

Information Sheet on EAA Flyway Network Sites (SIS) – 2013 version

Available for download from <http://www.eaaflyway.net/about/the-flyway/flyway-site-network/>

*Categories approved by Second Meeting of the Partners of the East Asian-Australasian Flyway Partnership in Beijing,
China 13-14 November 2007 - Report (Minutes) Agenda Item 3.13*

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2. Date this sheet was completed:

2/09/2016

3. Country:

Australia

4. Name of the Flyway Network site:

Adelaide International Bird Sanctuary

5. Map of site:



6. Geographical coordinates (latitude/longitude, in decimal degrees):

Due to the narrow 'boomerang'-like shape of the proposed site it was not possible to distinguish a centre point. Instead three points in a triangular shape have been selected to provide geographical coordinates. The geographical coordinates are taken from the northernmost boundary of the specified area of interest above Clinton Conservation Park and the southernmost points of the eastern boundary below the Dry Creek

wetlands and the western boundary below the Price saltfields. The coordinates have been provided in degrees, minutes, seconds:

Northern boundary -	138° 7' 31.637" E
	34° 4' 35.407" S
South-western boundary -	173° 57' 38.872" E
	34° 23' 27.524" S
South-eastern boundary -	138° 34' 26.67" E
	34° 50' 17.21" S

7. Elevation:

Using Australian Height Datums (AHD) of tidal patterns recorded at Outer Harbour on the lower south-east of the site, the lowest astronomical tide that would expose mudflats used by migratory birds, has been identified as -1.45 AHD. The maximum elevation through the site is likely to be less than +10m.

8. Area:

Total area count for the proposed Adelaide International Bird Sanctuary nominated site is approximately 37,069 ha.

9. General overview of the site:

The Adelaide International Bird Sanctuary, also known as the Sapphire Coast, is a highly productive and ecologically significant ecosystem. The mosaic of marine, coastal, inland and man-made habitats provide important feeding and roosting areas for migratory waterbirds, particularly shorebirds. These habitats include: expansive tidal flats, mangrove forests, seagrass meadows, tidal saltmarshes, salt evaporation pans, artificial stormwater detention wetlands and effluent water treatment ponds and a seasonal freshwater lake (Farrelly, 1998). The area has been identified by BirdLife Australia as an Important Bird Site (IBS).

This area supports nationally and internationally significant numbers of migratory and resident shorebirds. At least 52 shorebird species, including 37 migratory species, have been recorded in the Adelaide International Bird Sanctuary area.

In addition to its value to shorebirds, the Adelaide International Bird Sanctuary is important habitat for many other coastal birds and seabirds, including the Sapphire Thornbill (also Known as Slender-billed Thornbill (*Acanthiza iredalei*), Elegant Parrot (*Neophema elegans*), Rock Parrot (*Neophema petrophila*), Little Egret (*Egretta garzetta*) and Fairy Tern (*Sternula nereis*). The Adelaide International Bird Sanctuary is part of the EPBC-listed (*Environment Protection and Biodiversity Conservation Act 1999*) subtropical and temperate coastal saltmarsh threatened ecological community, and contains the largest area of critical habitat for the

nationally vulnerable Bead Samphire (*Tecticornia flabelliformis*). It also supports many regionally significant species, including coastal-dependent reptiles and rare butterflies.

10. Justification of Flyway Site Network criteria:

Reviewers Note: This section refers only to the nomination boundaries known as the Adelaide International Bird Sanctuary (hereafter referred to as 'the site') and excludes count data from the Dry Creek Saltfields and the Barker Inlet Wetlands collected as part of the Gulf St Vincent Population Monitoring Project (2008-2016) and is the most accurate and up to date data available (Purnell *et al.* 2015).

Where possible ground-based counts have been conducted simultaneously across 18 separate 'count areas' throughout the Gulf at least once a season to provide an estimate of the overall shorebird population. It is important to note that access limitations to one or more significant count areas (e.g. Port Wakefield Proof and Experimental Range, Clinton Conservation Park or Price Saltfield – although these locations have not been included in the boundary map for the current Adelaide International Bird Sanctuary nomination) each season may result in incomplete count of the entire site. Therefore the summed counts presented below should be considered a minimum population estimate for the site.

Incidental counts of any one count area are also presented for some species. In some cases these opportunistic counts of localised roosts may document significant populations but are not accounting for the population on the site scale, as the simultaneous counts strive to do, and should similarly be referred to as minimum population estimates.

Notes on Listings

The following species accounts refer to the latest available information on conservation status and population size that has been compiled both on a global scale and for the proportion of the species using the East Asian-Australasian Flyway (EAAF). They include:

- Wetlands International (2016). "Waterbird Population Estimates". Retrieved from wpe.wetlands.org on Tuesday 6 Sep 2016.
- BirdLife International. 2015. Species factsheets: IUCN Red List for birds
- Guidelines for Application of IUCN Red List Criteria at Regional and National Levels; Version 4.0

Bar-tailed godwit (*Limosa lapponica*): Both subspecies of Bar-tailed Godwit (*menzbieri* and *baueri*) are considered to occur in Adelaide International Bird Sanctuary area however there is no detail on what proportions of each are present. A combined population estimate for both subspecies is referenced in this nomination.

Red knot (*Calidris canutus*): It is not known which subspecies of Red Knot (*piersmai* or *rogersi*) occurs in the Adelaide International Bird Sanctuary. A combined population estimate for both subspecies is referenced in this nomination.

Group B Criterion 2:

The Adelaide International Bird Sanctuary regularly supports nationally significant numbers (>0.1% EAAFP) of two globally Endangered species (IUCN Red List) and both the Eastern Curlew and Great Knot are listed as Critically Endangered under the Australian *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act):

- Eastern curlew (*Numenius madagascariensis*)
- Great knot (*Calidris tenuirostris*)

The Adelaide International Bird Sanctuary supports nationally significant numbers of three species

- Bar-tailed godwit (*Limosa lapponica*)
- Curlew sandpiper (*Calidrius ferruginea*)
- Sharp-tailed Sandpiper (*Calidris acuminata*)

Under the EPBC Act, the two subspecies of Bar-tailed Godwit are listed as Critically Endangered (subspecies *menzbieri*) and Vulnerable (subspecies *baueri*) respectively; and Curlew Sandpiper (*Calidrius ferruginea*) is listed as Critically Endangered.

The site also regularly supports internationally significant (>1% EAAFP) numbers of Red Knot, which is listed as Endangered under the EPBC Act.

- Red knot (*Calidris canutus*)

Group B Criterion 6:

The Adelaide International Bird Sanctuary regularly supports internationally significant populations of two species of migratory waterbirds; Red Knot (*Calidris canutus*) and, Red-necked Stint (*Calidris ruficollis*).

Red Knot (*Calidris canutus*)

While it is not clear which subspecies of Red Knot occurs in the Adelaide International Bird Sanctuary, the latest combined 1% threshold for the two subspecies is 990. This threshold was exceeded in 6 of the last 8 years (Table 1).

Table 1. Population count data for Red Knot in Gulf St Vincent (2008-2016). Note Gulf St Vincent is the geographical area including and surrounding the Adelaide International Bird Sanctuary.

Season starting	Max Count	date
2008	1,637	28/2/2009
2009	1,103	23/1/2010
2010	1,615	12/3/2011
2011	1,095	2/2/2012
2012	2,055	5/12/2012
2013	836	17/3/2014

2014	1,109	2/2/2015
2015	1,291	22/2/2016

Red-necked Stint (*Calidris ruficollis*)

The latest 1% threshold is 3,150 birds. The threshold was exceeded in 6 of the last 8 years (Table 2).

Red-necked Stints regularly occur in internationally significant numbers (>1% EAAFP) at the Dry Creek saltfields, which are directly adjacent to the Adelaide International Bird Sanctuary. As the largest supratidal area of habitat in Gulf St Vincent, Red-necked Stints use the saltfields as a supplementary high-tide feeding and roosting site. Given counts in Gulf St Vincent are predominantly conducted at high-tide roosts, they do not completely account for habitat usage at all tide heights and a proportion of the birds that are counted at the saltfields are considered to move to nearby intertidal areas (the Adelaide International Bird Sanctuary) on a falling tide. As the saltfields counts are excluded from this nomination it is important to consider the population data for the remaining sites as a minimum.

Table 2. Population count data for Red-necked Stint in Gulf St Vincent (2008-2016).

Summer	Max Count	date
2008/09	10,764	28/2/2009
2009/10	4,277	23/1/2010
2010/11	2,927	12/3/2011
2011/12	2,200*	9/11/2011
2012/13	3,369	1/12/2012
2013/14	3,795	17/3/2014
2014/15	3,297	2/2/2015
2015/16	5,231	22/2/2016

*NB: A single count of 2,200 Red-necked stints was made on the coastline adjacent to the Port Wakefield Proof and Experimental Range in 2011, which is land managed by the Department for Defence. This one incidental count exceeded the accumulative count for all other sites on the simultaneous count for that season. Due to access restrictions enforced by the Department for Defence, this area has only been counted twice in the last decade.

Sharp-tailed Sandpipers (*Calidris acuminata*), regularly occur within the site in nationally significant numbers (2014/15 count of 247).

References

BirdLife International. (2016). Species factsheets: IUCN Red List for birds. Accessed 11 July 2016 at: <http://www.birdlife.org/datazone/species/search>.

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Purnell, C., Peter, J., Clemens, R. (2015). Shorebird Population Monitoring within Gulf St Vincent: July 2014 to June 2015 Annual Report. BirdLife Australia report for the Adelaide and Mount Lofty Ranges Natural Resources Management Board.

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11. Wetland Types:

Marine/Coastal Wetlands:

G Intertidal mud, sand or salt flats.

I Intertidal forested wetlands; includes mangrove swamps, nipah swamps and tidal freshwater swamp forests.

B Marine subtidal aquatic beds; includes kelp beds, sea-grass beds, tropical marine meadows.

H Intertidal marshes; includes salt marshes, salt meadows, saltings, raised salt marshes; includes tidal, brackish and freshwater marshes

E Sand, shingle or pebble shores; includes sand bars, spits and sandy islets; includes dune systems and humid dune slacks.

F Estuarine waters; permanent water of estuaries and estuarine systems of deltas.

Inland Wetlands:

N Seasonal/intermittent/irregular rivers/streams/creeks.

P Seasonal/intermittent freshwater lakes (over 8ha); includes floodplain lakes. (note: in summer, this transitions into "R **Seasonal/intermittent saline brackish/alkaline lakes and flats**").

Human-made wetlands:

5 Salt exploitation sites; salt pans; salines, etc. (Price Saltfield)

8 Wastewater treatment areas; sewage farms, settling ponds, oxidation basins, etc. (Bolivar)

6 Water storage areas; reservoirs/barrages/dams/impoundments (generally over 8ha) (storm water detention wetlands)

9 Canals and drainage channels, ditches.

Overall order of area covered :-

G H I B E P/R 5 8 6 9 F N

12. Jurisdiction:

State Government of South Australia

Department of Environment, Water and Natural Resources, South Australian Government, including the Natural Resource Management Regions of:

- Adelaide Mount Lofty Ranges
- Northern and Yorke

Local Government Councils:

- City of Port Adelaide-Enfield
- City of Salisbury Council
- City of Playford
- District Council of Mallala
- Wakefield Regional Council
- Yorke Peninsula Council

13. Management authority:

Department of Environment, Water and Natural Resources (DEWNR) South Australian Government.

Address: 81-95 Waymouth Street, Adelaide, South Australia, 5000

- 1) Natural Resources, Adelaide Mount Lofty Ranges (DEWNR)

Contact: Regional Director, Mr Brenton Gear – [Adelaide International Bird Sanctuary Site Manager](#)

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- 2) Protected Areas Unit, Conservation and Land Management (DEWNR)

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Local Councils

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Yorke Peninsula Council

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14. Bibliographical references:

Bamford, M.J., Watkins, D.G., Bancroft, W., Tischler, G. and Wahl, J. (2008). *Migratory Shorebirds of the East Asian-Australasian Flyway: Population Estimates and Important Sites*. Wetlands International, Oceania, Canberra.

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Willson, A. and Bignall, J. (2009) *Regional Recovery Plan for Threatened Species and Ecological Communities of Adelaide and the Mount Lofty Ranges, South Australia*. Department for Environment and Heritage, South Australia.

WWF Australia Shorebird Conservation Project. (2002) *Gulf St Vincent Site Assessment*.

15. Physical features of the site:

Additional information for this question, including a table of climate statistics and two climate graphs, maps of the natural features described below and a list of reference documents, is supplied in the Supplementary Material for Question 15.

Geology, geomorphology & soils

The Adelaide International Bird Sanctuary site is located in an area where the surficial geology is recent, comprising Quaternary deposits from the Holocene (St Kilda Formation), deposited around the margins of Gulf St Vincent during the post glacial Flandrian Transgression.

The topography of the Adelaide International Bird Sanctuary is a flat, low lying coastal plain located entirely within the graben of the St Vincent Basin, which extends under the current Gulf St Vincent and is bounded to east and west by faults and elevated lands. Four of the faults (Redbank, Whitwarta, Templeton and Ardrossan-Kulpara) are presumed to cross the Adelaide International Bird Sanctuary at depth, in the vicinity of St Kilda, Middle Spit and south of Port Wakefield in the eastern site, and south of Mac's Beach in the western part of the site, respectively.

In the southern region of the Adelaide International Bird Sanctuary, sandy deposits form the northern end of LeFevre Peninsula and the sand islands of Bird Island (Section Bank) and Torrens Island. A band of mangroves backed with saltmarsh extends around the southern and eastern boundary of Barker Inlet, extending northward to the top of the Gulf then continuing down the western side of the Gulf. Wide tidal flats are exposed at low tide. Several rivers and creeks reach the sea within the site: the estuary of the Barker Inlet and Port River, Dry Creek (Swan Alley), Little Para, Gawler River, Salt Creek, River Light, Wakefield River and Wills Creek. Many of these drain via deltaic formations. A large number of tidal creeks and channels are also located within the site.

Large salinas (the ponds of solar saltfields) are located landward of the mangroves and saltmarshes in two locations – on the east of the Gulf between Dry Creek and Middle Beach and on the west side of the Gulf between Price and Ardrossan. Constructed stormwater treatment wetlands and ponded wastewater treatment ponds occur on low-lying land above the reach of the tides around the southern and eastern parts of Barker Inlet.

Due to limitations of protection that can be achieved over the salinas of the Dry Creek Saltfield, as well as the wastewater treatment ponds these are not included within the Adelaide International Bird Sanctuary, though are recognised for the role they play in supporting shore bird populations and potential for future inclusion. Backing the saltmarshes north of Middle Beach there are low-lying coastal playas (sabkhas), dunes, chenier ridges and tidal creeks.

There is less than 10m of topographic relief throughout the Adelaide International Bird Sanctuary, with the areas of greatest relief being the eastern boundaries of the sabkhas north of the River Light. Agricultural land abuts the site in the western and northern parts of the site.

The soils within the Adelaide International Bird Sanctuary are estuarine sediments and are dominated by calcareous, fossiliferous sand and mud of intertidal sand flats, beaches and tidal marshes, with clays increasing at depth. Gypseous clay is found on supratidal flats. These recent (6,700-10,000 years) marine sediments were deposited over a formerly alluvial dune and salt lake landscape and are strongly biogenic in origin, dominated by molluscan fragments with lesser quantities of bryozoans and foraminifera.

Tidal currents carry the fine carbonate material into the northern part of the Gulf from the south. This material settles out in the quieter waters of the northern Gulf. Over geological time, the northern portions of the Gulf have gradually become shallower, transforming into coastal wetlands. Other sources of sediments that accumulate in the northern Gulf include discharges from quarries at Rapid Bay, Kleins Point and Christies Beach, from the dredging at Outer Harbor and from the resuspension of settled sediments by tidal rips near Cape Jervis and North Spit. Settled sediment is stabilized by seagrass. The shelter of the seagrass beds allows more sediment to settle out and coralline algae growth, contributing to the further enlargement of the seagrass beds and their eventual terrestrialisation.

The recent geological high stand of the sea has resulted in an increasing volume of water overlying the continental shelf. This has caused differing degrees of coastal warping and resulted in a geographically variable, apparent sea-level fall around the much of the state's shoreline over the past 6,000 years. In the northern part of this site, near the head of Gulf St Vincent, the apparent sea-level fall over that period is in the order of 3-5 metres. This is in contrast to the Port River estuary in the south of the Adelaide International Bird Sanctuary, which is one of the few areas of the state displaying a sea-level rise (related to compaction of loose estuarine sediments) over the same period.

The combination of coastal warping and terrestrialisation of sediments deposited in the head of the Gulf explains how the shoreline at the head of the Gulf has migrated seaward several kilometres since the sea level stabilized about 6,000 years ago.

Origins

Wetlands of the Adelaide International Bird Sanctuary are generally naturally occurring extensive tidal wetlands and ephemeral freshwater wetlands. However, there are also a number of artificial wetlands in the form of salinas (salt fields), stormwater treatment wetlands, and an artificial lake.

Stormwater treatment wetlands are common around the southern edge of Barker Inlet. Magazine, Range and Barker Inlet South Wetlands occur in the City of Port Adelaide-Enfield, while Greenfields Stages 1-3, Whites Road and Swan Alley Wetlands are located in the City of Salisbury. These wetlands occur in what would have been the estuarine wetland zone of Barker Inlet prior to the industrial development that occurred in the early 20th Century.

Buckland Park Lake is an artificially impounded lake within the delta area of the Gawler River. The initial embankments across Chapman Creek and the Gawler River that created this lake were constructed in the late 1890s.

Hydrology

The **tides** that inundate the tidal wetlands of northern Gulf St Vincent have a mixed pattern, where there are two high waters and two low waters daily, with a marked inequality in the range of the diurnal and semi-diurnal tide each day. In addition to the inequality of the daily tides, there is also a normal lunar progression between spring and neap tidal heights. Gulf St Vincent is microtidal and spring tides are generally about 1.5m above and below sea level, while neap tides vary much less. At times (near the equinoxes) the neap tidal variation is so small that a “dodge” tide occurs and there may be negligible variation in water level over much of a day.

The combination of the mixed tide pattern and the dual opening of the Gulf into Investigator Strait results in high water occurring at much the same time throughout the Gulf, with lag times only noticeable in long estuaries. This specific combination of features also results in spring high waters occurring at approximately the same time (6 am and 6pm) every 14.8 days, with the morning high water being the greatest of the day's tides in summer and the evening high water being the greater in winter.

The Adelaide International Bird Sanctuary occurs around the northern end of an inverse estuary. Salinities offshore are higher in the northern part of the Gulf and also where extensive intertidal saltmarshes occur. The main flushing agency for the removal of evaporatively-concentrated salt is a low salinity current that flows northwards along the western side of the Gulf and then outflows south along the eastern side of the Gulf. A smaller, additional flushing mechanism occurs in winter during neap and dodge tides. When tidal

stirring is reduced, vertical stratification allows transient salt wedges to form. The dense higher salinity bottom water discharges along the western channel while the lighter inflow flows north along the surface.

The Adelaide International Bird Sanctuary's wetlands are traversed by a number of **rivers and tidal creeks**. Rivers and larger creeks with estuaries in the site include the Barker Inlet and Port River, North Arm, Dry Creek & Swan Alley, Little Para, Chapman Creek, Gawler River, River Light, Baker Creek, Port Wakefield River and Wills Creek.

Waterways entering the Adelaide International Bird Sanctuary all have short catchments, as the site is closely constrained by the elevated land surrounding the St Vincent Basin. The relatively low rainfall and short catchments combine to ensure the rivers of the coastal plains are ephemeral. As they cross the plains the rivers incise deeply into the alluvium of the plains. This incision is compounded by the deposition of soil that occurs during the occasional flooding, building up levees adjacent to the rivers. These slight levees tend to disappear within the site, where regular tidal flooding occurs.

Benthic surveys conducted in the estuarine zone of several creeks in the delta of the River Light and further south suggest the benthic elevation (bottom) of many tidal creeks and small rivers where they traverse the mangroves before entering the Gulf may be as much as 2m below average sea level in the reaches closest to land. The seagrass meadows immediately offshore from the mangroves are sedimentary formations that have an elevation of around -0.1m AHD, or just a little below average sea level. This is considerably more elevated than the benthos of the rivers and creeks and even during neap low tides these near-shore seagrass beds are a considerable obstacle to navigation.

Where boat launching facilities are located in tidal creeks or small rivers (for example Salt Creek at Middle Beach) seaway is only accessible during high tides. The waterway of such creeks maintains a deep "bathtub" within the stretches of the river that are sheltered by mangroves and saltmarshes where vessels can lie at anchor awaiting the high tide to allow them cross the seagrass meadows offshore that are exposed at low tide. Larger rivers used by boating, such as the Gawler and Wills Creek, maintain an open mouth. Two rivers that discharge within the site (Port Wakefield River and the Port River) are maintained by dredging and channelizing. At Port Wakefield the main discharge of the river has been channelized into a straight east-west channel just north of the town, and the dredged spoil used to construct an embankment along the southern riparian of the new channel. The Port River and Outer Harbor are the main port facilities for the city of Adelaide and are maintained by regular dredging. While spoil was deposited offshore in the past, there is now on-land disposition of the dredge materials.

The **standing waters** of the coastal plain within the Adelaide International Bird Sanctuary are all artificially constructed. The most naturalistic is Buckland Park Lake, constructed in the 1890s by constructing embankments across Chapman Creek and the potamon of the Gawler River. The shallow lake that resulted has rapidly accreted sediment and has changed from being permanently standing water to being a seasonal

lake. All other standing water bodies in the Adelaide International Bird Sanctuary are managed systems – either stormwater treatment wetlands, or the salinas of Price. The salinas have regular water levels and a spatially distributed salinity gradient that varies from eusaline at the intake pumps to a salinity of over 300g/L at the entry to the crystallising pans.

Groundwater underlies the Adelaide International Bird Sanctuary in several distinct aquifers. In coastal margins, thin unconfined quaternary aquifers or perched water table aquifers can occur within quartz-sand sediments of the Semaphore Sands or shelly sands of the St Kilda Formation. These contain water of variable salinity. While they are used by householders on the LeFevre Peninsula for irrigation and may be accessed by trees as a water source, they are subject to seawater intrusion and evaporative concentration. Within the eastern parts of the site, the salinity of these shallow aquifers may be more concentrated than seawater and may discharge sub-tidally along the shore of Gulf St Vincent. On the western side of the Gulf some of the very shallow water lenses discharge as coastal fresh springs at Tiddy Widdy Beach.

On the eastern side of Gulf St Vincent, west of the Para Fault, deeper tertiary aquifers occur underlying the Hindmarsh Clay at more than 70m below the surface, generally. These tertiary aquifers provide freshwater for the local horticulture industry located inland of the site. A very deep (>250m sub surface) tertiary aquifer is hypersaline, yielding brine approximately twice seawater salinity (50g/L).

Climate

The Adelaide International Bird Sanctuary occurs within a Mediterranean climate region, with cold, wet winters and hot dry summers. Specific weather data presented here comes from the Price climate statistics from the Bureau of Meteorology and from archived data from the now closed Dry Creek Saltworks weather station. The latter was chosen as the nearby stations with climate statistics are further inland and so show more temperature variability.

Temperatures are fairly uniform across the site with summer maxima between 26°C and 28°C in January and February, while winter maxima in the coldest months' average 14°C to 16°C. Overnight minimum temperatures in summer average 16°C while the winter minimas average 6°C in July. The number of days when minima fall below 2°C and frost is possible is low. Data for potential frost days averages 4.2 per year at Price in the north-west of the Adelaide International Bird Sanctuary.

Rainfall is variable across the extensive Adelaide International Bird Sanctuary with an average of 450mm of rain in the south-eastern part of the site and approximately 330mm rain on average in the north-westerly parts of the site. Most rainfall occurs between May and October. The northern parts of the Adelaide International Bird Sanctuary have a relatively even distribution of winter rain while the southerly parts of the site see peak rainfall occurring in May-August.

Evaporation exceeds precipitation by a considerable amount, with annual gross evaporation in the 1800-2000mm range. Strong south-westerly winds occur during autumn and spring, with hot northerly winds occurring during summer. The Adelaide International Bird Sanctuary experiences stronger breezes in the afternoon with calmer conditions in the mornings. In winter on the northern Adelaide Plains a light northerly breeze (the hibernal breeze) blows in the early mornings. Lightning storms occur throughout the year, but with higher intensity in mid to late spring.

16. Physical features of the catchment area:

Additional information for this question, including a table of climate statistics and two climate graphs, maps of the natural features described below and a list of reference documents, is supplied in the Supplementary Material for Question 16.

Regional surface area

The Adelaide International Bird Sanctuary is located within the St Vincent subregion of the Eyre Yorke Block (Interim Biogeographic Regionalisation for Australia), and is the seaward boundary of several major catchments. This subregion is an erosional and depositional coastal plain, containing alluvial and littoral plains. In isolated areas, NW-SE longitudinal dunes, mainly stabilized, occur. Near the Mt Lofty Ranges the plains have a detritic westerly gradient, merging eastwards with the alluvial fans of the Ranges. Regional geology and geomorphological features.

The Eyre Yorke Block consists of Archaean basement rocks and Proterozoic sandstones overlain by undulating, occasionally hilly calcarenite and calcrete plains and areas of aeolian quartz sands, with mallee woodlands, shrublands and heaths on calcareous earths, duplex soils and calcareous to shallow sands. Much of the bioregion is now largely cleared for agriculture.

The coastal wetlands of the site are entirely within the graben of the St Vincent Basin, which is located mostly under the current Gulf St Vincent. The Basin is flanked to the west by The Hummocks and the Ardrossan-Kulpara Fault. The Mount Lofty Ranges and the Willunga, Eden, Para, Alma, Redbanks, Whitwarta and Templeton Faults mark the eastern boundary of the Basin.

Weathered bedrock underlies Tertiary sediments over much of the Basin. Close to the edges of Gulf St Vincent, Quaternary sediments overly the bedrock. The saline swamps and mangroves adjacent the Gulf are underlain by the St Kilda Formation. This is described as calcareous, fossiliferous sand and mud of intertidal sand flats, beaches and tidal marshes, as well as gypseous clay found on supratidal flats. The slightly higher land of the east of the tidal wetlands are underlain by the Pooraka Formation of gravely and sandy clay, commonly gypcreted or calcreted.

Regional soil types

Soils in the St Vincent subregion comprise cracking clays, brown calcareous earths, highly calcareous loamy earths, plastic saline clay soils, and hard setting loamy soils with red clayey subsoils.

Regional climate (including climate type)

The climate of the Northern Adelaide Plains and the north-eastern Yorke Peninsula is Mediterranean, as detailed in the earlier Q15.

17. Hydrological values:

Question 15 (Hydrology subsection) provided a summary of important surface water and groundwater features of the site. There is little measured environmental flow data to provide information on hydrological values, and that only for the larger rivers that reach the sea within the Adelaide International Bird Sanctuary.

Starting from the north, the Port Wakefield River is ephemeral with a highly erratic pulse system, while Wills Creek on the western side of the Gulf is a tidal creek.

Further south on the eastern side of the Gulf, the Light River estuary is classed as an inverse estuary that is tide and river dominated. The Light River estuary is distinguished by relatively high tidal energy at the river's mouth, and strong tidal currents transport sediment into the estuary. A variable flow regime is natural for the River Light, with flow reaching the deltaic estuary of this river annually between late winter and spring. Runoff from the Light River does not generally occur in the months of May and June given that the soils of the upper Light Catchment are not saturated, and the river below Mallala is generally dry in summer and autumn. Occasional larger storm events with heavy rainfall are generally of short duration, but can provide large flows and inundation of the surrounding floodplains.

As the inverts of the Gawler River and River Light are elevated above the plains, floods spread widely across the plains, and the flooded deltaic areas of the Gawler River, Salt Creek and Light River become contiguous. The sabkha areas to the north of the River Light become detention basins during such overflows. The hydrology of the sabkhas is generally dominated by evaporation, even during periods when no floodwaters are present.

The Gawler River is highly modified with 56% of its natural flow diverted for consumptive purposes. The remaining flows are heavily regulated via dams, weirs and diversions from the river and its tributaries. Within the site the river debouches into the artificial Buckland Park Lake. In the period since it was constructed in the 1890s the lake has trapped sediments so that its base is now elevated more than a meter above the original surface. While the lake fills seasonally, it is shallow and now becomes dry through summer and autumn. Overflows occur only every few years.

The Port River and Barker Inlet is highly modified along its western channel, which forms the main shipping channel for Port Adelaide and Outer Harbor. To the south a flow-through system was constructed in the

1970s to draw seawater through West Lakes and discharge it into the Port River. The eastern extent of Barker Inlet comprises a network of shallow tidal creeks and mangrove forests. Along the southern and eastern shores of Barker Inlet the main stormwater drains for the city of Adelaide and the northern suburbs debouch, as do a number of industrial discharges. Bitterns (a mixture of salts left after saltmaking) was historically discharged into Barker Inlet via Dry Creek. The Little Para also discharges into Barker Inlet.

Rivers and creeks crossing the alluvial deposits of the Northern Adelaide Plains become losing streams. That is, their streamflow contributes to groundwater underlying these areas. Information on the groundwater systems and base flow within the catchment is limited, however the shallow groundwater within the site generally appears to have high salinities.

The estuarine and deltaic areas that form much of the site provide significant hydrological services. Floods coming down the rivers and creeks spread out across the site allowing the rate of flow to reduce, and sediment to settle, before the water enters the sea. This accumulation of sediment stabilises the shoreline and permits saltmarsh and mangroves to build land, an important ameliorant in the face of ongoing sea level rise. It remains to be seen whether sea-level change as a result of future climate change will occur slowly or rapidly. In comparison to the long period of stable water levels that has occurred over the last 6,000 years the change is likely to be rapid, suggesting that inundation of the shorelines is likely to occur. The impact on coastal wetlands may be large in that case, unless terrigenous supply to coastal wetlands is maintained.

18. General ecological features:

More detailed habitat descriptions, mapping of habitats and significant wetlands and a list of reference documents are provided in the Supplementary Material for this question in the Appendices.

The Adelaide International Bird Sanctuary occurs on low-lying land that generally lies between the highest storm surge elevation and the lowest tides, with some small areas of slightly higher land. The Adelaide International Bird Sanctuary encompasses a range of habitats, which are described very briefly here and more comprehensively in the Supplementary material for this question.

The majority of the coastal wetlands of the Adelaide International Bird Sanctuary are classified as having national importance. Intertidally, mud flats occupy the seaward parts of the site and are exposed daily by the ebbing tide. These mud flats may be bare, or clothed with intertidal seagrass meadows. They provide a feeding resource for large flocks of a wide diversity of shorebirds during low tide periods. Mangrove forests of *Avicennia marina* occur along much of the site, either as dense woodlands in sheltered areas or sparsely scattered along sandier parts of the coast.

Mangroves provide lesser habitat for many species of shorebirds, however Eastern Curlew use the mangroves, as do Grey-tailed Tattlers (*Tringa brevipes*), Lesser sand plovers (*Charadrius mongolus*), Whimbrels (*Numenius phaeopus*) and the Pacific golden plover (*Pluvialis fulva*).

Salt marshes form extensive meadows that border the sea, or they may form in a band between a mangrove forest and the higher land. Salt marshes exhibit zonation that is related to inundation, and they may (for simplicity) be divided into low-lying (submergent) and upper (emergent) salt marshes. Submergent salt marshes are utilised heavily by a wide range of shorebirds, especially when high tide makes the tidal flats inaccessible. High or emergent marsh develops where tides are less frequent. These higher saltmarshes have denser vegetation and are therefore utilised by fewer shorebirds. Tidal creeks criss-cross the mangroves and salt marshes. Common Sandpipers, Little Stint and Masked Lapwings have been recorded in the tidal creeks.

Supratidal sabkhas are the dominant landform and habitat type between Middle Beach and Port Wakefield. Sabkha environments are harsh, with evaporation during the summer months greatly exceeding the rainfall. Marine flooding may occur during storm surge events, or freshwaters may flood over them during rare flood events. During the periods the sabkhas are inundated they provide a feeding resource for shorebirds. At other times they are used for high-tide roosting, particularly by Grey Plovers.

Swamplands, sedgeland and constructed wetlands occur landward of, or penetrate into, the saltmarshes. Estuarine swamplands occur in small pockets throughout the study area. Extensive constructed wetland habitats are also present, in the form of the artificial Buckland Park Lake, stormwater treatment wetlands and the salinas of solar saltworks. These habitats provide shorebird feeding resources for some, or all of the year. Some provide food resources for a wide range of shorebirds while others, with a narrower range of prey species, are preferred by specific bird species.

Higher landforms that are located above the highest storm surges include seawalls and other embankments, chenier ridges, beach berms and dunes, grasslands, saltbush and small areas of mallee woodlands.

Embankments provide safe nesting areas for locally resident shorebirds and high-tide roosting areas for many of the larger migratory shorebirds. Dunes and cheniers host relatively few shorebirds, with only Masked Lapwings and Sanderling being recorded using them. Some specific species of shorebirds utilise grasslands – the larger plovers in particular.

In addition to providing feeding and roosting habitat for shorebirds, and feeding, roosting and breeding sites for a wide range of waterbirds (including a major site of cormorant breeding activity), the habitats of the site provide a range of other ecosystem services. The seagrass meadows, tidal creeks and saltmarshes provide nursery areas for a number of commercially and recreationally important marine fish and crustacean species.

The wetlands of the site provide regulating services including flood mitigation, groundwater recharge, water purification, sediment retardation and retention, sequestration of carbon and biological control of pests and diseases. Although quantification of these services has not yet been attempted at a site scale, there is ongoing work to measure sequestration of carbon within the site's habitats. Estimates for sequestration

evaluate the standing biomass as well as the below ground plant and soil carbon. In tidal habitats the burial rate for carbon can be very high, with saltmarshes, mangroves, mudflats (\pm cyanobacterial mats) and seagrass meadows sequestering carbon at rates an order of magnitude higher than terrestrial habitats.

19. Noteworthy flora:

A species list of noteworthy flora and maps of the vegetation associations of the Adelaide International Bird Sanctuary are supplied in the Supplementary material for an earlier Question 18 Ecological features, found in the Appendices.

There are likely to be in the region of 650 species of native plants and possibly 230 species of exotic plants, for a total within the site of approximately 880 flora species.

Two Commonwealth listed species of flora may occur within the Adelaide International Bird Sanctuary. *Euphrasia collina* ssp *osbornii*, Osborn'e eyebright, was last recorded at Taperoo in 1943 in the LeFevre Peninsula. This semi-parasitic herb is listed as Endangered under the EPBC Act and occurs in coastal grasslands, a habitat that has been widely impacted in the region.

More widely, *Tecticornia flabelliformis*, the Fan or Bead samphire is found at Torrens Island, Gawler River, Middle Beach, the River Light delta, Port Prime, Thompson Beach, Parham, Middle Spit, North Middle Spit, landward in the Bald Hill Beach South and at Wills Creek. This species is listed under the EPBC Act as Vulnerable and occurs as mainly monospecific stands occurring on sabkha landforms within the Adelaide International Bird Sanctuary.

Twenty-four species with State conservation ratings have been recorded within coastal assessment "cells" that are located within the Adelaide International Bird Sanctuary. There were at least 141 species with subregional (St Vincent IBRA subregion) conservation ratings. A table detailing observed species with conservation significance is provided in the Supplementary material for this question.

In addition to species with conservation significance in their own right, individual flora species maybe noteworthy for the habitat values they provide, particularly if they support threatened fauna.

Swards of low growing submergent saltmarsh, dominated by *Sarcocornia quinqueflora* and *Suaeda australis* are prime feeding habitat for a number of shorebird species and for *Neophema* parrots. *Tecticornia arbuscula*, the shrubby samphire, grows down by the tidal creeks and provides habitat for the Samphire Thornbill. Stands of the coast bitter-bush *Adriana quadripartita*, growing on coastal dunes and cheniers, are necessary for hosting the Bitterbush Blue Butterfly. Extensive sedgeland of *Gahnia filum* (thatching grass) are necessary for the survival of the Yellowish Sedge Skipper, while the varied species of tussock grasses forming coastal grasslands are the habitat for the Cynone Grass Skipper. The dryland tea-tree (*Melaleuca lanceolata*) shrublands of the site support mistletoes that provide food for a range of bush birds and for specific butterflies.

The site supports a varied range of habitats, and floral species are distributed across it in vegetation associations that reflect the underlying geomorphological and hydrological conditions.

20. Noteworthy fauna:

A detailed species list is provided in the Supplementary Material for this question in the Appendices.

Shorebirds

Fifty-one species of shorebirds (resident and migratory species) have been observed within the Adelaide International Bird Sanctuary. Thirty-seven of these are listed as migratory species under the EPBC Act. Twenty-two species of shorebirds occurring on the site are listed under the South Australian *National Parks and Wildlife Act 1974* (NPW Act) as Rare or Vulnerable. Five species (six subspecies) of migratory shorebirds recorded on the site have been listed as threatened (Critically Endangered, Endangered or Vulnerable) under the EPBC Act.

Some shorebird species are present at the Adelaide International Bird Sanctuary in large numbers – it hosts internationally significant numbers of Red-necked Stints (2015/16 count of 5,231) and Red Knot (2015/16 count of 1,291). Sharp-tailed Sandpiper (*Calidris acuminata*) also regularly occur within the Adelaide International Bird Sanctuary in nationally significant numbers (2014/15 count of 247).

Others species that are present in lower numbers find safe roosting in particular habitats within the Adelaide International Bird Sanctuary – for example Eastern Curlew roost in the mangroves, while Grey Plover move daily between the tidal flats and northern sabkhas. While the majority of the shorebirds across Adelaide International Bird Sanctuary are migratory, and migrate along the East Asian-Australasian Flyway, there are some species that are locally resident or that only migrate within Australia or nearby islands.

The resident Fairy tern (*Sternula nereis*) is known to be present in the Adelaide International Bird Sanctuary (129 observed in 2005) and is listed as Vulnerable under the EPBC Act and Endangered in NPW Act as well as the resident Caspian tern – both resident and migratory populations (*Hydroprogne caspia*) in larger numbers, 197 observed in 2014.

Migratory terns that use the Adelaide International Bird Sanctuary are the White-winged black tern (*Chlidonias leucopterus*), the Little tern – both resident and migratory populations (*Sternula albifrons*), Whiskered tern – both resident and migratory populations, (*Chlidonias hybrid*) 22,425 observed in 2006, and Greater crested tern (*Thalasseus bergii*) where 80 were observed in 2014.

Resident shorebirds are present in large numbers include Banded stilt (*Cladorhynchus leucocephalus*) (2014/15 count of 2,791), Black-winged stilt (*Himantopus himantopus*) (2014/15 count of 304), Red-capped plover (*Charadrius ruficapillus*) (2014/15 count of 1,039) and to a lesser extent Red-necked avocets

(*Recurvirostra novaehollandiae*) (2014/15 count of 550). One species, Double-banded plover (*Charadrius bicinctus*) migrates east-west between Australia and New Zealand. Three species of shorebirds recorded in the Adelaide International Bird Sanctuary are rare visitors that usually use flyways through the Americas (White-rumped sandpiper (*Calidris fuscicollis*), Hudsonian godwit (*Limosa haemastica*) and Lesser yellowlegs (*Tringa flavipes*).

Bush birds

In addition to shorebirds, more than two hundred species of birds have been recorded within the Adelaide International Bird Sanctuary. A range of these have conservation significance. There is a single recent record of three of the nationally Critically Endangered Orange-bellied Parrot at Port Gawler, but other *Neophema* parrots of conservation significance also use the site (Blue-winged, Elegant and Rock Parrots). Extensive submergent saltmarshes (dominated by *Sarcocornia quinqueflora* and *Suaeda australis*) are the preferred feeding grounds for these parrots. These saltmarshes occur at Mutton Cove and adjacent to many of the tidal creeks and larger watercourses that reach the sea within the Adelaide International Bird Sanctuary. Yellow-tailed Black Cockatoos, by contrast, prefer the rare wooded northern and western parts of the Adelaide International Bird Sanctuary.

'Samphire' Thornbills (a subspecies of Slender-billed Thornbills) have a State and National rating of Vulnerable. They are recorded in the tall Shrubby Samphire that grows closest to the tidal creeks in large areas of undisturbed saltmarsh. The delta of the River Light is the stronghold of this species, although smaller numbers have been recorded in other extensive intertidal saltmarshes within the site, particularly in the Clinton Conservation Park and the saltmarshes near Price Saltfield.

Waterbirds

Nineteen species of wildfowl and waterbirds with State conservation ratings occur on the site along with large populations of common species. Observations of duck species with conservation ratings (Musk duck, Chestnut teal, Blue-billed duck, Freckled duck and Australasian shoveler) and more common species such as the Grey teal, Pacific black duck and Pink-eared duck tend to be concentrated in the south-eastern parts of the site, where the larger rivers as well as Buckland Park Lake, and stormwater wetlands provide long periods with fresh and/or deep water. These habitats are also where bitterns and crakes tend to be observed.

The wide variety of habitats within the Adelaide International Bird Sanctuary provides niche opportunities for many wildfowl and waterbird species: Black swans feed on the tidal flats and in the marine salinas on both sides of the Gulf where seagrasses occur, Australian pelicans are most common in the marine salinas on both sides of the Gulf and at the colony on Section Bank, although small numbers occur right around the site. Cormorants occur right around the site, however Black-faced cormorants breed on the Outer Harbor breakwater, while a large colony of Little pied cormorants has a roosting colony on the sheltered skeletons of mangroves that were drowned during the construction of one of the salinas at Dry Creek. Fishing species like

egrets and herons seem to occur widely across the site, while spoonbills have been recorded mostly on sheltered mudflats with protecting mangrove fringes and within the salinas on both sides of the Gulf. A roosting colony of Nankeen night heron is found in the mangroves edging Chapman Creek, south of Port Gawler. Grebes are found commonly in the salinas and in tidal creeks and channels in the mangroves, or in pannes within the saltmarshes.

Seabirds

Seabirds including several species of terns and gulls are found widely round the Adelaide International Bird Sanctuary. One species, the Fairy Tern (listed as Vulnerable under the EPBC Act and with a State conservation listing of Endangered), is strongly associated with the salinas on the western side of the Gulf, at Price Saltfield. This is listed above under shorebirds. Two other notable seabirds that are coastally dependant are found at the Adelaide International Bird Sanctuary – Osprey and White-bellied sea-eagles - both with State conservation ratings of Endangered. White-bellied sea-eagles have been observed right around the Adelaide International Bird Sanctuary and were recorded breeding at the pump station adjacent the salinas near Buckland Park Lake for many years, while Osprey observations have been more limited, mainly Torrens Island and Section Bank.

Mammals

Several mammals with State ratings of Rare (Brushtail possum, Australian sea-lion and a single record of a Bryde's whale) have been recorded across the Adelaide International Bird Sanctuary. Species recorded with regional conservation significance observed within the site include the Long-nosed fur-seal, Water-rat, Western grey kangaroo, Short-beaked echidna and the Large forest bat. Several other common native mammals use the supratidal and forested parts of the site (Euros, Bush rats, and a number of bat species). Brushtail possums find the shelter offered by buildings and trees in the small coastal townships beneficial. Bats are common in the mangroves.

Marine mammals

The pinniped marine mammals use the Outer Harbor breakwater as a haul-out. Solely aquatic marine mammals of the Adelaide International Bird Sanctuary include the occasional whale stranding, and a resident population of Common bottlenose dolphins inhabits the tidal creeks and estuaries of the south-eastern part of the site, within the adjacent Adelaide Dolphin Sanctuary.

Exotic mammals

Exotic mammals are also present (deer, foxes, feral cats, black and brown rats, house mice, rabbits and hares). Foxes and cats are predators and their impact on shorebirds is a threatening process that needs ongoing management.

Reptiles and amphibians

Thirteen of the reptile species recorded throughout the Adelaide International Bird Sanctuary have regional conservation significance. Two of those are snakes (Common death adder and Yellow-faced whip snake). The lizards include a large varanid (Sand goanna), three are agamids (dragon lizards), one, a pygopodid (Lined worm lizard) and the remaining six are scincid species, including both species of large Bluetongue lizard. Two of the reptile species are dependent on coastal habitat. The Painted dragon is restricted to coastal dunes and cheniers, while the Common Death Adder is usually found in coastal woodlands, although it has also been historically recorded in seagrass wrack on beaches north of the River Light.

The amphibian species recorded within the Adelaide International Bird Sanctuary have all been common species. Their distribution is limited to the relatively small areas where freshwater is present for at least some months of the year.

Insects

No South Australian insects have conservation ratings; however, several coastal butterfly species are increasingly threatened. Within the Adelaide International Bird Sanctuary, the Cynone grass-skipper (*Anisynta cynone gracilis*) uses grassy coastal sites. Where there are stands of Dryland tea-tree (*Melaleuca lanceolata*) with mistletoe, usually growing with *Acacia* sp, the Wood white (*Delias aganippe*) and Amaryllis azure (*Ogyris amaryllis meridionalis*) can be found. Bitter-bush blue butterflies (*Theclinesthes albocincta*) may be seen where there are large stands of its host plant *Adriana quadripartita*, which grows on sandy coastal dunes. Large populations of the plants occur on Torrens Island, Port Gawler, Port Parham and south of Price. The Yellowish sedge-skipper (*Hesperilla flavescens flavia*) is a recently extinct species on the Adelaide International Bird Sanctuary, but a recovery plan for the species has seen its habitat (*Gahnia filum* sedgeland) recovering and it may be possible to re-introduce the species from populations in southern Yorke Peninsula.

Invertebrates

Initial studies into the benthic and shallow pelagic invertebrates that provide food sources for shorebirds have been undertaken and these show pronounced small-scale spatial and temporal patterns. The site-specificity of the habitats suggests maintaining a varied network of potential shorebird feeding sites is important.

A table showing the vertebrate fauna species that have conservation significance and that have been recorded within the site is attached in the supplementary material for this question. A separate table in that section provides information on all the species of shorebirds recorded within the site, their conservation status and the agreements that apply to them. The reference documents used for this section are also listed.

21. Social, economic and cultural values:

a) Social values:

Recreation: The several coastal settlements and towns provide direct access to the beaches and coastal waters of the Adelaide International Bird Sanctuary, as well as access from metropolitan Adelaide. As a result the Adelaide International Bird Sanctuary's water, beaches, coastal dunes and tidal creeks are used intensively for recreational activities including: boating (kayaking), fishing, crabbing, cockle and bait harvesting, camping, walking, swimming and bird watching.

Clay pans and supratidal saltflats (sabkhas) are other habitats within the site that are used for recreation by off-road vehicles such as four-wheel drives and dirt bikes. There are numerous coastal walking trails, many with interpretive signage (St Kilda Mangrove Trail and Thompsons Beach South Shorebird Walking Trail) that add to the social/recreational value of the Adelaide International Bird Sanctuary.

Research and Education: The Adelaide International Bird Sanctuary is renowned amongst local and overseas ornithologists as an important shorebird area and attracts researchers and a diversity of bird watchers due to the large numbers of shorebirds and waterbirds and the myriad of habitats that can be found within the Adelaide International Bird Sanctuary.

In 2002, WWF-Australia selected the Adelaide International Bird Sanctuary, as one of five sites within Australia for their Commonwealth-funded Shorebird Conservation Project. WWF-Australia recognised the region as a vital feeding ground for migratory shorebirds and sought to raise the profile of the international importance of the wetlands as well as the existing threats for shorebirds within the area.

BirdLife Australia has listed the Adelaide International Bird Sanctuary as an 'Important Bird Area' (IBA) as part of their national IBA program. Since 2008, the Adelaide and Mt Lofty Ranges Natural Resources Management Board have provided funding support to BirdLife to undertake shorebird monitoring as part of BirdLife's national Shorebird 2020 program and produce annual reports. The survey data from these reports have been used to justify the nomination of as the Adelaide International Bird Sanctuary a flyway site (see question 10).

Middle Beach Caravan Park and Education Centre historically supported university and school groups with facilities to host overnight stays and a samphire boardwalk interpretive trail. The privately owned facility has recently begun to reinvest in the site as an education centre with the hopes of attracting school groups, researchers, bird watchers etc.

Economic values:

The waters surrounding the Adelaide International Bird Sanctuary are considered to be an important nursery for a number of commercial and recreational marine fish, including King George Whiting (*Sillaginodes punctatas*), Yellowfin whiting (*Sillago schomburgkii*), Garfish (*Hyporhamphus melanochir*) and Yellow-eye mullet (*Aldrichetta forsteri*) and crustacean species Blue swimmer crab (*Portunus pelagicus*) and Western

king prawn (*Melicertus latisulcatus*), Southern calamary (*Sepioteuthis australis*) and Slipper lobster (*Ibacus* spp.) (PIRSA, 2007 and Farelly, 1998).

Green Infrastructure

The value of green infrastructure in urban landscapes is becoming increasingly recognised by health professionals, water managers, planners and policy makers around the world. The Adelaide International Bird Sanctuary provides as 'wild' green infrastructure space that is valued for the benefits provided to visitors and local communities.

Carbon value

The following is an estimate of carbon sequestration based on 22,895 ha that could be 'easily' measured for carbon. This figure is based on the sequestration potential of 20t per hectare (based on a low/mid-range vegetation value). The estimated potential to sequester 20,000 tonnes of carbon per 1,000 hectare each year as 500,000 tonnes of carbon a year for the Adelaide International Bird Sanctuary. At the current Emissions Reduction Fund price of around \$15 this would equal approximately 7.5M in revenue to manage the site if it was managed for its carbon values on the market.

Stimulate economic activity

A strategy to increase economic participation and activity is being developed for the Adelaide International Bird Sanctuary through an assigned community and stakeholder leadership group, The Collective, and affiliated taskforce groups. The Taskforce groups are defining the actions to be implemented that will most benefit shorebird conservation and opportunities for people. This is in close relation with local Aboriginal leaders, to establish pathways for both young and older people to identify, start-up and expand current cultural services provided across the sanctuary. This includes services such as cultural tours, sharing language and performances connecting people to the sanctuary and economically benefitting the local Aboriginal people, who consider themselves as the guardians of the area.

Socio-economic /Tourism:

Included in the Adelaide International Bird Sanctuary is the waterway of Adelaide's Port River and Barker Inlet. This area on the north-western fringe of metropolitan Adelaide is economically, socially, culturally and historically important. It is one of the most intensively used marine waterway in South Australia and contains the state's major port, a wastewater treatment plant, both light and heavy industries, industrial and residential developments, significant European and Aboriginal cultural and historical values and important recreational activities (fishing, bird watching and dolphin watching).

The Upper Gulf St Vincent Marine Park offers plenty of opportunities to explore the coastal habitats that support the variety of marine species that visit the area. The park features wetlands of national importance, including the Light River Delta, which is considered one of the most ecologically-intact mangrove and saltmarsh systems in South Australia. Located north of Parara Point to the northern end of Port Gawler

Beach, the park feature a major fish nursery and spawning ground, ensuring thousands of juvenile fish and other animals survive their first season.

Beyond these nurseries are great fishing spots, with blue crab, snapper and yellowfin whiting regularly caught in these waters. Visitors can also dive among the protected pipe fish that live in the sea grass habitats of this park or the razor fish beds in the intertidal mudflats and near-shore seagrass meadows. The Marine Park is home to the uncommon magpie fiddler ray which has not been recorded elsewhere. The shipwrecks that lie on the sea bed also offer an interesting insight into life at sea gone by. Access to Upper Gulf St Vincent Marine Park is from Ardrossan, Port Wakefield, Port Arthur, Port Parham and Thompsons Beach.

The Adelaide Dolphin Sanctuary was established by the South Australian *Adelaide Dolphin Sanctuary Act 2005* to protect and maintain a resident population of dolphins' habitat and food sources within the Port River, Barker inlet and the adjoining section of Gulf St Vincent. The area supports 30 or more Indo-Pacific bottlenose dolphins (*Tursiops aduncus*), with some 300 more dolphins thought to visit. Several privately run tourism operations currently use the Adelaide International Bird Sanctuary for their tour options.

Cultural values:

The majority of the Adelaide International Bird Sanctuary is within the lands traditionally owned and cared for by the Kurna people. The other traditional owners within the site are the Narungga people of Yorke Peninsula. There are several known sites with cultural heritage significance located within the flyway nomination site. The Greenfields Archaeological and Burial site on the floodplains of Dry Creek adjacent to the Saltfields was traditionally used as a camping area by the Kurna people (Farely, 1998). Torrens Island is another site with strong cultural values and known as an important camping, ceremonial, cultural practice and burial ground. In 2011, the remains of 66 Aboriginal ancestors were re-buried in a special repatriation ceremony held by the Kurna Nation Cultural Heritage Association and then in 2015 Aboriginal and non-aboriginal school children, Kurna community members and the general community planted 500 native plants over the graves of the Aboriginal ancestors.

Several other significant sites within the Port Wakefield area and the Department of Defence's Proof and Experimental Range land have been recorded within the area to be nominated and are on the register of Aboriginal sites and objects (Farely, 1998).

In recognition of the Kurna people living on-country and their on-going association with this land, the State Government Department of Environment, Water and Natural Resources has engaged several Kurna Elders to assist in a co-design process for the development of the Adelaide International Bird Sanctuary; this has included commissioning a Cultural Heritage Survey and Plan for the Adelaide International Bird Sanctuary (currently in draft). A Kurna name for the Adelaide International Bird Sanctuary is currently being negotiated.

b) Is the site considered of international importance for holding, in addition to relevant ecological values, examples of significant cultural values, whether material or non-material, linked to its origin, conservation and/or ecological functioning?

If yes, tick the box and describe this importance under one or more of the following categories:

- I. Sites which provide a model of wetland wise use, demonstrating the application of traditional knowledge and methods of management and use that maintain the ecological character of the wetland:
- II. Sites which have exceptional cultural traditions or records of former civilizations that have influenced the ecological character of the wetland:
- III. Sites where the ecological character of the wetland depends on the interaction with local communities or indigenous peoples:
- IV. Sites where relevant non-material values such as sacred sites are present and their existence is strongly linked with the maintenance of the ecological character of the wetland:

The links to Aboriginal Cultural Heritage and future stewardship are being developed initially through a Kurna Cultural Heritage Survey and Plan for the area. This is currently in draft. As part of this several Kurna names have been provided by the Kurna Peoples to the Adelaide International Bird Sanctuary as a way of recognising Kurna lands and waters and cultural significance to the area. These are:

1. Kudla yarlu kurrarinthi – “To approach peacefully”
2. Wi naityi naityi Pangkara - This name is derived from the general Kurna name for all bird species (Wi naityi naityi), and their boundary or country within the sanctuary is Pangkara.

Kurna members also carried out research to identify Kurna place names along the planned bird sanctuary location and identified the following:

- Port Gawler – Muliakki (actual location near Port Gawler).
- Thompson Beach – Widninga (actual location near Thompson Beach).
- St Kilda - Moilong (a Kurna word meaning – where the tide comes in).

22. Land tenure/ownership:

a) Within the Adelaide International Bird Sanctuary 12,132 hectares is Freehold land, ie: land for which a title or deed is issued or a land holder has a right to a freehold title and 13,822 hectares is Crown land - land whose tenure vests in the Crown.

A process is currently in place to proclaim lands across the Adelaide International Bird Sanctuary as a national park. This will happen in several stages with the first stage being finalised and the national park for the Adelaide international Bird Sanctuary being proclaimed on late October 2016. Approximately 2, 457 hectares will be proclaimed as national park in the first round.

b) In the surrounding area, the majority of the land adjacent to the Adelaide International Bird Sanctuary is also freehold - privately owned land.

23. Current land (including water) use:

a) Within the Adelaide International Bird Sanctuary the following land uses and respective boundary areas are provided in the table below:

Land-use	Area (ha)
AGRICULTURE	4987
COMMERCIAL	1
FOOD_INDUSTRY	20
GOLF	4
HORTICULTURE	0
LIVESTOCK	5681
MINE_QUARRY	2016
PUB_INSTITUTION	76
RECREATION	282
RESERVE	5807
RESIDENTIAL	53
RET_COMMERCIAL	2
RURAL_RESID	107
UTIL_INDUSTRY	235
VACANT	6911
VACANT_RESID	155

b) In the surroundings/catchment:

Land use adjacent to the site is predominantly agriculture.

24. Factors (past, present or potential) adversely affecting the site's ecological character, including changes in land (including water) use and development projects:

Supplementary material for this question and a table presented showing the distribution of these factors across the Adelaide International Bird Sanctuary can be found in the Appendices.

Factors that could adversely affect the capacity of the Adelaide International Bird Sanctuary to support shorebirds relate to direct impacts on the birds, and indirect impacts that change the character of the site and thereby its ability to support shorebirds. Direct impact on shorebirds include both disturbance and predation (injury impacts).

Within the Adelaide International Bird Sanctuary the most significant impacts are due to disturbance, and in particular at sites closest to regional and urban settlements and the city of Adelaide. This is mostly prevalent in the southern sections of the Adelaide International Bird Sanctuary. Urban area disturbance is primarily caused by dog walking and bait digging. Bait digging has a secondary impact of competing for the same prey the shorebirds use.

Further north disturbance impacts are dominated by off-road vehicle use, and occasional disturbance also comes from crabbing activities and horse training. Brine shrimpers operate in the salinas and their harvesting method has the capacity to reduce salina shrimp populations below that useful to shorebirds.

Predation losses from foxes are widespread around the Adelaide International Bird Sanctuary, and near coastal settlements it is likely that cat predation is an issue as well. Vehicle and powerline strike are issues at specific localities where roads and powerlines cross saltmarshes, sabkhas or between salinas.

Indirect impacts on shorebirds are those that create changes to the carrying capacity of the site. These changes may be influenced by actions that occur off-site as well as on-site.

Management of stormwater and waste water treatment plant (WWTP) discharges in the past has led to impacts on the intertidal seagrass beds offshore between St Kilda and Port Gawler, while the channelization of drains, creeks and rivers and the damming of watercourses has led to sediment shortages for some areas of saltmarsh in parts of the site south of Middle Beach.

Weeds that could change the character of the wetland surrounding Buckland Park Lake have been noted, but in general terrestrial weed species are mostly restricted to the higher parts of the Adelaide International Bird Sanctuary. In the intertidal zone, the presence of two introduced seaweeds has an unknown potential to cause changes to the seagrass beds in the Barker Inlet area.

Climate change is likely to bring increased sea levels. A major aspect of sea level rise (SLR) that may impact shorebirds negatively is the landward migration of mangroves across saltmarsh. Where the saltmarshes are constrained by seawalls or a rapid change in land geomorphology they may not be able to retreat landward. This issue is largest in the southern part of the site but some landward movement of mangroves has been observed further north at the River Light and at Wills Creek near Price Saltfield.

Other aspects of SLR relate to the increased frequency of inundation causing changes in saltmarsh vegetation associations. In some cases, for example where *Sarcocornia* spreads further onto sabkhas or sabkha cyanobacterial mats are wet more frequently, this may actually increase the shorebird carrying capacity.

Long term predictions are that the Adelaide Plains (lands adjacent to the Adelaide International Bird Sanctuary) are likely to be impacted from drying as climate change progresses. This is likely to result in lower water flows to estuarine areas of the Adelaide International Bird Sanctuary with associated salinity changes and alterations to the invertebrate population. What impact this may have on the shorebird carrying capacity of the site is currently unknown.

25. Conservation measures taken:

List national and/or international category and legal status of protected areas, including boundary relationships with the Flyway Network site:

Torrens Island Conservation Park - Located within the Adelaide International Bird Sanctuary boundary site. If appropriate, list the IUCN (2008) protected areas category/ies which apply to the site (tick the box or boxes as appropriate, see Annex 3):

Ia ; Ib ; II ; III ; IV ; V ; VI ; N/A

Does an officially approved management plan exist?

Yes. Torrens Island Biodiversity Action Plan 2013 Web link: http://www.foti.net.au/wp-content/uploads/2014/08/Torrens-Island-Biodiversity-Action-Plan_FINAL_October2013.pdf

If yes, is it being implemented?

Yes – on-ground conservation works.

Port Gawler Conservation Park - Located within the Adelaide International Bird Sanctuary boundary site.

If appropriate, list the IUCN (2008) protected areas category/ies which apply to the site (tick the box or boxes as appropriate, see Annex 3):

Ia ; Ib ; II ; III ; IV ; V ; VI ; N/A

Does an officially approved management plan exist; and is it being implemented?:

No.

If yes, is it being implemented?: If no, is one being planned?

The Port Gawler Conservation Park is planned to be included in the creation of the new national park for the Adelaide International Bird Sanctuary. This is due to be finalised in early 2017. At this time a Management Plan will be written for the whole area.

Clinton Conservation Park - Located within the Adelaide International Bird Sanctuary.

If appropriate, list the IUCN (2008) protected areas category/ies which apply to the site (tick the box or boxes as appropriate, see Annex 3):

Ia ; Ib ; II ; III ; IV ; V ; VI ; N/A

Does an officially approved management plan exist; and is it being implemented?:

Yes. It is managed under the *Department of Heritage Management Plan: Mainland Conservation Parks of Yorke Peninsula 2009*. Web link: www.environment.sa.gov.au/files/.../park_management/mainland-cps-of-yp-mp.pdf

If yes, is it being implemented?: If no, is one being planned?

Yes.

Wills Creek Conservation Park - Located within the Adelaide International Bird Sanctuary.

If appropriate, list the IUCN (2008) protected areas category/ies which apply to the site (tick the box or boxes as appropriate, see Annex 3):

Ia ; Ib ; II ; III ; IV ; V ; VI ; N/A

Does an officially approved management plan exist; and is it being implemented?:

Yes. It is managed under the *Department of Heritage Management Plan: Mainland Conservation Parks of Yorke Peninsula 2009*. Web link: www.environment.sa.gov.au/files/.../park_management/mainland-cps-of-yp-mp.pdf

If yes, is it being implemented?: If no, is one being planned?

Yes.

Adelaide Dolphin Sanctuary - Partially within the Adelaide International Bird Sanctuary and wholly in adjacent lands and waters. Web link: <http://www.naturalresources.sa.gov.au/adelaidemtloftyranges/coast-and-marine/dolphin-sanctuary>

If appropriate, list the IUCN (2008) protected areas category/ies which apply to the site (tick the box or boxes as appropriate, see Annex 3):

Ia ; Ib ; II ; III ; IV ; V ; VI ; N/A

The Adelaide Dolphin Sanctuary is constituted under the *Adelaide Dolphin Sanctuary Act 2005*. The Act provides for the protection of Dolphins and the habitat within the Sanctuary.

Does an officially approved management plan exist; and is it being implemented?:

Yes. *Adelaide Dolphin Sanctuary Management Plan, June 2008*

If yes, is it being implemented?: If no, is one being planned?

Yes.

Barker Inlet Aquatic Reserve - Partially within the Adelaide International Bird Sanctuary.

If appropriate, list the IUCN (2008) protected areas category/ies which apply to the site (tick the box or boxes as appropriate, see Annex 3):

Ia ; Ib ; II ; III ; IV ; V ; VI ; N/A

Does an officially approved management plan exist; and is it being implemented?:

No.

If yes, is it being implemented?: If no, is one being planned?

Aquatic reserves are managed under Primary Industries and Regions South Australia.

St Kilda Chapman Aquatic Reserve - Partially within the Adelaide International Bird Sanctuary.

If appropriate, list the IUCN (2008) protected areas category/ies which apply to the site (tick the box or boxes as appropriate, see Annex 3):

Ia ; Ib ; II ; III ; IV ; V ; VI ; N/A

c) Does an officially approved management plan exist; and is it being implemented?:

No.

If yes, is it being implemented?: If no, is one being planned?

Aquatic reserves are managed under Primary Industries and Regions South Australia.

Upper Gulf St Vincent Marine Park - Overlaps the Adelaide International Bird Sanctuary and in adjacent waters.

If appropriate, list the IUCN (2008) protected areas category/ies which apply to the site (tick the box or boxes as appropriate, see Annex 3):

Ia ; Ib ; II ; III ; IV ; V ; VI ; N/A

There are three different zones within the Upper Gulf St Vincent Marine Park that fall within the Adelaide International Bird Sanctuary – Sanctuary (IUCN II), Habitat Protection (IUCN IV) and General Management Use (IUCN VI) zones.

Does an officially approved management plan exist; and is it being implemented?:

Yes. Upper Gulf St Vincent Marine Park Management Plan 2012. Web link:

<http://www.environment.sa.gov.au/marineparks/find-a-park/yorke-peninsula/upper-gulf-st-vincent>

If yes, is it being implemented?: If no, is one being planned?

Yes.

Describe any other current management practices:

The Adelaide International Bird Sanctuary

The creation of the Adelaide International Bird Sanctuary initiative is an election commitment by the South Australian Government. The initiative is being delivered by the Department of Environment, Water and Natural Resources (DEWNR), providing facilitation of resources to community groups and stakeholders to form sustainable leadership of the Adelaide International Bird Sanctuary.

To establish and manage the Adelaide International Bird Sanctuary:

- A National Park is being proclaimed within the Adelaide International Bird Sanctuary, through preparing Crown Land parcels to be dedicated as a National Park under the *National Parks and Wildlife Act 1974*. Stage 1 of this new national park is proposed to be dedicated in late October 2016/. Additional parcels will be added to the National Park over the subsequent two years and as they become available for purchase or re-dedication (eg intertidal Crown land).
- A community and stakeholder leadership group 'The Collective' have been convened to represent local interests and ensure the protection of shorebirds and the Adelaide International Bird Sanctuary is in partnership with adjacent landowners, developments and opportunities. The framework being used for partnerships is the Collective Impact model. Taskforce groups have been convened to action the four focus areas as outlined by The Collective (Protecting Shorebirds, Stimulating Economy, Enhancing Wellbeing and Expanding Global Flyway Conservation).
- An Interim Management Statement is being prepared to guide the conservation of the Adelaide International Bird Sanctuary throughout 2016-2018.
- The management plan for the Adelaide International Bird Sanctuary is being developed through the collaborative process of Collective Impact and will be finalised in 2017/2018.
- Social media, education, events and promotions have formed a large part of the community engagement and outreach to the general public and specially the birding community since 2016.
- An annual festival is held at the Adelaide International Bird Sanctuary in celebration of the return of migratory shorebirds.

Samphire Coast Icon Project

A variety of priority on-ground threat abatement, habitat restoration and management works to benefit of migratory and resident shorebirds, other native fauna, and native flora, have been undertaken through the Samphire Coast Icon Project. This has been led by the Natural Resources Adelaide and Mount Lofty Ranges (AMLR), Coast and Marine program and the AMLR Natural Resource Management Board's support. This project has been funded by the Australian Government. Conservation works undertaken through this project include control of pest plants and animals in priority habitats, fencing to exclude and manage access by off-road vehicles, and revegetation with local provenance indigenous coastal plants to regenerate degraded habitats and close off unwanted tracks. Priorities for this work are based on the Metropolitan Adelaide and Northern Coastal Action Plan 2009, and the Samphire Coast Icon Project. Community engagement, awareness raising and education workshops have also formed a major priority for the Samphire Coast Icon Project.

26. Conservation measures proposed but not yet implemented:

The future management planning process for the Adelaide International Bird Sanctuary includes a prioritisation of actions determined to protect shorebirds and create opportunities for people. The management planning process has begun, alongside community, stakeholders and shorebird experts. The full management plan for the Adelaide International Bird Sanctuary will be completed by 2018.

Additionally:

- The Port Adelaide-Enfield Council has drafted a Biodiversity Management Plan for area: https://www.portenf.sa.gov.au/webdata/resources/files/Plan_BiodiversityManagement2016-2020_BackgroundReport_DraftFinal.pdf
- The City of Salisbury have a range of programs in place for the future management of wetlands: http://www.salisbury.sa.gov.au/Live/Environment_and_Sustainability/Wetlands_and_Water
- The City of Playford are working towards better use of storm water and wetlands: <http://www.playford.sa.gov.au/page.aspx?u=1304>
- The District Council of Mallala recognise partnerships with DEWNR, AMLR and the Adelaide International Bird Sanctuary: <http://www.mallala.sa.gov.au/coastandmarine> and <http://www.mallala.sa.gov.au/internationalbirdsantuary>

South Australia's most significant planning strategy, the 30 Year Plan for Greater Adelaide (Draft as of September 2016), recognises much of the Adelaide International Bird Sanctuary area as a Nature Protection Area. These are largely undeveloped areas that retain significant environmental values recognised through existing legislation. This includes protected public lands (such as conservation and marine parks), private protected lands (such as Heritage Agreements) and areas of native vegetation. These areas should be protected from development unless specific exemptions apply. Web link: <https://livingadelaide.sa.gov.au/>.

27. Current scientific research and facilities:

A variety of research and monitoring is undertaken across the Adelaide International Bird Sanctuary through several agencies, Universities and NGO's however there is no formal field research station or on-site facilities. Current research includes:

- Flinders University – Impacts of European Shore Crab (funded through NR AMLR Board Levey/Natural Resources AMLR Coast & Marine program).
- Victorian Wader Studies group/Friends of Shorebirds South-East/ AMLR Board and AMLR Coast & Marine Program - Migratory Shorebird Banding and Satellite Tracking.
- Deakin University PhD research program (Reece Pedler) – Banded Stilt research project.
- BirdLife Australia/ AMLR Board and AMLR Coast & Marine Program – Red-capped Plover banding & monitoring program (including Citizen Science component).
- AMLR Board and AMLR Coast & Marine Program – Population studies, habitat assessment and habitat retreat modelling for Bitterbush Blue Butterfly.

- AMLR Board and AMLR Coast & Marine Program & collaborators – habitat retreat modelling for saltmarsh.
- BirdLife Australia and AMLR Board and AMLR Coast & Marine Program – Shorebird Monitoring (including Shorebird 2020 Citizen Science component).
- AMLR Board and AMLR Coast & Marine Program & collaborators – Off-shore Reef Habitat Assessment (Northern Gulf St Vincent sites).
- Other Uni & Agency (e.g. South Australian Research and Development Institute) research projects on soil & water chemistry, sea-grass ecology and fish populations.

28. Current communications, education and public awareness (CEPA) activities related to or benefiting the site:

The Adelaide International Bird Sanctuary is being promoted extensively through several active engagement channels that cross over communications, engagement, marketing and promotions. Raising public awareness about the value of the area to people and wildlife is a key component of all communications about the area. An e-newsletter is generated monthly to share resources and updates, celebrate local community champions of the Adelaide International Bird Sanctuary and keep people engaged. Membership to this newsletter, as of September 2016, is at over 4,200 people.

The Adelaide International Bird Sanctuary recognizes the EAAF partnership and as such promotes the EAAF partnership logo on all official promotions and further promotes campaigns such as celebrating World Migratory Bird Day and Welcome Shorebirds.

Links to the Adelaide International Bird Sanctuary public profile sites are-

Adelaide International Bird Sanctuary Facebook Page:

<https://www.facebook.com/adelaideinternationalbirdsanctuary/?ref=settings>

Friends of Adelaide International Bird Sanctuary Facebook Page:

<https://www.facebook.com/groups/871299676278185/>

DEWNR webpage for the Adelaide International Bird Sanctuary:

http://www.environment.sa.gov.au/parks/Find_a_Park/Browse_by_region/Adelaide/adelaide-international-bird-sanctuary

Adelaide and Mount Lofty webpage for Adelaide International Bird Sanctuary:

<http://www.naturalresources.sa.gov.au/adelaidemtloftyranges/plants-and-animals/adelaide-bird-sanctuary>

On-site locations for education and public awareness:

- Thompson Beach Shorebird walking trails & interpretive signage.
- St Kilda Mangrove Trail.
- St Kilda Foreshore – shorebirds sign.

- Adelaide Dolphin Sanctuary Dolphin trail (Port River-Barker Inlet).
- Adelaide Dolphin Sanctuary Kayak tours.
- Adelaide International Bird Sanctuary bird watching tours.
- Port Clinton to Wills Creek section of 'Walk the Yorke' coastal walking trail.
- Adelaide International Bird Sanctuary – community engagement activities.
- AMLR NRM Education Program – curriculum-based activities being developed for learning in and about the Adelaide International Bird Sanctuary.

Current educational/communication materials:

- BirdLife Australia Samphire Coast Icon Project brochure – Where to See Shorebirds in the Adelaide International Bird Sanctuary.
- BirdLife Australia Shorebird Identification booklet.
- Adelaide International Bird Sanctuary brochure 'Birds of St Kilda'.
- Adelaide International Bird Sanctuary visitors guide (in development).
- AMLR booklet 'Samphire Identification Guide'.
- WWF-Australia and Thompson Beach Progress Association 'Samphire Coast Shorebird Trails' booklet.
- DEWNR, Adelaide Dolphin Sanctuary User's Guide.
- DEWNR, Upper Gulf St Vincent Marine Park Management Plan Summary (user's guide).
- DEWNR, Interim Management Statement for the Adelaide International Bird Sanctuary (in development).

29. Current recreation and tourism:

Recreation: The coastal waters of the Adelaide International Bird Sanctuary is accessible from metropolitan Adelaide, coastal townships scattered along the northern tip of the Gulf and also through un-developed access (mainly ORV) tracks leading to beaches. As a result, the beaches and waters are used intensively for recreation.

Table 1. Recreational activities and estimated frequency/intensity at the following at sites within the Northern Adelaide International Bird Sanctuary.

Site	Popular Activities	Frequency/intensity
Port River, Adelaide Dolphin Sanctuary	Fishing, kayaking, general boating, dolphin watching, bird watching	High
St Kilda foreshore	Fishing, kayaking, boating, bird watching, walking trails	High
Pt Gawler Conservation Park	Fishing, kayaking, dirt-biking, quad-biking, 4 WD, horseback riding, land-yachting	Medium
Middle Beach	Fishing, kayaking,	Medium - low
Port Prime	Fishing, kayaking, dirt-biking, quad-	Medium

	biking, 4 WD, camping	
Thompson Beach	Fishing, crabbing, dirt-biking, quad-biking, 4-WD, walking trails, cockle harvesting, bird watching	High
Parham & Webb Beach	Fishing, walking, camping, horseback riding, swimming (Baker Creek)	Medium-high
Port Wakefield/Bald Hill	Fishing, walking, camping, nature photography, bird watching, dirt-biking, boating	Medium
Clinton Conversation Park/Port Arthur	Bird watching, camping, fishing	Low-medium
Port Clinton	Fishing, crabbing, camping, boating, walking, swimming, bird watching	Medium
Wills Creek Conversation Park /Price	Boating, fishing, kayaking, camping	Medium
Ardrossan	Fishing, crabbing, camping, boating, walking, swimming, bird watching, cockle harvest	High

Tourism:

The Adelaide Dolphin Sanctuary is located at the southern point of the nominated site boundary and takes in the metropolitan Adelaide area; it attracts the largest number of tourists including international and local day-visitors.

Beyond the Adelaide Dolphin Sanctuary there are a number of formal walking/ interpretative trails that attract regular visitors.

A number of camping grounds within the nominated site boundary also attract both local and international visitors.

30. Threats

Which of the following threats is present historically – when the threat stopped but the effects are still there (H), currently (C) or potentially (P)?

	Historically	Currently	Potentially
Residential and commercial development			
housing and urban areas	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
commercial and industrial areas	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
tourism and recreation areas	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Agriculture and aquaculture			
annual and perennial non-timber crops	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
wood and pulp plantations	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

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livestock farming and ranching	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
marine and freshwater aquaculture	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Energy production and mining			
oil and gas drilling	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
mining and quarrying	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
renewable energy	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Transportation and service corridors			
roads and railroads	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
utility and service lines	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
shipping lanes	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
flight paths	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Biological resource use			
hunting and collecting terrestrial animals	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
gathering terrestrial plants	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
logging and wood harvesting	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
fishing and harvesting aquatic resources	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
Human intrusions and disturbance			
recreational activities	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
war, civil unrest and military exercises	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
work and other activities	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Natural system modifications			
fire and fire suppression	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
dams and water management/use	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
other ecosystem modifications	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Invasive and other problematic species and genes			
invasive non-native/alien species	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
problematic native species	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
introduced genetic material	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
Pollution			
household sewage and urban waste water	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>

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industrial and military effluents	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
agricultural and forestry effluents	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
garbage and solid waste	<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
air-borne pollutants	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
excess energy	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Geological events

volcanoes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
earthquakes/tsunamis	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
avalanches/landslides	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Climate change and severe weather

habitat shifting and alteration	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
droughts	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
temperature extremes	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
storms and flooding	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Please write here any additional threats and comments/queries you have on the threats.

Annex 1: Criteria for the inclusion of sites in the Flyway Site Network

(From the Partnership Text)

To be considered for inclusion in the Flyway Site Network, this Partnership adopts the following criteria:

- a. Convention on Wetlands (Ramsar, Iran, 1971) criteria for internationally important sites for migratory waterbirds. That is:
 - Criterion 2: A wetland should be considered internationally important if it supports vulnerable, endangered, or critically endangered species or threatened ecological communities.
 - Criterion 5: A wetland should be considered internationally important if it regularly supports 20,000 or more waterbirds.
 - Criterion 6: A wetland should be considered internationally important if it regularly supports 1% of the individuals in a population of one species or subspecies of waterbird.

- b. The staging criteria as applied under the Asia - Pacific Migratory Waterbird Conservation Strategy. That is:
 - i. A staging site should be considered internationally important if it regularly supports 0.25% of individuals in a population of one species or subspecies of waterbirds on migration.
 - ii. A staging site should be considered internationally important if it regularly supports 5,000 or more waterbirds at one time during migration.

- c. Under exceptional circumstances a site can be nominated if it supports migratory waterbirds at a level or stage of their life cycle important to the maintenance of flyway populations. Justification of such nominations will be considered by the Partnership on a case by case basis.

Annex 2: Ramsar Classification System for Wetland Type

The codes are based upon the Ramsar Classification System for Wetland Type as approved by Recommendation 4.7 and amended by Resolutions VI.5 and VII.11 of the Conference of the Contracting Parties. The categories listed herein are intended to provide only a very broad framework to aid rapid identification of the main wetland habitats represented at each site.

To assist in identification of the correct Wetland Types to list in section 19 of the RIS, the Secretariat has provided below tabulations for Marine/Coastal Wetlands and Inland Wetlands of some of the characteristics of each Wetland Type.

Marine/Coastal Wetlands

- A -- **Permanent shallow marine waters** in most cases less than six metres deep at low tide; includes sea bays and straits.
- B -- **Marine subtidal aquatic beds**; includes kelp beds, sea-grass beds, tropical marine meadows.
- C -- **Coral reefs.**
- D -- **Rocky marine shores**; includes rocky offshore islands, sea cliffs.
- E -- **Sand, shingle or pebble shores**; includes sand bars, spits and sandy islets; includes dune systems and humid dune slacks.
- F -- **Estuarine waters**; permanent water of estuaries and estuarine systems of deltas.
- G -- **Intertidal mud, sand or salt flats.**
- H -- **Intertidal marshes**; includes salt marshes, salt meadows, saltings, raised salt marshes; includes tidal brackish and freshwater marshes.
- I -- **Intertidal forested wetlands**; includes mangrove swamps, nipah swamps and tidal freshwater swamp forests.
- J -- **Coastal brackish/saline lagoons**; brackish to saline lagoons with at least one relatively narrow connection to the sea.
- K -- **Coastal freshwater lagoons**; includes freshwater delta lagoons.
- Zk(a) – **Karst and other subterranean hydrological systems**, marine/coastal

Inland Wetlands

- L -- **Permanent inland deltas.**
- M -- **Permanent rivers/streams/creeks**; includes waterfalls.
- N -- **Seasonal/intermittent/irregular rivers/streams/creeks.**
- O -- **Permanent freshwater lakes** (over 8 ha); includes large oxbow lakes.
- P -- **Seasonal/intermittent freshwater lakes** (over 8 ha); includes floodplain lakes.
- Q -- **Permanent saline/brackish/alkaline lakes.**
- R -- **Seasonal/intermittent saline/brackish/alkaline lakes and flats.**

- Sp -- **Permanent saline/brackish/alkaline marshes/pools.**
- Ss -- **Seasonal/intermittent saline/brackish/alkaline marshes/pools.**
- Tp -- **Permanent freshwater marshes/pools;** ponds (below 8 ha), marshes and swamps on inorganic soils; with emergent vegetation water-logged for at least most of the growing season.
- Ts -- **Seasonal/intermittent freshwater marshes/pools on inorganic soils;** includes sloughs, potholes, seasonally flooded meadows, sedge marshes.
- U -- **Non-forested peatlands;** includes shrub or open bogs, swamps, fens.
- Va -- **Alpine wetlands;** includes alpine meadows, temporary waters from snowmelt.
- Vt -- **Tundra wetlands;** includes tundra pools, temporary waters from snowmelt.
- W -- **Shrub-dominated wetlands;** shrub swamps, shrub-dominated freshwater marshes, shrub carr, alder thicket on inorganic soils.
- Xf -- **Freshwater, tree-dominated wetlands;** includes freshwater swamp forests, seasonally flooded forests, wooded swamps on inorganic soils.
- Xp -- **Forested peatlands;** peatswamp forests.
- Y -- **Freshwater springs; oases.**
- Zg -- **Geothermal wetlands**
- Zk(b) – **Karst and other subterranean hydrological systems, inland**

Note: “**floodplain**” is a broad term used to refer to one or more wetland types, which may include examples from the R, Ss, Ts, W, Xf, Xp, or other wetland types. Some examples of floodplain wetlands are seasonally inundated grassland (including natural wet meadows), shrublands, woodlands and forests. Floodplain wetlands are not listed as a specific wetland type herein.

Human-made wetlands

- 1 -- **Aquaculture** (e.g., fish/shrimp) **ponds**
- 2 -- **Ponds;** includes farm ponds, stock ponds, small tanks; (generally below 8 ha).
- 3 -- **Irrigated land;** includes irrigation channels and rice fields.
- 4 -- **Seasonally flooded agricultural land** (including intensively managed or grazed wet meadow or pasture).
- 5 -- **Salt exploitation sites;** salt pans, salines, etc.
- 6 -- **Water storage areas;** reservoirs/barrages/dams/impoundments (generally over 8 ha).
- 7 -- **Excavations;** gravel/brick/clay pits; borrow pits, mining pools.
- 8 -- **Wastewater treatment areas;** sewage farms, settling ponds, oxidation basins, etc.
- 9 -- **Canals and drainage channels, ditches.**
- Zk(c) -- **Karst and other subterranean hydrological systems, human-made**

Annex 3: IUCN Protected Areas Categories System

IUCN protected area management categories classify protected areas according to their management objectives. The categories are recognised by international bodies such as the United Nations and by many national governments as the global standard for defining and recording protected areas and as such are increasingly being incorporated into government legislation.

Ia Strict Nature Reserve

Category Ia are strictly protected areas set aside to protect biodiversity and also possibly geological/geomorphical features, where human visitation, use and impacts are strictly controlled and limited to ensure protection of the conservation values.

Ib Wilderness Area

Category Ib protected areas are usually large unmodified or slightly modified areas, retaining their natural character and influence without permanent or significant human habitation, which are protected and managed so as to preserve their natural condition.

II National Park

Category II protected areas are large natural or near natural areas set aside to protect large-scale ecological processes, along with the complement of species and ecosystems characteristic of the area, which also provide a foundation for environmentally and culturally compatible, spiritual, scientific, educational, recreational, and visitor opportunities.

III Natural Monument or Feature

Category III protected areas are set aside to protect a specific natural monument, which can be a landform, sea mount, submarine cavern, geological feature such as a cave or even a living feature such as an ancient grove. They are generally quite small protected areas and often have high visitor value.

IV Habitat/Species Management Area

Category IV protected areas aim to protect particular species or habitats and management reflects this priority. Many Category IV protected areas will need regular, active interventions to address the requirements of particular species or to maintain habitats, but this is not a requirement of the category.

V Protected Landscape/ Seascape

A protected area where the interaction of people and nature over time has produced an area of distinct character with significant, ecological, biological, cultural and scenic value: and where safeguarding the integrity of this interaction is vital to protecting and sustaining the area and its associated nature conservation and other values.

VI Protected area with sustainable use of natural resources

Information Sheet on EAA Flyway Network Sites

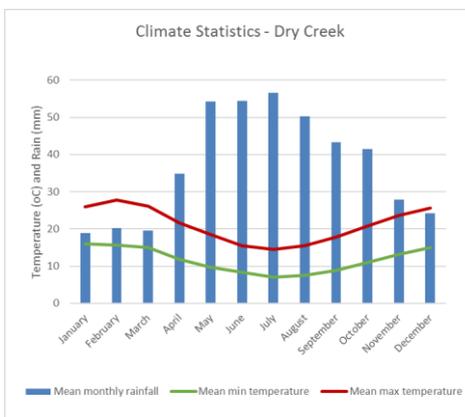
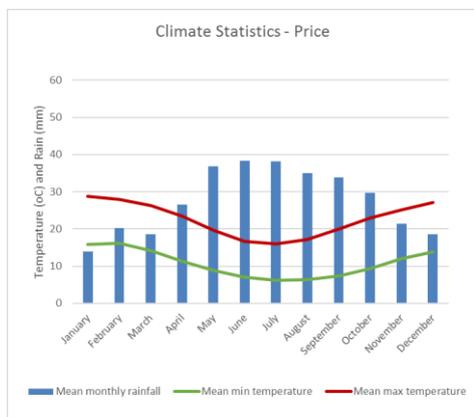
Category VI protected areas conserve ecosystems and habitats together with associated cultural values and traditional natural resource management systems.

APPENDICIES

SUPPLEMENTARY MATERIAL FOR QUESTION 15: PHYSICAL FEATURES OF THE SITE.

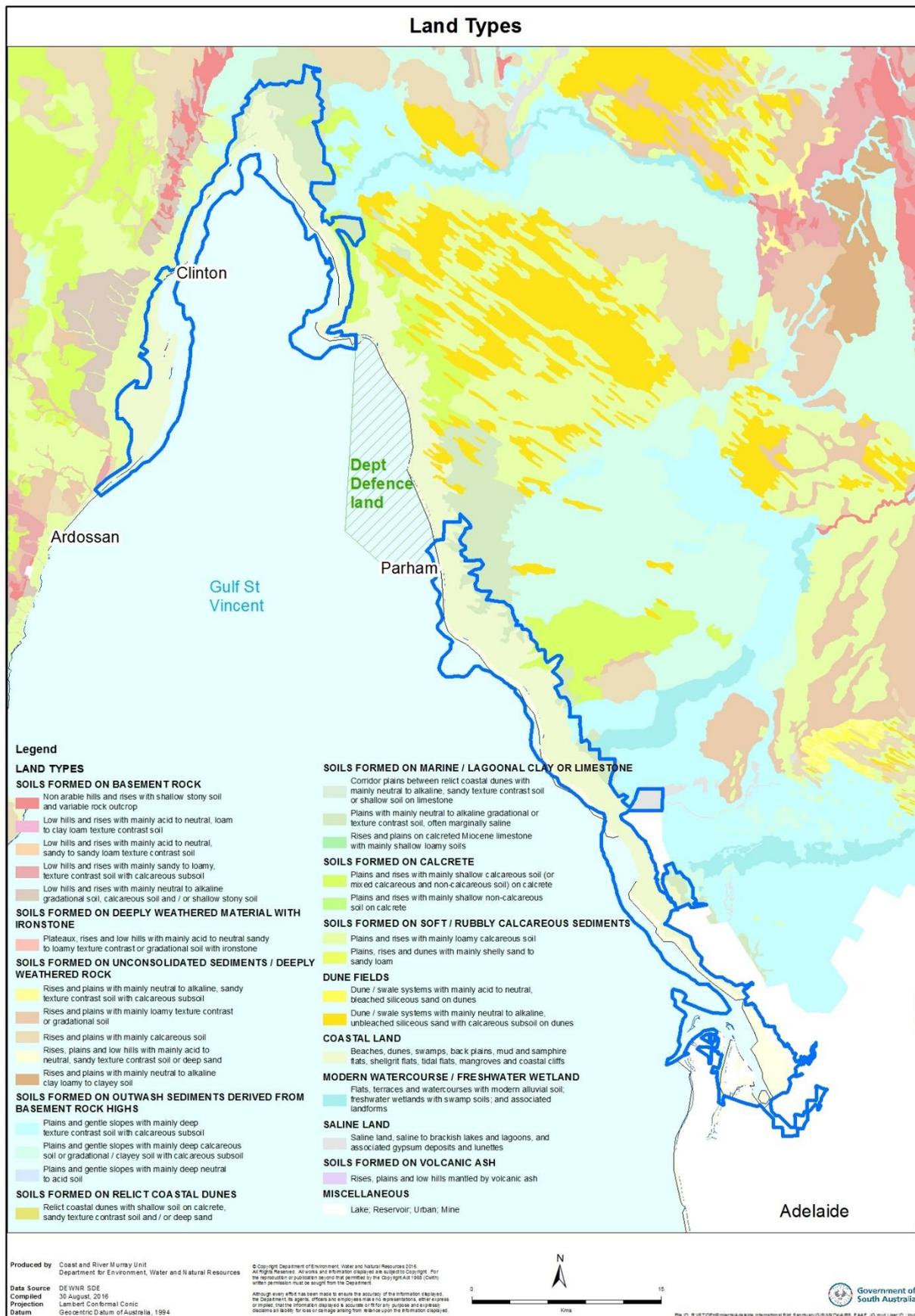
Climate statistics:

Weather statistics													
PRICE	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Ann tot
Mean max temp	28.7	28	26.3	23.4	19.6	16.6	16	17.2	19.9	22.9	25.1	27.1	
Mean min temp	15.9	16.1	14.2	11.3	8.9	7.1	6.2	6.3	7.4	9.4	12	13.9	
Mean monthly rainfall	14	20.2	18.5	26.5	36.8	38.3	38.1	35	33.8	29.7	21.4	18.6	330.9
Mean daily gross evap	8.6	7.8	6.2	4.1	2.6	1.8	1.9	2.6	3.9	5.4	7.1	8	1825
DRY CREEK													
Mean max temp	26.01	27.75	26.07	21.56	18.52	15.56	14.45	15.48	17.88	20.87	23.57	25.57	
Mean min temp	15.91	15.58	14.98	11.82	9.59	8.41	7.05	7.57	8.85	11.05	13.15	15.03	
Mean monthly rainfall	19	20	20	35	54	54	57	50	43	41	28	24	445.8
Mean daily gross evap	9.6	8.8	6.7	4.4	2.6	1.9	1.9	2.5	3.7	5.4	7.3	8.7	1931
NB: temperatures measured in °C, rainfall and evaporation measured in mm													



Appended mapping for Question 15:

1. **Land types:** Landforms and soils, derivation from the underlying geology.
2. **Soils:** Soil classes.
3. **Shoreline:** Geomorphology of the marine-terrestrial interface.





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SUPPLEMENTARY MATERIAL FOR QUESTION 18: ECOLOGICAL FEATURES

Habitat descriptions:

The Adelaide International Bird Sanctuary occurs on low-lying land that generally lies between the highest storm surge elevation and the lowest tides, with some small areas of higher land. This encompasses a range of habitats, described further here, working inland from the tidal flats towards higher ground.

Tidal flats are known to have high invertebrate biodiversity and are settlement sites for larvae, providing food resources for prawns, fish and birds. The mudflats are exposed daily by the ebbing tide, and with the recession of the tide the most obvious components of the vegetation of the tidal flats are the seagrasses, dominated in the shallows by *Zostera* and *Heterozostera* species and various green algae including the sea lettuce, *Ulva lactuca*. Unvegetated soft bottoms are also present.

Large flocks of a great diversity of shorebirds are a common sight feeding in the shallow, but wide, band of water and exposed mud of the low tide periods, while Black Swans graze the seagrasses in deeper water. The tidal flats are wide in the sheltered Barker Inlet, relatively narrow in the southern part of the Gulf north of Barker Inlet and then widen out again to the north, a result of the 'terrestrialisation' of seagrass banks.

Mangrove forests comprising monospecific open woodlands of *Avicennia marina* occur in the intertidal zone along much the site from Port Adelaide to Price. They do not occur on the western side of LeFevre Peninsula and are only intermittent along the Port River. They also become intermittent along the coast in the vicinity of Light Beach, Thompson Beach and Middle Spit. While the woodlands provide habitat for fishing birds and roosting habitat for several species including the Nankeen Night Herons, they provide lesser habitat for many species of shorebirds. However Eastern Curlew use the mangroves for roosting, as do Grey-tailed Tattlers, Lesser Sand Plovers, Whimbrels and the Pacific Golden Plover.

Salt marshes within the site are dominated by chenopod species, particularly samphires. They form extensive meadows that border the sea, or they may form in a band between a mangrove forest and the higher land. Salt marshes exhibit zonation that is related to inundation, and they may (for simplicity) be divided into low-lying (submergent) and upper (emergent) salt marshes. Low-lying salt marsh is inundated on a daily basis and is dominated by the genera *Sarcocornia* and *Tecticornia* in those areas vegetated with flowering plants, and by cyanobacterial mats where no flowering plants are present. Saltmarsh pannes or "rotten spots" can occur in low lying parts of the saltmarsh and these ponded areas may support seagrass associations dominated by *Lepilaena* and *Ruppia* species.

Submergent salt marshes provide an important juvenile fish feeding ground and are utilised heavily by a wide range of shorebirds (especially when high tide makes the tidal flats inaccessible), as well being an important feeding resource for small parrots of the *Neophema* genus.

In areas where less frequent tidal inundation occurs, a high or emergent marsh develops that is dominated by *Tecticornia pergranulata*, *T. halocnemoides*, *Maireana oppositifolia*, *Frankenia pauciflora* and *Wilsonia humilis*. Being considerably drier than the low-lying salt marshes, the upper saltmarsh supports a wide variety of more “terrestrial” species, both plant and animal. Reptiles are common, along with colonial web-sharing spiders and marsh terns that feed on the hatching samphire galls. These higher saltmarshes have denser vegetation and are therefore utilised by fewer shorebirds.

In some areas of the Adelaide International Bird Sanctuary saltmarshes have been isolated from tidal inundation by roads and natural or man-made embankments or ridges. Stranded saltmarshes may retain the species which dominated them prior to isolation, but may have senescing plants with low numbers of juveniles. These stranded saltmarsh habitats frequently appear robust but may have little resilience to further disturbance.

Sabkhas are extensive natural salt pans that form in the supratidal areas of low-lying, relatively arid regions. Sabkhas are the dominant landform and habitat type between Middle Beach and Port Wakefield. The hydrologic regime in such areas is interesting. There is usually a saline, shallow water table underlying the sabkha itself. Any large dunal “islands” on the sabkha surface may have a brackish freshwater lens perched on top of the saline water table, but the majority of such “islands” support a sparse plant population with no more than the moisture from precipitation, held interstitially. Little grows on the sabkha surface other than the cyanobacterial mats and occasional occurrences of the nationally vulnerable samphire *Tecticornia flabelliformis*, however they are edged with chenopod vegetation, dominated by *Tecticornia halocnemoides* and *Atriplex* species.

The dominant hydrologic process in many sabkhas is evaporative pumping during the drier months. Water lost from the subsurface brines is replenished by subsurface flow from the sea, leading to a horizontal salt concentration gradient under the soil surface.

Sabkha environments are harsh, with evaporation during the summer months greatly exceeding the rainfall. Surface soil temperatures in the high 40°C range are not uncommon. Marine flooding may occur during storm surge events, or freshwaters may flood over them from nearby rivers during rare flood events.

During the periods the sabkhas are inundated, the surface cyanobacterial mats activate and drive a food web that culminates with shorebirds as the top level consumers. Historically sabkhas have been under-

observed as shorebird habitat – they become very inaccessible when wet, and this is the time they are of most value for shorebirds. When dry, sabkhas are used for high-tide roosting, particularly by Grey Plovers.

Tidal creeks criss-cross the mangroves and salt marshes. In the saltmarshes these creeks are often edged with shrubby samphires (*Tecticornia arbuscula*), habitat of the threatened Samphire Thornbill. Marine algae and seagrasses grow in these creeks, which also support a variety of marine invertebrates. Once again, the close presence of dense mangroves and deeper, fast flowing waters can deter shorebirds from using this habitat, although within the site Common Sandpipers, Little Stint and Masked Lapwings all have been recorded in the tidal creeks.

Swamplands & constructed wetlands occur landward of, or penetrate into, the saltmarshes. Extensive constructed wetland habitats are also present in the form of stormwater treatment wetlands and salinas.

Back swamps, supratidal sedgeland and freshwater tidal swamps are estuarine wetlands that develop where creeks and rivers enter the intertidal zone throughout the site (for example at the estuary of the Little Para). Such wetlands within the site are typically dominated by rushes and sedges that can tolerate occasional inundation with tidal water. *Bolboschoenus* spp and *Phragmites australis* are the dominant species, with areas of *Juncus kraussii* and the introduced *Juncus acutus*. *Triglochin* spp and *Cotula* spp grow in the water, and there is a diverse planktonic flora. Depending upon seasonal variations in salinity, numerous insect larvae can be found in the deeper ponds and around the bases of the emergent vegetation. These habitats are well utilised by a wide diversity of shorebirds.

Trees are not common in the backswamps and estuarine freshwater swamps of the site, with the exception of Buckland Park Lake and its surrounds. This man-made impoundment of the Gawler River supports *Eucalyptus camaldulensis* where the river enters the Lake on its east, and a dense stand of the introduced *Casuarina glauca* around the Lake's western edge. A remnant stand of the swamp paperbark, *Melaleuca halmaturorum*, occurs north-west of the Lake on a small chenier. Swamp paperbark habitat is rare in South Australia. Dense stands of lignum (*Muehlenbeckia florulenta*) mark the flooded extents of the Lake (its surrounds). The evaporating waters of Buckland Park Lake provide feeding shallows that are used by a wide range of shorebirds and waterbirds.

Sedgelands occur above the highest tides where seasonally waterlogged conditions exist, and were historically dominated by *Gahnia filum*, the host plant for the Yellowish Sedge-skipper butterfly. Sedgelands have been extensively cleared and drained for horticulture regionally, leaving only small remnants such as that located within the site at Brooks Road.

Stormwater treatment wetlands are a more recent development, built in the areas north of Adelaide that drain to the Barker Inlet. The wetlands provide a range of habitats that enable large numbers of small fish to thrive, as well as a rich invertebrate fauna. Shorebirds have “adopted” the wetlands, and can be seen roosting and feeding there. Some resident species of shorebirds (for example the Red-capped Plovers and Black-winged Stilts) are known to breed in the stormwater wetlands.

Salinas are artificially controlled saline ponds used to produce common salt. The salinas at Price are maintained at controlled salinities and water depths, creating a range of lagoonal biomes with salinities varying from seawater salinity (the very first ponds) through to extremely hypersaline (the final ponds). Each biome contains a range of algal and faunal species specific to its salinity range.

At present, the future hydrological regime of the abandoned salinas at Dry Creek have not been determined, hence they have not been included within the boundary.

Conservation values are frequently high in salinas. Depending to a large extent of the depth and salinity of individual ponds, they are attractive to migratory shorebirds. The networks of sheltered ponds, islands and embankments form good feeding, roosting and nesting habitats.

Marine salinas comprise the largest area within a saltfield operation. The initial ponds are supplied with seawater by pumps. The pumping basins replicate a high-impact coast, with oxygen-rich waters flowing rapidly past rock-lined embankments. These pumping basins contain high densities of rocky shore marine species. The marine or eusaline ponds themselves are shallow and sheltered, with salinities ranging from 39-65 g/L Total Dissolved Salts (TDS). They support seagrass meadows and a wide diversity of invertebrates and piscifuna. Mangroves readily colonise islands in these ponds, despite the lack of tides. The deeper parts of the marine salinas host fishing birds like Pelicans and Cormorants, and waterbirds including Spoonbills and Egrets, but the shallow edges and islands have conditions suitable for shorebirds.

As the succeeding salinas develop metasalinity (low range hypersalinity) and salinities reach 65-110 g/L TDS, the species present change. While some species of small fish (hardyheads) occur in these ponds, gradually crustaceans, molluscs and insects become the dominant fauna, with an ever-changing array of plankton. These ponds are shallower than the earlier ponds and so the invertebrate life in them is more accessible for predation by shorebirds.

Vegetated bottoms disappear in the medium hypersaline ponds (110-175 g/L TDS) where flos ferri (calcium carbonate) and gypsum (calcium sulfate) begin to precipitate. At this point the remaining macrofauna are the brine shrimps, *Artemia franciscana* (exotic species) and *Parartemia zietziana* (native), along with larval stages of the brine flies (*Ephydrella* sp.) and some salinity tolerant ostracods and copepods. While the

diversity of invertebrate species in this salty water is low, the densities can be very high. In most solar salt operations these salinas are much shallower than the earlier ponds and provide excellent feeding areas for shorebirds, particularly when the tidal flats are inundated at high tide. Some shorebirds, such as Banded Stilts, may reach huge populations in the central ponds of the salinas.

Benthic microbial mats start to become a dominant feature of the salinas that are highly hypersaline (175-287 g/L TDS). Microbial mats contain layers of microalga, mainly cyanobacteria (blue-green algae), diatoms and bacteria. In many salinas the mats grow into balls, and are referred to (incorrectly) as stromatolites. The different layers of the microbial mats consist of a top layer of diatoms, a lower layer of cyanophyta and a lowest layer of purple bacteria. Benthic mats and planktonic microalgae provide food sources for brine shrimp. The two species of brine shrimp found within the salinas of the site move between the ponds in response to salinity changes over the seasons. *Parartemia zietziana* dominates in the lower salinity hypersaline ponds while the introduced *Artemia franciscana* is the sole crustacean in areas of highest salinity.

Hypersaline salinas provide a reliable food supply to shorebirds that have a preference for the specific prey sizes that are available in these extreme environments. Migratory shorebirds that can harvest these ponds include Red-necked Stints and Sharp-tailed Sandpipers, both species found in internationally significant numbers within the Adelaide International Bird Sanctuary.

Artemia franciscana continues to be present in salinas where brines are almost saturated for sodium chloride, even up to the crystallisation point of salt (330 g/L TDS). The halotolerant green microalga *Dunaliella salina* and several types of pink bacteria are found in the crystallising pans. The crystallising pans themselves do not provide a food source for shorebirds.

In addition to the varied wetland habitats, the site also contains areas of higher land that rarely, if ever, are flooded by tidal waters.

Seawalls and other embankments are frequently found marking the boundary between salt marshes and grazing or farming land. Under appropriate management conditions (with good weed control), seawalls support a very rich flora, including a number of rare species.

The main vegetation found along embankments within the site has much in common with that found on dunes or on naturally occurring adjoining high marsh or saltbush areas. *Nitraria billardieri*, *Myoporum insulare* and various *Maireana* and *Atriplex* species are the dominant plants. Other plants are represented on the embankments as they occur naturally in contiguous areas. For example, in the Barker Inlet area, embankments that are contiguous with chenier ridges or stranded dunes frequently have *Alyxia buxifolia*,

Olearia, *Adriana* and *Acacia* species growing on them, while embankments north of the Light River may support *Geijera linearifolia*, *Callitris preissii* or even *Santalum acuminatum*.

Embankments provide safe nesting areas for many birds including locally resident shorebirds such as the Red-capped Plover. They also provide high-tide roosting areas for many of the larger migratory shorebirds. North of St Kilda, embankments provide habitat for locally less common vertebrates such as the Water Rat.

Chenier ridges, beach berms and dunes mark the retreat of the Flandrian Transgression, starting from about 6,000 years ago. Some of the older of these chenier ridges are over a kilometre inland. Chenier ridges and the more modern dunes and beach berms share similar vegetation of shrublands over native grasses. *Nitraria billardieri*, *Myoporum insulare*, *Alyxia buxifolia*, *Olearia*, *Adriana*, *Atriplex* and *Acacia* species are common in the south of the site while *Geijera linearifolia*, *Callitris preissii*, *Melaleuca lanceolata* and *Santalum acuminatum* are recorded more frequently further north.

Dune areas are well drained and host a wide variety of both vertebrate and invertebrate species. Reptiles are common, as are rabbits and predatory foxes. These habitats form only a small part of the site. They host relatively few species of shorebirds, with only Masked Lapwings and Sanderling being recorded using them.

Grassland and saltbush zones form small areas of the site and are dominated by *Atriplex paludosa* and the various *Maireana* species (bluebushes). *Nitraria billardieri* is also found in the more saline areas. In open spaces native grasslands dominated by *Austrostipa* species, *Chloris truncata*, *Austrodanthonia* species and tiny stonecrops are common. The native garland lily (*Calostemma purpurea*) can form swards of colourful flowers across the coastal grasslands in late summer and early autumn. Saltbush and grassland areas within the site are nearly all grazed, and some areas have been cultivated. Once cultivation has ceased the areas revert quite rapidly to a dense cover of *Atriplex paludosa* and *Maireana brevifolia*, however what effect this form of management has on the faunal biodiversity is unknown. Grasslands and saltbush habitats within the site are important for a number of species of coastal butterflies. Some specific species of shorebirds utilise grasslands – the larger plovers in particular.

Mallee woodlands are found in very small areas of the site on higher ground, on elevations above the coastal wetlands and chenier ridges. Common species include the yorrell (*Eucalyptus gracilis*), red summer mallee (*Eucalyptus socialis*) and white mallee (*Eucalyptus dumosa*). Mallee habitats are not considered attractive to shorebirds.

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Appended mapping:

Wetlands: Outline of the areas that have been classified as wetlands of national significance within the site

Saltmarsh and Mangroves: Detailed intertidal and supratidal mangrove and saltmarsh vegetation associations

Supplementary information for Question 19 Noteworthy flora

Significant flora	Conservation Rating (subregion as per Gillam & Urban)			Occurrence within the site according to Caton et al (2006, 2009)																							
	Aus	SA	St Vincent Subregion (IBRA)	MA14 LeFevre Pen	MA15 Port Adelaide	MA16 Torrens Is	MA17 Barker Inlet	MA18 Gawler R	MA19 Middle Beach	MA20 Light Delta	MA21 Port Prime	MA22 Thompson	MA23 Parham	MA24 Middle Spit	NY6 North	NY7 Bald Hill Bch	NY8 Bald Hill Bch	NY9 Sandy Point	NY10 Port	NY11 Head of Gulf	NY12 Clinton North	NY13 Clinton South	NY14 Wills Creek	NY15 Price	NY16 Macs Beach	NY17 Tiddy Widdy	
<i>Acacia cupularis</i>			NT	x		x		x	x		x																x
<i>Acacia dodonaeifolia</i>		R	R	x																							
<i>Acacia iteaphylla</i>		R	RA				x																				
<i>Acacia salicina</i>			NT	x	x			x																			
<i>Acrotriche patula</i>			RA										x	x													x
<i>Actites megalocarpa</i>			NT	x																							
<i>Adriana quadripartita</i>			RA	x		x	x	x	x	x			x	x													x
<i>Apium annuum</i>			NT	x		x	x	x	x		x							x		x							
<i>Apium prostratum</i> var <i>prostratum</i>			EN						x																		
<i>Asperula</i> sp. (both species have a rating)			VU/NT											x													
<i>Atriplex australasic</i>		R	VU	x				x																			

Significant flora	Conservation Rating (subregion as per Gillam & Urban)			Occurrence within the site according to Caton et al (2006, 2009)																							
	Aus	SA	St Vincent Subregion (IBRA)	MA14 LeFevre Pen	MA15 Port Adelaide	MA16 Torrens Is	MA17 Barker Inlet	MA18 Gawler R	MA19 Middle Beach	MA20 Light Delta	MA21 Port Prime	MA22 Thompson	MA23 Parham	MA24 Middle Spit	NY6 North	NY7 Bald Hill Bch	NY8 Bald Hill Bch	NY9 Sandy Point	NY10 Port	NY11 Head of Gulf	NY12 Clinton North	NY13 Clinton South	NY14 Willis Creek	NY15 Price	NY16 Macs Beach	NY17 Tiddy Widdy	
<i>Crassula colorata</i> var <i>colorata</i>			RA				x																				x
<i>Crassula exserta</i>		R	RA			x																					
<i>Crassula sieberiana</i> (now <i>C. colligata</i> - ssp, only some rated)		E	RA			x		x			x																x
<i>Cratystylis conocephala</i>			RA											x													
<i>Cullen australasicum</i>			RA	x																							
<i>Daviesia arenaria</i>			CR				x																				
<i>Dillwynia hispida</i>			CR	x			x																				
<i>Dissocarpus biflorus</i> var <i>biflorus</i>			RA						x	x											x						
<i>Distichlis distichophylla</i>			NT	x			x	x	x	x	x			x							x						
<i>Enteropogon ramosus</i>			RA					x																			
<i>Epilobium</i>			RA	x																							

Significant flora	Conservation Rating (subregion as per Gillam & Urban)			Occurrence within the site according to Caton et al (2006, 2009)																							
	Aus	SA	St Vincent Subregion (IBRA)	MA14 LeFevre Pen	MA15 Port Adelaide	MA16 Torrens Is	MA17 Barker Inlet	MA18 Gawler R	MA19 Middle Beach	MA20 Light Delta	MA21 Port Prime	MA22 Thompson	MA23 Parham	MA24 Middle Spit	NY6 North	NY7 Bald Hill Bch	NY8 Bald Hill Bch	NY9 Sandy Point	NY10 Port	NY11 Head of Gulf	NY12 Clinton North	NY13 Clinton South	NY14 Wills Creek	NY15 Price	NY16 Macs Beach	NY17 Tiddy Widdy	
<i>Lepidium pseudohyssopifolium</i>			RA	x			x																				
<i>Lepidosperma gladiatum</i>			NT	x										x													
<i>Leucopogon parviflorus</i>			VU											x													
<i>Leucophyta brownii</i>			RA	x																							
<i>Limosella australis</i>			VU		x																						
<i>Linum marginale</i>			NT											x													
<i>Lomandra juncea</i>			RE	x		x																					
<i>Lomandra leucocephala ssp robusta</i>			VU	x		x																					
<i>Lotus australis</i>			RA	x		x	x	x	x					x													
<i>Lotus cruentus</i>			RA																								x
<i>Maireana decalvans</i>		E	EN																								
<i>Maireana suaedifolia</i>		R	NE											x													
<i>Melaleuca armillaris ssp. akineta</i>		R	NE	x																							
<i>Melaleuca halmaturorum</i>			NT	x		x	x	x	x																		
<i>Melaleuca lanceolata</i>			NT	x			x	x	x		x	x	x	x	x												

Significant flora	Conservation Rating (subregion as per Gillam & Urban)			Occurrence within the site according to Caton et al (2006, 2009)																							
	Aus	SA	St Vincent Subregion (IBRA)	MA14 LeFevre Pen	MA15 Port Adelaide	MA16 Torrens Is	MA17 Barker Inlet	MA18 Gawler R	MA19 Middle Beach	MA20 Light Delta	MA21 Port Prime	MA22 Thompson	MA23 Parham	MA24 Middle Spit	NY6 North	NY7 Bald Hill Bch	NY8 Bald Hill Bch	NY9 Sandy Point	NY10 Port	NY11 Head of Gulf	NY12 Clinton North	NY13 Clinton South	NY14 Willis Creek	NY15 Price	NY16 Macs Beach	NY17 Tiddy Widdy	
<i>Puccinellia stricta</i> var <i>stricta</i>			RA	X		X	X	X	X					X				X									
<i>Pultenaea largiflorens</i>			RA	X																							
<i>Pultenaea tenuifolia</i>			RA	X																							
<i>Radyera farragei</i>			RA											X													
<i>Ranunculus sessiliflorus</i>			VU									X															
<i>Rhodanthe sturtiana</i>			NT											X													
<i>Rorippa laciniata</i>		R	RE			X																					
<i>Sagina maritima</i>			NT		X					X				X													
<i>Samolus repens</i>			NT	X		X	X	X		X				X													
<i>Scaevola crassifolia</i>			RA	X																							
<i>Sclerolaela diacantha</i>			RA		X			X	X		X	X	X	X						X							
<i>Sclerolaela muricata</i> var.		R	RA			X	X																				

Supplementary information for Question 20: Noteworthy fauna

Shorebirds found within the site and their conservation status (from Coleman & Cook 2009)

Common Name	Scientific Name	EPBC Act	NPW Act	CAMBA	ROKAMBA	JAMBA	BONN
Australian Pratincole	<i>Stiltia isabella</i>						
Baird's Sandpiper	<i>Calidris bairdii</i>	Mi/Ma					
Banded Lapwing	<i>Vanellus tricolor</i>						
Banded Stilt	<i>Cladorhynchus leucocephalus</i>		V				
Bar-tailed Godwit	<i>Limosa lapponica</i>	Mi/Ma CR/VU ssp	R				
Black-fronted Dotterel	<i>Euseyornis melanops</i>						
Black-tailed Godwit	<i>Limosa limosa</i>	Mi/Ma	R				
Black-winged Stilt	<i>Himantopus himantopus</i>						
Broad-billed Sandpiper	<i>Limicola falcinellus</i>	Mi/Ma					
Buff-breasted Sandpiper	<i>Tryngites subruficollis</i>	Mi/Ma					
Common Greenshank	<i>Tringa nebularia</i>	Mi/Ma					
Common Redshank	<i>Tringa totanus</i>	Mi/Ma					
Common Sandpiper	<i>Actitis hypoleucos</i>	Mi/Ma	R				
Curlew Sandpiper	<i>Calidris ferruginea</i>	Mi/Ma					
Double-banded Plover	<i>Charadrius bicinctus</i>	Mi/Ma					
Eastern Curlew	<i>Numenius madagascariensis</i>	Mi/Ma	V				
Great Knot	<i>Calidris tenuirostris</i>	Mi/Ma CR	R				
Greater Sand Plover	<i>Charadrius leschenaultii</i>	Mi/Ma VU	R				
Grey Plover	<i>Pluvialis squatarola</i>	Mi/Ma					
Grey-tailed Tattler	<i>Heteroscelus brevipes</i>	Mi/Ma	R				
Hudsonian Godwit	<i>Limosa haemastica</i>						
Latham's Snipe	<i>Gallinago hardwickii</i>	Mi/Ma	R				
Lesser Sand Plover	<i>Charadrius mongolus</i>	Mi/Ma EN	R				
Lesser Yellowlegs	<i>Tringa flavipes</i>						
Little Curlew	<i>Numenius minutus</i>	Mi/Ma					
Little Ringed Plover	<i>Charadrius dubius</i>	Mi/Ma					
Little Stint	<i>Calidris minuta</i>	Mi/Ma					
Long-toed Stint	<i>Calidris subminuta</i>	Mi/Ma	R				
Marsh Sandpiper	<i>Tringa stagnatilis</i>	Mi/Ma					
Masked Lapwing	<i>Vanellus miles</i>						
Oriental Plover	<i>Charadrius veredus</i>	Mi/Ma					
Oriental Pratincole	<i>Glareola maldivarum</i>	Mi/Ma					
Pacific Golden Plover	<i>Pluvialis fulva</i>	Mi/Ma	R				

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Painted Snipe	<i>Rostratula benghalensis</i>	Mi/Ma	V				
Pectoral Sandpiper	<i>Calidris melanotos</i>	Mi/Ma	R				
Pied Oystercatcher	<i>Haematopus longirostris</i>		R				
Red Knot	<i>Calidris canutus</i>	Mi/Ma EN					
Red-capped Plover	<i>Charadrius ruficapillus</i>						
Red-kneed Dotterel	<i>Erythrogonys cinctus</i>						
Red-necked Avocet	<i>Recurvirostra rufogularis</i>						
Red-necked Phalarope	<i>Phalaropus lobatus</i>	Mi/Ma					
Red-necked Stint	<i>Calidris ruficollis</i>	Mi/Ma					
Common Name	Scientific Name	EPBC Act	NPW Act	CAMBA	ROKAMBA	JAMBA	BONN
Ruddy Turnstone	<i>Arenaria interpres</i>	Mi/Ma	R				
Ruff	<i>Philomachus pugnax</i>	Mi/Ma	R				
Sanderling	<i>Calidris alba</i>	Mi/Ma	R				
Sharp-tailed Sandpiper	<i>Calidris acuminata</i>	Mi/Ma					
Sooty Oystercatcher	<i>Haematopus fuliginosus</i>		R				
Terek Sandpiper	<i>Xenus cinereus</i>	Mi/Ma	R				
Whimbrel	<i>Numenius phaeopus</i>	Mi/Ma	R				
White-rumped Sandpiper	<i>Calidris fuscicollis</i>						
Wood Sandpiper	<i>Tringa glareola</i>	Mi/Ma	R				

EPBC Act: Mi = Migratory listing, Ma = Marine listing (Commonwealth waters), CR = Critically endangered, EN = Endangered, VU = Vulnerable

NPW Act: R = Rare, V = Vulnerable

CAMBA: China-Australia Migratory Bird Agreement

ROKAMBA: Republic of Korea-Australia Migratory Bird Agreement

JAMBA: Japan-Australia Migratory Bird Agreement

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Supplementary material for Question 24 Adverse Factors

More detailed factor discussion:

Resting (roosting), breeding (resident species only) and feeding opportunities can be compromised by fishing and recreational activities that take place on tidal flats and beaches, and by development very near wetlands. Even when shorebirds remain and use a site in the face of ongoing disturbance, the energetic costs of the disturbance may be high enough that it prevents them building up energy reserves, putting their migration at risk.

In South Australia linear coastal development is discouraged by the Coast Protection Board, who recommend nodal coastal communities, and do not support the creation of more foreshore blocks by subdivision, thus minimising the amount of developed foreshore. This, combined with the use of coastal reserves, minimises the **disturbance impacts** from coastal residential and urban development, however some disturbance is inevitable from existing coastal communities. Besides the urban areas of Port Adelaide, Gillman, Wingfield and Dry Creek there are several coastal communities within the site: St Kilda, Middle Beach, Thompson Beach, Webb Beach, Port Parham, Port Wakefield, Clinton, Price and Tiddy Widdy.

An assumed disturbance on shorebird habitat is the widespread off-road vehicle (ORV) use on the beaches and low tide mud flats, on the extensive sabkhas north of the River Light, and along embankments used for roosting. This activity has increased markedly since the late 1970s.

Locally popular outdoor recreation activities sometimes occur close to shorebird feeding areas. These are often geographically restricted, such as dog walking and cycling near coastal communities, long-distance horse exercise (Port Gawler) and swimming of racehorses (the Port River).

Some fishers also utilise the same area as the shorebirds – bait digging and crabbing occur on the mud flats while brine shrimping occurs in the salinas on both sides of the Gulf. Crabbing is concentrated close to coastal communities with shore access, at and north of St Kilda. The Barker Inlet - St Kilda Aquatic Reserve prohibits crabbing in the area south of St Kilda. The removal of fish by rod and line or handline and the collecting of blood worms for bait by use of a hand net are the only fishing activities permitted in the aquatic reserve, but digging for bait seems to occur sporadically inside the reserve at Torrens Island. Outside the reserve, bait digging is common in the Port River, Port Gawler, Middle Beach and all the coastal communities north of the River Light and around onto the Yorke Peninsula. This activity has a dual impact, with **competition for shorebird food resources** being added to its disturbance impact. This dual impact is also present for brine shrimp poaching.

Predation and injury also directly impact shorebirds. While rats (native and exotic) may predate eggs of resident shorebird species, migratory species are adults and are mostly subject to predation by feral animal species, particularly foxes and cats. Cat predation is likely to be relatively closely associated with coastal townships, but foxes are widespread. Although fox control is undertaken by the land managers they remain a significant ongoing control problem, right around the Adelaide International Bird Sanctuary.

A further source of injury are power lines and roads. This is a specific problem that only occurs where a road or a power line crosses a low-lying area used by shorebirds for feeding or roosting (particularly low tide night

roosting). The roads into St Kilda, Middle Beach, Thompson Beach, Webb Beach and Port Parham are all in this category. Large vehicle kills (more than 20 individual Banded Stilts in one night) of roosting flocks have been reported from St Kilda Road, and the power line along that road frequently has been recorded as injuring birds flying between the two salinas on either side of the road. The direct impacts from fox predation, vehicle and powerline strike account for regular small losses to shorebird populations in the Adelaide International Bird Sanctuary but may not be sufficiently large impacts as to pose a significant threat.

Indirect, habitat threats are just as significant to the survival of shorebirds. Migratory shorebirds complete long flights each year and to do this they depend on the availability of adequate food sources and resting places. The ability of a specific area to support shorebirds is complex and is related to the types and quality of specific habitats, and abundance and availability of food species, as well as the level of disturbance & predation. The specialised feeding techniques and preferences of some shorebirds may make them sensitive to small changes to the feeding environment, or to prey abundance (carrying capacity).

Dump sites and other filling of coastal wetlands alienate saltmarsh habitat and consequently extirpate food resources in those habitats. Filled areas are common at Outer Harbor, Garden and Torrens Island, as well as historic dump sites at St Kilda and around Port Wakefield and Price townships. The activity is ongoing.

Mining in the site has historically included salt making, shellgrit extraction in several locations north of Port Gawler to the Head of Gulf, and sand extraction on Torrens Island.

Saltfields enclose and displace extensive naturally sustainable saltmarsh areas. Even though the salina habitats they create have value for shorebirds, and the production of salt is essentially a renewable form of mining, the long-term operation of these sites is dependent on market forces. In the event the market becomes unfavourable, abandoned salinas do not maintain their value for shorebirds, and may take many years to revert to natural saltmarsh without intervention. There is a possibility that some of the abandoned salinas south of Middle Beach may be rehabilitated into sustainable natural landscapes.

Shellgrit mining leaves a hardened surface that is difficult to rehabilitate. While some successful rehabilitation has occurred within the Proof Range area, other smaller operations (eg Port Gawler to Middle Beach, Port Prime and Port Wakefield) have not been successfully rehabilitated. These leases are still operational.

Sand mining at Torrens Island has ceased. The rehabilitation of the site has seen saltmarsh colonise into the low-lying areas from where the sand was harvested. There are no future plans to mine the island.

Development zoning and future land use plans that are incompatible with shorebird use can see proposed developments that lead to loss of intertidal and freshwater wetland feeding habitats by filling or dredging for coastal development, direct loss and fragmentation of higher land used for roosting areas through new non-nodal coastal development, and increased levels of disturbance and predation adjacent to developments.

The Dry Creek saltfields are extensive and their redevelopment or rehabilitation is not yet fully decided. South of Dry Creek the crystalliser area is proposed for landfilling for future urban uses (commercial and residential are likely). This proposal has the potential to increase the levels of disturbance occurring in nearby areas of use to shorebirds including Greenfields and Barker Inlet Wetlands. Design of internal open space to deflect people from these high value areas may possibly mitigate this impact.

Unused leases that were part of the Dry Creek salt fields north of Middle Beach have largely been purchased by the State Government for incorporation (as a National Park) into the Adelaide International Bird Sanctuary, ensuring these lands will not be developed and provide land for adaptation of tide-dependent ecosystems subject to sea level rise..

Management of stormwater & WWTP discharge can have a number of effects on the receiving environment. Highly turbid, nutrient-rich wastewater, often highly coloured with dissolved organic matter can lead to offshore seagrass loss. This has happened along the Adelaide coast as a result of discharges from the Barker Inlet and Port estuary, and also within the site offshore from the Bolivar WWTP outfall. The loss of the

seagrass beds creates a cascading series of impacts – there is an immediate loss of invertebrate feeding resources for the shorebirds, but the bathymetric deepening as a result of the loss of the seagrass beds may also mean these areas will remain unusable to shorebirds even after the seagrass begin to recolonise, when the discharges are mitigated.

In recent years, closure of the Soda Ash plant at Osborne has reduced ammonium discharges to the Adelaide coastal waters by nearly 50% and the operators of the WWTP are working with the EPA to reduce their discharge.

One of the reasons stormwaters and wastewaters can be so detrimental is that in urban environments the creeks and discharges are channelized, delivering the water directly offshore. Besides the impacts this has on the seagrasses, there is an impact on the estuarine saltmarsh and mangrove habitats that would have historically sedimented the runoff from land before it reached the sea. A lack of sediment to saltmarsh & mangroves prevents them from building land, a basic function that allows them to respond to changes in sea level. Most of the discharges to estuaries within the part of the site south of Middle Beach are channelized. The salina seawalls effectively channelize all the rivers and creeks between Dry Creek and Middle Beach. Seawalls on the LeFevre Peninsula, and at Port Adelaide and Gillman act to channelize flows to the Barker Inlet and Port River. The Port Wakefield River also has a direct channel cut to sea, away from its original more winding approach.

Sediment starvation for saltmarshes can also be created by on-stream dams such as those at Salt Creek and the one forming Buckland Park Lake, which trap sediment further upstream. On-stream damming is no longer permitted in South Australia.

Mangroves that are drained, stranded or ponded usually die. This has occurred to mangroves in the Barker Inlet between North Arm Creek and Broad Creek (ponding behind powerline embankment), Dry Creek (draining of ponded mangroves), north of St Kilda (sand released after seagrass loss blocked the mangrove creeks) and at Price (mangroves drowned after a new salina changed the groundwater elevation). Where these issues have been identified and remedial action taken, new cohorts of mangroves have replaced the dead trees within a few years of the mitigation works.

Sabkhas are subject to groundwater stranding. Roads to coastal communities like Middle Beach, Thompson Beach, Webb Beach and Port Parham all cross sabkhas, preventing the horizontal movement of groundwater. This last is a particular threat to the Vulnerable samphire *Tecticornia flabelliformis*.

Invasion of exotic plant species can change habitat character and this may make an area less valuable for shorebirds. Weeds such as rice grass, *Spartina* spp have been shown to change the structure of the intertidal mudflats and the range of invertebrates that use them. In the past an area of *Spartina* was located at Port Gawler but it appears to have been successfully controlled. *Casuarina glauca* and *Juncus acutus* are both present as a large infestation in wetlands surrounding Buckland Park Lake. There are efforts currently underway to control both species. In the Port River and Barker Inlet the exotic seaweeds *Caulerpa taxifolia* & *Caulerpa racemosa* and the European fan worm *Sabella spallanzanii* may be having an as yet undetermined impact on shorebirds. They are definitely changing the biodiversity composition of the shallow sedimentary areas they are invading.

The most obvious impact of climate change in the site is likely to be sea level rise resulting in mangrove incursion. Mangroves are relatively poor habitat for shorebirds and where mangroves invade salt marsh they reduce its value for shorebirds as the birds will not use small remnant patches of marsh. In the southern parts of the study area mangrove incursion as a result of relative sea-level rise (exacerbated by ground subsidence) is already evident.

Less spectacular mangrove incursion is occurring at Torrens Island. In the more northerly parts of the Gulf (eg Price and Port Wakefield) most mangrove expansion has been seawards, as a result of good terrigenous supply. But with sea level rise accelerating since the mid-90s there is now some evidence of landward

migration in the northern areas. Landward migration in the River Light delta and at Wills Creek near Price has been observed by comparing temporal series of aerial photographs.

Where increased tidal inundation as a result of SLR occurs in areas north of the River Light delta, the resulting changes to sabkha vegetation associations may see increased areas of *Sarcocornia quinqueflora* occurring on the seaward extents of the sabkhas, or the cyanobacterial mats of the sabkhas being wetted more frequently. These areas may then provide a more frequent feeding resource than they currently do.

An aspect of climate change within this site may well be reduced natural flows to the estuaries. This may alter salinity regimes and faunal composition, but the impact of this on shorebird feeding resources is currently unpredictable.

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