Adelaide Enfield (2008) *City of Port Adelaide Enfield Biodiversity Management Plan 2009-2014*, City of Port Adelaide Enfield
[9] Thorp and Lynch (2000) *The Determination of Weeds of National Significance*, National Weeds Strategy Executive Committee
[10] Cook and Coleman (2003) *Environmental Management Plan: Mutton Cove, South Australia*, Department of Environment and Heritage (DEH) Coastal Protection Branch
[11] Aquasave Consultants (2011) *Ecological Implications for Freshwater Fishes Arising from Specific Hydrological Changes to the Lower River Torrens, Adelaide*, AMLR NRM Board
[12] DEH (2008) *Marine Habitats in the Adelaide and Mount Lofty Ranges NRM Region*, AMLR NRM Board
[13] Hammer *et al.* (2009) *Action Plan for South Australian Fishes 2009*, DEH
[14] ALA (n.d.) Atlas of Living Australia, Commonwealth Scientific and Industrial Research Organisation (CSIRO), www.ala.org.au
[15] Commonwealth of Australia (2013) EPBC Act Protected Matters Search Tool, Commonwealth of Australia
[16] SKM (2013); Caton *et al.* (2009); Gillam and Urban (2014); ALA (n.d.); Commonwealth of Australia (2013)

A total of 93 **significant native flora species** listed at Federal, State, and/or regional/local levels (Table 2.1) were identified within the region, with 83 of these species known to occur[17] (Appendix A)**.** These include:

- 13 species listed as significant at the Federal level (8 endangered, 4 vulnerable);
- 26 species listed as significant at the State level (8 endangered, 4 vulnerable, 14 rare); and
- 88 species listed as significant at regional/local levels (24 uncommon, 2 threatened, 31 rare, 11 vulnerable, 15 endangered, 3 critically endangered, and 2 listed as extinct though reported as known in the region).

The region has experienced extensive vegetation clearing for urban development purposes, leaving many of the currently vegetated areas as highly disturbed, managed and containing non-native and pest species. However, the following **significant ecological communities, reserves and protected areas** still persist in the region:[18]

- Barker Inlet and St Kilda wetland is listed as an important wetland at the Federal level;
- The following Federally threatened ecological communities may occur or are likely to occur:
    - Grey box (*Eucalyptus microcarpa*) grassy woodlands and derived native grasslands of South-eastern Australia (may occur in all three council areas);
    - Peppermint box (*Eucalyptus odorata*) grassy woodland of South Australia (may occur in Port Adelaide Enfield area); and
    - Subtropical and temperate coastal saltmarsh (likely to occur in Port Adelaide Enfield area);
- The River Torrens (outside of Adelaide City) is listed at the Federal level as a Natural Place on the Register of National Estate (RNE);
- Fort Glanville Reserve and Folland Park Reserve are both listed at the Federal level as important "State or territory reserves" (N.B. Folland Park is listed in EPBC Act as Unnamed-HA308);
- Torrens Island Conservation Park and Barker Inlet-St Kilda Aquatic Reserve are both listed as important at the Federal level;
- The Adelaide Dolphin Sanctuary, Torrens Island Conservation Park, and Fort Glanville Conservation Park are listed as protected areas at the State level;
- Mutton Cove Conservation Reserve is regionally/locally significant as the last remaining area (~38.92ha) of remnant samphire and mangrove woodland

[17] SKM (2013); Caton *et al.* (2009); Gillam and Urban (2014); ALA (n.d.); Commonwealth of Australia (2013); City of Port Adelaide Enfield (2008)
[18] SKM (2013); Caton *et al.* (2009); Gillam and Urban (2014); ALA (n.d.); Commonwealth of Australia (2013)

remaining on the Lefevre Peninsula; the Reserve provides important habitat for a number of significant flora and fauna species, including migratory bird species. It is listed as a Conservation Zone in the Port Adelaide Enfield Metropolitan Open Space System;

- Barker Inlet and Port River Estuary sustains the largest southern-most colony of grey mangroves, globally;[19]
- Swamp paperbark low woodland at Patawalonga Creek is considered regionally/locally significant, being listed on the Significant Tree Register;[20]
- The following dune reserves of particular significance at the regional/local level due to their less disturbed nature, composition of threatened flora species and provision of habitat/foraging resources for threatened fauna species:
    - Tennyson Dune Reserve – the most significant area of remnant dune vegetation along Adelaide's metropolitan coastline;[21]
    - Semaphore Park Dunes – in addition to Tennyson Dune Reserve, is the only other area of old, well-established native dune vegetation;[22] and
    - Torrens outlet significant dune area – though younger and less well established than Tennyson and Semaphore Park dune reserves still provides important flora and fauna habitat;
- Four key regionally/locally significant remnant vegetation communities and the locations in which they occur:
    - Samphire shrubland (Mutton Cove, Barker Inlet wetlands, The Range wetlands, and Magazine Creek wetlands);
    - Spinifex grassland (Semaphore foreshore);
    - Coastal shrubland (Tennyson and West Beach); and
    - Eucalyptus woodland (Folland Park).

In addition to significant native species, a number of **significant pest (non-native) species** are recorded in the region[23] (Table 2.1) (Appendix B), including:

- 24 fauna species (11 birds, 11 mammals, 2 invertebrates) listed as significant pests at Federal, State and/or regional/local levels, of which 20 are known to occur in the region:
    - 2 bird species are listed as "alert species" at the Federal level;

[19] Australian Marine Wildlife Research and Rescue Organisation (AMWRRO) (2011) *Mangrove Revegetation*, http://www.amwrro.org.au/about-amwrro/projects
[20] SKM (2013)
[21] Cordingley and Petherick (2006a) *Vegetation Management Plan Tennyson Dune Reserve Yaitya Worra (True Indigenous Sand)*, City of Charles Sturt
[22] Cordingley and Petherick (2006a) *Vegetation Management Plan Semaphore Park Coastal Reserve*, City of Charles Sturt
[23] Caton *et al.* (2009); Gillam and Urban (2014); Thorp and Lynch (2000); Cook and Coleman (2003); ALA (n.d.); Commonwealth of Australia (2013); City of Port Adelaide Enfield (2008)

- 45 plant species listed as significant pests at Federal, State and/or regional/local levels, of which 27 are known to occur in the region:
    - 19 species are declared Federally as weeds of national significance (WoNS);
    - 32 species are declared pests under the State's NRM Act; and
    - At least 15 species are declared pests at the regional/local level.

Table 2.1: Selected relevant matters listed as significant at the Federal, State or Regional/Local levels. EPBC = Federally significant species listed under the *Environment Protection and Biodiversity Conservation Act 1999* (native and pest species); NPW/NRM = State significant species listed under the *National Parks and Wildlife Act 1972* (native species and protected areas) or the *Natural Resource Management Act 2004* (pest species); R/L = Regionally/locally significant species.

Significant Matters	EPBC	NPW/NRM	R/L	Total in Region
Threatened fauna species	24	70	95	128
Threatened flora species	13	26	86	90
Migratory species	56	n/a	n/a	56
Listed marine species	97	n/a	n/a	97
Whales and other cetaceans	8	n/a	n/a	8
Threatened ecological communities	3	n/a	5	5
Important wetlands	1	n/a	1	1
Important places/reserves	5	3	6	13
Pest fauna species	22	2	n/a	22
Pest flora species	25	32	15	45

Sources:[24]

2.3.2. Other species and ecological communities

The following section outlines **other native species, ecological communities and natural places** known to occur within the region. This is not considered or intended to be a comprehensive list.[25]

- At least 265 other native fauna species (non-significant) are recorded in the region, including:
    - 176 birds;
    - 7 mammals (including 2 marine mammals and 3 microbats);
    - 6 reptiles;
    - 5 amphibians;
    - 8 fishes;

[24] SKM (2013); Caton *et al.* (2009); Gillam and Urban (2014); Thorp and Lynch (2000); ALA (n.d.); Commonwealth of Australia (2013); City of Port Adelaide Enfield (2008)
[25] SKM (2013); Caton *et al.* (2009); Gillam and Urban (2014); ALA (n.d.)

  - 2 chondrichthyes (1 shark, 1 ray); and
  - 61 inverts;

- Over 300 other native plant species (non-significant) are recorded in the region including terrestrial, aquatic, and marine species; and
- Mangrove Cove (Patangga), located on the upper reaches of the Port River in the suburb of Ethelton (City of Port Adelaide Enfield) comprises flora and fauna species of value (including threatened species), and also comprises elements of European and indigenous cultural significance[26];
- A number of street trees across the region are protected by Tree Protection Zones; and
- Man-made structures occurring in the region may also offer suitable artificial habitat for some species, such as pylons and rip-rap associated with the Port Adelaide River which provide habitats for benthic organisms (e.g. mussels), algae, and small fishes and crustaceans. These in turn can offer shelter and foraging resources for other species[27].

2.3.3. Water resources

The region contains a variety of water resources, including surface water (e.g. lakes, rivers and wetlands) and ground water (e.g. licensed and unlicensed bores). For the most part, the quality of natural waterways in the region is highly degraded, with cyanobacteria outbreaks being a particular issue in the River Torrens.[28] Surface water resources in the region include:

- Watercourses (i.e. rivers and creeks, see Section 2.3.2): within the region these have generally been highly disturbed and modified due to urbanisation (e.g. widened, deepened, course altered);[29]
- Wetlands: most in the region have been constructed for storm water treatment purposes, though also provide significant benefits to biodiversity;
  - The Barker Inlet wetlands provide significant habitat for threatened and migratory bird species. These wetlands form part of a series of wetlands (including The Range and Magazine wetlands at Gillman) which together are the largest constructed wetlands in Australia;[30]
  - The most recent wetlands in the region are those constructed within the City of Charles Sturt as part of the "Waterproofing the West"

[26] Coleman and Eden (2005) *Environmental Management Plan, Mangrove Cove, SA,* A report prepared by Delta Environmental Consulting for the Land Management Corporation, South Australia; Eco Management Services Pty Ltd (2013) *Port Adelaide/LeFevre Peninsula (Phase 2) Port Adelaide Seawall Study: Volume 3 - Environmental Assessment.* Port Adelaide Enfield Council, South Australia
[27] Eco Management Services Pty Ltd (2013)
[28] AMLR NRM Board (2013) *River Torrens Water Quality Improvement Trial – Summer 2013-2014*, Government of South Australia
[29] SKM (2013), p.113
[30] AMLR NRM Board (2011)

project (Stage 1), which once fully operational (expected 2015) will be able to treat up to 2,400 million litres of storm water and River Torrens water per year.[31] Wetlands constructed as part of this project are:

- Old Port Road Wetlands – wetlands with Aquifer Storage and Recovery (ASR), located along the central median of Old Port Road at the junction of the suburbs of Queenstown, Royal Park and Hendon, and offering water harvesting, quality improvement and reuse services, as well as flood mitigation;
- Cooke Reserve Wetlands – wetlands located in the suburb of Royal Park (opposite West Lakes Golf Course) with ASR components;
- West Lakes Golf Course Wetlands – wetlands located in the suburb of Royal Park (opposite Cook Reserve) with ASR components; and
- St Clair Wetlands: located in the suburb of St Clair at the former Cheltenham Racecourse site , providing treated storm water for ASR and irrigation purposes;

- Prescribed wells areas (PWA): the region coincides with two PWAs:[32]
    - Northern Adelaide Plains PWA; and
    - Central Adelaide Plains PWA;

- Other constructed systems:
    - The man-made Patawalonga Lake System runs parallel to the coastline from Glenelg to West Beach. The City of West Torrens contains “Lake North”, which is the upper reaches of this system and includes 2 weirs, a diversion basin, and the Patawalonga Creek collection pond;[33] and
    - The Glenelg to Adelaide Pipeline provides the City of West Torrens with between 11,500,000 and 20,000,000 L of water which is currently used to irrigate Richmond Oval.[34]

Ground water resources in the region include:

- 495 operational drill holes, including 390 registered since 1960 for domestic purposes only in the City of Port Adelaide Enfield, with a particularly heavy distribution on the Lefevre Peninsula. There are also 686 wells with permit holdings

[31] City of Charles Sturt (n.d.) *Water Proofing the West*, www.charlessturt.sa.gov.au/page.aspx?u=609
[32] SKM (2013), p.123
[33] City of West Torrens (n.d.) *City of West Torrens*, www.westtorrens.sa.gov.au
[34] City of West Torrens (n.d.) *City of West Torrens*, www.westtorrens.sa.gov.au

including 378 for domestic purposes, 112 for irrigation, 23 for industrial use, and 173 unknown uses;[35]

- Approximately 492 drill holes registered as water wells in Charles Sturt, with variable operational status;[36] and
- 1,267 drill holes in West Torrens, of which 184 are known to be operational (though not necessarily for water extraction), 998 are private bores of unknown operational status, and 85 are no longer operational (i.e. dry, abandoned, or filled).[37]

Within the region, there are 106 bores licensed for water extraction (5,224 ML allocated), as well as an additional 67 license applications (requesting a total of 5,433 ML).[38] This number may not include private bores.

2.4. Existing conditions - open space

2.4.1. Marine

Marine open spaces areas offer numerous recreation opportunities, and also often provide significant habitat and feeding resources for several flora and fauna species, including listed marine and migratory species (Section 2.3.1). The main marine open space areas of relevance to the region are the:

- Port River Estuary and Barker Inlet (including the Adelaide Dolphin Sanctuary);
- Port River Coastline (including Port Adelaide River, North Arm, North Arm Creek, Angas Inlet, and Mutton Cove);
- Barker Inlet-St Kilda Aquatic Reserve, including the Barker Inlet wetlands (specifically the inter-tidal ponds forming the Northern Basin); and
- West Lakes' recreational lake system.

2.4.2. Aquatic

Freshwater open spaces in the region offer recreation, aesthetic, and biodiversity services are dominated by man-made systems, and include:

- 6 natural, though highly modified, watercourses (Table 2.2);
- 16 constructed wetlands (Table 2.2); and

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[35] City of Port Adelaide Enfield (2012), p.183
[36] Government of South Australia (2014) *WaterConnect*, https://www.waterconnect.sa.gov.au/Systems/GD/Pages/default.aspx#Coordinates
[37] City of West Torrens (2009) *City of West Torrens ICLEI Water Campaign: Milestone 3 – Water Management Action Plan*, City of West Torrens, p27;
[38] SKM (2013), p.123

- 1 ornamental lake on Delfin Island.

Table 2.2: Details of watercourses, wetlands and lakes comprising the aquatic open space category

Aquatic Open Space Category	Inclusions/Locations
Watercourses	River Torrens, Dry Creek, Grange Creek, Keswick Creek, Brownhill Creek, Patawalonga Creek, Magazine Creek,
Wetlands	Barker Inlet wetlands (specifically the freshwater ponds forming the Southern Basin), Magazine Creek wetland, Range wetland, Old Port Road wetlands, Cooke Reserve wetlands, St Claire wetlands, Brown Hill Creek linear wetland, Patawalonga Creek linear wetland, Apex Park wetland, Breakout Creek wetlands, additional managed ARSs at Regent Gardens and Northgate Reserve, and wetlands associated with four golf courses: West Lakes, Glenelg, The Grange, and Royal Adelaide
Lakes	Delfin Island ornamental lake

2.4.3. Terrestrial

Approximately 1,473 ha of terrestrial open space is said to occur in the region: 552 ha in the City of Port Adelaide Enfield, 559 ha in the City of Charles Sturt and 361 ha in the City of West Torrens.[39] Categories for terrestrial open spaces used here have been adapted from a combination of categories used by each of the local councils comprising the region. Six categories are proposed:

- Terrestrial reserves – areas predominantly consisting of remnant vegetation, excluding sand dunes, and primarily managed for conservation and biodiversity purposes (e.g. Folland Park Reserve);
- Linear parks – narrow strips of vegetated areas that tend to follow waterways (e.g. River Torrens Linear Park; Dry Creek Linear Park);
- Council parks/playgrounds/gardens – areas that are vegetated (predominantly grassed) and highly managed for human recreation purposes, including dog off-leash areas (e.g. Point Malcolm Reserve);
- Sporting grounds/ovals – formal sporting fields and ovals, including public and private golf courses (e.g. Riverside Oval in Port Adelaide Enfield Council Area); and
- Coastal/foreshore – include dunes systems (e.g. Tennyson Dunes Reserve; RB Connolly Reserve).

Terrestrial Reserves have been largely cleared historically to make way for urban development and expansion. The remnant vegetation patches remaining in the

[39] SKM (2013), p.128

region are generally small and comprised as part of parks, reserves and dune systems (managed by council and community groups), and golf courses (privately managed). Key locations and their remnant vegetation communities in the region include:[40]

- Mutton Cove saltmarsh and mangrove communities;
- Near Range wetland, Magazine Creek wetland, and Barker Inlet Wetlands;
- Folland Park eucalypt community;
- The Semaphore foreshore, Tennyson and West Beach dune communities;
- Remnant sand dunes at: Tennyson, Semaphore, Semaphore Park, Largs Bays, Taperoo, and North Haven; and
- RB Connelly Reserve coastal shrubland community.

In addition, Biodiversity Park on the Lefevre Peninsula represents one of the largest remaining open space areas in metropolitan Adelaide (~80ha). Although remnant vegetation in this area has been subjected to substantial degradation, considerable revegetation work has been conducted over the last decade by a local community group (The Friends of Biodiversity Park). This park is of high urban ecology value, yet is under threat from recreational misuse and rezoning proposals, as well as climate change hazards.[41]

The main **linear park** in the region is the River Torrens Linear Park, situated along the boundaries of the City of West Torrens and City of Charles Sturt. This linear park is the only east-west vegetated, landscape-scale link between the coast and hills.[42] Other linear parks include the Westside Bikeway[43] as well as several other local-scale vegetated links comprised primarily of street trees and gardens and along creek lines.

The region contains numerous **council parks, playgrounds and gardens**, with over 122 occurring in the City of Port Adelaide Enfield alone, and 72 parks and 1 memorial garden identified for the City of West Torrens.[44] The size, facilities and vegetated nature of these areas vary significantly, but all are designed specifically for recreational and aesthetic purposes. For example, the Port Adelaide Enfield council specifically endeavour in their area planning to provide a playground within ~500m or 15min walking distance of all residents.[45]

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[40] Caton *et al.* (2009); City of Port Adelaide Enfield (2002) *Annual Review 01-02: City of Port Adelaide Enfield*, p.10
[41] Port Adelaide Residents Environment Protection Group (n.d.) *Biodiversity Park*, http://www.parepg.org.au/BioPark
[42] SKM (2013), p.115
[43] SKM (2013), p.115
[44] City of West Torrens (2009a) *Community Land Management Plans: Parks*, City of West Torrens, p.3-4; City of West Torrens (2009b) *Community Land Management Plans: Memorial Gardens*, City of West Torrens, p.8
[45] City of Port Adelaide Enfield (n.d.) *Playgrounds, Parks and Gardens*, http://www.portenf.sa.gov.au/page.aspx?u=365

The region also contains a number of formal **sporting grounds/ovals** including 24 ovals listed for the City of Port Adelaide Enfield[46] and 14 recreation/sports grounds listed within the City of West Torrens.[47] In addition, 457ha of golf courses have been mapped in the region.[48]

Coastal/foreshore areas in the region are highly varied in their substrate, structure and recreational/biodiversity services. Seven main types have been identified and mapped within the region:[49]

- Artificial foreshores;
- Boulder beaches;
- Fine-medium sand beach;
- Mangroves;
- Mudflats (unconsolidated);
- Sandflats; and
- Seagrass intertidal/shallow emergent.

Of the seven coastal/foreshore types identified, mangroves, mudflats, sandflats and seagrass intertidal/shallow emergent offer the highest biodiversity services, whereas fine-medium sand beaches offer the highest recreational services. Approximately 20 km of fine-medium sand areas occurs in the region, stretching along the region's western boundary from West Beach in the south to North Haven in the north.[50] A number of dune systems occur along this stretch of coastline, with many of the dunes being highly degraded from their natural state, though some retain highly significant remnant values (see Section 2.2.1).

2.5. AdaptWest regional values, features and aspects

An important aspect of the AdaptWest project is the involvement of stakeholders to help identify, assess and prioritise the region's vulnerabilities to climate change and options to adapt.

The initial stage of this involvement was a workshop in which representatives of key stakeholder organisations identified those aspects of Western Adelaide that are important to their objectives and core functions and contribute to the vitality and functioning of the region and beyond.

The AdaptWest project team developed stakeholder input into a list of regional values with associated features and aspects that will form the basis of subsequent project tasks and in particular the IVA.

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[46] City of Port Adelaide Enfield (n.d.) *Parks & Reserves*, http://www.portenf.sa.gov.au/page.aspx?u=1202
[47] City of West Torrens (2009c) *Community Land Management Plans: Recreation/Sports Grounds*, City of West Torrens, p.3
[48] SKM (2013), p.128
[49] SKM (2013), p.131
[50] SKM (2013), p.133

Table 2.3 describes Western Adelaide's values, features and aspects that have a direct relationship to environment and open space in the region.

Table 2.3: Western Adelaide values, features and aspects relating to environment and open space

What we value in the Western Region	Features or aspects that relate to this value	Relationship to environment and open space in Western Adelaide
A strong and connected community	Diversity Equity and social justice Vulnerable members of the community	The environment and open space areas within the region are popularly used by residents and visitors for a range of recreational, sporting, and business activities, thereby facilitating an active and interactive lifestyle. The resulting direct or indirect interactions between people commonly using these spaces promote increased community connectedness, as well as improving community tolerances towards cultural, linguistic and demographic diversity of the region.
Amenity and quality of life	Safety and health Sport, recreation, entertainment and tourism facilities Coastal /water based recreation Open and green spaces Natural and historical environments	Environment and open space areas provide the foundation of an improved quality of life within the region. The ability to connect/interact with nature and wildlife has been scientifically proven to be beneficial for human health, even in the case of minor or indirect interactions, such as being able to walk through or sit in a treed park or even having a natural outlook from one's work or home premises (e.g. ocean, river, forest, parkland). In addition to the aesthetic values and indirect health benefits, environment and open spaces also provide important sources for active sport, recreation, entertainment, and tourism activities. In this sense, of particular importance within the region are: the numerous parklands and gardens, the extensive stretches of coastline and beachfronts, the wetlands and other habitats supporting numerous flora and fauna species and with facilitated access to promote nature interactions (e.g. boardwalks and interpretive signage), and the street trees and linear parks and gardens which provide a more natural streetscape in which to travel and live.

What we value in the Western Region	Features or aspects that relate to this value	Relationship to environment and open space in Western Adelaide
Biodiversity	Gulf and marine biodiversity Coastal and dune biodiversity Riverine Ecosystem services Intrinsic value	Biodiversity in the Western Adelaide region is intricately linked with the quality, quantity and location of the region's environment and open space areas. Environment areas, in particular, offer critical habitat and resources for numerous species, including nationally and internationally significant flora and fauna species (marine, terrestrial and migratory), and ecological communities. A number of ecosystem services are additionally provided by environment and open space areas, for example, the numerous of wetlands in the region help to capture, store and improve water quality and availability, as well as providing important species habitats.
Coastal and riverine water quality	Port River River Torrens Gulf St Vincent Water Sensitive Urban Design (WSUD) Stormwater capture and reuse	Environment and open space areas within the region include marine and aquatic waterways, including rivers, creeks, wetlands, and estuaries. Many of these have been highly modified from their natural form or are entirely man-made. Maintaining and improving water quality within the region is recognised as an important goal and a large amount of consideration and resources are already directed to manage water quality within freshwater and marine environments. Implementing appropriate WSUD is a key component of achieving this goal. A number of constructed wetlands incorporating ASR components have also been implemented within the region, which help to capture, store and treat storm water run-off so as to improve water quality before being recycled (e.g. used for irrigation purposes) or discharged into marine and estuarine systems.

What we value in the Western Region	Features or aspects that relate to this value	Relationship to environment and open space in Western Adelaide
Coastal environment	Environmental values Community and recreation Tourism Assets and infrastructure	The coastal environments are significant components of the region's environment and open space areas and underpin the region's environmental, social and economic values. In particular, remnant coastal dune, mangrove and saltmarsh vegetation communities, together with near-shore marine environments offer critical habitat and resources for numerous flora and fauna species, including nationally and internationally important species and ecological communities. Such areas also offer a range of additional services such as: aesthetic, educational, tourism and passive recreation opportunities, as well as some dune protection against coastal erosion.
Infrastructure and essential services	Port facilities Adelaide Airport Water and wastewater treatment Power generation Transport Open space Defence industries Community facilities	Environment and open space offer a range of essential services. For example, wetlands provide water quality improvement services and are also valued for their amenity and biodiversity services. Open spaces such as sporting ovals and public parks provide areas for community recreation which facilitates health and well-being within the region, as well as improving community connectedness. Many of the environment and open spaces in the region are also commonly associated with various infrastructures. For example, constructed wetlands are often associated with stormwater management and reuse infrastructure, which may also link to open space areas where such stormwater management and reuse infrastructure is used to irrigate open space areas such as sporting fields and parks. Open space areas also often contain other infrastructure such as public amenities, clubhouses, and playground equipment.

What we value in the Western Region	Features or aspects that relate to this value	Relationship to environment and open space in Western Adelaide
Management and use of stormwater	Protection of homes Protection of infrastructure Water Sensitive Urban Design (WSUD) Stormwater capture and reuse	Within the region's highly urbanised environment, it will be important to ensure appropriate infrastructure and engineering is in place to appropriately channel, capture and reuse storm water (in the case of extreme events) for recycling and asset protection purposes. Existing stormwater management and reuse infrastructure in the region include, but are not limited to: the Breakout Creek weir, constructed wetlands and aquifer storage infrastructure associated with the "Waterproofing the West" project (e.g. along Old Port Road), and the weirs, diversion basin, and collection pond associated with Patawalonga Creek.
Regional productivity and economic contribution to the state	Infrastructure and industries of state significance: - Port facilities - Adelaide Airport - Defence industries - Gillman industrial area - Tourism infrastructure e.g. Adelaide Shores - Adelaide Entertainment Centre	As well as providing important biodiversity, recreational, and ecosystem services, certain areas (particularly marine systems) within the region also provide important economic services. For example, the Barker Inlet-St Kilda Aquatic Reserve provides important habitat for a range of marine species and is a popular location for recreational users (e.g. kayaking, recreational fishing, boating). However, the mangrove and seagrass communities protected within this area also provide critical nursery habitats and resources for a variety of important commercial fish and crustacean species.[51] Further, the Adelaide Dolphin Sanctuary also generates important local economic revenue each year through eco-tourism ventures (e.g. dolphin spotting cruises) and associated expenditures.

[51] City of Port Adelaide Enfield (2012)

2.6. Key decisions

Consideration of the relationship between climate impacts and key decision lifetimes is another focus of the AdaptWest project (refer Section 1.2).

At the same workshop described in Section 2.5, stakeholders identified the key decisions for the region relating to the environment and open space theme. These theme-specific key decisions are set out in Table 2.4, and contributed to the broader regional key decisions summarised in Figure 1.1 (refer Section 1.2).

Table 2.4: AdaptWest key decision relating to social and community resilience and health

Decision lifetime	Key decision

Short lifetime decisions
(0-10 years)
	• Elected Council cycle – political decisions (within 4 years)
	• Community plans
	  o Strategic plans (within 5 years)
	  o Environmental plans
	• Responding to storm surge
	• Forecasting climate hazards
	• Heatwave/staff management with increased temperatures and high rainfall events
	• Council work times

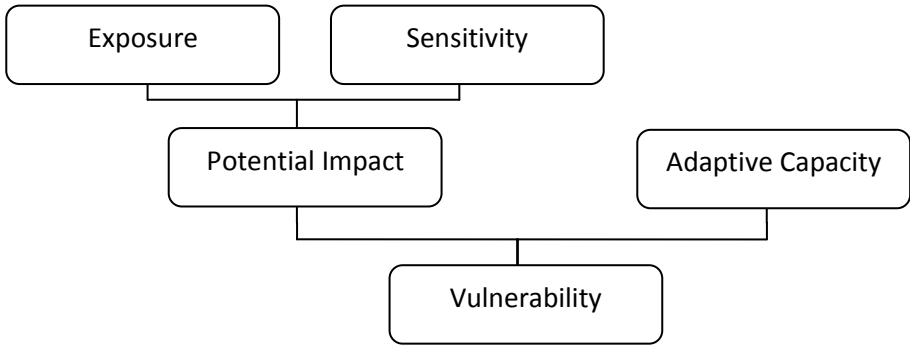
Medium lifetime decisions
(10-30 years)
	• Street tree choice – planting
	• Ecosystems
	  o Regeneration – arid species
	  o Diversity of species
	  o Planning for future climate/rainfall when revegetating
	• Accumulated decisions over time
	• Development planning

Long lifetime decisions (30+ years)	• Footpath, roadways and transport • Stormwater infrastructure – rainfall • Removal of significant trees • Land use planning – regeneration of old industrial sites • Risks and public liability

2.7. Preliminary identification of IVA indicators

The AdaptWest research papers are a resource to support completion of an IVA for the region. The IVA will assign scores against a range of indicators in relation to their exposure and sensitivity to climate variables, as well as the region's adaptive capacity (refer Figure 2.1;adaptive capacity is further discussed in Section 5.0). An IVA is a tool that helps to identify areas of vulnerability to the impacts of climate change and assists with prioritising or identifying areas for focusing adaptation action.

Figure 2.1: Assessment of vulnerability in the IVA



Based on the existing conditions in the region and their relationship to values, a list of suggested indicators that could be used to assess the vulnerability of environment and open space in Western Adelaide has been developed and is included in Appendix C.

These suggested indicators will be considered further by the AdaptWest project team in development of a list of regional indicators that will assist in identifying vulnerabilities across the project themes and regional values.

3.0 Exposure factors

This section outlines the climate hazards that the region may be exposed to as a result of changing climatic conditions. The exposure of Western Adelaide to climate hazards is summarised in Table 3.1.

Table 3.1: Exposure of Western Adelaide to potential climate hazards

Climate hazard	Exposure of Western Adelaide
Increasing average temperature	Entire region exposed
Increasing frequency, intensity and duration of heatwaves	Entire region exposed
Declining average annual rainfall	Entire region exposed
Increasing rainfall intensity	Entire region exposed
Coastal inundation caused by sea level rise /storm surge	Marine and coastal areas of the region exposed
Increased coastal recession due to accelerated erosion	Marine and coastal areas of the region exposed
Increasing temperature of Gulf waters	Marine and coastal areas of the region exposed
Increasing acidity of Gulf waters	Marine and coastal areas of the region exposed

Unless otherwise stated, the discussion of projected changes in climate below is based on a medium emissions scenario and median model outputs (often referred to as the "best estimate"). Baseline conditions refer to the period 1980-1999, which is the standard reference period identified by CSIRO and Bureau of Meteorology (BoM).[52]

3.1. Increasing average temperature

Temperatures in southern Australia have been increasing by about 0.2ºC per decade since 1950[53] and are expected to rise further over the coming decades. By 2030, average annual temperatures are projected to rise by 0.6-1ºC and by 2070 by 1.5-2ºC compared with baseline conditions (ranging from 1-3ºC under low to high emissions).[54] Mean maximum temperatures are expected to increase greatly,

[52] CSIRO and BOM (2007-2014) *Climate Change in Australia*. www.climatechangeinaustralia.com.au
[53] CSIRO and BOM (2007-2014)
[54] CSIRO and BOM (2007-2014)

particularly during summer months.[55] For example, average maximum February temperatures could increase from 28.2 ºC to 32.7 ºC.

3.2. Increasing frequency, intensity and duration of heatwaves

Heatwave typically describes a prolonged period of excessive heat, with common measures being the number of consecutive days over 35°C or 40°C. Three or more consecutive days where the average of daily maximum and minimum temperatures is greater than 32°C is a trigger used by the State Emergency Service for preparation of Extreme Heat Plans to mitigate the impact of extreme heat events on the community.[56]

The frequency of heatwaves with an average of the daily maximum and minimum temperatures of more than 32°C for 3 or more days is projected to increase from 1 in 20 years under current conditions to 1 in every 1 to 5 years (under high emissions or low emissions, respectively) by 2070. The duration of heatwaves will also increase by 2070, with projections suggesting that the region could experience periods of 5 to 6 days where an average of the daily maximum and minimum temperatures exceeds 32°C (1 in every 20 years).

With regard to intensity across each year, the number of days with maximum temperatures of 35°C or more is projected to increase from less than 15 to over 17 per year by 2030 and to over 35 by 2070 (high emissions, 50th percentile). Days with temperatures over 40°C are projected to increase from less than 2 per year to 2.5 per year by 2030 and over 10 per year by 2070 (high emissions, 50th percentile).

3.3. Declining average annual rainfall

Average annual rainfall is expected to decrease across the Western Adelaide region in the coming decades. Median projections are for rainfall to decline by 2-5% by 2030 and between 5-20% by 2070 throughout South Australia.[57]

Using information from meteorological stations in Western Adelaide, the most likely outcome under a medium and high emissions scenario is for average annual rainfall to decline by about 60 to 75 millimetres per year by 2070.[58]

Seasonally, a greater decline in rainfall has been predicted for spring than for autumn, however observations imply that autumn to winter rainfall patterns have changed and may be attributed to climate change impacts on atmospheric circulation patterns.[59]

[55] SKM (2013), p.36
[56] SKM (2013) p.37
[57] CSIRO and BOM (2007-2014)
[58] SKM (2013) p.42
[59] SKM (2013) p.42

3.4. Increasing rainfall intensity

Extreme rainfall events are forecast to become more intense by 2070, particularly during spring and summer. Historically, the total daily rainfall that is exceeded only once per year on average (i.e. a 1 year average recurrence interval (ARI) is 27 millimetres. Under a medium emissions scenario, the daily rainfall totals exceeded for 10 year and 100 year ARIs are 50 millimetres and 75 millimetres, respectively.

Under a high emissions scenario there is an increase in rainfall intensity with the 10 year and 100 year ARI events anticipated to rise from 50 millimetres and 75 millimetres, to 58 millimetres and 90 millimetres (respectively) by 2070.[60]

3.5. Coastal inundation caused by sea level rise /storm surge

Global mean sea level rise for 2081–2100 relative to 1986–2005 will likely be in the range of 0.3 to 0.6 m for RCP4.5 and RCP6.0[61] (equivalent to a low to medium emissions scenario).[62] Tide gauging in the Western Adelaide region has found sea levels to be rising at a rate of 2.06 millimetres per year and 2.08 millimetres per year at the Inner Harbour and Outer Harbour areas respectively.[63]

Sea level rise could exacerbate exposure to non-climate specific threats such as land subsidence from natural causes and anthropogenic activities (e.g. landfill developments and large-scale groundwater extraction), and saline intrusion of aquifers.[64]

Sea level rise is also expected to intensify storm surge events. These are events where sea levels rise significantly above normal tide levels for a temporary period of time. Presently, the mean sea level at Outer Harbor is 0.13 m below the Australian Height Datum (AHD). However, the 100 year ARI water level for Outer Harbor based on current mean sea levels is 2.4 metres above AHD. This means that under a high sea level rise scenario, storm surge events could cause tides to reach areas that are presently 2.4 metres above AHD.[65]

3.6. Increasing coastal recession due to accelerated erosion

Coastal recession is defined as the landward retreat of a coastline. Coasts which are composed of erodible sediments (such as sand or mud) may retreat in response to sea level rise. The rate of change of coastal recession is dependent on many factors such as the rate of sea level rise, the resistance of the coast to erosion, effectiveness of any coast protective infrastructure, and longshore sediment movement.[66]

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[60] SKM (2013), p.42
[61] RCP = Representative Concentration Pathway, as referred to in: IPCC (2013) *Summary for Policymakers*, Cambridge University Press
[62] IPCC (2000) *Summary for policymakers: Emissions Scenarios*, IPCC
[63] DEH (2005) *Adelaide's Living Beaches: A Strategy for 2005-2025*, Department of Environment and Heritage, p.54
[64] SKM (2013) p.60; DEH (2005), p.55
[65] DEH (2005) p.101
[66] SKM (2013), p.61

Most of the coast in the Western Adelaide region is highly erodible as it is comprised mainly of sand and mud. Areas along the coast of St Vincent's Gulf are unprotected and are therefore more susceptible to wave action. Coastal recession in the Western Adelaide region could be between 50m and 100m in a high sea level rise scenario (i.e. 1m) if no control measures are implemented.[67]

3.7. Increasing temperature of gulf waters

The best estimate of changing sea surface temperatures are for a 1.5 to 2°C warming of oceans off South Australia by 2070.[68] How this translates to changes in the shallower Gulf waters is yet to be seen. Past work found approximately equal rates of warming in the deep ocean waters of the Great Australian Bight compared with the mouth of Spencer Gulf (i.e. 0.11°C and 0.12°C per decade since 1950, respectively).[69]

3.8. Increasing acidity of gulf waters

The Intergovernmental Panel on Climate Change's (IPCC) Fifth Assessment Report suggests that the earth's oceans will become more acidic under all scenarios assessed. Projections for decreasing pH range from 0.06 to 0.32 by 2100, with a best estimate more likely to be in the order of a 0.2 pH unit decrease.[70] This compares with a 0.1 pH unit decrease that has already been experienced since the beginning of the industrial era 250 years ago.

[67] South Australian Coast Protection Board (1992), *Coastal Erosion, Flooding and Sea Level Rise Standards and Protection Policy*, Coastline, p.6
[68] CSIRO and BOM (2007-2014)
[69] Suppiah *et al.* (2006) *Climate Change Under Enhanced Greenhouse Conditions in South Australia*, CSIRO Marine and Atmospheric Research, p.5-6
[70] IPCC (2013) *Summary for policymakers*, University Press, p.25

4.0 Sensitivity factors

Projected climate changes considered relevant to this region (Table 3.1) will directly and indirectly impact all elements of environment and open space. For example:

- Decreasing rainfall will decrease water availability yet increase the demand for water, such as for irrigation of ovals and parks;
- Sea level rise may directly result in coastal erosion and loss of coastal dunes, leading to indirect impacts on flora and fauna communities reliant on dune habitats; and
- Increasing temperatures may directly alter oceanic water temperatures and chemistry, leading to indirect impacts on distribution and abundance of marine flora and fauna.

This section further describes the potential sensitivities of Western Adelaide's values relating to environment and open space to climate hazards. Table 4.1 below summarises the values and the climate hazards to which they are sensitive.

Table 4.1: Potential sensitivities of environment and open space values to climate hazards

	CLIMATE HAZARD							
VALUE	**Increased temperatures**	**Increased heatwaves (IFD)**	**Reduced mean annual rainfall**	**Increased rainfall intensity**	**Coastal inundation**	**Coastal recession**	**Increased temperature of Gulf waters**	**Increased acidity of Gulf waters**
Amenity and quality of life	X	X	X	X	X	X	-	-
Biodiversity	X	X	X	X	X	X	X	X
Coastal environment	X	X	X	X	X	X	X	X
Coastal and riverine water quality	X	-	X	X	X	-	X	X
Infrastructure and essential services	X	X	X	X	X	X	-	-
Storm water management and use	X	X	X	X	X	-	-	-
Strong and connected community	X	X	X	X	X	X	-	-

4.1. Amenity and quality of life

The features and aspects relating to amenity and quality of life in the Western Adelaide region are: sport, recreation, entertainment, and tourism facilities; coastal /water based recreation; open and green spaces; and, natural and historical environments.

Environment and open space areas provide the foundation of an improved quality of life in the region. Increasing temperatures and heat waves, altered rainfall regimes, sea level rise, and coastal inundation will all have an impact on the region's amenity and quality of life either directly or indirectly. For example, increasing temperatures and decreasing rainfall may result in vegetation die back such as mature trees (e.g. street trees or those in reserves or parklands) and grassed areas of parks and sporting ovals. As well as not being aesthetically pleasing, such die back may present a hazard for residents and recreational users (e.g. tree or limb falls).

Such degradation or loss of vegetation and associated flora and fauna species may also impact on the mental and physical health of people living and working in the area by diminishing the connection/interaction that people have with nature and wildlife on a daily basis; with such interactions having been proven to be beneficial to human health.[71]

Die back issues may further cause a decreasing appeal of local streets, paths and open space areas for exercising and spending time in, thereby further impacting on human health. Decreasing water quality of popular rivers, lakes, and marine areas (e.g. River Torrens, West Lakes' Boating Lake, Adelaide Dolphin Sanctuary) may also impact on the quality of life for users, particularly if the lower water quality affects human health.

4.2. Biodiversity

The features and aspects relating to biodiversity in the Western Adelaide region are: gulf and marine biodiversity, coastal and dune biodiversity, riverine biodiversity, terrestrial biodiversity, ecosystem services, and intrinsic value.

The marine and aquatic (riverine) environments within the region support diverse flora and fauna communities, including freshwater fishes and plants, marine fishes, cetaceans and mammals, and marine plants (Appendix A). Such environments, however, are at high risk from impacts associated with the altered landscapes in which they exist and associated land-uses, For example, urbanised areas will influence the rate, amount and quality (content and temperature) of water run-off into aquatic and marine systems as well as facilitating the introduction of non-native plants and animals. Such impacts from the urban environment are likely to be

[71] Maller *et al.* (2005) *Healthy nature, healthy people: 'contact with nature' as an upstream health promotion intervention for populations*, Health Promotion International; Berman *et al.* (2008) *The cognitive benefits of interacting with nature*, Psychological Science; Bell *et al.* (2008) *Greenspace and Quality of Life: A Critical Literature Review*, Greenspace Scotland; Zelenski and Nisbet (2014) *Happiness and feeling connected: the distinct role of nature relatedness*, Environment and Behaviour

exacerbated by climate change impacts such as altered rainfall regimes and increasing temperatures.

The highly urbanised nature of the Western Adelaide region has also resulted in extensive clearing and degradation of natural terrestrial environments. Consequently, biodiversity (particularly terrestrial diversity) within the region has declined substantially since pre-European times.[72] Despite this, a number of common, urban-adapted terrestrial flora and fauna species occur within the built matrix (so-called "habitat generalists"), with species diversity peaking in the remaining pockets of remnant vegetation scattered throughout the region which provide important habitats and resources for a number of "habitat specialist" species (i.e. those species reliant on suitable vegetated habitat for survival), including nationally and internationally significant flora and fauna. In addition, the near-shore marine and estuarine environments offer important habitats for marine and aquatic species.

All species will exhibit varied sensitivities to different climate hazards, depending on their physiological sensitivities, habitat requirements, and movement abilities. However, in general, habitat specialists will be particularly sensitive to climate hazards, particularly if such hazards negatively impact the condition or extent of their required habitat or resources. For example, sea level rise will result in a loss of dune habitats and with it, a loss of dependent flora and fauna species. Similarly, a loss of mangrove or wetland communities will have significant implications for the diversity of flora and fauna species that require these habitats for breeding and foraging purposes, including international migratory bird species.

As well as a loss of habitat area, biodiversity may also be compromised by increased habitat degradation leading to a loss of habitat suitability. For example, for marine and freshwater species, increased water pollution and turbidity levels due to reduced rainfall (diminishing stream flows) coupled with increasing rainfall intensity (increased run-off) will significantly influence the habitat quality of their aquatic environments. Under climate change, weedy (habitat generalist) species are also likely to spread and degrade currently high quality remnant habitats.[73] For example, the important Barker Inlet estuary wetlands and surrounding near-shore marine areas may be susceptible to invasion from the non-native macroalgae, caulerpa (*Caulerpa taxifolia*); an introduced species of major concern for the region and already known to occur in nearby areas including Torrens Island, North Arm and the upper Port River.[74] Such impacts on habitat quality may further compromise ecosystem services such as water quality improvement services generally provided through wetlands.

[72] DEH (2010) *Informing Biodiversity Conservation for the Adelaide and Mount Lofty Ranges Region South Australia: Priorities, Strategies and Targets*, Department of Environment and Heritage, p.1
[73] DEH (2005)
[74] Baker and Gurgel (2011) *Biodiversity and Conservation of Macroalgae in the Adelaide Mount Lofty Ranges Region, Including an Assessment of Biodiversity and Distribution of Marcoalgae in the Gulf St Vincent Bioregion.* AMLR NRM Board

4.3. Coastal environment

The features and aspects relating to the coastal environment in the Western Adelaide region include: environmental values and community and recreation values.

The coastal environment is highly exposed to all climate variables relevant to the region, though will be particularly susceptible to coastal inundation and erosion. Environmental values such as the sand dune systems (including their dependent flora and fauna communities) and inter-tidal wetland, mangrove and saltmarsh communities will be particularly susceptible to coastal inundation as a result of storm surges, habitat loss due to coastal erosion and altered water and soil conditions due to increased rainfall intensity and associated run-off.[75] Native seagrass habitats in near shore marine areas will also be particularly sensitive to storm surges and altered oceanic temperatures and chemistry.[76]

Although many coastal communities are better adapted to drier environments, increased temperatures are likely to influence mangrove communities through increased evapotranspiration, and inter-tidal wetlands may be negatively influenced if changes in rainfall regimes alter the current water chemistry balance.[77] Such impacts on coastal and near-shore marine habitats will have subsequent flow-on effects to the native flora and fauna species (including nationally and internationally significant species) reliant on these habitats for roosting, breeding, and foraging.

Increased temperatures and heatwaves, together with coastal inundation and coastal recession will also impact on community and recreation values of the coastal environments. Increasing temperatures and heatwaves will likely result in an increased recreational demand for access to sandy beaches by residents and visitors seeking reprise from hotter daily temperatures. Such demand may lead to further degradation of coastal environments, though access may also inhibited by erosion and coastal recession as well as coastal inundation.

4.4. Coastal and riverine water quality

The features and aspects relating to coastal and riverine water quality in the Western Adelaide region include the Port River and Torrens River, the Gulf St Vincent, the application of Water Sensitive Urban Design (WSUD), and the capture and reuse of storm water.

Water quality in the River Torrens and Dry Creek, as well as in near shore marine habitats such as the Barker Inlet-Port Adelaide River system are repeatedly compromised by algal blooms resulting from nitrate pollution associated with fertiliser use upstream, sewage pollution, and stormwater runoff.[78] Such degraded water

[75] Cook and Coleman (2003)
[76] Connolly (2009) *Seagrass*, NCCARF; Waycott *et al*. (2007) *Vulnerability of seagrasses in the Great Barrier Reef to climate change*, Great Barrier Reef Marine Park Authority and Australian Greenhouse Office
[77] Cook and Coleman (2003)
[78] Aquasave Consultants (2011); City of Port Adelaide Enfield (2012)

quality has flow-on implications for freshwater fishes inhabiting the lower stretches of affected rivers and creeks as well as for marine species and habitats in the near-shore marine habitats.[79] Without considered management (e.g. freshwater flushing from upstream weir releases and ongoing water quality monitoring of marine environments)[80] such compromised water quality and algal blooms are likely to increase under increasing temperature and decreasing rainfall conditions.

Increasing rainfall intensity will also negatively influence water quality in the waterways and marine habitats by increasing the rate of run-off and, due to an overall decreasing annual rainfall, the concentration of pollutants in each run-off event. Together these impacts will increase pollutants and turbidity of affected waters, which will have flow-on effects to the flora and fauna species reliant on high quality aquatic and marine habitats. For example, seagrass beds in near-shore marine areas are likely to be detrimentally impacted by increased turbidity,[81] which will be particularly problematic for seagrass species (e.g. *Posidonia* spp.) which are slow to establish or re-establish.[82]

Water sensitive urban design features in the region may also be sensitive to altered rainfall regimes. Although there is little information available on specific impacts, it could be reasonably assumed that decreasing average rainfall but with periodic more intense rainfall events would alter wetland vegetation communities which could subsequently impact on the water quality services provided by such systems.

4.5. Storm water management and use

The features and aspects relating to the management and use of storm water in the Western Adelaide region are: Water Sensitive Urban Design (WSUD) and storm water capture and reuse. Storm water capture infrastructure such as constructed wetlands can provide habitat for native flora and fauna species, as well as water for use irrigating open spaces.

Declining average annual rainfall, together with increasing temperatures and heatwaves will impact significantly on environment and open space areas in the region. Native vegetation and ecological communities may experience diebacks and degradation if not enough water is regularly available resulting in negative consequences for concomitant flora and fauna species; the irrigation of managed parks, gardens, sporting ovals and golf courses will also be inhibited resulting increased management intervention and associated costs, which are likely to be passed on to rate payers and club members.

Given that rainfall will generally decline, being able to effectively capture, store and treat those rainfall and resulting run-off events that do occur will be vital in ensuring adequate water is available for use in managing native environments and open space areas (e.g. for irrigation use). WSUD features will be a key mechanism in facilitating this outcome, such as those implemented as part of constructed

[79] Aquasave Consultants (2011); City of Port Adelaide Enfield (2012)
[80] Aquasave Consultants (2011); City of Port Adelaide Enfield (2012)
[81] DEH (2008), pp.16 & 36
[82] Meehan and West (2000) *Recovery times for a damaged Posidonia australis bed in south eastern Australia*, Aquatic Botany

wetlands. The pumping station at Apex Park Wetlands is also a mechanism in place to help capture and redirect storm water to help prevent localised flooding events.[83]

4.6. Infrastructure and essential services

The features and aspects relating to infrastructure and essential services in the Western Adelaide region are: water and wastewater treatment, open space, and community facilities.

Environment and open space areas in the region often contain various community and public infrastructure. Impacts of increased temperatures, rainfall variability, and coastal inundation on infrastructure in environment and open spaces will also likely impact the condition and accessibility of the areas for human and native flora/fauna species use, alike. For example:

- Council parks and playgrounds often contain a range of facilities designed for recreational users of the areas (e.g. amenities blocks, picnic facilities and/or playground equipment). The accessibility and condition of such areas may be compromised by coastal inundation. Similarly, increased temperatures and heatwaves together with altered rainfall regimes will influence the safety and maintenance of such areas and may inhibit use for certain purposes;
- Sporting ovals are often accompanied by club houses, amenities blocks, night lighting and parking lots. Increasing costs associated with increasing maintenance requirements (e.g. irrigation) due to decreasing rainfall and increasing temperatures will exacerbate existing maintenance costs associated with the upkeep of infrastructure and these costs may be passed on to clubs and users thereby affecting their ongoing viability;
- A large amount of residential and commercial development (including road networks and power lines) is located adjacent to foreshore and dune areas and are therefore at particular risk from coastal inundation and sea level rise. Such infrastructure also presents a built barrier which effectively prevents the natural migration of coastal dune systems as an adaptation response to storm surges and sea level rise;
- Large and well established remnant vegetation and wetlands may include dedicated human use paths and interpretive signage (e.g. walking path and signs at Mutton Cove; walking/cycle "Coastal Way"[84] boardwalk through remnant dune vegetation along the Largs Bay foreshore); wetlands may also comprise ASR infrastructure. These features will be impacted by temperature and rainfall changes as well as coastal inundation and sea level rise. Negative impacts on such wetland communities will also affect any water treatment services provided by these areas;

[83] City of Charles Sturt (2007) *Asset Management Plan for Stormwater Pumping Stations*, City of Charles Sturt
[84] City of Port Adelaide Enfield (2008) *Biodiversity Management Plan 2009-2014*, City of Port Adelaide Enfield

- The large recreational lake at West Lakes (i.e. Boating Lake) contains recreational infrastructure associated with rowing sports as well as adjacent recreational user infrastructure (e.g. walking/bike paths, playgrounds, amenities). Decreasing rainfall and increasing temperatures will impact the water quality of the lake which may in turn increase health risks from recreational use of the lake (e.g. from direct contact with the water or from eating fish caught from the lake); and
- Weirs and water flow regulation infrastructure are implemented at certain waterways and estuaries in the region (e.g. Patawalonga Creek, River Torrens estuary, and Port Adelaide Estuary). Such infrastructure plays important roles in regulating water flow and quality within the region's waterways and estuaries. Coastal inundation and sea level rise may compromise the integrity of these structures with associated flow-on effects to flora and fauna species and communities, as well as recreational users.

4.7. Strong and connected community

The features and aspects relating to a strong and connected community in the Western Adelaide region are: diversity, equity and social justice, and vulnerable members of the community.

The environment and open space areas within the region help to promote a sense of community and connectedness by facilitating interactions between diverse ranges of people who commonly use these spaces for various activities. The efforts made in planning the accessibility of environment and open space areas for residents also helps to facilitate a more active lifestyle which will help to decrease key health risk factors.

The impacts of climate change hazards on the environment and open space areas within the region may result in decreased availability of these areas (either directly or indirectly) which will have subsequent flow-on effects to the community strength and connectedness. For example, coastal inundation may create dangerous damage to popularly used open space areas and associated infrastructure (e.g. Coastal Way[85] boardwalk), which could result in increasing lengths of closures to the public of affected open spaces (e.g. parks and playgrounds). Indirect losses of availability of open spaces may occur through associated increasing maintenance costs which may be required to be passed on to local residents and users of open spaces, and so potentially inhibit use.

[85] City of Port Adelaide Enfield (2008) *Biodiversity Management Plan 2009-2014*, City of Port Adelaide Enfield

5.0 Adaptive capacity factors

Adaptation is the process of adjustment to actual or expected climate and its effects, and in the case of human systems, seeks to moderate harm or exploit beneficial opportunities. Adaptive capacity is the ability to adapt - to adjust to potential damage, take advantage of opportunities, or respond to consequences.[86]

In determining adaptive capacity, consideration is given to what extent a feature or function in its current form, with current practices in place, could continue to function and respond to the consequences and opportunities presented by expected future climate conditions (in 2070 for the AdaptWest project).

In a regional context, adaptive capacity is complex and made up of a range of factors associated with systems, institutions, humans and other organisms. These factors can include natural attributes, physical infrastructure, technology, management plans and practices, funding, and governance arrangements. Social and cultural factors such as social capital, social networks, values, customs and perceptions also impact upon adaptive capacity, in for example the functionality of stakeholder relationships within governance arrangements, and whether barriers exist to implementing management practices on the ground.

A differentiation can be made between autonomous adaptation - an innate response to changes to systems, and planned adaptation – a conscious response to conditions that have or will change.[87] Adaptive capacity can be considered in a similar way, occurring 'naturally' (i.e. autonomously), or being deliberately developed (i.e. planned) to increase resilience to known and projected challenges.

The following discussion provides a brief overview of current features and conditions that contribute to Western Adelaide's adaptive capacity in relation to environment and open space. Those living, working, providing services and doing business in the region are considered to be most knowledgeable about the region, and as such it is intended that this summary be tested, refined and built upon by the region's stakeholders as part of the collaborative IVA that will be undertaken in the next stage of the project.

5.1. Physical factors

A key influence on adaptive capacity of the environment in the Western Adelaide region is climate velocity, which is the rate and direction at which climate suitability shifts across a landscape in relation to topographic diversity.[88] As the climate changes, species have two main adaptation options: they can remain in place or move. If species remain in place, they can:

- Increase or decrease their abundance, depending on climatic suitability; or
- Evolve to cope with the new conditions.

[86] IPCC (2007) *Glossary,* Cambridge University Press
[87] IPCC (2007)
[88] Pinsky *et al.* (2013) *Marine taxa track local climate velocities*, Science

Species that are unable to evolve or persist in the new conditions will need to move (migrate) to remain within a climatically favourable area and avoid extinction. This is the mechanism by which most species have adapted to historical climate change, however, the rate at which climate change is now occurring, and predicted to occur in the future, is faster than that experienced historically. As such, species are at risk of being unable to match the rate of shifting suitable climates and so face an increased risk of extinction. This is particularly problematic for species with limited dispersal capabilities, as well as those living in highly fragmented landscapes (e.g. urban areas).

Climate velocity is faster in topographically simple landscapes (i.e. flat landscapes as opposed to mountainous ones) and therefore, species living in flat landscapes need to shift further and faster in order to match local climatic rates of change. This is directly relevant to the Western Adelaide region, where the coastal and plains natural landscape types both have low topographic diversity and thus are exposed to high climate velocity. As such, it can be expected that the adaptive capacity to projected climate change in the region will generally be low to very low.

More specifically, native plant communities in Western Adelaide will face two primary challenges in relation to climate change. First, rising sea levels will reduce the availability of habitat for coastal vegetation. Where areas such as native dune plant communities, samphire and mangroves are backed by hard infrastructure or developed land, their adaptive capacity is low as there is nowhere for this habitat to retreat (move), which is the normal adaptive response. Where there is an opportunity for coastal plant communities to move inland, they will also need to adapt to warmer and drier conditions. However, the high climate velocity will mean that a number of species will not be able to persist. Whether these areas then remain vegetated will depend on natural dispersal or replanting programs, both being examples of potential adaptation response.

Further inland, native plant communities such as remnant Eucalyptus woodland exist in patches of open space (e.g. Folland Park). Their ability to remain in the region will be dependent on the suitability of projected climate to the species that make up these communities. However, adaptive capacity is likely to be low to projected changes in temperature and rainfall as there will be no suitable alternate climatic areas within the region for these vegetation communities to move. As such, persistence of native vegetation is likely to require active management of these areas as part of a planned adaptation response.

In comparison to coastal and terrestrial vegetation, native aquatic vegetation in the Gulf such as seagrass communities are likely to have higher adaptive capacity because habitat will remain as the climate changes, although suitability of this habitat will also be reliant on water quality which is known to have impacted the condition of seagrass communities in the past.[89] Ultimately, adaptive capacity of these communities will be determined by factors such as the temperature range of individual species, and if these can no longer persist, whether sea grass more suited to projected conditions can disperse to the region.

[89] DEH (2008)

The adaptive capacity of native fauna will primarily be affected by their ability to access suitable habitat for foraging, roosting and breeding. Because Western Adelaide is a highly urbanised region, the majority of native animals are already generalists in terms of preferred habitat. This means that they are able to fulfil their foraging, roosting and breeding requirements using a range of different habitat types, including built structures and human food waste, and regardless of the species composition of vegetated areas. A secondary aspect for adaptive capacity will be the ability for native fauna to disperse to new areas of habitat if climate change means existing habitat is lost or shifts. In this instance, adaptive capacity could vary greatly between species in the region, for example, the painted dragon (*Ctenophorus pictus*) will be much less able to move to remaining habitat in urban areas than would for example, musk lorikeet (*Glossopsitta concinna*).

With respect to open space, the advent of warmer and drier conditions will mean that the main determinants of adaptive capacity will be current species selection (i.e. vegetation more suited to projected climatic conditions) and the ability to water grassed areas, street trees and other areas of vegetation. Provision of water for irrigation of open space will link strongly with WSUD strategies such as storm water management.

The number of man-made wetlands in the region increase adaptive capacity both in terms of water capture and storage, and also in terms of improving water quality (with flow on impacts to improving riverine and near-shore marine habitats). Range wetlands and Magazine Creek wetlands, for example, were initially designed and constructed in the 1980's to intercept and improve water quality of run-off before entering the adjacent mangrove estuary.[90] These wetlands, however, also help to improve adaptive capacity to potential local coastal inundation due to sea level rise by acting as a temporary storage area in the case of high tides and inundation.[91] The primary contemporary water reuse scheme in the region is "Water Proofing the West"; a major stormwater capture and storage scheme located in the City of Charles Sturt, with Stage 1 having now been completed. The scheme, which also assists with flood protection, will provide water for irrigation of open space in the Council in the short term and in the longer term has the potential to further expand and provide water more broadly across the region and to other users e.g. schools. Provided funding for this can be obtained, this would provide significant additional adaptive capacity for the region's open space.

5.2. Administrative factors

A range of local policies, plans and strategies are in place in Western Adelaide that address various aspects of environment and open space and potentially contribute to the region's adaptive capacity (Appendix D). National, State-wide and metropolitan-wide strategies, plans, and policies also contribute to the region's adaptive capacity.

[90] City of Port Adelaide Enfield (2012)
[91] City of Port Adelaide Enfield (2012)

Decision making is influenced by the context in which decisions are made. Proposed decisions will be more or less acceptable to decision-makers depending on the existing values, rules and knowledge which they are drawing upon.[92] These elements can either contribute or limit decisions being made and subsequent adaptive capacity of the region.

Examples of elements that contribute to decision-making and adaptive capacity in the Western Adelaide region include:

- Governance arrangements, such as the:
    - Metropolitan Seaside Councils' Committee, which is a local government committee that provides a forum for councils to develop a common response to shared concerns, to facilitate collaboration to source funding, to address priority concerns across council boundaries, and to raise the profile of our coastal environments; and
    - Presence of a range of community groups within the region that can support on-ground works, such as in maintenance and restoration of vegetation in dune systems. Groups include, but are not limited to, the: Tennyson Dunes Group**,** Semaphore Park Coastcare, Coastal Ecology Protection Group, Friends of the Patawalonga Creek, Schroder Park Our Patch Group, Friends of Biopark, and the Friends of Gulf St Vincent;
- Funding programs currently in place, empower local governments to undertake local adaptation, such as the Regional Natural Resource Management Planning for Climate Change Fund, which supports regional natural resource managers and organisations;
- Increasing knowledge of the impacts of climate change on environment and open space in the region, which will assist planning efforts;
- Strong emphasis on water sensitive urban design actions, such as Waterproofing the West, which provide habitat for native flora and fauna and a source of water for irrigating open space;
- There are a number of existing arrangements and mechanisms in place in South Australia for managing the coastal zone; these cover land use planning, natural resource management, climate change adaptation, emergency response and management of public assets; and
- A number of existing policies also currently manage activities in the coastal zone, including Adelaide's Living Beaches: A Strategy for 2005 – 2025, which sets out a plan for future management of Adelaide's metropolitan beaches and includes measures for continued replenishment to maintain a sand foreshore and building gup dune buffers to protect coastal infrastructure.

[92] Goddard *et al.* (in review) *Values, rules and knowledge: Adaptation as change in the decision context*

Examples of elements that limit decision-making and adaptive capacity in the Western Adelaide region include:

- Significant funding constraints on the provision of resources to protect native flora and fauna and significant ecological communities, including uncertainty of long term funding limiting ability to undertake long term planning;
- Lack of public awareness and concern for environmental values which can have an effect on government priorities and impacts on the ability to deal with future uncertainty and allocation of resources;
- Cost of implementing adaptation measures, including obtaining and communicating information and ongoing monitoring;
- The existing arrangements and mechanisms in place for managing the coast zone fall across numerous regulatory systems at all levels of government, this complexity can lead to overlap and confusion regarding ownership and enforcement of certain policy areas. Achievement of system objectives requires engagement with a variety of systems that have different and sometimes competing objectives (e.g. planning, land tenure, industry);[93] and
- Timeframes for execution of Commonwealth and State funding can be in conflict with local implementation timeframes.

Limitations to decision-making may also be due to a lack of information, which once collected, may convert to decision-making enablers. The following information gaps and opportunities for further studies have been identified:

- Improved local scale understanding of the impacts of climate change on aquatic and coastal environments, noting the coastal environments such as saltmarsh communities are generally accepted as being poorly understood at a national scale;
- Improved understanding of the localised impacts of climate change on locally important native flora and fauna, recognising that for most local species there have been no climate change impact assessments undertaken and hence a vulnerability assessment will draw largely on expert opinion;
- Modelling of beach recession to identify priority areas for sand replenishment, and where to maintain sandy beaches;
- How will local scale impact here impact the availability of resources for migratory wading birds; and
- Implications of State-wide irrigation of open space strategies for the region, especially the extent to which open space currently not irrigated may be irrigated in the future.

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[93] URPS (2013) *Defining the Sea Level Rise Problem in South Australia*, prepared for the Local Government Association of South Australia in partnership with the Climate Change Unit, Water and Climate Change Branch, Department for Environment, Water and Natural Resources, and the Coast Protection Board

6.0 Summary of conclusions

Environment and open space are fundamentally important for the Western Adelaide region, underpinning the region's liveability and economic prosperity by providing critical conservation, human health, community, economic, aesthetic, and tourism services.

Despite much of the remnant vegetation having been cleared and modified for urbanisation, the region still supports a high diversity of native terrestrial, aquatic, and marine flora and fauna species and communities, including those considered significant at local, State, Federal, and/or global scales. These will need to be considered as a priority in long-term management plans in order to ensure their ongoing persistence in the face of increasing urbanisation and climate change impacts. Specifically, the region supports:

- Over 400 native fauna species, of which at least 184 are listed as significant (including international migratory species);
- Over 400 native plant species, of which at least 97 are listed as significant; and
- A wide range of habitat types, including 22 significant ecological communities, reserves or protected areas (including important foraging habitats for migratory species).

Given the generally highly disturbed and urbanised nature of the region, a number of significant pest species (22 fauna and 45 flora) also occur. These will also need to be carefully considered in monitoring and management plans in order to limit their spread and impact on native species and communities.

The region also comprises a variety of surface water (e.g. lakes, rivers, and wetlands) and ground water (e.g. bores) resources. Given the highly modified surrounding land uses, water quality in the region's natural waterways has been highly degraded, though the establishment of a large number of wetlands helps to treat and improve water quality (including stormwater run-off) before it is discharged into the Barker Inlet Estuary and Gulf St Vincent. In addition to helping to address water quality, these constructed wetlands, together with associated aquifer storage and recovery infrastructure, store large quantities of water.

In addition to a diversity of environmental features, the region also comprises a diversity of open spaces which provide a range of recreational, aesthetic, economic, and biodiversity services. The main open spaces in the region include:

- Four key marine areas;
- 23 aquatic areas; and
- Approximately 1,473ha of terrestrial areas.

The importance of these environment and open spaces areas to the community was reflected by certain values identified during stakeholder workshops, including: a strong and connected community; amenity and quality of life; biodiversity; coastal and riverine water quality; coastal environment; infrastructure and essential services;,

management and use of stormwater; and, regional productivity and economic contribution to the State. These values and the environmental and open spaces elements within the region will be sensitive to the climate change hazards identified for the region. In particular, increasing temperatures and heatwaves, altered rainfall regimes, and coastal flooding will have significant impacts on the terrestrial and aquatic environments. Altered oceanic conditions (i.e. increased ocean temperatures and acidity) will be of particular significance for the marine environments, though these environments may also be impacted secondarily by decreased water quality of waterways and run-off as well as altered rainfall intensity, which may increase turbidity in marine environments as a result of increased rates of discharge.

Although the region's environments and open spaces are considered highly sensitive to climate change, a number of actions have already been taken to facilitate the region's adaptive capacity. For example, the number of constructed wetlands in the region are evidence of a strong emphasis on WSUD, with these wetlands offering multiple adaptive capacity services such as improving water quality and water availability, as well as providing managed habitats for a number of species and communities. A large number of community groups also operate within the region, providing important support for on-ground maintenance and restoration works. Several policies, funding arrangements and mechanisms in place also help to ensure adaptation actions are able to be conducted in an informed and sensitive manner.

Adaptive capacity and associated decision-making within the region could be improved through increasing understanding of climate change impacts, disseminating this knowledge to create enhanced community awareness, and applying the knowledge to help manage and prioritise impacts on beach erosion, foraging and habitat resources for migratory wading birds, and irrigation practices for open spaces.

The exposure, sensitivity and adaptive capacity of Western Adelaide, including in relation to environment and open space, will be further explored in collaboration with regional stakeholders through the IVA process.

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8.0 Appendices

Appendix A: Significant native species in the Western Adelaide region

The following species list is not considered to be comprehensive. Species listed are based on searches of databases[94] and available reports.[95] Species are listed alphabetically within major taxonomic groups (birds, mammals, reptiles, sharks, fishes, plants). For each species the following information is provided: scientific and common names; conservation status at Federal (F), State (S), and regional/local (R/L) levels (CE = critically endangered; E = endangered, NT – near threatened; T = threatened; R = rare; V = vulnerable); relevant migratory designation under the EPBC Act's other matters of national environmental significance (MNES) (species may be identified as wetland, marine or terrestrial migrants); whether the species is listed as a marine species under the EPBC Act Other MNES (Y = yes); any relevant listing under international agreements (A = ACAP, B = Bonn Convention, C = CAMBA, J = JAMBA, R = ROKAMBA); and the species' likelihood of occurrence. A dash (-) indicates information is not relevant or available.

		Status			EPBC Other MNES			
Scientific Name	**Common Name**	**F**	**S**	**R/L**	**Listed Migratory**	**Listed Marine**	**International Agreements**	**Likelihood of Occurrence**
BIRDS								
Acanthiza iredalei rosinae	Slender-billed thornbill	-	V	V	-	-	-	Known
Acanthiza pusilla	Brown thornbill	-	-	V	-	-	-	Known
Acanthorhynchus tenuirostris	Eastern spinebill	-	-	R	-	-	-	Known
Acrocephalus australis	Australian reed-warbler	-	-	R	-	-	-	Known
Actitis hypoleucos	Common sandpiper	-	R	E	Wetlands	Y	C; J; R	Known
Anas rhynchotis	Australasian shoveler	-	R	NT	-	-	-	Known
Anhinga novaehollandiae	Australasian darter	-	R	V	-	-	-	Known
Apus pacificus	Fork-tailed swift	-	-	R	Marine	Y	C; J; R	Known

[94] ALA (n.d.); Commonwealth of Australia (2013)
[95] SKM (2013); Caton *et al.* (2009); Gillam and Urban (2014); Port Adelaide Enfield (2008)

		Status			EPBC Other MNES			
Scientific Name	**Common Name**	**F**	**S**	**R/L**	**Listed Migratory**	**Listed Marine**	**International Agreements**	**Likelihood of Occurrence**
Aquila audax	Wedge-tailed eagle	-	-	V	-	-	-	Known
Ardea alba	Great egret	-	-	-	Wetlands	Y	C; J	Known
Ardea ibis	Cattle egret	-	R	V	Wetlands	Y	C; J	Known
Ardea intermedia	Intermediate egret	-	R	-	-	-	-	Known
Arenaria interpres	Ruddy turnstone	-	R	E	Wetlands	Y	C; J; R	Known
Biziura lobata	Musk duck	-	R	R	-	-	-	Known
Botaurus poiciloptilus	Australasian bittern	E	V	CE	-	-	-	Known
Cacatua galerita	Sulphur-crested cockatoo	-	-	R	-	-	-	Known
Calidris acuminata	Sharp-tailed sandpiper	-	-	-	Wetlands	Y	C; J; R	Known
Calidris alba	Sanderling	-	R	-	Wetlands	Y	C; J; R	Known
Calidris canutus	Red knot	-	-	-	Wetlands	Y	C; J; R	Known
Calidris ferruginea	Curlew sandpiper	-	-	CE	Wetlands	Y	C; J; R	Known
Calidris melanotos	Pectoral sandpiper	-	R	R	-	Y	J; R	Known
Calidris ruficollis	Red-necked stint	-	-	-	Wetlands	Y	C; J; R	Known
Calidris subminuta	Long-toed stint	-	R	R	-	Y	C; J; R	Known
Calidris tenuirostris	Great knot	-	R	R	Wetlands	Y	C; J; R	Known
Cereopsis novaehollandiae	Cape Barren goose	-	R	R	-	-	-	Known
Charadrius bicinctus	Double-banded plover	-	-	R	Wetlands	Y	-	Known
Charadrius leschenaultii	Greater sand plover	-	R	-	Wetlands	Y	C; J; R	Known

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Charadrius mongolus	Lesser sand plover	-	R	V	Wetlands	Y	C; J; R	Known
Charadrius ruficapillus	Red-capped plover	-	-	E	-	Y	-	Known
Charadrius veredus	Oriental plover	-	-	-	Wetlands	Y	R	Known
Cheramoeca leucosernus	White-backed swallow	-	-	R	-	-	-	Known
Chrysococcyx lucidus	Shining bronze-cuckoo	-	-	R	-	-	-	Known
Cinclosoma punctatum anachoreta	Spotted quail-thrush (Mt Lofty Ranges)	CE	E	-	-	-	-	May occur
Circus approximans	Swamp harrier	-	-	E	-	-	-	Known
Cisticola exilis	Golden-headed cisticola	-	-	V	-	-	-	Known
Cladorhynchus leucocephalus	Banded stilt	-	V	V	-	-	-	Known
Corvus coronoides	Australian raven	-	-	V	-	-	-	Known
Coturnix ypsilophora	Brown quail	-	V	V	-	-	-	Known
Diomedea epomophora epomophora	Royal albatross (southern ssp.)	V	V	-	Marine	Y	A; B	Likely
Diomedea epomophora sanfordi	Royal albatross (northern ssp.)	E	E	-	Marine	Y	A; B	Likely
Diomedea exulans	Wandering albatross	V	V	-	Marine	Y	A; B; J	Likely
Diomedea exulans antipodensis	Antipodean albatross	V	-	-	Marine	Y	A; B	Likely
Diomedea exulans exulans	Tristan albatross	E	-	-	Marine	Y	A; B	May occur
Egretta garzetta	Little egret	-	R	-	-	-	-	Known
Egretta sacra	Eastern reef egret	-	R	CE	-	-	C	Known

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Epthianura albifrons	White-fronted chat	-	-	R	-	-	-	Known
Falco peregrinus	Peregrine falcon	-	R	E	-	-	-	Known
Falco subniger	Black falcon	-	-	R	-	-	-	Known
Falcunculus frontatus	Crested shrike-tit	-	R	E	-	-	-	Known
Gallinago hardwickii	Latham's snipe	-	R	E	Wetland	Y	B; C; J; R	Known
Gallinago megala	Swinhoe's snipe	-	-	-	-	Y	C; J; R	Likely
Gallinago stenura	Pin-tailed snipe	-	-	-	-	Y	C; R	Likely
Gallirallus philippensis	Buff-banded rail	-	-	V	-	-	-	Known
Geopelia cuneata	Diamond dove	-	-	R	-	-	-	Known
Geopelia placida	Peaceful dove	-	-	V	-	-	-	Known
Haematopus fuliginosus	Sooty oystercatcher	-	R	E	-	-	-	Known
Haliaeetus leucogaster	White-bellied sea-eagle	-	E	E	Terrestrial	Y	C	Known
Haliastur sphenurus	Whistling kite	-	-	E	-	-	-	Known
Himantopus himantopus	Black-winged stilt	-	-	-	-	Y	-	Known
Hirundapus caudacutus	White-throated needletail	-	-	CE	-	-	C; R	Known
Lalage tricolor	White-winged triller	-	-	R	-	-	-	Known
Larus dominicanus	Kelp gull	-	R	-	-	-	-	Known
Larus pacificus	Pacific gull	-	-	U	-	-	-	Known
Lewinia pectoralis	Lewin's rail	-	V	E	-	-	-	Known

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Limicola falcinellus	Broad-billed sandpiper	-	-	-	Wetlands	Y	C; J; R	Known
Limosa lapponica	Bar-tailed godwit	-	R	-	Wetlands	Y	C; J; R	Known
Limosa limosa	Black-tailed godwit	-	R	-	Wetlands	Y	C; J; R	Known
Macronectes giganteus	Southern giant-petrel	E	V	-	Marine	Y	A	May occur
Macronectes halli	Northern giant-petrel	V	-	-	Marine	Y	A	May occur
Malacorhynchus membranaceus	Pink-eared duck	-	-	R	-	-	-	Known
Malurus cyaneus	Superb fairy-wren	-	-	R	-	-	-	Known
Malurus leucopterus	White-winged fairy-wren	-	-	CE	-	-	-	Known
Melithreptus lunatus	White-naped honeyeater	-	-	R	-	-	-	Known
Melopsittacus undulata	Budgerigar	-	-	R	-	-	-	Known
Merops ornatus	Rainbow bee-eater	-	-	R	Terrestrial	Y	-	Known
Myiagra cyanoleuca	Satin flycatcher	-	E	-	Terrestrial	Y	-	Likely
Neophema chrysogaster	Orange-bellied parrot	CE	E	CE	-	Y	-	May occur
Neophema chrysostoma	Blue-winged parrot	-	V	V	-	-	-	Known
Neophema elegans	Elegant parrot	-	R	R	-	-	-	Known
Neophema petrophila	Rock parrot	-	R	E	-	-	-	Known
Ninox navaeseelandiae	Southern boobook	-	-	V	-	-	-	Known
Numenius madagascariensis	Eastern curlew	-	V	V	Wetlands	Y	C; J; R	Known
Numenius minutus	Little curlew	-	-	-	Wetlands	Y	C; J; R	Known

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Numenius phaeopus	Whimbrel	-	R	R	Wetlands	Y	C; J; R	Known
Nymphicus hollandicus	Cockatiel	-	-	R	-	-	-	Known
Oxyura australis	Blue-billed duck	-	R	V	-	-	-	Known
Pandion haliaetus	Osprey	-	E	E	-	Y	-	Known
Petrochelidon ariel	Fairy martin	-	-	R	-	-	-	Known
Petroica goodenovii	Red-capped robin	-	-	V	-	-	-	Known
Phalaropus lobatus	Red-necked phalarope	-	-	-	-	Y	C; J; R	Known
Phaps chalcoptera	Common bronzewing	-	-	R	-	-	-	Known
Phaps elegans	Brush bronzewing	-	-	V	-	-	-	Known
Philomachus pugnax	Ruff	-	R	R	-	Y	C; J; R	Known
Phylidonyris albifrons	White-fronted honeyeater	-	-	R	-	-	-	Known
Plegadis falcinellus	Glossy ibis	-	R	R	-	-	C;	Known
Pluvialis fulva	Pacific golden plover	-	R	CE	Wetlands	Y	R	Known
Pluvialis squatarola	Grey plover	-	-	NT	Wetlands	Y	C; J; R	Known
Podiceps cristatus	Great crested grebe	-	R	R	-	-	-	Known
Porzana fluminea	Australian spotted crake	-	-	V	-	-	-	Known
Porzana pusilla	Baillon's crake	-	-	V	-	-	-	Known
Porzana tabuensis	Spotless crake	-	R	E	-	-	-	Known
Puffinus carneipes	Flesh-footed shearwater	-	R	-	Marine	Y	J; R	Likely

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Recurvirostra navaehollandiae	Red-necked avocet	-	-	-	-	Y	-	Known
Rostratula australis	Australian painted snipe	E	-	E	Wetlands	-	-	Likely
Rostratula benghalensis	Painted snipe	E	V	-	Wetlands	Y	C	Likely
Sterna albifrons	Little tern	-	E	-	Marine	Y	B; C; J; R	May occur
Sterna hirundo	Common tern	-	R	R	-	-	C; J; R	Known
Sternula nereis nereis	Australian fairy tern	V	E	E	-	-	-	Known
Stictonetta naevossa	Freckled duck	-	V	V	-	-	-	Known
Thalassarche cauta cauta	Shy albatross	V	V	-	Marine	Y	A	Likely
Thalassarche cauta steadi	White-capped albatross	V	-	-	Marine	Y	A	Likely
Thalassarche melanophris	Black-browed albatross	V	V	-	Marine	Y	A	May occur
Thalassarche melanophris impavida	Campbell albatross	V	-	-	Marine	Y	A	May occur
Thinornis rubricollis	Hooded plover	-	V	E	-	Y	-	Known
Todiramphus sanctus	Sacred kingfisher	-	-	R	-	-	-	Known
Tringa brevipes	Grey-tailed tattler	-	R	CE	Wetlands	Y	C; J; R	Known
Tringa glareola	Wood sandpiper	-	R	E	Wetlands	Y	C; J; R	Known
Tringa stagnatilis	Marsh sandpiper	-	-	R	Wetlands	Y	C; R	Known
Vanellus tricolor	Banded lapwing	-	-	E	-	-	-	Known
Xenus cinereus	Terek sandpiper	-	R	R	Wetlands	Y	C; J; R	Known
MAMMALS								

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Arctocephalus forsteri	New Zealand fur-seal	-	-	R	-	Y	-	Known
Arctocephalus pusillus	Australian fur-seal	-	R	-	-	Y	-	May occur
Balaenoptera edeni	Bryde's whale	-	R	-	Marine	Y	B	May occur
Caperea marginata	Pygmy right whale	-	R	-	Marine	Y	-	May occur
Delphinius delphis	Common dolphin	-	-	-	-	Y	-	Known
Eubalaena australis	Southern right whale	E	V	-	Marine	Y	-	Known
Hydromys chrysogaster	Water rat	-	-	R	-	-	-	Known
Lagenorhynchus obscurus	Dusky dolphin	-	-	-	Marine	Y	-	May occur
Megaptera novaeangliae	Humpback whale	V	V	-	Marine	Y	-	Likely
Neophoca cinerea	Australian sea-lion	V	V	R	-	Y	-	Known
Trichosurus vulpecula	Common brushtail possum	-	R	E	-	-	-	Known
Tursiops aduncus	Indian Ocean bottlenose dolphin	-	-	-	-	Y	-	Likely
Tursiops truncatus s. str.	Bottlenose dolphin	-	-	-	-	Y	-	May occur
Vespadelus darlingtoni	Large forest bat	-	-	R	-	-	-	Known
REPTILES								
Acanthopsis antarcticus	Common death adder	-	-	R	-	-	-	Known
Aprasis striolata	Lined worm-lizard	-	-	V	-	-	-	Known
Caretta caretta	Loggerhead turtle	E	E	-	Marine	Y	B	Likely
Chelonia mydas	Green turtle	V	V	-	Marine	Y	B	Known

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Ctenophorus pictus	Painted dragon	-	-	R	-	-	-	Known
Demansia psammophis	Yellow-faced whipsnake	-	-	V			-	Known
Dermochelys coriacea	Leatherback turtle	E	V	-	Marine	Y	-	Known
Tiliqua scincoides	Eastern bluetongue	-	-	R			-	Known
SHARKS								
Carcharodon carcharias	Great white shark	V	-	-	Marine	-	-	Known
Lamna nasus	Mackeral shark	-	-	-	Marine	-	-	Likely
FISHES								
Acentronura australe	Southern pygmy pipehorse	-	-	-	-	Y	-	May occur
Campichthys tryoni	Tryon's pipefish	-	-	-	-	Y	-	May occur
Filicampus tigris	Tiger pipefish	-	-	-	-	Y	-	May occur
Heraldia nocturna	Upside-down pipefish	-	-	-	-	Y	-	May occur
Hippocampus abdominalis	Big-belly seahorse	-	-	-	-	Y	-	May occur
Hippocampus breviceps	Short-head seahorse	-	-	-	-	Y	-	May occur
Histiogamphelus cristatus	Rhino pipefish	-	-	-	-	Y	-	May occur
Hypselognathus rostratus	Knifesnout pipefish	-	-	-	-	Y	-	May occur
Kaupus costatus	Deepbody pipefish	-	-	-	-	Y	-	May occur
Leptoichthys fistularius	Brushtail pipefish	-	-	-	-	Y	-	May occur
Lissocampus caudalis	Australian smooth pipefish	-	-	-	-	Y	-	May occur

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Lissocampus runa	Javelin pipefish	-	-	-	-	Y	-	May occur
Maroubra perserrata	Sawtooth pipefish	-	-	-	-	Y	-	May occur
Notiocampus ruber	Red pipefish	-	-	-	-	Y	-	May occur
Phycodurus eques	Leafy seadragon	-	-	-	-	Y	-	May occur
Phyllopteryx taeniolatus	Common seadragon	-	-	-	-	Y	-	May occur
Pugnaso curtirostris	Pugnose pipefish	-	-	-	-	Y	-	May occur
Solegnathus robustus	Robust pipefish	-	-	-	-	Y	-	May occur
Stigmatopora argus	Spotted pipefish	-	-	-	-	Y	-	May occur
Stigmatopora nigra	Widebody pipefish	-	-	-	-	Y	-	May occur
Stipecampus crisatus	Ringback pipefish	-	-	-	-	Y	-	May occur
Urocampus carinirostris	Hairy pipefish	-	-	-	-	Y	-	May occur
Vanacampus margaritifer	Mother-of-pearl pipefish	-	-	-	-	Y	-	May occur
Vanacampus phillipi	Port Phillip pipefish	-	-	-	-	Y	-	May occur
Vanacampus poecilolaemus	Longsnout pipefish	-	-	-	-	Y	-	May occur
Vanacampus vercoi	Verco's pipefish	-	-	-	-	Y	-	May occur
INVERTEBRATES								
Theclinesthes albocincta	Bitterbush blue butterfly	-	-	U	-	Y	-	Known
PLANTS								
Acacia cupularis	Cup wattle	-	-	R	-	-	-	Known

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Acacia dodonaeifolia	Hop-bush wattle	-	R	R	-	-	-	Known
Acacia salicina	Willow wattle	-	-	V	-	-	-	Known
Acacia victoriae ssp. *victoriae*	Elegant wattle	-	-	V	-	-	-	Known
Adenanthos terminalis	Yellow gland-flower	-	-	U	-	-	-	Known
Adriana quadripartita	Coast bitter-bush	-	-	U	-	-	-	Known
Alyxia buxifolia	Sea box	-	-	R	-	-	-	Known
Angianthus preissianus	Salt angianthus	-	-	R	-	-	-	Known
Apium annuum	Annual celery	-	-	R	-	-	-	Known
Argentipallium obtusifolium	Blunt everlasting	-	-	U	-	-	-	Known
Aristida behriana	Brush wire-grass	-	-	U	-	-	-	Known
Atriplex australasica	-	-	R	R	-	-	-	Known
Austrodanthonia laevis	Smooth wallaby-grass	-	R	R	-	-	-	Known
Bolboschoenus medianus	Marsh club-rush	-	-	R	-	-	-	Known
Bulbine semibarbata	Small leek-lily	-	-	R	-	-	-	Known
Caladenia argocalla	White-beauty spider-orchid	E	E	CE	-	-	-	May occur
Caladenia behrii	Pink-lipped spider-orchid	E	E	E	-	-	-	May occur
Caladenia conferta	Coast spider-orchid	E	E	-	-	-	-	May occur
Caladenia gladiolata	Bayonet spider-orchid	E	E	CE	-	-	-	May occur
Caladenia rigida	Stiff white spider-orchid	E	E	E	-	-	-	May occur

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Caladenia tensa	Greencomb spider-orchid	E	-	R	-	-	-	Likely
Calandrinia eremaea	Dryland purslane	-	-	U	-	-	-	Known
Callistemon teretifolius	Needle bottlebrush	-	-	R	-	-	-	Known
Callitris gracilis	Southern cypress pine	-	-	U	-	-	-	Known
Calotis erinacea	Tangled burr-daisy	-	-	E	-	-	-	Known
Calotis scapigera	Tufted burr-daisy	-	R	X	-	-	-	Known
Centrolepis cephaloformis	Cushion centrolepis	-	R	-	-	-	-	Known
Crassula exserta	Large-fruit crassula	-	R	R	-	-	-	Known
Crassula sieberiana	Sieber's crassula	-	E	E	-	-	-	Known
Cullen australasicum	Tall scurf-pea	-	-	R	-	-	-	Known
Cymbonotus preissianus	Austral bear's-ear	-	-	U	-	-	-	Known
Eucalyptus porosa	Mallee box	-	-	U	-	-	-	Known
Euphrasia collina ssp. o*sbornii*	Osborn's eyebright	E	E	E	-	-	-	Known
Frankenia cupalaris	-	-	R	-	-	-	-	Known
Gahnia filum	Thatching grass	-	-	R	-	-	-	Known
Gnaphalium indutum	Tiny cudweed	-	-	R	-	-	-	Known
Haloragis brownii	Swamp raspwort	-	R	V	-	-	-	Known
Helichrysum leucopsidium	Satin everlasting	-	-	U	-	-	-	Known
Hemichroa diandra	Mallee hemichroa	-	-	V	-	-	-	Known

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Hemichroa pentandra	Trailing hemichroa	-	-	R	-	-	-	Known
Hydrocotyle medicaginoides	Medic pennywort	-	-	R	-	-	-	Known
Kunzea pomifera	Muntries	-	-	U	-	-	-	Known
Lepidium pseudohyssopifolium	-	-	-	E	-	-	-	Known
Lepidosperma gladiatum	Coast sword-sedge	-	-	U	-	-	-	Known
Limosella australis	Australian mudwort	-	-	U	-	-	-	Known
Lomandra collina	Sand mat-rush	-	-	R	-	-	-	Known
Lomandra effusa	Scented mat-rush	-	-	R	-	-	-	Known
Lomandra juncea	Desert mat-rush	-	-	U	-	-	-	Known
Lomandra leucocephala ssp. *robusta*	Wooly mat-rush	-	-	R	-	-	-	Known
Lotus australis	Austral trefoil	-	-	U	-	-	-	Known
Maireana decalvans	Black Cotton Bush	-	E	E	-	-	-	Known
Maireana enchylaenoides	Wingless bluebush	-	-	U	-	-	-	Known
Melaleuca armillaris ssp. a*kineta*	Needle-leaf honey-myrtle	-	R	-	-	-	-	Known
Melaleuca halmaturorum	Swamp paper-bark	-	-	V	-	-	-	Known
Melaleuca lanceolata	Dryland tea-tree	-	-	U	-	-	-	Known
Melaleuca uncinata	Broombrush	-	-	R	-	-	-	Known
Millotia myosotidifolia	Broad-leaf millotia	-	-	U	-	-	-	Known
Myoporum parvifolium	Creeping boobialla	-	R	V	-	-	-	Known

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Olearia pannosa subsp. pannosa	Silver daisy-bush	V	V	E	-	-	-	May occur
Ophioglossum lusitanicum	Austral adder's-tongue	-	-	U	-	-	-	Known
Pelargonium australe	Australian pelargonium	-	-	U	-	-	-	Known
Persicaria lapathifolia	Pale knotweed	-	-	T	-	-	-	Known
Picris squarrosa	Squat picris	-	R	E	-	-	-	Known
Pittosporum angustifolium	Native apricot	-	-	R	-	-	-	Known
Podolepis rugata var. *rugata*	Pleated copper-wire daisy	-	-	E	-	-	-	Known
Pogonolepis muelleriana	Stiff cup-flower	-	-	U	-	-	-	Known
Poranthera ericoides	Poranthera	-	-	R	-	-	-	Known
Poranthera huegelii	Heath poranthera	-	-	R	-	-	-	Known
Prasophyllum pallidum	Pale leek-orchid	V	R	E	-	-	-	Likely
Prasophyllum pruinosum	Plum leek-orchid	E	V	E	-	-	-	Likely
Pterostylis arenicola	Sandhill greenhood orchid	V	V	CE	-	-	-	Known
Ptilotus polystachyus var. *polystachyus*	Long-tails	-	-	T	-	-	-	Known
Pultenaea tenuifolia	Narrow-leaf bush-pea	-	-	R	-	-	-	Known
Rhagodia parabolica	Mealy saltbush	-	-	V	-	-	-	Known
Rhagodia spinescens	Spiny saltbush	-	-	E	-	-	-	Known
Rorippa laciniata	Jagged bitter-cress	-	R	X	-	-	-	Known
Samolus repens	Creeping brookweed	-	-	U	-	-	-	Known

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Santalum acuminatum	Quandong	-	-	V	-	-	-	Known
Scaevola angustata	Coast fanflower	-	-	V	-	-	-	Known
Scaevola crassifolia	Cushion fanflower	-	-	R	-	-	-	Known
Schoenoplectus pungens	Spiky club-rush	-	-	U	-	-	-	Known
Sclerolaena diacantha	Grey bindyi	-	-	R	-	-	-	Known
Sclerolaena muricata var. *villosa*	Five-spine bindyi	-	R	R	-	-	-	Known
Senecio cunninghamii var. *cunninghamii*	Shrubby groundsel	-	-	E	-	-	-	Known
Senecio hypoleucus	Pale groundsel	-	-	U	-	-	-	Known
Tecticornia flabelliformis	Bead glasswort	V	V	V	-	-	-	Known
Thelymitra mattewsii	Spiral sun-orchid	V	-	-	-	-	-	May occur
Thysanotus baueri	Mallee fringe-lily	-	-	E	-	-	-	Known
Vittadinia australasica var. *australasica*	Sticky New Holland daisy	-	-	R	-	-	-	Known
Vittadinia blackii	Narrow-leaf New Holland daisy	-	-	R	-	-	-	Known
Wilsonia humilis	Silky wilsonia	-	-	U	-	-	-	Known
Wilsonia rotundifolia	Round-leaf wilsonia	-	-	V	-	-	-	Known
Zygophyllum billardierei	Coast twinleaf	-	-	R	-	-	-	Known

Appendix B: Significant invasive species in the Western Adelaide region

The following species list is not considered to be comprehensive. Species listed are based on searches of databases [96] and available reports.[97] Species are listed alphabetically within major taxonomic groups (birds, mammals, plants). For each species the following information is provided: scientific and common names; conservation status at Federal (F), State (S), and regional/local (R/L) levels (I = invasive; A = alert pest; D = declared weeds; WoNS = weed of national significance); and, the species' likelihood of occurrence. A dash (-) indicates information is not relevant or available.

		Status			
Scientific Name	**Common Name**	**F**	**S**	**R/L**	**Likelihood of Occurrence**
BIRDS					
Acridotheres tristis	Common mynah	I	A	-	Known
Alauda arvensis	Skylark	I	-	-	Known
Anas platyrhynchos	Mallard	I	-	-	Known
Carduelis carduelis	European goldfinch	I	-	-	Known
Carduelis chloris	European Greenfinch	I	-	-	Known
Columbia livia	Rock pigeon	I	-	-	Known
Passer domesticus	House sparrow	I	-	-	Known
Pycnonotus jocosus	Red-whiskered bulbul	I	A	-	Known
Streptopellia chinensis	Spotted turtle-dove	I	-	-	Known
Sturnus vulgaris	Common starling	I	-	-	Known
Turdus merula	Common blackbird	I	-	-	Known
MAMMALS					
Bos taurus	Domestic cattle	I	-	-	Likely
Canis lupus familiaris	Domestic dog	I	-	-	Known
Capra hircus	Goat	I	-	-	Unlikely
Felis catus	Feral cat	I	-	-	Known
Lepus capensis	Brown hare	I	-	-	Known
Mus musculus	House mouse	I	-	-	Known
Oryctolagus cuniculus	European rabbit	I	-	-	Known
Rattus norvegicus	Brown rat	I	-	-	Likely
Rattus rattus	Black rat	I	-	-	Known
Sus scrofa	Pig	I	-	-	Unlikely
Vulpes vulpes	Red fox	I	-	-	Known
PLANTS					
Ambrosia tenuifolia	Lacy ragweed	-	D	-	Known
Anredera cordifolia	Madeira vine	WoNS	D	-	Likely
Asparagus aethiopicus	Asparagus fern	WoNS	-	-	Likely
Asparagus asparagoides	Bridal creeper	WoNS	D	D	Known

[96] ALA (n.d.); Commonwealth of Australia (2013)
[97] SKM (2013); Caton *et al.* (2009); Gillam and Urban (2014); Thorp and Lynch (2000); City of Port Adelaide Enfield (2008)

		Status			
Scientific Name	**Common Name**	**F**	**S**	**R/L**	**Likelihood of Occurrence**
Asparagus plumosus	Climbing asparagus-fern	WoNS	-	-	Likely
Asparagus scandens	Climbing asparagus fern	WoNS	D	-	Likely
Asphodelus fistulosus	Onion weed	-	D	D	Known
Austrocylindropuntia spp.	Prickly pears	I	-	-	Likely
Carduus tenuiflorus	Slender thistle	-	D	D	Known
Chondrilla juncea	Skeleton weed	-	D	D	Known
Chrysanthemoides monilifera	Bitou bush	WoNS	-	-	Likely
Chrysanthemoides monilifera subsp. monilifera	Boneseed	WoNS	D	-	Likely
Cuscuta campestris	Golden dodder	-	D	-	Known
Cylindropuntia spp.	Prickly pears	I	-	-	Likely
Cynara cardunculus ssp. *flavescens*	Artichoke thistle	-	D	-	Known
Cytisus scoparius	Broom	WoNS	D	-	Likely
Diplotaxis tenuifolia	Lincoln weed	-	D	-	Known
Echium plantagineum	Salvation Jane	-	D	-	Known
Emex australis	Three-corner Jack	-	D	D	Known
Euphorbia paralias	Sea spurge	-	-	D	Known
Euphorbia terracina	False caper	-	D	D	Known
Genista linifolia	Flax-leaved broom	WoNS	D	-	Likely
Genista monspessulana	Montpellier broom	WoNS	D	-	Likely
Genista sp. X genista monspessulana	Broom	I	-	-	Likely
Juncus acutus	Spiny rush	-	D	D	Known
Lantana camara	Lantana	WoNS	D	-	May occur
Lycium ferocissimum	African boxthorn	WoNS	D	D	Known
Marrubium vulgare	Horehound	-	D	-	Known
Nassella neesiana	Chilean needle grass	WoNS	-	-	Likely
Olea europaea	Olive	I	D	D	Known
Opuntia spp.	Prickly pears	WoNS	D	-	Known
Orobanche minor	Lesser broomrape	-	D	D	Known
Oxalis pes-caprae	Soursob	-	D	D	Known
Pennisetum clandestinum	Kikuyu	-	-	D	Known
Phalaris aquatica	Phalaris	-	-	D	Known
Pinus halepensis	Aleppo pine	-	D	-	Known
Pinus radiata	Radiata pine	I	-	-	Known
Protasparagus plumosus	Ferny asparagus	I	-	-	Likely
Reseda lutea	Cut-leaf mignonette	-	D	-	Known
Rubus fruticosus aggregate	Blackberry	WoNS	D	-	Likely

		Status			
Scientific Name	**Common Name**	**F**	**S**	**R/L**	**Likelihood of Occurrence**
Salix spp. (*except S.babylonica, S.x calodendron, S.x reichardtii*)	Willows except weeping willow, pussy willow, sterile pussy willow	WoNS	D	-	Likely
Solanum elaeagnifolium	Silver nightshade	WoNS	D	-	Known
Tamarix aphylla	Athel pine	WoNS	D	-	Likely
Trachyandra divaricata	Dune onion weed	-	-	D	Known
Tribulus terrestris	Caltrop	-	D	-	Known

Appendix C. Suggested IVA indicators

		Environment and open space values						
Primary Indicator	**Secondary Indicator**	**A strong and connected community**	**Amenity and quality of life**	**Biodiversity**	**Coastal and riverine water quality**	**Coastal environment**	**Infrastructure and essential services**	**Management and use of stormwater**
Biodiversity	Condition and extent of native vegetation cover by vegetation type (Grassy woodland)			X				
Biodiversity	Condition and extent of native vegetation cover by vegetation type (Saltmarsh)			X	X	X		
Biodiversity	Condition and extent of native vegetation cover by vegetation type (Native dune plant communities)			X		X		
Biodiversity	Condition and extent of native vegetation cover by vegetation type (Native wetland plant communities)			X	X	X		
Biodiversity	Condition and extent of native vegetation cover by vegetation type (Swamp paperbark low woodland)			X	X	X		

		Environment and open space values						
Primary Indicator	**Secondary Indicator**	**A strong and connected community**	**Amenity and quality of life**	**Biodiversity**	**Coastal and riverine water quality**	**Coastal environment**	**Infrastructure and essential services**	**Management and use of stormwater**
Biodiversity	Condition and extent of native vegetation cover by vegetation type (Mangroves)			X	X	X		X
Biodiversity	Condition of near shore marine environment			X	X	X		
Biodiversity	Condition of Barker Inlet-St Kilda Aquatic Reserve			X	X	X		
Biodiversity	Number of significant native fauna species			X		X		
Biodiversity	Number of significant native flora species			X		X		
Biodiversity	Number of significant ecological communities, reserves and protected areas (Federal, State)			X		X		
Biodiversity	Abundance and diversity of freshwater fish			X	X	X		
Biodiversity	Abundance and diversity of frogs			X	X			

		Environment and open space values						
Primary Indicator	**Secondary Indicator**	**A strong and connected community**	**Amenity and quality of life**	**Biodiversity**	**Coastal and riverine water quality**	**Coastal environment**	**Infrastructure and essential services**	**Management and use of stormwater**
Biodiversity	Abundance and diversity of terrestrial birds			X	X	X		
Biodiversity	Abundance and diversity of terrestrial mammals			X	X	X		
Biodiversity	Abundance and diversity of marine mammals			X	X	X		
Biodiversity	Abundance and diversity of waterbirds			X	X	X		
Biodiversity	Abundance and diversity of reptiles			X	X	X		
Biodiversity	Abundance and diversity of seabirds			X	X	X		
Biodiversity	Abundance and diversity of waders			X	X	X		
Community connectedness	Participation in organised sport, church or community group in local area	X	X				X	X

		Environment and open space values						
Primary Indicator	**Secondary Indicator**	**A strong and connected community**	**Amenity and quality of life**	**Biodiversity**	**Coastal and riverine water quality**	**Coastal environment**	**Infrastructure and essential services**	**Management and use of stormwater**
Community connectedness	Rates of volunteerism	X	X				X	
Land assets	Condition of cultural heritage sites		X	X				
Pest plants and animals	Impact of pest plant and animal threats to the terrestrial environment			X		X		
Pest plants and animals	Impact of pest plant and animal threats to the riverine			X	X			
Pest plants and animals	Impact of pest plant and animal threats to marine and estuary environments			X	X	X		
Recreation	Condition of open spaces (e.g. parks and gardens)	X	X	X	X	X	X	X
Service networks	Condition of storm water management infrastructure				X		X	X
Service networks	Condition of wastewater management assets						X	X

		Environment and open space values						
Primary Indicator	**Secondary Indicator**	**A strong and connected community**	**Amenity and quality of life**	**Biodiversity**	**Coastal and riverine water quality**	**Coastal environment**	**Infrastructure and essential services**	**Management and use of stormwater**
Social inclusion/exclusion	Number of outdoor civic events held by Councils	X	X				X	X
Water	Condition of groundwater dependent ecosystems		X	X	X	X		X
Water	Quality of surface water (watercourses and run-off)			X	X	X		X
Water	Quantity of surface water			X	X	X		X
Water	Quality of groundwater			X	X	X		X
Water	Quantity of groundwater			X	X	X		X
Water resources	Availability of water for irrigation of open space	X	X				X	X

Appendix D. Local policies and plans contributing to adaptive capacity

Plans, policies and strategies	Port Adelaide Enfield	Charles Sturt	West Torrens
Annual Service Plans (City Assets, City Works, Regulatory Services)			X
Asset/Land Management Plans/Policies (e.g. for buildings, roads, stormwater infrastructure and pumping stations, drainage reserves, open space and recreation areas, linear reserves, bikeways, memorial gardens, beaches, waterways and water bodies)	X	X	X
Biodiversity Management Plan 2009-2014	X		
Climate Change Action Plan			X
Community/City Plan	X	X	X
Corporate Plan	X	X	
Development Plans (including Strategic Directions Report: Development Plan Review)	X	X	X
Environmental Health Management Plan Stage 1	X		
Environment Strategy 2009-2014	X		
Environmental Sustainability Policy		X	
Flood Management Master Plan			X
Garden Practice Awareness Program (Home Garden Water Wise Rebate Program) Policy	X		
Living Green to 2020 Draft Environmental Plan		X	
Local Area Bicycle Plan 2008-2012	X		
Natural Environment Policy			X
Open Space Strategy/Public Place Plans	X	X	X
Play Space Policy		X	
Public Open Space and Water Consumption Policy		X	

Plans, policies and strategies	Port Adelaide Enfield	Charles Sturt	West Torrens
Regional Public Health Plan		X	
Shade Over Playgrounds Policy	X		
Strategic Directions Report: Development Plan Review		X	
Street Trees and Reserve Plantings Policy	X		
Sustainable Environment – Discharge to Wetlands Policy	X		
Tree and Streetscape Policy		X	
Urban Tree Management Policy			X
Urban Verge Management Policy			X
Water Management Action Plan			X
Vegetation Management Plans (Henley South & West Beach, Henley Beach to Tennyson, Semaphore Park Coastal Reserve, Tennyson Dune Reserve)		X	