Shorebird Population Monitoring within Gulf St Vincent: July 2010 to June 2011 Annual Report

Chris Purnell, John Peter and Rob Clemens

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Birds Australia
60 Leicester Street, Suite 2-05
Carlton VIC 3053
Australia

Tel: (Australia): (03) 9347 0757 Fax: (03) 9347 9323
(Overseas): +613 9347 0757 Fax: +613 9347 9323
E-mail: mail@birdsaustralia.com.au

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Article I. EXECUTIVE SUMMARY

Shorebirds (also known as “waders”) appear to be declining throughout the world, and their long-term survival will require managers and planners to identify and protect shorebird habitats, to identify and reduce the impacts of any threats to shorebirds long-term survival, and to identify population declines in shorebirds sufficiently early to limit the severity of any declines through management. The importance of conservation of migratory shorebirds has been confirmed in the recognition of migratory shorebirds as species of national significance in Australia’s Environment Protection and Biodiversity Conservation Act 1999, and also in several international conservation agreements to which Australia is a signatory.

This report: (a) repeats an overview of shorebirds, habitats and threats; (b) provides details on the 2011 count; (c) reports on three workshops: two workshops to recruit and train counters; and one workshop for managers to raise awareness of shorebirds, raise awareness of the threats to their populations, and to discuss future management of key shorebird habitat in Cheetham’s Dry Creek Saltfields; (e) reports on the refined shorebird habitat mapping of Gulf St Vincent; (f) provides detailed summaries of the shorebird habitat Adelaide region identified as gaps in the 2010 report; and (g) provides information that is relevant to the management of shorebirds and the threats they face in Gulf St Vincent, including initial explorations into how management and planning can improve shorebird conservation in the region.

The results of the 2011 summer count were down on last years’ results, due to inconsistent coverage and dispersal of birds into inland wetlands. The updated mapping focussed on areas within the Adelaide region such as the habitats found within the Dry Creek salt fields.

As a result of further fieldwork, a literature review, a review of development proposals, and a managers’ and stakeholders’ workshop, it seems clear that: (1) disturbance and habitat loss or degradation are the two greatest threats to shorebirds in the Adelaide region; (2) the artificial wetlands of Dry Creek Salt fields support the greatest abundance of migratory shorebirds in the region, and informed adaptive management of these habitats will be required to maintain shorebird populations, especially if existing management practises change; (3) reinstating pre-mining lease habitat conditions, namely coastal saltmarsh, to the Dry Creek Saltfields will not provide for the current population of shorebirds to persist in GSV (4) potential feeding areas on intertidal zones surrounding the Bolivar Treatment outlet have been degraded to the point they have become functionally useless to shorebirds; (5) many of the proposed developments in the region are unlikely to have significant impacts to shorebirds on their own, but their cumulative impact could result in drastic impacts without cross jurisdictional cooperation and planning (6) current councils, land managers, and the Adelaide and Mount Lofty NRM should be commended for the progressive steps they have already taken to protect shorebirds in Gulf St Vincent; and (7) we look forward to another year in which we can further inform on how to optimise shorebird monitoring and conservation effort

Article II. INTRODUCTION

Gulf St Vincent is an internationally significant area for shorebirds (Bamford *et al.* 2008), and over the last 25 years, counts of migratory shorebirds have been conducted there by volunteer counters from organisations such as the Australasian Wader Studies Group and Birds SA. The importance of migratory shorebird conservation has been recognised globally and nationally. Further, shorebirds are considered good indicators of the health of wetlands. The need for shorebird conservation has been growing in recent years with evidence that migratory shorebirds are declining throughout the world (Morrison *et al*. 2001; IWSG 2003; Olsen *et al*. 2003; CHSM 2004; van de Kam *et al*. 2004), and growing evidence of shorebird population declines in Australia (Gosbell & Clemens 2006; Nebel *et al*. 2008; Birds Australia unpublished data). In this context, in 2009 the Adelaide and Mount Lofty Ranges NRM provided funding to Birds Australia for the coordination of a complete count of the shorebirds within Gulf St Vincent, including supplementary surveys of poorly known shorebird habitat. This was done to reinvigorate shorebird population monitoring, and identify the important shorebird habitats in the region. The project also delivered GIS layers of shorebird habitat and a report highlighting the distribution and abundance of shorebirds in Gulf St Vincent, as well as current and potential threats to shorebirds in the region. Work also included holding two shorebird training workshops to recruit, train and inform counters. Additional funding from the Adelaide and Mount Lofty NRM will allow this work to continue through 2011. This report highlights the results to July 2011. Work from July 2009 to June 2010 has increased the number of active, trained volunteers required to carry out shorebird surveys in Gulf St Vincent, increased the spatial resolution of mapping and filled some of the gaps in our knowledge about the distribution of shorebirds in Gulf St Vincent. Work in 2011 also included the coordination of three simultaneous counts of shorebirds in Gulf St Vincent, another two workshops to recruit and train counters, and a shorebird management workshop. We have also increased our understanding of the threats to shorebirds in Gulf St Vincent as well as the types of management required to ensure long-term shorebird conservation.

Specifically, work this year has included:

1. Refined shorebird-habitat mapping in the Adelaide region, including:
   - Buckland Park Lake
   - intertidal zone from St Kilda to Middle Beach
   - supratidal zone from Thompsons Beach to Port Parham
   - intertidal zone from Port Wakefield to Clinton Conservation Park.

2. Workshops and field trips:
   - A workshop to engage managers and planners, focusing on habitat issues surrounding a potential decommissioning of Dry Creek Saltfields.
   - Two workshops to train and recruit shorebird counters.
   - Meetings with Birds SA and other key data contributors.

The reinvigoration of shorebird monitoring work in Gulf St Vincent is providing valuable information to Birds Australia's Shorebirds 2020 Program, which coordinates national shorebird population monitoring. The Shorebirds 2020 Program was initiated in 2007 in response to growing concern over declining shorebird populations in Australia and the need to reliably determine population trends for species. The aim of the Program is to collect data on the populations of shorebirds which can be used to aid their conservation and management. Specifically, the aim is to understand national (and, where possible, site-based) population trends, and explore the potential causes of change through increasing our understanding of the relationship between habitat, habitat quality and threats, and how they interact to affect the distribution and abundance of shorebirds in Australia.

Recent work has identified a need to conduct annual surveys at over 150 sites throughout Australia to detect the national population trends of migratory shorebirds and ten resident species of shorebirds. Gulf St Vincent is considered the second-most important shorebird area in South Australia due to the abundance and diversity of species of shorebirds that occur there, and it is crucial in terms of areas that must be surveyed to determine national population trends.

With projected growth estimates predicting that Adelaide's population will increase to 560,000 people (including 160,000 in the northern Adelaide region) in the next 30 years, it is imperative to inform managers and planners about how to ensure the long-term conservation of shorebirds in Gulf St Vincent. This project has delivered some of the first steps required to achieve that long-term aim. First, most of Gulf St Vincent's shorebird habitat has been identified, mapped at fine scale, and described with regard to the relative importance for shorebirds of each area. This should allow improved planning and threat minimisation. Awareness of the need for shorebird conservation has been raised within the birdwatching community and stakeholders involved in the management of shorebird habitat through workshops. These workshops, together with work by Birds SA, have also increased the number of skilled shorebird counters. Shorebird monitoring has been reinvigorated within Gulf St Vincent and steps are being taken to optimise that monitoring to inform on adaptive management of shorebird habitats. Results from recent analyses suggest current monitoring is sufficient to help inform on national shorebird trends, but significantly more counts would be required to identify anything other than a catastrophic (>70%) decline of shorebirds within Gulf St Vincent over 20 years. Field work, a literature review and stakeholder discussions have increased our understanding of the specific threats to shorebirds in Gulf St Vincent, and highlighted some of the management and conservation measures required to limit the impact of those threats. These threats are growing and it is clear that some pristine areas, such as the northern beaches, will need to be protected, while other areas will require active management to maintain shorebird populations. This report highlights the progress towards these required steps for long-term shorebird conservation in Gulf St Vincent, but ultimately shorebird conservation in the region will depend on the role that local planners and managers adopt regarding shorebird conservation.

Background Information on Shorebirds, Habitats and Threats

Section 2.01 What are shorebirds?

Shorebirds (also known as “waders”) in Gulf St Vincent include sandpipers, plovers, stints, oystercatchers, godwits, curlews, knots and greenshanks. All shorebirds are characterised by their long legs, and general association with wetlands. There is no agreed taxonomic or morphological definition of a shorebird; they are a bit of an arbitrary group within the order Charadriiformes. This order also includes non-shorebirds such as gulls, terns, auks, and even button-quail. In Australia, shorebirds are categorised as either migratory or resident: 36 species of migratory shorebirds regularly spend the non-breeding season in Australia, having flown up to 13,000 kilometres from their breeding grounds; 18 resident shorebird species breed in Australia, remaining throughout the year (Geering *et al*. 2007).

The 2 million migratory shorebirds that visit Australia each year are born in the arctic tundra of Russia and Alaska, in meadows within the belt of the northern hemisphere’s boreal forests, or in the rugged deserts and steppes of the middle-northern latitudes in places such as Mongolia and northern China. Many shorebirds hatch into the care of a male and female which have travelled to the same place to breed, year after year. Others hatch in areas where food was plentiful that year, where either the male or the female mates with many partners, leaving the parental care to their many mates. A few hatch into families where the male takes care of one clutch of eggs while the female cares for a second. No matter where they were born, or the type of family they come from, all must grow up incredibly quickly before embarking on a remarkably difficult journey.

Almost as soon as a shorebird hatches it is able to walk around and forage on its own. Parental care consists mostly of distracting predators, such as Arctic Foxes or Snowy Owls, and leading young to patches of food. When the chicks are only six weeks old, the mother often leaves on her migration to the southern hemisphere, and the father often follows a week later. Just eight weeks after hatching, the chicks are fully grown, and must fly south without their parents or risk freezing in the coming snows. In a physiological frenzy, the young birds may increase in mass by up to 80% until their body mass comprises 55% fat, their weight increasing by 2—5% per day. Just before they leave on migration, the young birds’ feeding organs shrink, their heart grows and their blood thickens. Then they set off south, burning their accumulated fat at a rate of up to 1 gram each hour, flapping constantly as their body, heart and muscles atrophy. Avoiding aerial hunters and poor weather along the way, the most difficult aspect of the journey is navigating distances of up to 13,000 kilometres by instinct, as there are no older birds to guide them. They fly non-stop for days at time, and most are only able to last the journey for about half way before they need to stop to feed so that they can once more increase their body mass. The areas they stop at must be rich intertidal ecosystems, with abundant food sources.

A few shorebirds have been shown to complete the flight in one hop. Some Bar-tailed Godwits were tracked flying directly from Alaska to New Zealand over nine days, comprising a non-stop 11,000-kilometre trip across the Pacific Ocean. On such long flights, there is evidence which suggests that: these birds can rest different parts of their brains independently; they can see the lines of polarity in the sky (like seeing a compass); they can sense low-frequency, long-distance travelling sounds called infrasound (a sound made by crashing waves among other things); they can navigate by the position of the sun and moon and the movement of the stars.

After completing their first migration by the time they are 3–4 months old, these juvenile birds inhabit the tidal flats and wetlands of Australia, where they may remain for up to five years before they migrate north again to breed. Meanwhile, adults migrate back and forth each year, building up their weight before each migration, and most appear to stop over to feed along the way. An extra refuelling stop on the northward migration may be necessary because their destinations in the northern latitudes are still cold when the birds arrive, and they need to have sufficient energy to breed successfully.

Unfortunately, these critical stop-over sites used to refuel are being destroyed at an alarming rate, and this appears to be driving both long- and short-term population declines in migratory shorebirds. In the past 25 years some of these species have decreased by 50–80%, and at least one species has experienced declines of 20% in just a few years. Up to 150,000 shorebirds of various species went missing in a single year after the destruction of just one vital tidal ecosystem (Rogers *et al*. 2008). The Eastern Curlew and Great Knot were both listed as vulnerable on the IUCN Red List recently after major population declines were detected , but more work is needed to monitor any further changes and explore how widespread these declines might be.

Given the size of the area migratory shorebirds rely on to survive each year, their conservation is not simple. It requires a level of international cooperation to maintain the vital habitats that occur from Siberia to Australia that shorebirds rely on to survive. However, Australia is uniquely placed to use good science to understand how shorebird populations may be changing. Without such knowledge it is difficult to make the case for the protection of shorebird habitats, to discover what is driving some of these declines, and what can be done to ensure shorebird populations can persist into the future.

Section 2.02 Global shorebird population trends

Throughout the world, many populations of shorebirds appear to be declining (Wilson 2000; Morrison *et al*. 2001; IWSG 2003; Olsen *et al*. 2003; CHSM 2004; van de Kam *et al*. 2004). In 2003, trend estimates were available for 41% of the 499 shorebird populations around the world. Of these, 44% appeared to be decreasing, 13% were increasing, 39% were stable and 4% had become extinct (Delaney 2003; IWSG 2003). The population declines detected coincide with accelerating loss and degradation of shorebird habitat (UNEP 2006). In the East Asian–Australasian Flyway, a disproportionately high number of shorebird species have been classified as threatened, and many are under increasing threat from habitat destruction (IWSG 2003). Of the species that are resident in Australia, the species of most concern is the Hooded Plover, populations of which appear to be declining, due mainly to human disturbance during their nesting period, as well as degradation of their habitats (Weston 2003). Recent population-trend analysis of the National Shorebird Database held at Birds Australia shows strong evidence of declines in the Australian populations of an additional 12 species of migratory shorebirds, and evidence of declines evident in another eight species of shorebirds (Birds Australia unpublished data).

Section 2.03 Global and national recognition of the importance of shorebirds

Recognising that the long-term conservation of viable populations of the world's species requires the identification, protection and management of their habitats, many governments have initiated conservation measures and signed international conservation agreements. The international agreements pertaining to Australia's shorebirds include the Ramsar Convention, the World Heritage Convention, the Bonn Convention, the Convention of Biological Diversity, the Asia–Pacific Migratory Waterbird Conservation Strategy and the East Asian–Australasian Shorebird Reserve Network. There are also several bilateral agreements, including the China–Australia Migratory Birds Agreement (CAMBA), the Japan–Australia Migratory Birds Agreement (JAMBA) and, most recently, the Republic of Korea–Australia Migratory Bird Agreement (ROKAMBA). In addition, Australia's Environment Protection and Biodiversity Conservation Act (1999) recognises migratory shorebirds as species of National Environmental Significance (NES), further highlighting the importance of shorebird conservation. All of these agreements require the identification and protection of areas for conservation.

Section 2.04 Shorebird needs in Gulf St Vincent

Gulf St Vincent provides a diverse range of shorebird habitats that are vital for shorebirds to survive and reproduce. All shorebird habitats must provide a combination of feeding areas that are rich in food and nearby roosting areas that allow shorebirds to rest without losing too much energy due to disturbance. Further, shorebird habitat must minimise the risk of predation by providing sufficiently open areas to allow shorebirds to detect and avoid predators. For resident shorebirds, the wetlands surrounding the Gulf must provide sufficient suitable habitat for successful breeding.

Section 2.05 Conservation status of shorebird areas in Gulf St Vincent

Most of the important shorebird sites in Gulf St Vincent are legally protected within the reserve system that is administered by the National Parks and Wildlife Service, or occur within protected Australian Defence Force land or on commercial saltfields.

The only classified conservation areas include Clinton Conservation Park, Torrens Island Conservation Park, Port Gawler Conservation Park, Barker Inlet Aquatic Reserve, St Kilda–Chapman Creek Aquatic Reserve, Adelaide Dolphin Sanctuary and the Upper Gulf St Vincent and the Lower Yorke Peninsula Marine Parks.

Clinton Conservation Park is situated at the northern end of the Gulf. It covers over 18 km^2 and supports mangroves, tidal flats, samphire and chenopod shrublands. It is the largest reserve in Gulf St Vincent, and one of the most significant sites in terms of shorebirds (Close & McCrie 1986; Watkins 1993). Large areas are leased from the State Government for salt harvesting, providing havens for shorebirds at Dry Creek Saltfields on the Gulf's east coast and Price Saltfields on the west coast.

The coastline between Clinton Conservation Park and Dry Creek Saltfields is known as the "Samphire Coast" and it includes a variety of habitats that support many species of shorebirds. The area also has small townships scattered along the coast and areas of agricultural land. These developed areas are interrupted by an undeveloped 18.5-kilometre stretch of coast which is reserved for the Australian Defence Force Proof and Experimental Establishment; it extends from north of Port Parham to south of Port Wakefield. This area has a public exclusion zone which extends beyond the tidal flats into the waters of the Gulf. Much of the Samphire Coast's intertidal flats fall under the protection of the 971-km^2 Upper Gulf St Vincent Marine Park. This Park includes the coast up to the median tide line and waters of the Gulf north of a line joining Parara Point and the northern end of Port Gawler Beach. The Lower Yorke Peninsula Marine Park is located around the 'heel' of the Yorke Peninsula, from Point Davenport Conservation Park to Stansbury, covering an area of 874 km^2. Troubridge Island, located within the Marine Park, provides feeding and roosting sites for a large number of shorebirds.

Adjacent areas include private land and foreshore reserves, and these receive varying levels of protection, though some are subject to disturbance and degradation of sand-dune environments, mainly from off-road vehicles. The potential impacts on important shorebird areas are greatest in these unprotected areas. If viable populations of shorebirds are to be maintained, protected areas and threats from adjacent unprotected areas require careful management.

Section 2.06 Key shorebird habitats in Gulf St Vincent

The coastal wetlands of Gulf St Vincent consist of a mosaic of artificial and natural shorebird habitats. The suitability and selection of roosting or feeding habitat by shorebirds is governed by ambient factors, including environmental, human, structural and abiotic features. It is important to determine the extent to which these factors affect use of various habitats and the associated implications for shorebird habitat protection, so that conservation strategies and informed management of human recreational use of these habitats can be formulated (Peters and Otis 2007; Oldland *et al*. 2008).

Four categories of habitat types have been identified as being of priority conservation value for the protection of shorebirds in Gulf St Vincent. They are: tidal flats; sandy shores; saltmarsh/saltpans; commercial saltfields /artificial wetlands. These sites are used according to temporal variations in prey abundance, tide conditions, human interference and the diversity and abundance of the shorebirds themselves.

Figure 1. The Bar-tailed Godwit is one of the intertidal specialists which visit the beaches of GSV in summer. Photo Jon Irvine

(a) Tidal Flats

A combination of sediments, currents, low relief and tidal range can produce large areas of tidal flats. In Gulf St Vincent, these factors have combined to form many expansive areas of tidal flats, for example, between Barker Inlet and Clinton Conservation Park, the tidal flats stretch for nearly 100 kilometres, and some of them are more than 250 metres wide.

The sand flats and mudflats which occur along Australia's coastlines are inhabited by abundant and diverse small burrowing invertebrates. These benthic bivalves, worms and crabs can be difficult to find, let alone catch, but shorebirds are expert at obtaining them. Accordingly, they are the most common birds on tidal flat systems around Australia.

In Australia, 14 of the most regularly occurring shorebirds, including species such as Red Knot, Bar-tailed Godwit (Figure 1) and Eastern Curlew, specialise in feeding on tidal flats. All of these species occur in Gulf St Vincent. They have evolved to exploit different food sources within tidal flats (Figure 2). When present during their non-breeding season, this is the only habitat that they forage in.

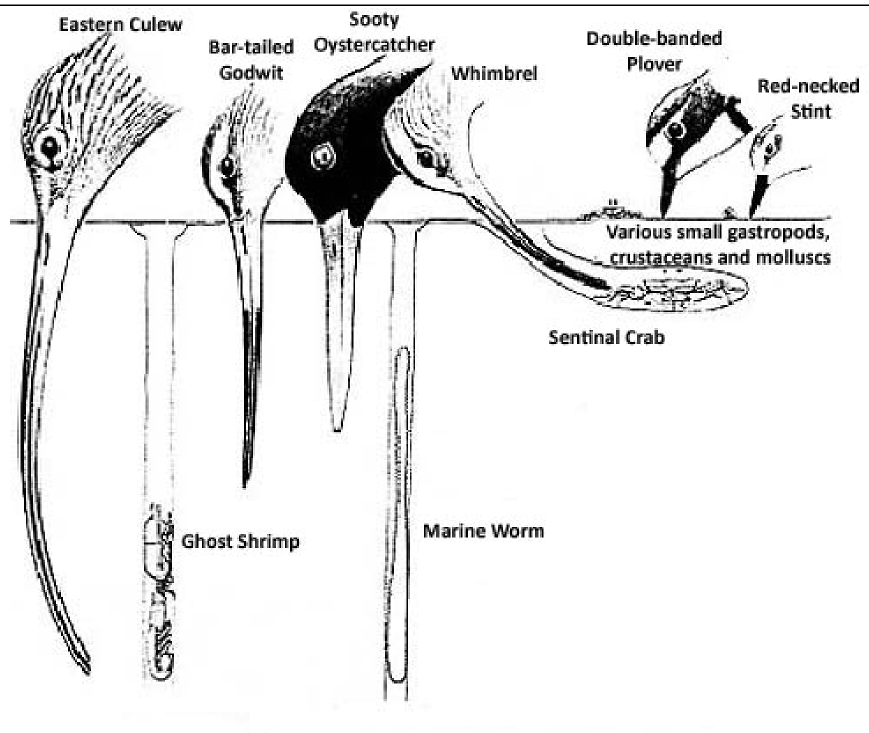


Figure 2. Shorebird bill adaptations to feeding in intertidal substrate. Reproduced from Lane (1987), with permission.

Significant areas of tidal flats in Gulf St Vincent support an array of invertebrates that are regularly eaten by shorebirds. Apart from the tidal flats of the Clinton Conservation Park, the most significant areas of shorebird feeding habitat occur between Light Beach and Bald Point, where thousands of foraging shorebirds congregate.

(b) Sandy Shores

Much of Australia's coastline comprises beaches, consisting of predominantly sandy shores of varying steepness and width. Beaches often occur on high-energy shorelines, and they support fewer burrowing invertebrates than tidal flats. Nevertheless, they provide a diversity of prey for a few species of shorebirds that specialise in foraging in these habitats: species such as the Ruddy Turnstone and Red-capped Plover are adept at picking invertebrates from the tidal wrack of decomposing seaweed that is washed up on some beaches.

In general, shorebirds occur in low densities in these habitats, with the exception of high-tide roosts where large flocks of shorebirds sometimes congregate (Figure 3). Such large flocks usually occur when the expansive flats are covered by the high tide, forcing birds to rest in open areas (without cliffs or trees in all directions) that have not been inundated.

Some species of shorebirds, such as the Hooded Plover and Red-capped Plover, are true ocean-beach specialists, foraging and nesting on beaches. They are less numerous than many other species of shorebirds, and a beach supporting only a few pairs may be of considerable conservation importance.

Sandy beaches often experience intensive recreational use from people, and some coastal parks record millions of visitors each year. However, few Australians consider beaches to be important habitat for wildlife, and, as a result, the impacts that coastal development, exploitation, modification and recreation have on shorebirds on beaches are often overlooked. If this trend continues unabated, many areas that are currently considered good habitat for shorebirds could be rendered unsuitable.

Although vast stands of mangroves line the coast between Barker Inlet and Light Beach, most of Section Banks consist of sandy shores. Sandy shores occur from Light Beach north to Bald Hill, where they form the dominant intertidal buffer between tidal flats and saltmarsh. They are often covered in thick layers of beachcast seaweed.

Figure 3. Red-necked Stints and Red-capped Plovers (foreground) roost along the sandy shoreline of Light Beach, while larger Eastern Curlews prefer to roost on the tide line. Photo: Chris Purnell

(c) Saltmarsh and Saltpans

Characterised as a mostly treeless plant community comprising a low mosaic of succulent shrubs and herbs, salt-tolerant grasses and sedges, saltmarsh is considered by some to be a lifeless wasteland. As a result, many saltmarshes have been in-filled, used as rubbish tips and places for recreational off-road vehicles (DECC 2008). Ignorance of the ecological value of saltmarsh has been reflected in the relative lack of protection afforded to the habitat when compared with most other ecosystems. Until recently, saltmarsh was the least studied of all of Australian marine habitats, even though the habitat occupies up to 16,000 km^2 of the Australian coastline and supports more than three times the number of vascular plant species than occur in mangrove forests (Saintilan and Williams 2000). There are 1,270 km^2 in Gult St Vincent, comprising 600 km^2along the eastern side, 200 km^2at the head of the Gulf and 470 km^2along the western shoreline.

Saltpans are also characteristically open and free of tall vegetation, and, like saltmarsh, they also remain vastly under-studied and under-protected in Australia. Formed in supratidal areas of low-lying, dry regions, they are seldom inundated by water (Coleman and Cook 2009); however, when they become inundated, cyanobacterial mats are able to grow, forming the basis of a food web in which shorebirds are the top predators.

Migratory and resident shorebirds feed and roost in saltmarshes and saltpans, and in the absence of freshwater wetlands they are the preferred habitat of species such as the Common Greenshank, Marsh Sandpiper, Black-winged Stilt and Pacific Golden Plover. These sites are especially crucial during spring tides and other periods of high tidal inundation, when regular feeding and roosting sites are rendered unsuitable for most shorebirds. The birds are forced inland to feed or roost in saltmarshes and saltpans, such as those at Third Creek. Thus, with the threat of rising sea levels, these sites are valuable for shorebird conservation.

As with tidal flats, saltmarshes provide wide open spaces which allow shorebirds uninterrupted views, enabling increased surveillance for predators, which enables more time to be spent feeding. Some tidal creeks and runnels which criss-cross saltmarsh open up into large saltpans which may support large flocks of feeding or roosting shorebirds. Similarly, small, shallow pools and streams may also provide areas where shorebirds can feed while roosting.

The eastern coast of Gulf St Vincent supports fragmented patches of low-lying saltmarsh and saltpans which are used by shorebirds, especially in the southern Barker Inlet–Dry Creek region. Further north, mangroves dominate the shoreline, and saltmarsh and saltpans of varying size and condition are bound by either mangroves or sandy shores on the seaward side, and, on the landward side, by higher land, ridges or development (Coleman and Cook 2009).

Much of the destruction of coastal saltmarsh in Australia has occurred through reclamation for agricultural, industrial, transport and residential development (Kratochvil *et al*. 1972; Finlayson and Rea 1999). Significant alterations to the hydrology of saltmarshes have followed the construction of levees, culverts and floodgates, leading to the loss of ecological function and alteration of the floristic composition. The discharge of stormwater in coastal areas also alters salinity regimes, increases nutrient levels and facilitates the spread of invasive weeds as well as the expansion of mangrove communities (Saintilan and Williams 1999). Similarly, unrestricted access into saltmarsh by walkers, cyclists, off-road vehicles (Figure 4) and grazing animals also adversely affects saltmarsh communities; for example, wheel ruts from off-road vehicles and trail bikes persist for many years in saltmarsh, even after vehicles have been excluded (DECC 2008). Faced with these threats, the NSW Department of Environment and Climate Change (DECC) recently classified Coastal Saltmarsh as an Endangered Ecological Community (EEC).

Figure 4. An off-road vehicle emerges from saltmarsh onto a tidal flat at Port Gawler. Photo: Chris Purnell

(d) Commercial Saltfields and Artificial Wetlands

Though many migratory shorebirds inhabit intertidal habitats while they are in Australia during the non-breeding season, their use of saltpans indicates that supratidal habitats can also provide suitable habitat for wintering shorebirds.

In Gulf St Vincent, the most significant supratidal habitats are artificial ones. Of these, the series of salt evaporation ponds (salinas) found within Cheetham Salt's Dry Creek Saltfields provide the greatest amount of shorebird habitat.

The presence of supratidal habitats can increase the number of shorebirds that a region can sustain, or reduce the detrimental impacts of the loss of intertidal habitats (Velasquez and Hockey 1992; Masero 2003). The reduction in area of intertidal foraging sites often results in an increase in the density of shorebirds in the remaining areas, which in turn leads to an increase in both the impact on shorebird food supplies and interference between foraging birds (Velasquez 1992). The presence of supratidal habitats, such as the Dry Creek Saltfields (Figure 5), which resemble intertidal habitats can provide alternative foraging areas for shorebirds and other species of waterbirds (Weber and Haig 1996). Several studies have suggested that the availability of high-tide foraging areas contribute significantly to the maintenance of both high foraging densities of shorebirds on intertidal mudflats and overall stability of non-breeding populations (Velasquez and Hockey 1992).

Figure 5. Several species of shorebirds thrive on the high densities of invertebrates found in the hypersaline ponds of Dry Creek Saltfields. Photo Chris Purnell

Commercial saltworks are man-made supratidal habitats managed for the production of salt. By the predictable manipulation of water depth and salinity used for salt production, these areas attract many species of shorebirds, as the fluctuations in water depth and salinity provide a variety of foraging habitats, each of which suits a particular guild of shorebirds. Because these artificial supratidal areas have salinity, fluvial dynamics and benthic substrates that differ from tidal communities, they support distinct invertebrate communities. Consequently, these habitats can provide both supplemental high-tide and preferential feeding habitats for different species of shorebirds (Masero *et al.* 2000).

Shorebirds represent about 25% of the more than 200 species of birds recorded in and around the Dry Creek Saltfields. Since 1976, 52 species of shorebirds have been recorded in the region (including nine of them in numbers considered to be of international significance). Together with the Price Saltfields, these artificial supratidal habitats are a major factor in Gulf St Vincent being an important shorebird area in South Australia, second in importance only to The Coorong.

Other supratidal habitats used by shorebirds include low-intensity aquaculture ponds, sewage treatment plants and artificial wetlands, such as Barker Inlet Wetlands and Magazine Road Wetlands. Unlike intertidal mudflats, time spent foraging in these habitats is not restricted by tidal inundation, allowing shorebirds to spend longer periods foraging for invertebrate prey (Velasquez and Hockey 1992; Weber and Haig 1996). The Barker Inlet Wetlands and the Magazine Road Wetlands also provide an open, shallow freshwater habitat for shorebirds such as Wood Sandpipers, which prefer feeding and roosting in freshwater or brackish conditions.

Importantly these habitats are not accessible to the public and remain largely undisturbed, apart from the occasional operational staff or birdwatcher (both of which are aware of the implications of disturbance).

Figure 6. Red-capped Plovers forage, roost and nest on tracks in Dry Creek Saltfield. The eggs and chicks are vulnerable to potential car strikes. Photo Chris Purnell

Section 2.07 Threats to shorebirds in Gulf St Vincent

The threats to shorebird populations and their habitats in Gulf St Vincent include human-induced habitat loss or degradation, disturbance, invasive species, pollution and human-induced mortality or breeding failure. The severity of these threats depends on the scale and cumulative effect of human actions throughout the area, and the degree to which shorebird populations are currently limited in the area. Previous reviews of wader populations in Gulf St Vincent have been limited by a shortage of data and are therefore subject to sampling error, and probable declines in shorebird numbers may be also be attributed largely to factors independent of the Gulf (Close 2008). These conclusions are based on a 50% decline (from 59,851 to 29,929) in numbers of northern hemisphere (or Palaearctic) breeding species recorded in the Gulf between 1979 and 2008. In contrast, resident species declined overall by only 12%. However, within the category of residents, the number of Red-necked Avocets declined by 96%, and numbers of Black-winged Stilts, Red-kneed Dotterels, Red-capped Plovers, Masked Lapwings and Banded Lapwings also declined greatly (Close 2008). The Shorebird Population Monitoring Program has recognised declines in both resident and migratory birds throughout south-eastern Australia (Gosbell and Clemens 2006), and recommends that threats to local shorebird habits must be identified.

The potential for development along the Gulf's coastline introduces all of the above-mentioned threats to the stability of shorebird habitats and creates irreversible flow-on effects.

(a) Habitat loss or degradation

Habitat loss and degradation is the prime long-term threat to migratory and resident shorebird populations in Gulf St Vincent. The urbanised stretch of coast south of Adelaide has historically supported a healthy number of shorebirds, including breeding Hooded Plovers, but since extensive development and increasingly intensive use by people, shorebird numbers in the area have plummeted (Close 2008) and beach-nesting birds, especially the Hooded Plover, have become increasingly uncommon.

This is the scenario now facing shorebird habitats north of Adelaide, with the projected population growth of the northern Adelaide region to exceed 160,000 over the next 30 years. Apart from direct habitat loss, it is the accumulative indirect affects that population growth has on shorebirds which will threaten populations in Gulf St Vincent. For example, large areas of tidal mudflats at St Kilda have been reclaimed and built upon, including a boat launch and marina. This has not only removed historic feeding and roosting sites and degraded surrounding habitats (Coleman and Cook 2003) but has also increased levels of disturbance from boat traffic, the occurrence of exotic predators, the potential for pollution and the introduction of coastal weeds.

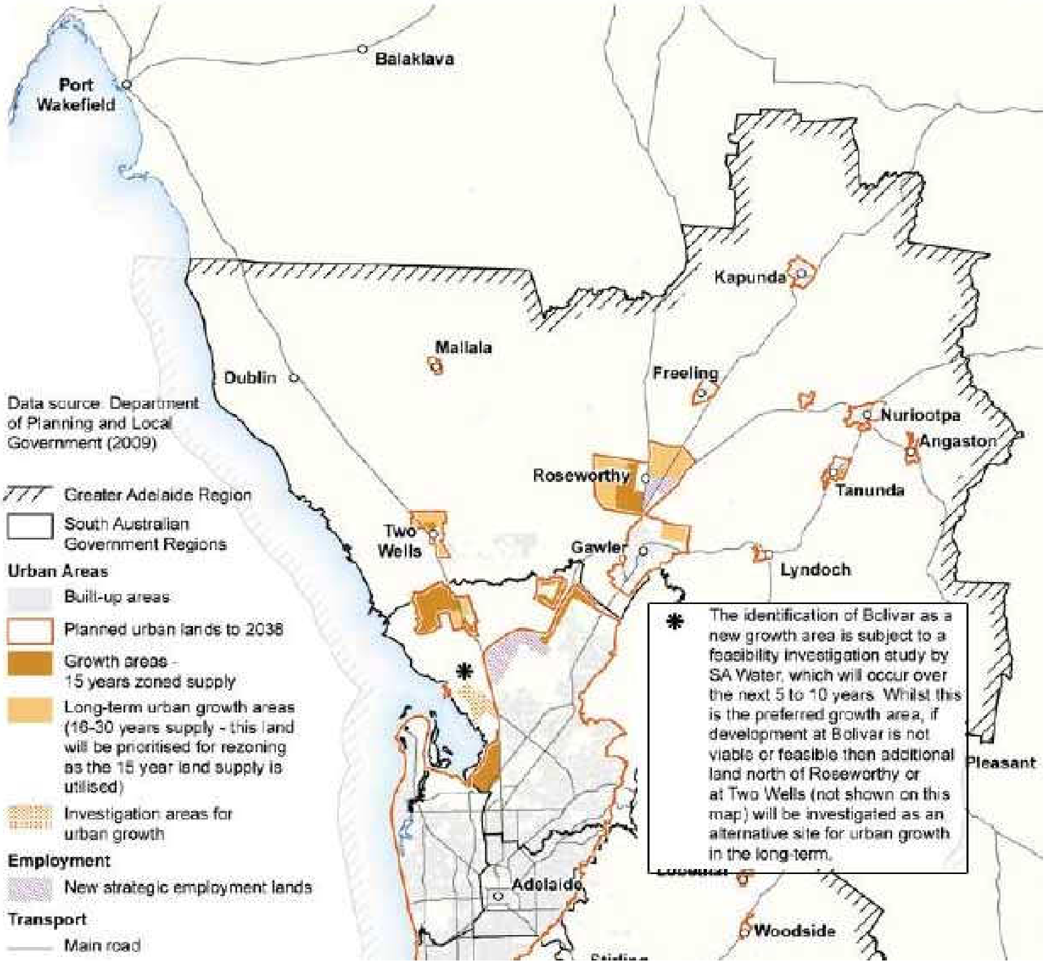


Figure 7. Urban expansion priorities .Image from *The 30-year plan for Greater Adelaide.*

When considering habitat loss or degradation on its own there are two major areas of consideration: the Dry Creek Saltfields–Buckland Park and the Samphire Coast.

The habitats that the Dry Creek Saltfields create as an active operation support an average population of nearly 15,000 shorebirds. However, it occupies valuable land along one of northern Adelaide's key growth areas (Figure 6). Developments proposed for the southern part of the saltfields and the Buckland Park area have been recently reconsidered. Similarly, an expansion of the Northern Expressway has been redirected. Previously, the expressway had been planned to bisect the saltfields and jeopardise the Magazine Road and Barker Inlet Wetlands as well as the operational future of the saltfields themselves. Given their proximity to both the city and the coast, there are likely to be similar propositions made for these valuable parcels of land in the future. Although it is difficult to gauge the extent to which such developments would impact on the shorebird population, migratory birds which congregate in large feeding and roosting flocks are likely to experience mass displacement and consequent population reductions throughout the Gulf. The disturbance created by such a large-scale development would displace many species, not only in construction areas, but also in adjacent habitat (Kellog *et al*. 2003). Scenarios for alterations of operation and potential decommission of the saltfields are the subject of a pending Program for Environmental Protection and Rehabilitation (PEPR) which is to be provided by Cheetham Salt. Discussion surrounding this document is referred to in further sections of this report.

Other notable shorebird areas along the Samphire Coast are susceptible to pressure from habitat loss or degradation. While development may not be a short-term priority in the northern coastal towns of Port Parham, Webb Beach and Thompsons Beach, an influx of off-road vehicles accessing areas of saltmarsh, intertidal zone and claypans from Port Gawler to Pt Parham threaten to reduce the habitat value of feeding areas. Off-road vehicles can compact sediment and the benthic macrofauna contained within (Schlacher *et* al.2008), drastically reducing the availability of shorebird prey. When driven in saltmarsh, Four-wheel drives and motorbikes can also destroy the samphire flora and change the structure of the habitat. The increased disturbance caused by four-wheel drives and dirt-bikes in roosting and feeding areas can prove tantamount to habit loss if birds are disturbed to the point where the energy costs of surveillance behaviour and disturbance flights outweigh the energy gained from the habitat (West *et al*. 2002; Goss-Custard *et al*. 2006; Rogers *et al*. 2006; Peters and Otis 2007). If disturbance is sustained, shorebirds may abandon even the most productive of habitats within and across seasons (West *et al*. 2001, Goss-Custard *et al*. 2006).

Figure 8. Off-road vehicle damage on saltmarsh. Photo: Glenn Ehmke

It is, therefore, important that the potential impacts of any development, proposed management or proposed activity within 1 kilometre of these important shorebird areas should be fully assessed.

(b) Disturbance

The largest ongoing threat to the survival of migratory shorebirds in Gulf St Vincent is disturbance. Further, as Adelaide grows, increasing numbers of people are likely to visit the coastal and wetland habitats used by shorebirds, and this threat is likely to escalate if thoughtful adaptive management of recreation is not applied.

Studies have shown that human disturbance of roosting shorebirds is related to local population declines (Pfister *et al*. 1992; Tubbs *et al*. 1992; Burger *et al*. 2004), lowered body condition (Durell *et al*. 2005), regional habitat shifts (Burton *et al*. 1996) and local avoidance behaviour (Kirby *et al*. 1993). Species with high roost-site fidelity and minimal movement between roosts are most at risk from human disturbance and require particular attention (Rehfisch *et al*. 1996).

Occasional disturbance to shorebirds, such as those caused by the appearance of a raptor, are common, but generally there tends to be a balance between the energy lost during these natural periodic disturbances and the ability to offset those losses by foraging for longer or on supplemental prey. In an increasing number of areas, however, human disturbance appears to be too great to be offset by supplemental feeding (West *et al*. 2002). Modelling suggests that some patterns of disturbance can result in net energetic losses at habitats that remain occupied, and in some cases these energetic losses are greater than would have occurred if the habitat had been lost entirely (West *et al*. 2002; Rogers *et al*. 2006; Gill 2007). These energetic losses can potentially affect species at the population level, and the relationship between disturbance and population declines in non-breeding areas have been shown conclusively overseas in populations of the Pink-footed Goose (Tombre *et al*. 2005; Gill 2007). The level of knowledge required to determine conclusively to what degree disturbance may impact on shorebird populations is far from being met.

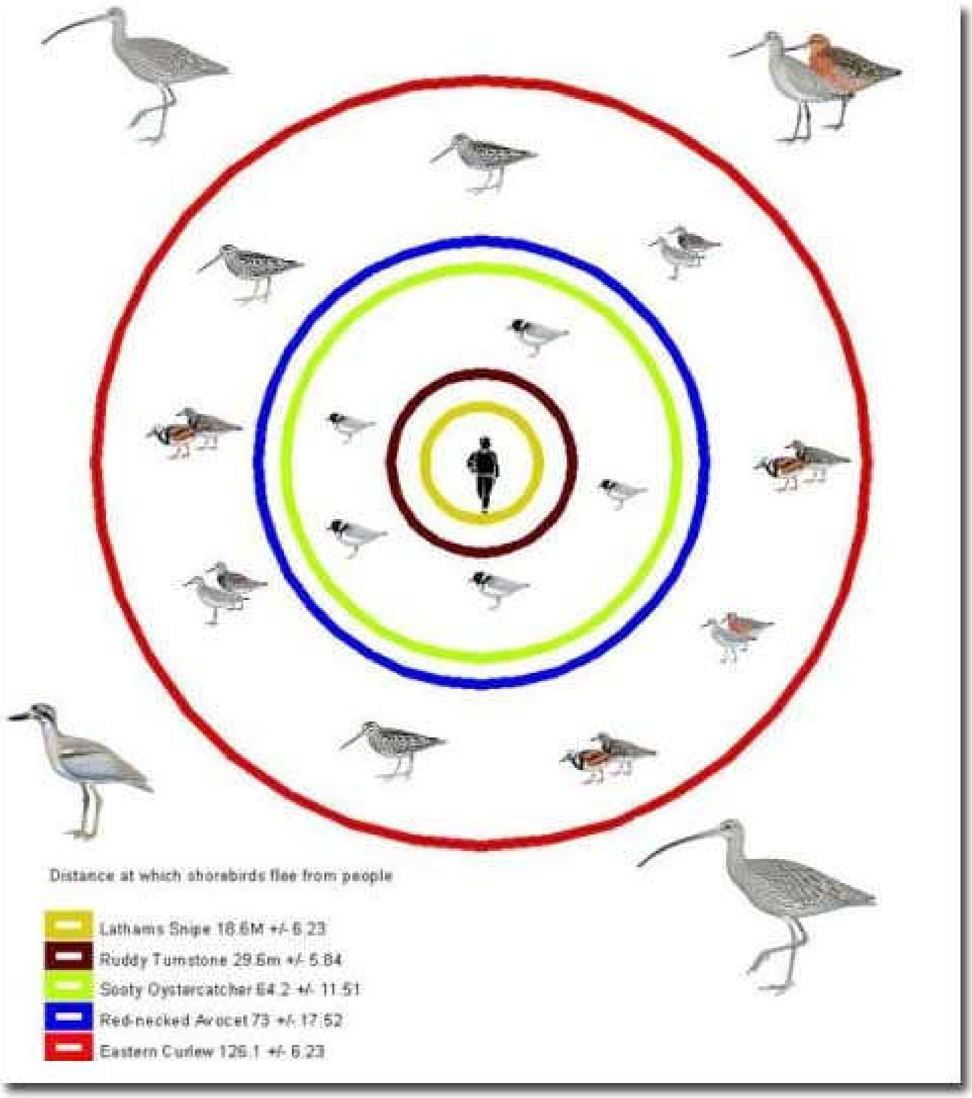


Figure 9. Each species of shorebird has its own tolerance to disturbance to human approaches. Distances given are from prelimanry data however further study may reveal larger buffers are required. Illustrations: Jeff Davies

A major complication in determining the impact of disturbance is the difficulty in determining the energetic cost of the wide variety of disturbances that may occur. Much work has been done to determine the distance at which different bird species fly off when confronted with different kinds of disturbance, and results vary from 50 metres to 250 metres, with Eastern Curlews more likely to fly off at greater distances (Figure 8); most birds respond at greater distances to unleashed dogs or noisy and fast watercraft (Paton *et al*. 2000; Blumstein 2003; Yasué 2005; Gill 2007; Glover 2009). Unfortunately, this intuitive measure of disturbance probably underestimates the true energetic impacts of disturbance.

The shorebird habitat in and around the populous and much-visited Samphire Coast has been identified as the habitat most effected by disturbance. The frequency of disturbance necessary to cause shorebirds to abandon an area is unclear. It is clear, however, that disturbance has energetic costs that could potentially reduce a shorebird's chances of survival or its ability to reproduce.

Pine Point on the western shores of the Gulf provides a good example. At this site, boats are continually launched by being towed by a tractor across shorebird feeding areas on the rocky reef and mudflat. The remaining edges of the tide line are patrolled by people catching crabs, many of whom are accompanied by dogs which constantly disturb feeding birds. Without historic counts for these areas it is difficult to gauge the effect of increased human activity on shorebirds over time, but a comparison with similar relatively undisturbed rocky reef/mudflat habitats at Black Point, 5 kilometres further south, shows a drastic difference. Although it receives limited disturbance, the small reef at Black Point is one of the most diverse sites in the Gulf, despite its remoteness.

i. Non-vehicular recreational activities

The most readily identified cause of disturbance to feeding and/or roosting shorebirds in Gulf St Vincent arises from non-vehicular recreational activities. These activities can be static (e.g. fishing, sunbaking, picnicking) or mobile (e.g. walking, jogging, walking dogs).

Static activities may not initiate flight but can cause habitat avoidance and increased surveillance behaviour among feeding and roosting shorebirds. Alternatively, mobile activities are of lower temporal impact but have greater likelihood of initiating flight. Of these activities, dog walking, especially of unleashed dogs, causes the greatest levels of disturbance (fig 9). This is due to the unpredictable behaviour and non-linear paths that dogs walk, as well as their obvious similarities to traditional shorebird predators. In a study of the Western Snowy Plover in North America, people with dogs were found to cause flushing of birds 100% of the time once they were within 50 metres, and 52% of the time when they were within 100 metres (Page *et al*. 1977).

Figure 10. An unleashed dog causing disturbance. Photo: Mike Weston

A steady increase in fishing is also contributing to high levels of disturbance as well as the destruction of habitat around the Gulf (Fitzpatrick and Bouchez 1998). The upper sections of Gulf St Vincent provide important breeding and nursery areas for a number of key marine species, including King George Whiting *Sillaginodes punctata* and Blue Swimmer Crab *Portunus pelagicus*, both of which are fished recreationally and commercially. In particular, crabbing seasons coincide with the arrival of thousands of migratory shorebirds in Gulf St Vincent. The Blue Swimmer Crab season begins in September and runs through summer as the crabs congregate in inshore areas to breed, peaking in February; they then disperse back into deeper water by April. Hundreds of crabbers may patrol the tide line, creating a constant disturbance for feeding and roosting birds. One popular crabbing technique, known as "dabbing", involves patrolling the tide line of shallow sandy beaches or mudflats. This overlap with shorebird habitat causes continual interaction and disturbance of feeding and roosting shorebirds. Fishermen may also compete directly with shorebirds when collecting benthic invertebrates to use as bait (Carpenter 2008).

ii. Boating

Boating traffic is a major source of disturbance to shorebirds, and it has been linked to long-term abandonment of roosts (Burton *et al*. 1996). Red Knots, which occur in great abundance in Gulf St Vincent, have been recorded avoiding roosts in areas where high boating activity occurs within 1 kilometre (Peters and Otis 2007). Apart from feeding and roosting sites situated on sandbars adjacent to boating channels (Section Banks, Middle Beach and Port Wakefield), most shorebird areas in the Gulf do not currently receive high levels of boating traffic, but if the level was to increase it would reduce the number of coastal sites available for roosting by some species.

iii. Off-road vehicles

Continuous stretches of sandy coastline allow access by recreational off-road vehicles (four-wheel drives and dirt bikes) to remote areas and unutilised fishing sites (Figure 4). This disturbs roosting and feeding shorebirds, and potentially causes resident shorebirds to abandon their nests. The use of off-road vehicles also has an impact on macrobenthic assemblages on sandy beaches (Schlacher *et al*. 2008).

The closure of the Port Gawler Off-road Vehicle Park in late 2006 resulted in an increase in the number of off-road vehicles using shorebird habitat. In particular, dirt-bike riders regularly gain access to protected areas by flattening fences, and they not only destroy habitat but also create disturbance at inland roosts. Recently, the Off-road Park was reopened, attracting considerable attention from the dirt-bike and four-wheel drive community: a facebook page run by the managers has attracted over 1,300 members. However, with a $40 entry price, limited opening hours (Saturday and Sunday), and no four-wheel drive facilities, there is still a large number of drivers using adjacent shorebird habitat in saltmarsh, most notably the Port Gawler intertidal foreshore. Off-road-vehicle drivers cause repeated disturbances, impacting on habitat quality and potentially causing accidental mortality to the two species of beach-nesting shorebirds that use the site. Research into the use of four-wheel drives in shorebird areas shows that only a small proportion (15%) of off-road drivers heed signs asking them to avoid these sensitive areas (McGrath 2006). This problem has escalated due to the increasing affordability and accessibility of off-road vehicles.

Other recreational activities, such as jet skis and para-surfing, at various sites in the Gulf all discourage shorebird feeding and roosting. These activities have caused multiple disturbances at many sites, including: Port Parham, Port Gawler, Light Beach and throughout the Samphire Coast, especially Thompsons Beach and the saltpan at Third Creek.

The evidence of increased disturbance can be more tangibly measured in resident beach-nesting shorebirds then on migratory shorebirds. Preventable sources of breeding failure or mortality arise from people, vehicles or dogs on the beach; all of these can disturb birds to the point that they are unable to incubate eggs or brood their chicks to maintain a suitable temperature or to ensure they are fed. Populations of Hooded Plovers (listed as Vulnerable under the National Parks and Wildlife Act 1972) breed on the beaches of the southern Fleurieu Peninsula, from Sellicks Beach to Port Willunga. They and the more-widespread Red-capped Plover and Masked Lapwing are threatened by human-induced breeding failure or mortality, and other pressures such as predation by foxes (Dowling and Weston 1999; Weston 2000).

Some form of disturbance occurs in most shorebird areas, but their effects are not fully understood, as birds may be able to find refuge in nearby habitat. Observations suggest that disturbance often occurs in many areas throughout Gulf St Vincent, forcing shorebirds to continually move and compounding the effect of each disturbance. This is likely to increase as coastal development expands. It is, therefore, important to set buffers to disturbance around these important shorebird areas now, before more areas become adversely affected.

(c) Introduced mammals

In natural ecosystems, there is a co-evolution between predator and prey species, with prey species evolving evasive or defensive behaviour in concert with evolving prey-capturing behaviour by predators. However, when exotic predators are introduced into the ecosystem, they often thrive in these environments, reaching high population densities. Because native species of prey have not evolved to cope with the strategies of these predators, their impacts can be severe (Maguire 2008).

Introduced animals pose a readily identifiable threat to shorebirds in Gulf St Vincent. Rats, dogs, foxes and cats have all been observed in shorebird habitat during the study period, and are likely to pose a threat to resident (beach-nesting and wetland-nesting) shorebirds in the Gulf. These exotic predators give rise to increased disturbance and surveillance behaviour among all shorebirds, and this is ultimately manifested in reduced feeding rates, increased energy expenditure and reduced breeding success.

i. Foxes

There is considerable variation in the impact of foxes on shorebirds. It is thought that even though urban development can encourage population densities of foxes that are three or more times greater than in rural areas (Coman *et al*. 1991; Marks and Short 1996), it is in relatively pristine areas that foxes become the dominant local threat to shorebirds, particularly beach-nesting birds. On the Victorian coast, for example, rates of nest failure of Hooded Plovers of between 17% and 27% were attributed to predation by foxes (Weston 2003; Maguire unuplished data). Elsewhere, in Western Australia, the contents of one fox's stomach contained the remains of 38 Red-capped Plovers (Geering *et al*. 2007).

ii. Dogs

Domestic dogs are not only a the greatest source of disturbance to shorebirds but they have also been recorded preying on both eggs and birds (Buick & Paton 1989). However, even when leashed, dogs are recognised as a greater cause of major disturbance to shorebirds than people (Figure 9).

(d) The impact of invasive plants on shorebird habitat

Coastal sand dunes and surrounding habitat are under threat from environmental weeds. This threat is recognised by local councils and control measures are in place. Marram Grass *Ammophila arenaria*, Sea Spurge *Euphorbia paralias*, African Boxthorn *Lycium ferrocissimum* and Tree Mallow *Lavatera arborea* are hardy opportunistic colonisers which threaten to choke shorebird habitat. Marram Grass was introduced from Europe in the 19th century to stabilise mobile sand dunes, and it has successfully colonised areas of open substrate throughout Gulf St Vincent, displacing indigenous vegetation. Chosen for its strong vertical growth and capacity to hold a large volume of sand, Marram Grass has changed the morphology of foredune systems from low, terraced dunes to higher dunes with steeper sides. Lower-terraced dunes are preferred by resident shorebirds such as Hooded Plovers and Red-capped Plovers, as are sparse native grasses which provide incubating birds with uninterrupted surveillance (Park 1994). Marram Grass is most common on beaches south of Outer Harbour, where it dominates, and has probably contributed to the decline of shorebirds in that area.

Sea Spurge, a native of the Mediterranean coasts, occurs on free-draining sandy beaches, around estuaries, on dunefields and in other associated coastal habitats (Wilcock 1997). It is widespread throughout the Gulf, especially north of Middle

Beach. Infestation by this plant may impact on beach-nesting birds such as terns, Hooded Plovers and Red-capped Plovers (Park 1994; Rudman 2003) and may result in steep dunes that are susceptible to wave erosion. Sea Spurge has received much attention on the southern beaches, and the Seacliff to Brighton Beach Sand Dune Restoration Project has targeted the aggressive spread of the weed with a routine of spraying and hand weeding.

African Boxthorn and Tree Mallow are woody weeds that occur on ridges and dunes. Although more confined to urban beaches, they threaten to proliferate along coasts throughout Gulf St Vincent and have already impacted areas surrounding Middle Beach, Thompsons Beach and Buckland Park Lake (Jensen 2004; Carpenter 2008). Infestations of these plants have blanketed bare sites favoured by nesting terns on Section Banks, and have caused significant problems in coastal habitats elsewhere, including the loss of valuable shorebird areas on Mud Islands in Victoria and West and Encounter Islands in South Australia (Veitch and Clout 2002; Carpenter 2008) and the displacement of nesting puffins in the northern hemisphere (McKie 2005). When mature, these plants also provide preferred nesting habitat for Silver Gulls *Chroicocephalus novaehollandiae* (Carpenter 2008) and cover for introduced predators such as foxes and feral cats.

(e) Encroachment onto habitat by native vegetation

Some native plants also pose a threat to shorebird habitat in Gulf St Vincent, with incursion by mangroves occurring in many coastal areas. Mangrove and saltmarsh habitats are seral — that is, their boundaries do not stay the same over time, but change to reflect factors such as changes in sea level and supply of sediment. In some parts of the Gulf, areas vegetated with Grey Mangrove *Avicennia marina* are expanding at an unprecedented rate (Saintilan and Williams 1999; Figure 10), and many young mangroves are sprouting among the saltmarsh plants. This is especially prevalent in Barker Inlet, where the saltmarsh is confined to an area between the mangroves and the seawalls, and has been gradually encroached upon since the 1940s so that now little remains.

There are many possible explanations for this trend of mangrove expansion. It has been suggested that the increased annual rainfall in the area since 1945 may have diluted salt levels within saltmarsh soils to the extent that mangrove colonisation was enhanced (Saintilan and Williams 1999). Increased nutrient levels and sedimentation from agriculture are also considered a possible cause of increased colonisation by mangroves (Hughes 2003; Straw and Saintilan 2006).

The expansion of mangroves can limit the availability of the open spaces that shorebirds use for roosting and feeding. Shorebirds prefer the security of open spaces with high visibility for the easy detection of approaching predators (Straw and Saintilan 2006). To illustrate shorebirds' preference for open areas, in a survey of 63 intertidal mudflats in nine estuaries in New South Wales, 90% of ground-roosting sites used by shorebirds were more than 10 metres from 2-

metre-tall trees and shrubs, and 83% were at least 30 metres from 5-metre-tall trees (Lawler 1996).

The expansion of the Grey Mangrove is viewed as unnatural in south-eastern Australia. Pressure is currently being exerted by residential, coastal development, planning and management authorities to remove and destroy mangroves, partly to protect and reinstate other impacted habitats such as saltmarsh and mudflats. Estuary management planning is a useful tool that can integrate and balance policy directions for mangroves and other estuarine habitats in a strategic manner. Options for management intervention, such as the controlled removal of mangrove seedlings and saplings from key shorebird feeding grounds, as well as the restoration and creation of mudflat and saltmarsh habitat, are currently being undertaken to conserve shorebird habitat in Hong Kong (Straw *et al*. 2006). Mangroves should not be considered as "bad" in isolation, but viewed as part of the mosaic of tidal habitats that are important for estuary function and health. In some areas of Gulf St Vincent, such as Dry Creek Salt fields, natural die-off of mangroves is exceeding expansion.

Figure 11. Satellite imagery reveals the extent of mangrove incursion in intertidal shorebird habitat at Port Gawler. Adapted from Google Earth imagery.

(f) Potential impacts of native birds

Locally nesting shorebirds are also under threat from expanding populations of opportunistic native birds. An increase in food resources, such as coastal rubbish tips and urban rubbish bins, may sustain artificially high populations of Little Ravens and Silver Gulls.

i. Ravens

Ravens, which are also attracted by fruiting events of coastal shrubs, have been identified as the major predator of the eggs of beach-nesting birds and, to a lesser extent, their chicks (Weston and Morrow 2000; Maguire 2008). In New South Wales, Victoria and Tasmania, ravens have been identified as predators of Hooded Plover and oystercatcher chicks, accounting for up to 11% of nest failures (Hanisch 1998; Weston 2000; Weston and Morrow 2000; Berry 2001; Keating and Jarman 2003; Maguire 2008).

ii. Gulls

Numbers of Silver Gulls have increased substantially throughout Australia (Blakers *et al*. 1984), and this has been mirrored in the Gulf over the last 50 years, reflecting the increased availability of food at rubbish tips (Carpenter 2008). Generally, beach-nesting birds are effective at defending their eggs and chicks against Silver Gulls (Weston 2000). However, Silver Gulls are able to approach nests more closely when the attending adults are disturbed and have moved away from the nest. This may suggest that gull predation is more likely to be a factor in highly disturbed areas (Weston 2000; Maguire 2008).

The negative impact that Silver Gulls have on nesting shorebirds has, in the past, prompted active gull control in Gulf St Vincent (Baxter 2003). Changes to the management of Wingfield Rubbish Tip since 2005 have reduced the amount of food available to gulls, which has resulted in a reduction of their numbers and restricted their breeding opportunities, but, nevertheless, they still occur in enormous numbers around the Gulf, and the Integrated Waste Services northern landfill site at Dublin provides an attraction near key shorebird areas.

(g) Human-induced mortality or breeding failure

The resident shorebirds that occur on several sandy beaches around Gulf St Vincent are under threat of accidental human-induced mortality or breeding failure. In these areas the threat is primarily due to well-camouflaged eggs or chicks that are accidentally stepped on or run over by vehicles. Eggs of Hooded Plovers and Red-capped Plovers are well camouflaged and are laid directly onto the sand, so they are especially susceptible to accidental crushing. Chicks are also relatively easy to overlook and trample.

Interestingly, vehicles are also a problem for breeding Red-capped Plovers at the Dry Creek and Price Saltfields. Access tracks running between the evaporation ponds in the Dry Creek Saltfields are favoured by Red-capped Plovers as nesting sites, and during car-based monitoring surveys in February 2009, only vigilant driving prevented many chicks from being run over. The narrow width of these roads means that chicks have few escape routes, and some were seen trying to outrun cars. Cheetham Salt's staff has been trained to be aware of wildlife on the tracks, and visiting birdwatchers have also been alerted to the threat.

(h) Pollution

i. Sewage outfall

Sewage outfall into marine habitats has been linked to various effects on native flora and fauna. Of particular note, sediments near nutrient-rich sewage discharge points are believed to support high densities of invertebrates and the species composition of these sites differs from those at sites further away (Poore and Kudenov 1978; Davies and Brown 1995; Rogers *et al*. 2007). As a consequence, this enhanced production may support large numbers of shorebirds and it has been noted that improvements in sewage treatment and disposal may lead to a decline in shorebird numbers (van Impe 1985; Bryant 1987, Raffaelli and Hawkins 1999).

Recent studies which took into account only shorebird prey have had varying results, with the number of certain species such as polycheates (common prey of species such as godwits and knot) showing a clear gradient extending out from the sewage outfall, whereas other species show reverse or no gradients at all (Rogers *et al*. 2007, Alves *et al*. 2011).

While moderate organic enrichment might be seen as having a beneficial effect on shorebird habitat, nutrient enrichment by sewage can also stimulate blooms of opportunistic benthic macroalgae, especially the green *Enteromorpha*, *Cladophora* and *Ulva* (Knox 1986; Rafaelli 1999; Mackenzie 2000). Such colonisation can be observed on intertidal mudflats surrounding the Bolivar sewage outlet in Gulf St Vincent. The increased nutrients and turbidity caused by the outlet has been linked to a die-off of seagrass communities (most notably *Amphibolis* and *Posidonia*) in a 19-kilometre stretch from St Kilda to Middle Beach (Coleman and Cook 2000; Fox *et al*. 2007; P Colman pers. comm.). The loss of seagrass equates to a loss of local biodiversity. An approximate 40-fold difference exists between biodiversity in seagrass and bare-sand communities (Fox *et al*. 2007). The absence of seagrass meadows and an increase in nutrients has seen this area of intertidal mudflats now colonised by mats of Sea Lettuce *Ulva lactuca*. Sea Lettuce is well-known nitrogen scavenger, and if dense algal mats are able to become established they can have catastrophic effects on the underlying invertebrate assemblages through deoxygenation of sediment (Rafaelli *et al*. 1999; Mackenzie 2000). Such a decline in benthic prey species would explain the surprising absence shorebirds feeding in the intertidal zone between Middle Beach and St Kilda (detailed in Section 5). The greatest rate of loss of seagrass occurred in the early 1970s, about 8 years after the maximum rate of population growth in the metropolitan region was recorded.

ii. Agricultural run-off

Run-off from the area's water catchments, waste water or storm-water outfalls that are contaminated with phosphorous, nitrogen or other nutrients or chemicals could have a great impact on shorebird feeding areas, and they have already been linked to a die-off in seagrass in the Gulf (Close 2008). In addition, in some areas, increased agricultural run-off with high nitrogen content has been shown to lead to an initial increase in the diversity of invertebrates in the mudflats used by foraging shorebirds, but excess nitrogen will lead to eutrophic conditions, which kills the food species (van de Kam *et al*. 2004).

The potential impacts of run-off from the proposed intake of toxic chemicals and heavy metals at Dublin's Integrated Waste Services northern landfill is a current matter of conjecture between the local council, residents and IWS. The installation of a high-temperature waste-disposal system would drastically reduce the risk of waste held on site leaching into the Gulf and surrounding areas. Thermal pollution, industrial run-off, effluent disposal, ballast water, heavy metals and other toxicants have all been identified as factors that are likely to impact on the Port River–Barker Inlet area, including valuable feeding areas such as Section Banks (Bryars 2003). Although the site is more than 4 kilometres from the coast, there is still potential for pollutants to leach into the waters of Gulf St Vincent in both the short and long term. The landfill site also borders stretches of saltmarsh, including areas potentially used as high-tide roosts by shorebirds.

iii. Munitions

The coastline encompassed by the Port Wakefield Proof and Experimental Establishment is exposed to a different suite of potential threats due to its use as a munitions testing ground. Surveys conducted by Sinclair Knight Merz in 2007 uncovered many expended artillery shells on the tidal mudflats and many impact sites where the subsurface material had been exposed. The potential impact of this munitions testing on shorebirds remains unclear, with critical factors being firing regimes and the chemical composition of the munitions.

iv. Oil Spill

The threat of pollution in the shorebird areas of Gulf St Vincent is focused around Port Adelaide. The boat traffic in the upper Gulf is relatively low, but should an oil spill occur, the effects could be catastrophic and have long-lasting effects on shorebird populations. Further, industrial development or increased capacity for more boats would increase the threat of a spill in these areas (Clemens *et al*. 2007a).

The Inter-governmental Agreement on the National Plan to Combat Pollution of the Sea by Oil and Other Noxious Substances (2002), includes the process for recovering clean-up costs from the polluter. The Government is committed to ensuring that all costs from oil spills, including environmental rehabilitation and monitoring, are met by those responsible. The South Australian Environment Protection (Sea Dumping) Act, which was passed by Parliament in 1984 to mirror Commonwealth legislation, has not been proclaimed. Therefore, the regulation of sea dumping in coastal waters currently rests with the Commonwealth. The Environment Protection Authority is currently reviewing the South Australian Act to align it, with subsequent modifications, to the Commonwealth's sea-dumping legislation. The Government will negotiate with the Commonwealth to bring 'coastal waters' within the control of the South Australian Government by demonstrating compliance with the London Protocol (NCHD 2004).

Article III. 2011 SHOREBIRD COUNT

Section 3.01 Count methods

In 2010, power analysis was undertaken to establish how long it would take to deliver high levels of statistical confidence in shorebird declines within Gulf St Vincent. The results indicated that if the present level of monitoring were to continue for 20 years, a statistically significant change would be likely to be detected only if the population had declined by more than 70%. To improve on this, Birds Australia recommended two or three simultaneous counts to be conducted each season in Gulf St Vincent. Following this recommendation, Birds SA organised three simultaneous counts for the summer of 2010–11. If sustained, this level of monitoring would increase the sensitivity of our trend analysis to a level where declines of 47%–64% would be detected within a 20 year period.

In addition to the annual mid-January count dates were organised for 4 December 2010 and 13 March 2011 (Table 1). These dates were chosen to identify temporal changes in habitats used by shorebirds. However, as a result of inclement weather and subsequent access issues, only a fraction of the count areas could be covered on the count dates. Notably, the second most significant shorebird sites in Gulf St Vincent, the Price Saltfields, was omitted from the counts altogether, with unseasonably heavy rain forcing Cheetham Salt to close the saltfields to public access due to hazardous track conditions. Dry Creek was omitted from the March counts for similar reasons. Other notable exceptions from count coverage in 2011 were the Clinton Conservation Park and the Section Banks, where over 3500 and 2200 shorebirds, respectively, were recorded as recently as 2009.

A **shorebird area** is the boundary around the total area used by the same group of shorebirds during the peak of the non-breeding season (November–March). Regular bird movement may be observed between habitats within a shorebird area, but birds seldom move in or out of the shorebird area during the peak of the non-breeding season.

A **count area** is a fixed boundary which defines the area within which a count of all shorebirds is made during any repeated monitoring survey. These areas are predefined and are based on identified roost or feeding habitats. There may be one or many count areas within a shorebird area. Count areas tend to be marked by boundaries of readily identifiable geographic features, and include areas easily surveyed by one counter in less than 4 hours.

Ten count areas could be covered in the November–December counts (Table 2), nine in the January counts (Table 3) and 13 in the March counts (Table 4), comprising 15 unique count areas. These areas were surveyed in the summer of 2010–11, and include the accessible shorebird habitats used by the greatest number of shorebirds that occur in the Gulf St Vincent ‘shorebird area’. During the peak of the non-breeding season, shorebirds tend to remain within a defined region, moving between proximate feeding and roosting sites in accordance with variations in habitat conditions, such as tide height. Shorebirds often return to these same areas within and between seasons (Peters and Otis 2007). Shorebirds were observed moving greater distances within Gulf St Vincent in 2010, but it has been suggested that there was little movement beyond the boundaries of the shorebird area as mapped in 2009, which extend north from Section Banks and around Gulf St Vincent to a point south of the Price Saltfields (Purnell *et al*. 2009). The site fidelity observed in most shorebirds suggests that any count conducted in Gulf St Vincent during the peak of the non-breeding season would encounter the same population of birds.

It is critical to conduct a coordinated survey within Gulf St Vincent so that multiple areas can be surveyed simultaneously. The greater-than-usual movements of shorebirds within this shorebird area in 2011 would almost certainly have resulted in high measurement error, as birds are likely to have been either missed or double-counted if counts had not been conducted simultaneously throughout the Gulf. Thus, ideally, simultaneous counts should be conducted across all count areas within the Gulf St Vincent shorebird area. Further, these counts should be conducted during the peak of the non-breeding period, in the same month as previous summer counts. In terms of national population monitoring, counts conducted outside the November–February window risk a measurement error at a national scale, with entire populations of shorebirds potentially being counted twice or not counted at all (Clemens *et al*. 2007b).

Section 3.02 2011 Count Results

Table 1. Summary of three simultaneous counts of the shorebirds in Gulf St Vincent, including threshold values of international and national significance.

	Significance		Population Counts					
Species	1% eaa*	0.1% eaa*	29 Nov-2008	28 Feb 2009	23-Jan 2010	4 Dec 2010	16 Jan 2011	13 Mar 2011
Banded Lapwing**	270		0	90	0	0	65	0
Banded Stilt**	2060		12062	3252	2228	110	2	0
Bar-tailed Godwit	3250	325	419	575	337	163	70	324
Black-fronted Dotterel**	170		25	0	1	0	0	4
Black-tailed Godwit	1600	160	0	0	0	0	0	0
Black-winged Stilt**	2660		310	99	408	7	47	0
Common Greenshank	600	60	154	703	367	241	36	19
Common Sandpiper	1000	100	1	4	27	0	1	0
Curlew Sandpiper	1800	180	228	535	259	126	3	58
Double-banded Plover	500	50	0	4	0	0	0	0
Eastern Curlew	380	38	9	36	29	12	0	1
Great Knot	3750	375	930	203	6	800	52	750
Greater Sand Plover	1100	110	2	8	10	8	0	2
Grey Plover	1250	125	164	291	122	46	47	25
Lesser Sand Plover	1400	140	7	8	0	0		
Long-toed Stint	250	25	0	0	1	0	0	0
Marsh Sandpiper	10000	1000	20	7	3	6	3	0
Masked Lapwing**	2870		94	148	124	23	41	15
Pacific Golden Plover	1000	100	5	2	1	1	0	0
Pectoral Sandpiper			1	0	0	0		
Pied Oystercatcher**	110		23	125	118	10	7	6
Red Knot	2200	220	1150	1637	1103	200	4	1615
Red-capped Plover**	950		608	4963	2026	80	119	19
Red-kneed Dotterel**	260		152	121	79	0	0	0
Red-necked Avocet**	1070		555	285	27	23	0	0
Red-necked Stint	3250	325	8391	11791	6749	2324	2927	1372
Ruddy Turnstone	350	35	57	91	70	41	7	23
Sharp-tailed Sandpiper	1600	160	1205	3224	3120	74	5	0
Sooty Oystercatcher**	40		0	160	61	0	0	3
Terek Sandpiper	600	60	0	2	1	1	0	0
Whimbrel	1000	100	6	26	4	3	0	0
Wood Sandpiper	10000	1000	2	2	8	0	0	9

* 1% eaa = International Significance (threshold of 1% of the estimated population in the East Asian–Australian Flyway); 0.1% eaa = National significance (threshold of 0.1% of the estimated population in the East Asian–Australian Flyway; Clemens *et al*. 2010).

** Resident shorebird.

Table 2. November–December counts

Start_time	11/11/2010	11/11/2010	11/11/2010	11/11/2010	3/12/2010	4/12/2010	5/12/2010	5/12/2010	5/12/2010	8/12/2010
Count_area	Barker Inlet Wetlands	Carrickalinga	Giles Point, Coobowie	Middle Beach	Port Clinton	Port Gawler seafront	Dry Creek Saltfields	Thompsons Beach North	Thompsons Beach South	Webb Beach
Banded Lapwing	0	0	0	0	0	0	0	0	0	0
Banded Stilt	0	0	0	0	0	0	110	0	0	0
Bar-tailed Godwit	0	0	0	0	0	0	18	125	0	20
Black-fronted Dotterel	0	0	0	0	0	0	0	0	0	0
Black-tailed Godwit	0	0	0	0	0	0	0	0	0	0
Black-winged Stilt	2	0	0	0	0	0	5	0	0	0
Common Greenshank	0	0	3	0	1	4	216	10	5	2
Common Redshank	0	0	0	0	0	0	0	0	0	0
Common Sandpiper	0	0	0	0	0	0	0	0	0	0
Curlew Sandpiper	0	0	1	0	0	4	116	5	0	0
Double-banded Plover	0	0	0	0	0	0	0	0	0	0
Eastern Curlew	0	0	0	0	0	6	6	0	0	0
Great Knot	0	0	0	0	0	0	0	0	800	0
Greater Sand Plover	0	0	0	0	0	0	0	8	0	0
Grey Plover	0	0	3	0	0	0	38	5	0	0
Long-toed Stint	0	0	0	0	0	0	0	0	0	0
Marsh Sandpiper	0	0	0	0	0	0	6	0	0	0
Masked Lapwing	2	6	2	3	0	0	8	2	0	0
Pacific Golden Plover	0	0	1	0	0	0	0	0	0	0
Pied Oystercatcher	0	0	2	2	3	1	0	0	0	2
Red Knot	0	0	0	0	0	0	0	0	200	0
Red-capped Plover	0	0	0	0	0	25	34	16	5	0
Red-kneed Dotterel	0	0	0	0	0	0	0	0	0	0
Red-necked Avocet	0	0	0	0	0	0	23	0	0	0
Red-necked Stint	0	0	25	0	0	260	1289	600	150	0
Ruddy Turnstone	0	0	16	0	0	0	0	25	0	0
Sharp-tailed Sandpiper	0	0	0	0	0	3	67	0	0	4
Sooty Oystercatcher	0	0	0	0	0	0	0	0	0	0
Terek Sandpiper	0	0	0	0	0	1	0	0	0	0
Whimbrel	0	0	0	0	0	2	1	0	0	0
Wood Sandpiper	0	0	0	0	0	0	0	0	0	0
	4	6	53	5	4	306	1937	796	1160	28

Table 3.January 2012 counts

Start_time	17/01/2011	15/01/2011	17/01/2011	12/01/2011	16/01/2011	15/01/2011	15/01/2011	15/01/2011
Count_area	**Bald Hill**	**Carrickalinga**	**Dry Creek Saltfields**	**Light Beach**	**Middle Beach**	**Port Parham**	**St Kilda**	**Webb Beach**
Banded Lapwing	0	0	0	65	0	0	0	0
Banded Stilt	0	0	2	0	0	0	0	0
Bar-tailed Godwit	57	0	0	0	0	0	0	13
Black-fronted Dotterel	0	0	0	0	0	0	0	0
Black-tailed Godwit	0	0	0	0	0	0	0	0
Black-winged Stilt	0	0	47	0	0	0	0	0
Common Greenshank	0	0	16	8	0	2	0	10
Common Redshank	0	0	0	0	0	0	0	0
Common Sandpiper	0	0	1	0	0	0	0	0
Curlew Sandpiper	0	0	3	0	0	0	0	0
Double-banded Plover	0	0	0	0	0	0	0	0
Eastern Curlew	0	0	0	0	0	0	0	0
Great Knot	25	0	0	0	0	0	0	27
Greater Sand Plover	0	0	0	0	0	0	0	0
Grey Plover	8	0	30	0	0	0	0	9
Long-toed Stint	0	0	0	0	0	0	0	0
Marsh Sandpiper	0	0	3	0	0	0	0	0
Masked Lapwing	0	4	25	2	2	0	0	8
Pacific Golden Plover	0	0	0	0	0	0	0	0
Pied Oystercatcher	2	0	2	2	1	0	0	0
Red Knot	0	0	0	0	0	0	0	4
Red-capped Plover	0	0	79	25	0	11	0	4
Red-kneed Dotterel	0	0	0	0	0	0	0	0
Red-necked Avocet	0	0	0	0	0	0	0	0
Red-necked Stint	254	0	1998	300	0	282	0	93
Ruddy Turnstone	2	0	0	0	0	0	0	5
Sharp-tailed Sandpiper	0	0	0	0	0	5	0	0
Sooty Oystercatcher	0	0	0	0	0	0	0	0
Terek Sandpiper	0	0	0	0	0	0	0	0
Whimbrel	0	0	0	0	0	0	0	0
Wood Sandpiper	0	0	0	0	0	0	0	0
	348	4	2206	402	3	300	0	173

Table 4. March 2012 counts

Start_time	6/03/2011	6/03/2011	12/03/2011	13/03/2011	13/03/2011	13/03/2011	13/03/2011	13/03/2011	14/03/2011	14/03/2011	14/03/2011	14/03/2011	14/03/2011
Count_area	**Bald Hill**	**Barker Inlet Wetlands**	**Carrickalinga**	**Giles Point, Coobowie**	**Magazine Road**	**Middle Beach**	**Port Arthur**	**Port Clinton**	**Port Prime**	**Thompsons Beach North**	**Thompsons Beach North**	**Thompsons Beach South**	**Webb Beach**
Banded Lapwing	0	0	0	0	0	0	0	0	0	0	0	0	0
Banded Stilt	0	0	0	0	0	0	0	0	0	0	0	0	0
Bar-tailed Godwit	10	0	0	0	0	0	0	0	14	0	50	250	0
Black-fronted Dotterel	0	0	0	0	4	0	0	0	0	0	0	0	0
Black-tailed Godwit		0	0	0	0	0	0	0	0	0	0	0	0
Black-winged Stilt	0	0	0	0	0	0	0	0	0	0	0	0	0
Common Greenshank	0	0	0	6	0	0	0	4	0	0	3	6	0
Common Redshank	0	0	0	0	0	0	0	0	0	0	0	0	0
Common Sandpiper	0	0	0	0	0	0	0	0	0	0	0	0	0
Curlew Sandpiper	0	0	0	50	0	0	0	0	0	0	0	8	0
Double-banded Plover	0	0	0	0	0	0	0	0	0	0	0	0	0
Eastern Curlew	1	0	0	0	0	0	0	0	0	0	0	0	0
Great Knot	0	0	0	0	0	0	0	0	750	0	0	0	0
Greater Sand Plover	2	0	0	0	0	0	0	0	0	0	0	0	0
Grey Plover	0	0	0	5	0	0	0	13	1	0	4	2	0
Long-toed Stint	0	0	0	0	0	0	0	0	0	0	0	0	0
Marsh Sandpiper	0	0	0	0	0	0	0	0	0	0	0	0	0
Masked Lapwing	0	0	2	4	0	2	3	0	0	0	0	2	2
Pacific Golden Plover	0	0	0	0	0	0	0	0	0	0	0	0	0
Pied Oystercatcher	0	0	0	2	0	0	0	4	0	0	0	0	0
Red Knot	0	0	0	0	0	0	0	0	0	0	135	1480	0
Red-capped Plover	0	0	0	0	0	0	0	1	0	15	0	1	2
Red-kneed Dotterel	0	0	0	0	0	0	0	0	0	0	0	0	0
Red-necked Avocet	0	0	0	0	0	0	0	0	0	0	0	0	0
Red-necked Stint	200	0	0	40	0	0	0	358	150	17	250	350	7
Ruddy Turnstone	10	0	0	12	0	0	0	1	0	0	0	0	0
Sharp-tailed Sandpiper	0	0	0	0	0	0	0	0	0	0	0	0	0
Sooty Oystercatcher	0	0	0	3	0	0	0	0	0	0	0	0	0
Terek Sandpiper	0	0	0	0	0	0	0	0	0	0	0	0	0
Whimbrel	0	0	0	0	0	0	0	0	0	0	0	0	0
Wood Sandpiper	0	0	0	0	9	0	0	0	0	0	0	0	0
	223	0	2	122	13	2	3	381	915	32	442	2099	11

Count results (continued)

This is the third year in which Birds SA and Birds Australia's Shorebirds 2020 Program have cooperated in the coordination of simultaneous counts of shorebirds in Gulf St Vincent. Simultaneous counts have been an important factor in reinvigorating the monitoring program across the region. They have brought the community together, and have enhanced the mentoring program for new or inexperienced shorebird surveyors. With the finalisation of the boundaries of count areas and an increase in the number of experienced counters, a rapid reduction in the variability of counts should be achieved.

A comparison of results from the four simultaneous counts conducted since 2008 provides an insight into the variation one might expect from repeated counts in Gulf St Vincent (Table 1). There are two possible sources of discrepancies: shorebirds' behavioural variation and count error.

A high variation in counts, such as that observed in resident species including Banded Stilts, Black-winged Stilts and Red-necked Avocets, suggests that these resident shorebirds may move in and out of the study area, which is inconsistent with the concept of a shorebird area in which birds remain over the peak summer months. This is perhaps not surprising considering the life history of each of these species. These resident shorebirds are generally associated with sudden, episodic increases in the availability of prey in coastal or inland wetlands. The use of flooded inland habitats by these shorebirds is often opportunistic, and sudden inland flooding sometimes results in rapid and dramatic breeding events involving many birds. For example, this was the situation in winter 2010, when 150,000 Banded Stilts descended on Lake Torrens to breed, with an estimated 200,000 chicks hatching. Many of these birds reportedly remained in nearby pastoral areas, where they bred again 7 months later when water generated from Tropical Cyclone Yasi once again inundated Lake Torrens. On this occasion an estimated 25,000 Banded Stilts were observed at the site. Similarly, migratory shorebirds such as the Sharp-tailed Sandpiper are thought to utilise episodic flood events which may save them a flight of over 150 kilometres further south to terminal non-breeding sites on Australia's southern coastline. This event was reflected in a 98% decline in Sharp-tailed Sandpipers observed in the Gulf between January 2010 and January 2011. Such events may account for some of the natural variation in counts which occurs over short time scales.

The second cause of variation in counts stems from incomplete or excessive count coverage. For example, the number of Pied and Sooty Oystercatchers recorded in 2008 and 2011 was low and probably did not capture the whole population. This possibly arose because Section Banks, where most oystercatchers are usually recorded in intervening years, was not surveyed in 2008 and 2011. Similarly, large numbers of Common Greenshanks, Red-capped Plovers, Sharp-tailed Sandpipers and Red-necked Stints were recorded in 2009; these numbers were inflated by a survey which was conducted at low-tide, while birds were feeding on the extensive mudflats of the Clinton Conservation Park, and may have resulted in double counts of birds that roosted at high tide in nearby count areas, such as Price Saltfields.

Variation in counts of small, common waders, such as Red-capped Plovers, Red-necked Stints and Sharp-tailed Sandpipers, may also be caused by difficulties in surveying areas of high shorebird abundance and diversity, such as Dry Creek Saltfields, where the sheer number of birds makes it difficult to count them. Due to the supratidal nature of such sites, birds may remain feeding throughout the day and often move throughout the saltponds to access different feeding and roosting areas. This sometimes results in either double counts or birds not being counted at all. To reduce this problem, counters work in teams, with the counting of a common species delegated to one person who is more able to keep track of movements and overall abundance. In addition, counters are encouraged to collect data which allows the completeness of a count to be assessed.

Alternatively, counts of regularly recorded and conspicuous species (such as Bar-tailed Godwits and Red Knots, which occur mainly on the northern beaches and Price Saltfields) show remarkable consistency in the total number observed in each complete survey of Gulf St Vincent. These results are encouraging as they demonstrate that with consistent coverage, sufficient counter experience and standardised methods, resulting data will have notably less variation than observed in previous shorebird surveys in Gulf St Vincent.

Birds SA and its volunteers should be commended for their excellent efforts in producing what are some of the most complete and consistent counts undertaken in Gulf St Vincent. If, however, Birds SA is keen to further reduce the variation between counts, which would enable researchers to detect population trends more quickly, a number of refinements could be made:

1. Conduct surveys at the same time of year each year. This assures that site conditions are similar each time and further increases the chances of counting the same group of birds.
2. Consider conducting three summer counts (see below).
3. Conduct surveys within a tighter time-frame, both within the week and within daily tide cycles, especially at proximate sites where there is a frequent exchange of birds. Tighter survey times would address the effects of daily movements between roosting and feeding sites and reduce the risk of counting birds twice or missing them altogether. This has not been accomplished yet, as there were insufficient counters with suitable experience available to cover each site simultaneously. Ideally, all count areas should be surveyed over the same four-hour high-tide period.
4. Provide volunteers with up-to-date maps marked with the boundaries of count areas to ensure that the areas being surveyed remain consistent.
5. Foster good count and identification techniques among counters through workshops and mentoring.

Article IV. WORKSHOPS

Section 4.01 Shorebird Training Workshops

In 2011, two shorebird workshops were conducted in the Greater Adelaide region to educate the local communities about shorebird conservation and identification, and to expand the pool of experienced counters in the Gulf St Vincent area.

Feedback from workshops held in previous years suggested that the volume and level of information presented on the day can be overwhelming to some participants. With this in mind, we aimed to split the material across two days: the first day focused on general shorebird ecology and threats, and the second on practical training, followed by a field trip.

The first workshop, conducted on 26 March in Hove, was attended by 21 participants and addressed the ecology of migratory waders and the threats they face globally, nationally and within Gulf St Vincent. For the first time, a section devoted to resident beach-nesting birds with a particular focus on the Hooded Plover was incorporated into the schedule. Although this venue was some distance from the key migratory shorebird areas which lie north of Adelaide, it was chosen as a middle-ground for potential and existing volunteers involved in beach-nesting bird monitoring on the Fleurieu Peninsula. The choice of location also aimed to engage a different audience to previous years.

The second workshop, conducted on 27 March at St Kilda Town Hall, was attended by 32 participants, 10 of whom had attended the previous day's session. Online survey feedback regarding the 2010 workshops indentified that the majority of "beginner" and "intermediate" shorebirders required more time spent on the identification section of the workshop. With this in mind, the majority of the afternoon session was dedicated to working through the diagnostic characteristics, behaviour and typical habitat choices of the 30 most common shorebird species observed in Gulf St Vincent. Presentation materials were also supplemented with shorebird identification sheets and a more in-depth identification tips document. This information was followed up by a field trip to Thompsons Beach, where participants were given hands-on experience in the use of optics and identifying and counting shorebirds.

The main goal of the workshops was to: (1) recruit counters to the shorebird monitoring program; and (2) train them as counters. Since the introduction of the program in 2008, recruitment has been successful, with approximately 80 counters becoming involved with shorebird monitoring in Gulf St Vincent in the summer of 2009–10. This represented a marked increase in counters over the 28 counters who participated the previous summer, and resulted in the most comprehensive survey coverage in Gulf St Vincent so far. However, as mentioned previously, volunteer participation fell off drastically in the 2010–11 counts. In addition to the climatic and access issues mentioned, insufficient volunteer follow up on a coordination level in the lead-up to the season was a likely contributor to the poor participation levels.

Future workshops will aim to coincide with periods of peak shorebird abundance within Gulf St Vincent to give participants a greater opportunity to be involved with simultaneous counts and maximise retention of active volunteers.

As the program grows we must insure that new counters receive appropriate training to equip them with the skills to conduct accurate surveys that can be replicated easily. This will continue to require providing counters with information on survey methodology as well as shorebird identification.

Training on wader identification has been developed with the knowledge that the superficial similarity between various species of shorebirds often causes frustration among potential surveyors and can lead to low rates of participation after initial contact. Identification tutorials, like the one given at St Kilda, are an effective introduction to general shorebird identification for beginners.

Elsewhere in Australia, shorebird mentor groups have successfully trained inexperienced observers in shorebird identification through planned field trips. This type of event is often advertised on forums and websites, such as **www.shorebirds.org.au** and **www.birding-aus.com.au**; locally, Birds SA advertises regular recreational field trips to shorebird sites around Gulf St Vincent at **www.birdpedia.com**. A more established program of dedicated shorebird identification field trips would be an effective means of following up on workshop attendees who indicate an interest. This type of effort would increase the retention of active counters and help further standardise data collection.

Section 4.02 Shorebird Management Workshop

A shorebird management workshop was conducted at the Watershed Function Centre, Mawson Lakes. A diverse range of stakeholders was invited. The event aimed to follow up on the 2010 workshop by providing a more focused look at what can be done to conserve priority shorebird sites. Having previously identified these areas with stakeholders, presentations and discussions further explored how development scenarios would be likely to impact on the 27,000 migratory and resident shorebirds which frequent the region, and investigated contingency planning for shorebird habitats. Given the range of potential developments, such as road or rail infrastructure projects, may have implications for the area, talks revolved mainly around Cheetham's Dry Creek Saltfields.

The workshop briefly showcased basic shorebird ecology, population monitoring and habitat mapping, and highlighted some of the threats that appear to be leading to widespread population declines in many species, both locally and internationally. Tony Flaherty from the Adelaide and Mount Lofty Ranges NRM provided a review of obligations, aims and on-ground actions being undertaken by the NRM as proponents to migratory shorebirds under the EPBC Act. Erik Lock from Primary Industries and Resources South Australia (PIRSA) provided a background on the guidelines that mining companies must adhere to in preparation of a Program for Environmental Protection and Rehabilitation (PEPR). Unfortunately, Cheetham Salt was not available to comment and discuss the production of the Dry Creek PEPR, but has agreed to do so in a less public arena, given that the requirement for consultation is the responsibility of the proponent to facilitate. Doug Robinson from Trust for Nature provided an insight about how TFN and other NGOs can facilitate opportunities for sympathetic management for shorebirds on freehold lands.

The workshop and discussions clarified several points:

- The management of the Dry Creek Saltfields is currently beneficial for shorebirds and salt production, but continued sympathetic management of those habitats will be required to conserve the large numbers of shorebirds that currently occur in the Dry Creek area. If changes to the existing management of the Saltfields are implemented, steps must be taken to ensure the area is managed with methods that will maintain the shorebird populations that use the area.
- PIRSA's guidelines for preparation of a Program for Environmental Protection and Rehabilitation outlines that operations should focus on outcomes and associated measurement criteria. Stakeholder input is critical to setting these outcomes (including closure) and the process should be transparent throughout. The most cost-effective method can be chosen as long as the outcome is achieved.
- When planning for decommission, the managers are obliged to include considerations that:
  a) Restore the area to a level equal to or above its original pre-lease conditions.
  b) Take into account affects on "receptors"
- To sustain conditions at the Dry Creek Saltfields on the current scale would not be economically viable from known funding.
- The majority of the identified habitat characteristics which are conducive to shorebird populations in the current operation can be recreated.
- Options to restore salinas to intertidal saltmarsh would significantly reduce the value of habitat for shorebird species (see Discussion, Article VIII)
- A consolidation of the current salinas onto a smaller scale is the most viable option. In this situation, priority areas (outlined in Appendix 1 map 1,2 and 3 and Purnell *et al*. 2010) can largely be conserved, but vast areas of functionally undesirable deep water could be subdivided into a small-scale system of evaporative salinas to compensate for losses of habitat elsewhere. This would aim to provide a similar diversity of salinity and invertebrate fauna as is available on the current scale of operation. This system should also aim to be gravity fed to minimise running and maintenance costs.
- High concentrations of CO_2 and soils potentially contaminated with acid sulphate caused by accumulation of sludge on the floors of the salinas will dictate the future management of some areas of the saltfields if decommissioned. This will put limitations on zoning changes, notably exempting land from potential residential zoning and the associated threats

of habitat loss and increased disturbance. In other areas, especially in hypersaline ponds south of St Kilda where accumulation has reached critical levels, CO_2 and sulphidic sludge will require neutralisation processes if salinas are to be drained and returned to intertidal land. This is a complex, expensive and time-consuming process. While the effects of hydrogen sulphide (in water or air) on birdlife is unknown (Coleman & Cook 2003), ecotoxicology studies confirm that hydrogen sulphide is toxic to many benthic macroinvertebrates (Bright 2002).

- The urgency of planning for alterations to the operations of the saltfield has been reduced with news that the Northern Expressway (originally planned to bisect the southern salinas) has been redirected.
- Finally, the workshop highlighted that, in the longer term, increasing disturbance to shorebirds could limit the numbers using any habitat. This threat will continue to grow with the expanding human population of Adelaide, and without sufficient planning and management it will severely limit the number of shorebirds able to use the habitats in the Greater Adelaide region. Interestingly, no single proposed action appears likely to result in excessive disturbance or other impacts to shorebirds, but the cumulative effects of many projects in conjunction with growing human population could lead to large declines in shorebird populations in Gulf St Vincent.

In the short term, making shorebird conservation resources and maps of shorebird distribution widely available should improve planning for shorebirds. In the longer term, it makes sense to advocate for a strategic assessment under the EPBC Act, something which would also take into consideration all matters that fall under EPBC Act. Without strategic cross-jurisdictional planning and policy across this broad and diverse region it is unlikely that shorebirds will continue to be supported in the same numbers.

This year's management and stakeholder workshop was successful at presenting the information surrounding shorebird conservation in the Adelaide region, with a particular focus on the Dry Creek Saltfields. In the coming year we would like to better engage Cheetham Salt over the preparation of the Dry Creek PEPR and provide advice on best-practice management for shorebirds.

Article V. HABITAT MAPPING

Section 5.01 Overview of methods and results

Subsequent to fine-scale mapping of the Dry Creek Saltfields, objectives in the 2011 mapping work focused on identifying alternative supratidal feeding and roosting sites in the eastern Gulf St Vincent. Mapping also sought to identify low-tide roosting and feeding sites on the seaward side of mangroves. These habitats were identified by Purnell *et al*. (2009, 2010) as being gaps in our knowledge of shorebird distribution and abundance in the region.

The following new areas were mapped in 2011: Buckland Park Lake, Thompsons Beach claypan Webb Beach claypan, intertidal zones between St Kilda and Middle Beach, intertidal zones between Port Wakefield and Clinton Conservation Park.

Satellite imagery on Google Earth combined with with GIS overlays of existing habitat mapping were used as references in the field. Shorebird habitats identified in the field were sufficiently recognisable from the satellite images, and it was possible to draw boundaries of feeding areas and roost sites directly onto the map. However, in nondescript, uniform habitats, such as sandy beaches (where the boundaries of roost sites were unclear), GPS points that bounded the area were collected.

Boundaries of count areas were digitised on screen-displayed digital ortho-photos in ArcMap 9.1, based on the hand-drawn boundaries on the field set of photos. The accuracy of these photos was confirmed by the comparison of GPS ground-control points with physical features. Shorebird feeding areas that had been determined in previous years were based mainly on a report which plotted polygons over shorebird areas (Close 2008). These were adjusted with reference to features visible on high-resolution digital ortho-photos, such as beds of seagrass, which provide a good indication of the boundaries of intertidal feeding areas. Due to the variable nature of some features in coastal environments, some of the polygons may not reflect the actual boundaries of shifting habitat features. For each polygon, a variety of attributes were added, such as latitude, longitude, positional accuracy of the polygon, the average and maximum count of each shorebird species recorded in the area and threat scores. A complete list of attributes, and further technical details of the GIS layers provided is available in the metadata which is separate to this report.

Mapping of roost sites and feeding sites was based on field observations, but some suspected feeding areas were also mapped by using local knowledge and habitat maps (Coleman and Cook 2009). In this, the third year of mapping, the only areas that remain subject to such assumptions are:

- **Suspected inland, tidal and supratidal feeding and roosting habitats from Light Beach to Port Prime**: These areas of saltmarsh and supratidal saltpans are important roosting and feeding sites that are utilised during spring tides, when lower-lying habitats are inundated. However, in comparison with those found in the Dry Creek Saltfields and Thompsons Beach claypan, they are likely to support only highly dispersed numbers of common species.
- **Coastal sections of the Proof and Experimental Establishment**: This region is contiguous with the extensive shorebird habitat that occurs throughout the northern beaches. Saltmarshes are bordered by sandy beaches and intertidal mudflats which support rich beds of bivalves (B. Anderson pers. comm.). These could provide a refuge for populations of declining intertidal specialists, such as Eastern Curlews, Red Knots and Bar-tailed Godwits, all of which have been observed at the northern and southern boundaries of the area.

Mapping of these areas will be completed 2012.

The distribution of shorebirds at all other sites has been comprehensively mapped, and the refinement of habitat boundaries has allowed new count areas to be defined accurately. Each count area has also been assigned a score rating of the threats it faces.

(a) Threat mapping

In Gulf St Vincent, potential threats fall into five categories:

1. Human-induced habitat loss or degradation
2. Human disturbance
3. Invasive species
4. Pollution
5. Human-induced mortality or breeding failure

These threats were scored by counters using a technique developed by the Western Hemisphere Shorebird Reserve Network. The maximum threat score from the five categories was reported, along with the sum of the five threat scores for each area (Table 5). While this technique is subjective and results varied between counters, it allows comparisons between potential threats (Clemens *et al*. 2007a). In Gulf St Vincent the greatest risks to shorebirds that observers have identified are habitat loss and disturbance. The relative scale of habitat loss or disturbance in different regions along the east coast of Gulf St Vincent have been mapped (Figures 11, 12), and reported. This mapping indicates that observers feel that the Dry Creek region is the area most threatened by habitat loss, while the northern beaches are most threatened by disturbance.

Table 5. Description of threats to shorebird areas and how threats were scored

Types of Threats Identified and their Scores:

Human-induced habitat loss and degradation
Human-induced disturbance
Invasive species/habitat loss or degradation due to natural causes (vegetation encroachment)
Pollution (oil spills, runoff, or anything that changes soil texture, elevation, acidity, toxicity, turbidity etc.)
Accidental mortality (not including oil spills; primarily refers to direct or indirect mortality during breeding for species, such as crushing of nests by vehicles, people etc.)

Scoring:

Timing of each threat type:	Timing Threat Score
Happening now	3
Likely in the short term (<3 years)	2
Likely in the long term (>3 years)	1
May have happened in the past but not likely again	0
Scope of each threat type:	Scope Threat Score
Entire area/population (>90%)	3
Most of area/population (50–90%)	2
Some of area (10–49%)	1
Small area	0
Unknown	1
Severity of each threat type:	Severity Threat Score
Severe/very rapid deterioration (>30% over 10 years)	3

Rapid to moderate deterioration (10–30% over 10 years)	2
Slow but significant deterioration (1–10% over 10 years) or large fluctuations	1
No or imperceptible deterioration (<1% over 10 years)	0
Unknown	1

Overall impact of threat:

Add threat scores for timing, scope and severity to get an overall score of the impact of each kind of threat

Impact score for each threat: 8–9 = high, 6–7 = medium, 2–5 = low, 0–1 = negligible

Then maximum threat score was reported

and the sum of threat scores was reported across five threats (max = 45)

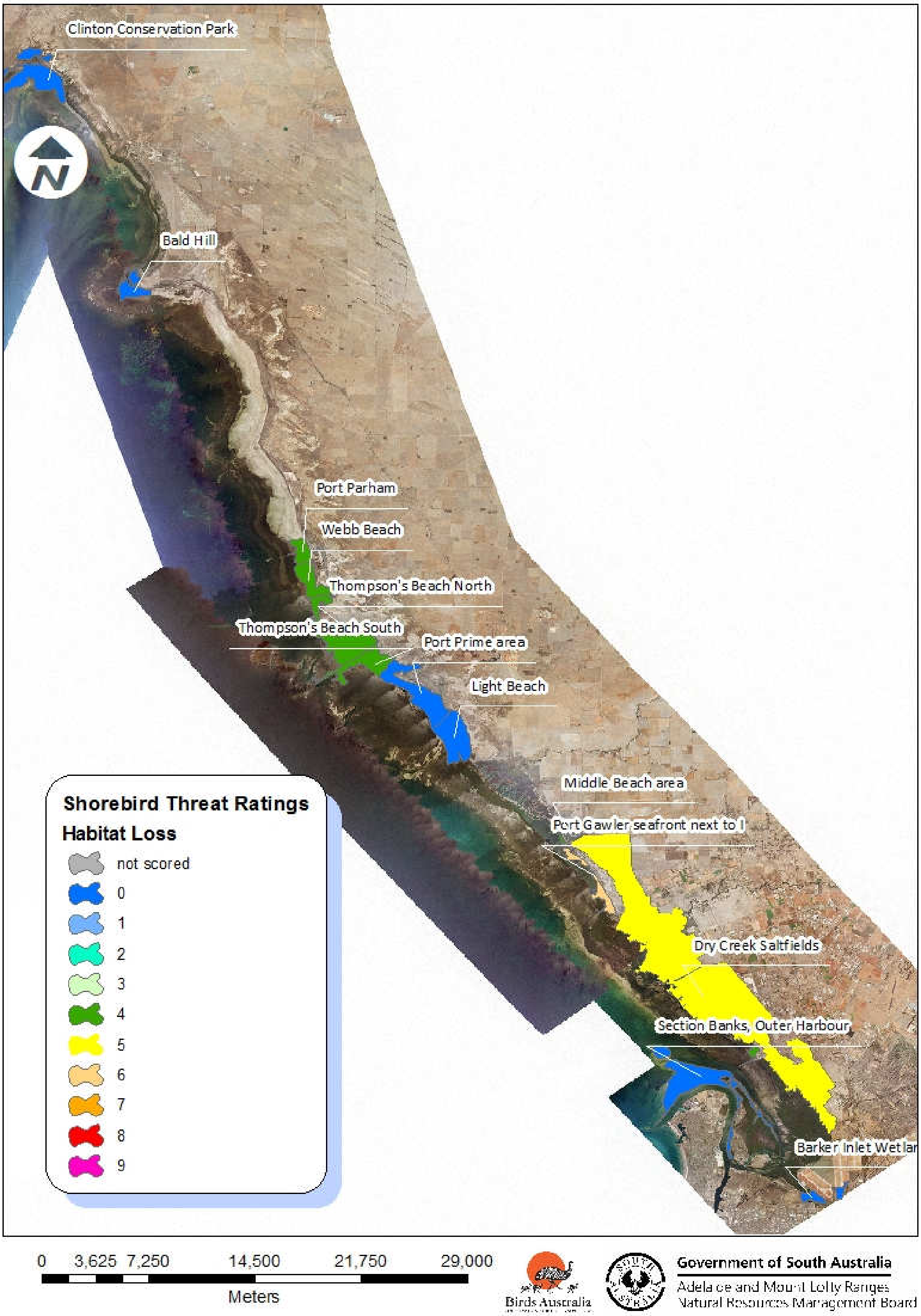


Figure 11. Shorebird habitat threatened by habitat loss.

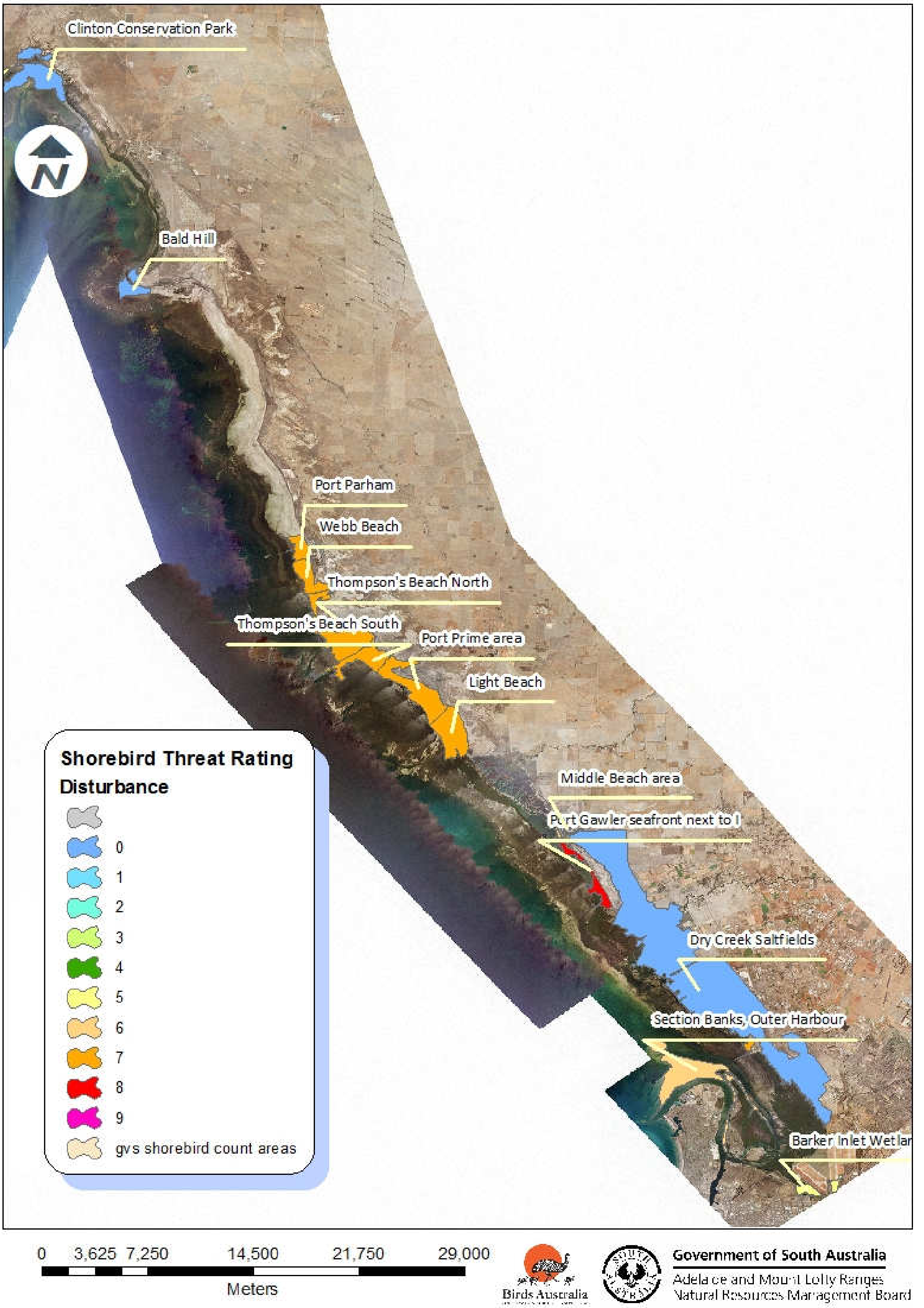


Figure 12. Shorebird habitat threatened by disturbance.

(b) Accuracy of mapping and attributes

The supply of digital ortho-photos enabled relatively easy and accurate mapping. The extent of shorebird habitats was drawn directly onto printouts of digital ortho-photos from Google Earth with the assistance of GPS coordinates where obvious geological landmarks were absent. Digital ortho-photos were found to be spatially accurate after comparisons with GPS field points. GPS readings fluctuated by only up to 10 metres in the field, but some features such as sandbars or the edge of mudflats may shift over time by over 100 metres. In a few remaining areas, the actual edge of the mapped shorebird habitat was uncertain, and boundaries were poorly defined. In these areas the discrepancy between our boundary and the boundary the birds used may be as off by as much as 50 metres. Despite this variation in spatial accuracy of digitised static boundaries, all spatial boundaries are believed to include the core of the important habitat, and an estimate of spatial accuracy which generally applies only to the boundary edges is reported in the attribute table.

For planners and managers requiring greater spatial resolution, some generalisations may assist in future interpretation of important shorebird areas. In general, roosting areas near the mouths of tidal creeks will continue to shift to wherever exposed sand remains at high tide. Further, they will be lost or diminished in importance as vegetation encroaches on roosting areas. Lastly, boundaries of feeding areas will change depending on where the channels shift to and as the distribution of benthic organisms shift.

The number of shorebirds reported in attribute tables also varies in accuracy depending on the number of times each area was surveyed, and how recently it was surveyed. Generally, however, the overall maximum and average numbers of shorebirds reported in the GIS attributes are relatively accurate. However, historically, shorebirds have been known to move significantly throughout Gulf St Vincent, so again the abundance figures may not be representative in areas where only a few surveys have been completed.

The surveys conducted in 2008–11 represent the most comprehensive counts of shorebirds in Gulf St Vincent. Therefore, the data presented in the GIS attribute tables represent the best available current information on the distribution and abundance of shorebirds in Gulf St Vincent.

(c) Detailed accounts of the habitats in the Greater Adelaide region

The following detailed accounts act as a supplement to those featured in the 2010 report (Purnell *et al*. 2010) and are largely based on the fieldwork completed in the 2011 season. Unlike habitats described in previous accounts, the areas featured in this section were not established count areas and therefore had no associated count data. The lack of knowledge pertaining to shorebirds in these habitats is largely due to their inaccessibility. For this reason the following accounts can only characterise sites by their condition at the time survey in January 2011.

Accounts include:

- Detailed descriptions of the habitat in each area; a description of shorebird use of the area.
- The relative importance of the area for shorebirds.
- Threats to the habitat or shorebirds found in the area.
- An overview of shorebird abundance, diversity, and noteworthy species.

Vagrant species and transient species, such as Red Knot and Black-tailed Godwit, which are thought to pass through Gulf St Vincent in the greatest numbers on migration during spring and autumn, may not be fully represented in these descriptions.

These accounts of discrete habitats are broken up into four areas within the Greater Adelaide region:

- Buckland Park Lake
- St Kilda to Middle Beach intertidal zone
- Thompsons Beach to Port Parham supratidal zone
- Port Wakefield to Clinton Conservation Park intertidal zone.

i. Buckland Park Lake (Appendix, Map 5)

Buckland Park Lake is situated to the west of salina XE7, and was established by ICI in the 1920s to prevent floodwaters from the Gawler River spilling into the saltwater evaporation ponds. Shorebird populations in and around the lake depend both on its level and the timing of its inundation (Figure 13). Due to reduced environmental flows and accumulated sediment (among other factors), the lake has changed from being a permanent wetland to being ephemeral (P. Coleman and R. Attwood pers. comm.). The heavy rains of late 2010 and early 2011 filled the lake, resulting in a freshwater wetland covering over $2km^2$.

Figure 12. Aerial imagery of Buckland Park Lake in varying levels of inundation. Image adapted from Google Earth imagery.

Shorebird Prey Species: Crustaceans, insects, spiders, water mites and worms.
Shorebird abundance: <150
Diversity: Seven species recorded during this study, 20 species historically.
Noteworthy species: Red-kneed Dotterels, Black-fronted Dotterels, Greenshanks, Marsh Sandpipers, Black-tailed Godwits, Wood Sandpipers, Common Sandpipers and Pectoral Sandpipers (all locally uncommon) have all been recorded here, as have Broad–billed Sandpipers and Long-toed Stints (both rare species), and four vagrant species (Cox's Sandpiper, Baird's Sandpiper, Ruff and Little Ringed Plover). The cryptic and enigmatic resident shorebird, the Australian Painted Snipe, has also been recorded at this site.

Description: Buckland Park Lake is an ephemeral wetland which is inundated only when the Gawler River is flooded. It was formerly a permanent wetland.

Use: The lake occasionally fills during winter, and by late spring the effects of evaporation and seepage sometimes cause the water level to recede to an attractive depth for shorebirds. Under these conditions, muddy edges suitable for shorebird foraging are revealed, coinciding with an increase in invertebrate abundance and accessibility, just as migratory shorebirds arrive. At the time of the 2011 surveys, the region had received higher-than-average summer rains on the back of a wet winter. This resulted in complete inundation of the lake. The shallow, freshwater environment created is the preferred feeding habitat for eight locally uncommon species of shorebirds.

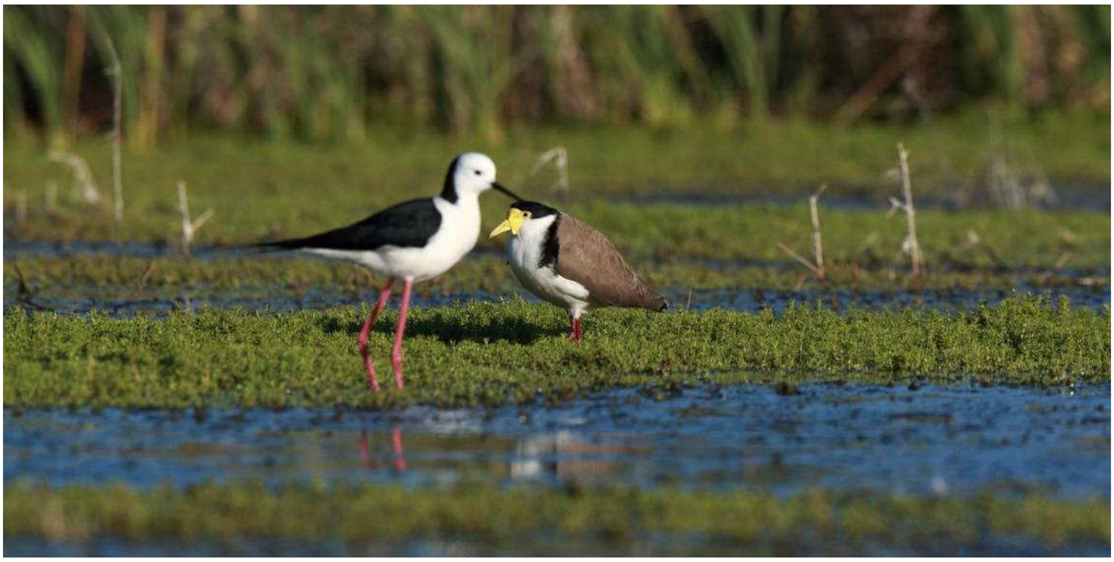


Figure 13. Black-winged Stilts and Masked Lapwings both breed at Buckland Park Lake. Photo Glenn Ehmke

Relative importance: Flocks of Black-tailed Godwits (a species that is declining rapidly throughout the East Asian–Australasian Flyway) stage in this area on arrival and departure on their annual migration. Although it is unclear where these flocks spend most of the non-breeding season, the lack of water in recent extended drought has meant that the species was seldom recorded in the region; there has been a single record in the past 4 years. Red-kneed Dotterels, Black-fronted Dotterels, Red-capped Plovers, Masked Lapwings and Black-winged Stilts all breed in the lake. The shallow complex shorelines and surrounding low vegetation of the lake have supported the endemic Australian Painted Snipe, as well as some vagrant species.

Threats: If left unmanaged, due to the natural hydrology of the area Buckland Park Lake will seldom experience inundation.

Figure 14. Waterbird, tern and shorebird roost atBuckland Park Lake, 201,1 as viewed from the south bank. Photo Chris Purnell

ii. Intertidal zone between Middle Beach and St Kilda (Appendix, Map 5)

This intertidal area directly east of the Dry Creek Saltfields has not been surveyed or mapped previously due to its inaccessibility from both land and sea. The dense mangrove forests, 1.5km wide in places, extend north from Barker Inlet and taper off at Light Beach, creating a barrier to access by land. Similarly, the shallow waters of this section of intertidal zone limit access by boat. For these reasons, surveys were completed by kayak in 2011.

Shorebird Prey Species: Unknown
Shorebird abundance: <400
Diversity: Six species recorded during this study, no historical data.
Noteworthy species: Eastern Curlew
Description: The intertidal flats traditionally supported meadows of *Zostera* seagrasses, interspersed with smaller amounts of green algae (*Ulva* and *Enteromorpha*). The calm waters, fine sediment and dense seagrass growth associated with these beaches would normally provide excellent habitat for invertebrates and small fish, but increased turbidity caused by the Bolivar Waste Water Treatment Plant outlet has caused a rapid die-off of seagrass meadows and encouraged the formation of large algal mats of Sea Lettuce (Coleman and Cook 2003; Fox *et al*. 2007).

Figure 15. The sand spit on the seaward side of the mangroves adjacent to pond XB 8. Photo Chris Purnell

These extensive mats are interrupted by sand spits which have formed in and along the edges of two tidal creeks within the region (Figure 15). These sand spits are located on the seaward side of the mouth of Salt Creek (Middle Beach) and on the seaward side of the mangroves adjacent to salina XB 8 (4 kilometres north of St Kilda and 3 kilometres from Section Banks).

Use: Although this site has never been mapped, mapping of similar areas of intertidal seagrass meadows throughout southern Australia (e.g. Clemens 2007; Herrod 2010; Maurer 2010; Herrod 2010,) led to the assumption that the shallows of the seagrass beds were utilised by shorebirds for low-tide feeding, but this was not the case in the 2011 surveys of this region. Although the intertidal zone supplied feeding habitat for wading waterbirds, shorebird feeding and roosting was strictly confined to the sand spits. These areas are functionally identical to the nearby sand spits of Section Banks.

Relative importance: The presence of intertidal habitats near the Dry Creek Saltfields provides alternate feeding areas for shorebirds using the Saltfields' supratidal salinas. This is particularly important for small waders and may become increasingly important if habitat within the Saltfields becomes compromised by either the loss of habitat or increased disturbance (e.g. earthworks).
Threats: *Habitat Loss* Sea-level rise and consequent deepening of areas that currently provide low-tide habitat is likely to be the greatest long-term impact caused by climate as these areas are rendered functionally useless to shorebirds.
Pollution Sewage outfall has been linked to the die-off of seagrass meadows and colonisation of nitrogen scavenging algae Sea Lettuce. This has had a drastic impact on benthic invertebrate communities and consequently use by shorebirds (see Section 2.07.)
Disturbance Boats coming to and from Middle Beach cause only minor disturbance to birds roosting on the Salt Creek sand spit.

iii. Port Wakefield sand spit (Appendix, Map 6)

This area has not been surveyed or mapped previously due to its inaccessibility from land. The dense mangrove forests, 1.5 kilometres wide in places, extend north from Bald Hill (Sandy Point) and taper off towards the head of the Gulf, where they give way to extensive tidal mudflats adjoining Clinton Conservation Park. Observations made from the northern banks of Bald Hill and the southern tidal flats of Clinton Conservation Park concluded that the areas on the seaward side of these forests are too deep to provide habitat for shorebirds, but aerial imagery identified a sand spit on the southern edges of the Port Wakefield boating channel which could provide habitat.

Shorebird Prey Species: Gastropods, crustaceans, insects, worms, bivalves, bryozoans, cnidarians, echinoderms and fish.
Shorebird abundance: <400
Diversity: Two species recorded during this study, no historical data.
Noteworthy species: None.

Description: At low tide the sand spit is only approximately 200m^2 and is unvegetated.

Use: Two species of shorebirds were observed roosting beside flocks of terns, gulls and cormorants. As the tide rose, the birds flew south, probably to roost or continue feeding at Bald Hill.

Relative importance: Within a short flight from the vast feeding areas of the Clinton Conservation Park intertidal mudflats (7.3 kilometres to the north) and Bald Hill (7.4 kilometres to the south), the sand spit at Port Wakefield provides a secure low-tide roost that is isolated from disturbance and risk of predation from terrestrial predators.

Threats: *Habitat Loss* Sea-level rise and consequent deepening of areas that currently provide low-tide habitat is likely to have the greatest long-term impact caused by climate change as these areas are rendered functionally useless to shorebirds.

Disturbance Boats coming to and from Middle Beach cause only minor disturbance to birds roosting on the Port Wakefield sand spit.

iv. Saltpans between Thompsons Beach and Port Parham (Appendix, Map 4)

Vast areas of hind-marsh are dominated by saltpans to the east and north-east of the coastal towns of Thompsons Beach, Webb Beach and Port Parham.

Shorebird Prey Species: Crustaceans and insects.

Shorebird abundance: >700

Diversity: Nine species recorded during this study, no historical data.

Noteworthy species: Red-capped Plover nesting site, Red-necked Avocet and Banded Stilt flocking site.

Figure 16. Red-necked Stints and Red-capped Plovers feed on an inundated saltpans south of Bakers Creek. Photo Chris Purnell

Description These continuous saltpans are the dominant landform north of Middle Beach and vary in condition depending on their connectivity to tidal creeks, relative distance from the coast, weather and tidal action.

Use: Shorebird habitat use throughout this area depends on the condition of the saltpans. The most fertile feeding habitat utilised by shorebirds are the areas inundated by Third Creek and those south of Bakers Creek (Figure 16).

1) In the saltpans at Third Creek, shorebirds feed on the edge of the incoming tides and across the cyanobacterial mats formed in areas affected by natural evaporative pumping. These areas are also commonly used by roosting shorebirds and waterbirds during high tides and one species (the Red-capped Plover) has been recorded nesting (Figure 17).
2) The saltpans immediately to the south of Bakers Creek are also inundated at varying times by evaporative pumping and tidal creeks (Figure 16). These areas provide feeding and roosting habitat for two small wader species. The Red-capped Plover has been recorded nesting in the area.
3) Areas further from the coast/tidal creeks are inundated only by the
4) highest tides, or they may hold water temporarily after rain events, but remain dry for most of the year. Nevertheless, these barren, harsh landscapes, such as those found to the east of Thompsons Beach, support shorebirds, though they occur in smaller numbers than elsewhere in the Gulf. Two species were recorded in the area. One species, the Red-capped Plover, nests in the area (Figure 17.

Relative importance: Located within a short flight from productive feeding habitats of the intertidal zone, the Samphire Coast's saltpans provide crucial high-tide roosting and feeding sites for a number of species of shorebirds. This will become increasingly important with sea-level rises threatening to render intertidal mudlflats functionally redundant to shorebirds.

The large open areas also provide the surveillance and hydrological predictability preferred by nesting Red-capped Plover

Threats: *Habitat Loss* While the habitats described above are more resilient to the effects of off-road vehicles than the neighbouring saltmarsh, increased levels of disturbance can result in abandonment of the site, which equates to loss of habitat.
Disturbance Frequent use by off-road vehicles can disturb birds as they feed or roost, resulting in unnecessary energy expenditure and loss of feeding time due to extra surveillance behaviour or flight initiation.
Accidental mortality Off-road vehicles may crush chicks or eggs of Red-capped Plovers.

Figure 17. Resident Red-capped Plovers nest on the claypans to the north-east of Thompsons Beach. This area is, however subject to disturbance and degredation from off-road vehicles (top).

Article VI. DISCUSSION: The importance of saltfields for shorebirds

Populations of shorebirds are declining throughout the world (Howe *et al*. 1989; Morrison *et al*. 2001; Olsen *et al*. 2003; CHSM 2004, Gosbell and Clemens 2006; Nebel *et al*. 2008). These declines are especially evident along the East Asia–Australasian Flyway, along which species of shorebirds that breed in the Siberian tundra migrate to the Southern Hemisphere to spend their non-breeding season. This long-distance migration entails birds flying distances of many thousands of kilometres; such an undertaking requires a huge expenditure of energy in a short time. Thus, migrating shorebirds must gain weight rapidly immediately before migrating, feed at suitable stop-over points along the way, and then feed again to recover their condition after they reach their destination.

The localised loss of shorebird foraging habitats is widespread along the shores of eastern Asia, where most of the prime stop-over points occur, and where the shorebirds often congregate in high numbers to refuel while on migration (Barter 2002; IWSG 2003; Geering *et al*. 2007).

The populations of many of these species of shorebirds are declining due to the widespread loss of habitat at these essential stop-over points along the Flyway through 'reclamation', the process of converting tidal mudflats into land for use by agriculture, aquaculture or industry. These sites typically come under pressure as they are often perceived to be 'wasteland' which is good for no particular purpose other than to be destroyed for the expansion of industrial or residential areas. The loss of these sites deprives the migratory shorebirds of their prime foraging habitats which are essential to their survival while on migration. The loss of a local area may not seem particularly adverse when viewed in isolation, but when it is widespread, the cumulative effect of these many localised losses of prime habitats in many areas can be devastating for populations of migratory shorebirds.

A prime example of this has occurred on the muddy shores of the Yellow Sea at Saemangeum in South Korea, where a large proportion of the shorebirds which migrate through the East Asian–Australasian Flyway stop over to feed. In recent years these mudflats were 'reclaimed' for the expansion of industry, with a direct result being a dramatic decline in populations of a number of species (the Great Knot and Eastern Curlew in particular), leading to these species being placed on the IUCN's Red List with a conservation status of 'Vulnerable', meaning that they are now 'at high risk of endangerment in the wild'. In addition, several other species of shorebirds are also under review because there is evidence which suggests that their populations are also undergoing similar rapid and severe declines.

In Australia there is nothing on the scale of the 'reclamation' of the mudflats of Saemangeum planned. Nevertheless, the incremental and cumulative loss of shorebird habitats in this country can be equally as devastating, so it is crucial that the declining number of sites suitable for shorebirds along the Australian coastline are protected and nurtured through sympathetic management.

Although shorebirds may occur in various habitats, each of these habitats has a number of common characteristics: they have (1) expansive open areas of soft substrate that is covered by shallow water (either permanently or inundated regularly) where the birds can feed, and (2) areas suitable for the shorebirds to rest (roost) while they are not foraging (e.g. Davis and Smith 1998; Warnock *et al*. 2002).

The habitats that occur at the Dry Creek Saltfields provide shorebirds with excellent conditions for both foraging and roosting, and the Saltfields are currently regarded as one of the most important sites for migratory shorebirds in South Australia. This is with good reason, as large numbers of shorebirds regularly spend their non-breeding season there, and it also sometimes supports species which are regarded as rare or vagrants to Australia. Part of the attraction of the saltponds to shorebirds is the diversity of habitats they present: ponds of different water depth and salinity which cater for the needs of a wide variety of shorebirds.

It is essential that this site be managed sympathetically and effectively with respect to maintaining the existing shorebird habitat. It is important to manipulate the hydrological aspects (the water-flow) of the system to maintain varied water levels and varied salinity between ponds, as different depths and salinities will favour different shorebirds (Rundle and Fredricksen 1981; Erwin 1996; Collazo *et al*. 2002; Warnock *et al*. 2002; Rodriguez *et al*. 2004).

Studies overseas have shown that saltponds may be significantly more important for migratory shorebirds than intertidal mudflats at some times (Dias 2009), providing high-quality foraging areas, particularly in the crucial period leading up to spring migration, when increased energy intakes are essential; prey obtained in saltponds contributes significantly to shorebirds' daily energy requirements at this time (Masero and Pérez-Hurtado 2001; Masero 2003).

With many shorebird-ecology studies focusing on the importance of foraging habitat, the importance of roosting habitats is often overlooked. Roosting sites also comprise a crucial component of shorebird habitat (e.g. Warnock *et al*. 2002; Rogers *et al*. 2006). Shorebirds occupy a significant part of the day roosting, ostensibly at high tide when foraging areas are inundated and rendered temporarily unsuitable, though they may sometimes also roost at low tide. So vital are they that seemingly suitable habitat may remain uninhabited by shorebirds if secure roost sites are unavailable nearby. Prime roosting habitats have four key components: (1) they must be near feeding sites (within a few hundred metres); (2) they must be accessible and obviously available to the shorebirds; (3) they should generally have minimal amounts of vegetation; and (4) they should be secure from stealth attacks by predators (Harrington 2004; Minton 2004; Dias *et al*. 2006).

One of the keys to maintaining roost sites to keep them attractive to shorebirds is to ensure that they do not become too vegetated (at least beyond minimally) — vegetation growing on a bank or island or in the shallow water surrounding reduces its availability for shorebirds, and the presence of shrubs should be minimised (Minton 2004). Similarly, if an area that was once a suitable roost site becomes unsuitable, for example, by becoming too densely vegetated, it may force birds to roost further away from their feeding areas. The quality of roosting habitat is generally related to shorebirds minimising their energy expenditure while resting (Rogers *et al*. 2006). Although shorebirds may regularly move between saltponds and nearby intertidal mudflats (e.g. Stenzel *et al*. 2002; Warnock *et al*. 2002), once the distance between feeding and roost sites becomes too great, the energetic losses involved with travelling farther between the sites become unsustainable, and the area will become less suitable for habitation by shorebirds (Dias *et al*. 2006). In this way, the destruction of roosts may force shorebirds to abandon an otherwise suitable area (Dias *et al*. 2006; Rogers *et al*. 2006).

The loss of shorebird habitat does not necessarily occur only through destruction by processes of reclamation or development. It is important to note that any modification of the habitat at the saltworks could amount to their destruction, whether through development, the restoration of a former habitat or the establishment of a different habitat. Any changes made to a sensitive environment will inevitably disturb the balance (or the equilibrium state) (Zhenshan and Zhenglei 2005).

Although the saltponds of the Dry Creek Saltfields are not a naturally occurring feature of the landscape of Gulf St Vincent, they have existed in the Gulf for many decades (Cooper 1966), and in that time they have come to comprise a habitat that is crucial for supporting an entire guild of the region's avifauna. Artificial habitats such as this now provide essential alternative or complementary feeding and roosting habitat for shorebirds in an area where many areas of natural foraging and roosting habitat have been lost (Masero and Pérez-Hurtado 2001; Masero 2003; Béchet *et al*. 2009; Dias 2009; Sripanomyom *et al*. 2011).

It has been suggested that the conversion of the saltponds in the Dry Creek Saltworks into saltmarsh habitats might enhance the ecological value of the local area. Both saltmarsh and saltponds provide essential habitat for various species of birds (Thébault *et al*. 2008), but by converting one habitat into another, some species will inevitably benefit at the expense of others (Takekawa *et al*. 2006). Though a few species will be able to adapt to the new habitat (Demers *et al*. 2010), most shorebirds will not, as they prefer more open habitats rather than intertidal saltmarsh habitats (Warnock and Takekawa 1995; Takekawa *et al*. 2006).

Restoring saltponds back into saltmarsh habitat will involve a major increase in the density of the vegetation. The suitability of ponds as feeding habitat is greatly diminished if vegetation is allowed to grow to any great extent. Ultimately, the conversion of saltponds to saltmarsh habitat is likely to result in a dramatically different food web and a reduced area of habitat that is suitable for invertebrate prey species which inhabit hypersaline environments (Takekawa *et al*. 2006; Hickey *et al*. 2007), and thus will reduce the area of suitable habitat available for overwintering shorebirds (Demers *et al*. 2010). Studies on shorebirds in Mexico have shown that saltmarsh was the least-used foraging habitat, and the few shorebirds that foraged in this habitat spent less time feeding and more time being vigilant for predators (Castillo-Guerrero *et al*. 2009), which would adversely affect their daily energy intake.

Saltponds on the shores of San Francisco Bay have, like the Dry Creek Saltworks, been identified as important for sustaining significant populations of shorebirds (Stenzel *et al*. 2002; Warnock *et al*. 2002; Takekawa *et al*. 2006, 2009; Thébault *et al*. 2008). The saltponds of San Francisco Bay have also been earmarked for revegetation to transform them into expanses of saltmarsh. However, a number of researchers have expressed that caution should be exercised in this situation: as many species of shorebirds rely on the saltponds for both foraging and roosting, they may be adversely affected by the loss of this crucial habitat (e.g. Warnock *et al*. 2002; Takekawa *et al*. 2006). It could, in effect, differ little from the 'reclamation' activities in the Yellow Sea, and could result in the reduction or loss of shorebird populations occurring in the area.

It is possible that there is a misconception that because the habitat of saltponds is considered 'artificial' that it may have limited value to wildlife, and that restoration works would be of greater ecological benefit. Though a few species may benefit from the conversion of saltworks to saltmarsh habitat, the significant populations of migratory shorebirds that inhabit Gulf St Vincent are likely to be adversely affected by the change, and the ecological value of the Gulf as a whole could decline as a result.

Article VII. CONCLUSIONS

This project is raising the community's awareness of shorebirds, and actively engaging them to participate in gathering the information needed to conserve shorebirds. In the short term, the destruction of tidal ecosystems will need to be mitigated, and the monitoring of shorebird populations in Gulf St Vincent will strengthen the case for protecting these important habitats. Further, monitoring shorebirds in Gulf St Vincent has the potential to provide crucial information about the efficacy of adaptive management to ensure shorebirds are conserved in the Gulf. The identification, description, and growing understanding of the significance of important shorebird habitat in the Gulf have all comprised a first critical step towards their long-term conservation. We believe that we can help secure a brighter future for these birds by educating and engaging stakeholders, building good science that informs on how and why shorebird populations are changing, and working to increase the number of people in the community who care about shorebirds.

The greatest threats to shorebirds in Gulf St Vincent can all be mitigated through the actions of local planners and managers, and we have outlined some of the issues that must be considered, and have further recommended some ways to move forward. It is clear that without the past actions of planners and managers in the region, the threats to migratory shorebirds would be greater, and shorebird populations could possibly have been further reduced in the region. For example, the Mallala City Council, the Mallala Foreshore Advisory Committee, the Foreshore Task Group and associated networks are all committed to the protection and environmental integrity of the Samphire Coast, and the Samphire Coast Conservation Strategy recognises the significance of this habitat for the conservation of shorebirds in Gulf St Vincent (Jensen 2004). The strategy outlines provisions which must be undertaken to sustain coastal environments and establish an interconnected system of proposed protected areas, including land- and marine-based parks and Ramsar listing within 5 years. The recent establishment of the Samphire Coast Shorebird Trails, with accompanying signage and information booklet, is a prime example of local councils working in conjunction with coast care groups and local residents to raise awareness of shorebird conservation and to encourage pride in a regional project.

The creation and maintenance of wetlands near the Dry Creek Saltfields by the City of Port Adelaide Enfield is a good example of councils reclaiming land for conservation and educational purposes. These wetlands comprise the Barker Inlet wetlands (about 50 hectares), which always contain brackish and salt water, and the Greenfields Wetlands, which consist of 114 hectares of fresh water at fluctuating levels. Situated within 20 minutes' drive of Adelaide's central business district, this project spreads awareness of shorebird conservation.

To maximise the conservation of shorebirds in Gulf St Vincent, it is vital that all planners and land managers in the region are aware of the important shorebird areas, and are able to assign a high priority to the importance of the habitats that occur in the Gulf. Incorporating the spatial shorebird GIS layers into existing environmental overlays would go a long way towards informing decision makers in the region of which areas are most the important for shorebirds. Further, by making the information about shorebirds readily available, the chance of planning and management activities adversely impacting shorebirds should be reduced. Finally, steps must be taken to ensure that sufficient buffers to disturbance of critical shorebird habitats are created, and that management sufficient to retain shorebird populations continues regardless of any changes in salt production.

Article VIII. RECOMMENDATIONS

1. Work to ensure the protection of the habitats that support shorebirds in Gulf St Vincent, including the protection of habitats along the Samphire Coast as pristine, undisturbed places.

2. Work in close consultation with Cheetham Salt throughout the development of a Program for Environmental Protection and Rehabilitation (PEPR) for the Dry Creek Saltfields to ensure best practice shorebird management is incorporated.

3. Constantly evaluate the impacts of proposed developments and changes to infrastructure on shorebird habitats, namely the Dry Creek Saltfields and the Greenfield and Globe Derby wetland system.

4. Set initial buffer distances around identified habitats at 250 metres to limit the impacts of disturbance, and use active monitoring to explore how to adjust those buffers with the understanding that buffers less than 250 metres may be sufficient in some areas, or for some forms of potential disturbance.

5. Encourage dog walkers to keep their dogs leashed when in shorebird areas.

6. Work to ensure sympathetic shorebird management of the Dry Creek Saltfields continues regardless of any change to salt production.

7. Steps must be taken to reduce the volume of wastewater, stormwater and industrial input into Gulf St Vincent, with a particular emphasis on re-establishing seagrass beds in the Bolivar Waste Water Treatment Plant outlet area. Recommendations on rehabilitation of seagrass meadows can be found in the Adelaide Coastal waters study (*Fox et al 2007*).

8. Educate the public (through signs, brochures, meetings and the like) about how visiting important shorebird areas can impact on resident and migratory shorebirds.

9. Work to quantify the frequency of disturbance, the site-specific distances at which birds respond to disturbance, the time taken to resume feeding, and the distance shorebirds must fly to find an undisturbed feeding or roosting habitat.

10. Continue conducting twice-yearly shorebird workshops to increase awareness of shorebird conservation and to expand the pool of experienced volunteer surveyors.

11. Contact counters directly to provide feedback in order to retain their participation from year to year.

12. Develop an understanding of how well monitoring will inform adaptive management, and optimise monitoring to inform on threats as understanding of the severity, and distribution of threats grows.

13. Conduct field trips and counts with experienced mentors to foster appropriate count methods and familiarise new counters with shorebird identification and shorebird count areas.

14. Consider a vehicle exclusion area for the coastline adjacent to and south of the Price Saltfields.

15. Use the abundance, diversity and species composition (i.e. vulnerable species) to prioritise conservation efforts, focusing on those areas under greatest threat.

16. Surveys of breeding shorebirds should be encouraged to identify and protect easily impacted breeding areas.

17. Continue to control and remove the invasive Sea Spurge from effected areas, and search for and eradicate any Sea Spurge, Tree Mallow, Marram Grass or African Boxthorn that appears in new areas. These invasive species spread rapidly and can be difficult to control once established.

18. Incorporate shorebird-area spatial layers and attributes into existing spatial-planning layers, such as the environmental significance overlays, so that shorebirds can easily be incorporated into the planning process.

19. Ensure that rigorous assessments of impacts to shorebirds are conducted for any planned activity or development that are likely to impact within 200 metres of these important shorebird areas, or any area of tidal flats.

20. Develop plans that facilitate cooperative cross-jurisdictional planning which is required to limit the likely cumulative impacts of increasing urban growth in the region.

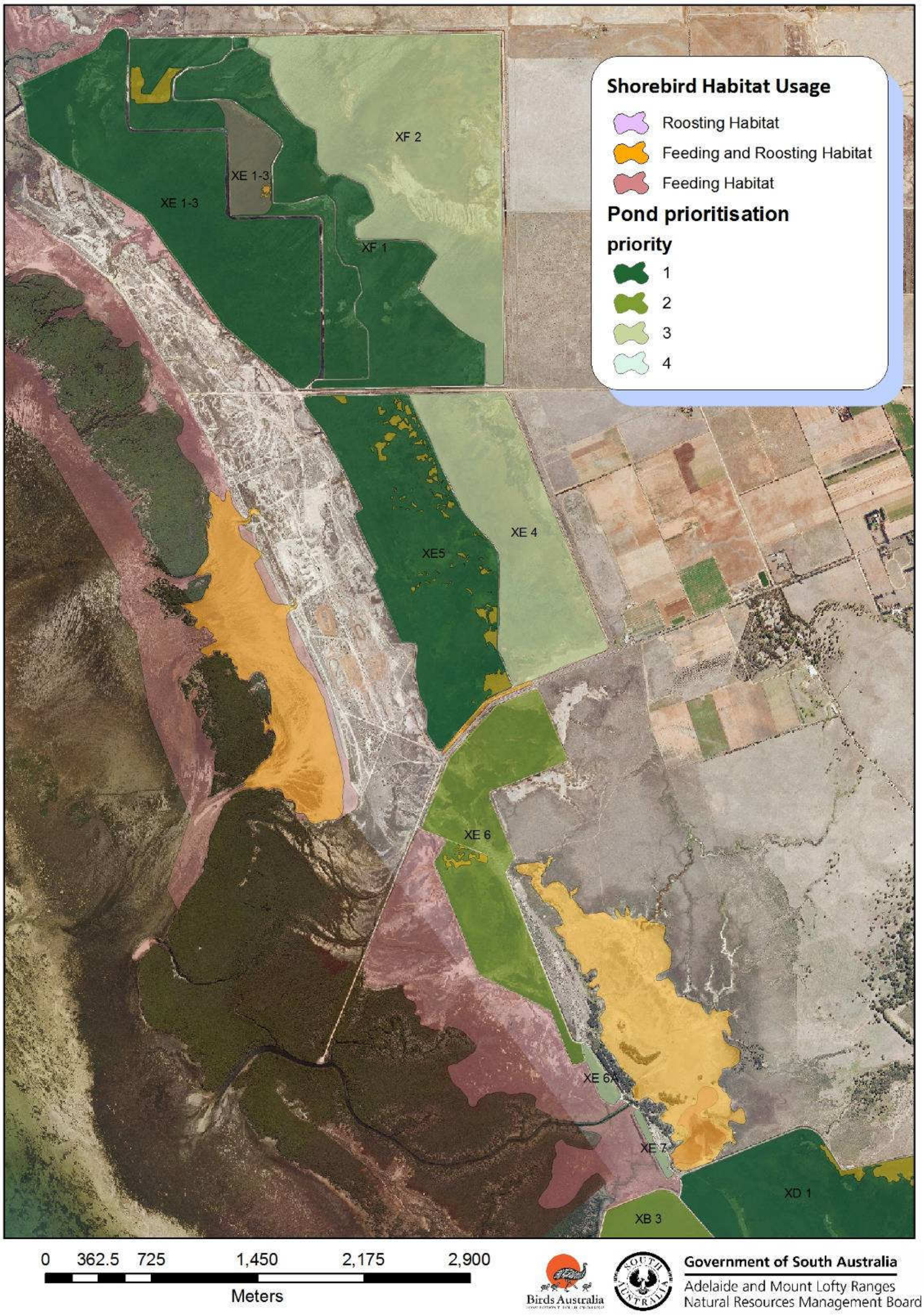
21. Continue to increase our understanding of both shorebird feeding habitat and the abundance and diversity of shorebirds using poorly understood habitats in the region.

22. Work in cooperation with the Australian Defence Force to organise comprehensive, regular, summer and winter shorebird counts of the Proof and Experimental Establishment.

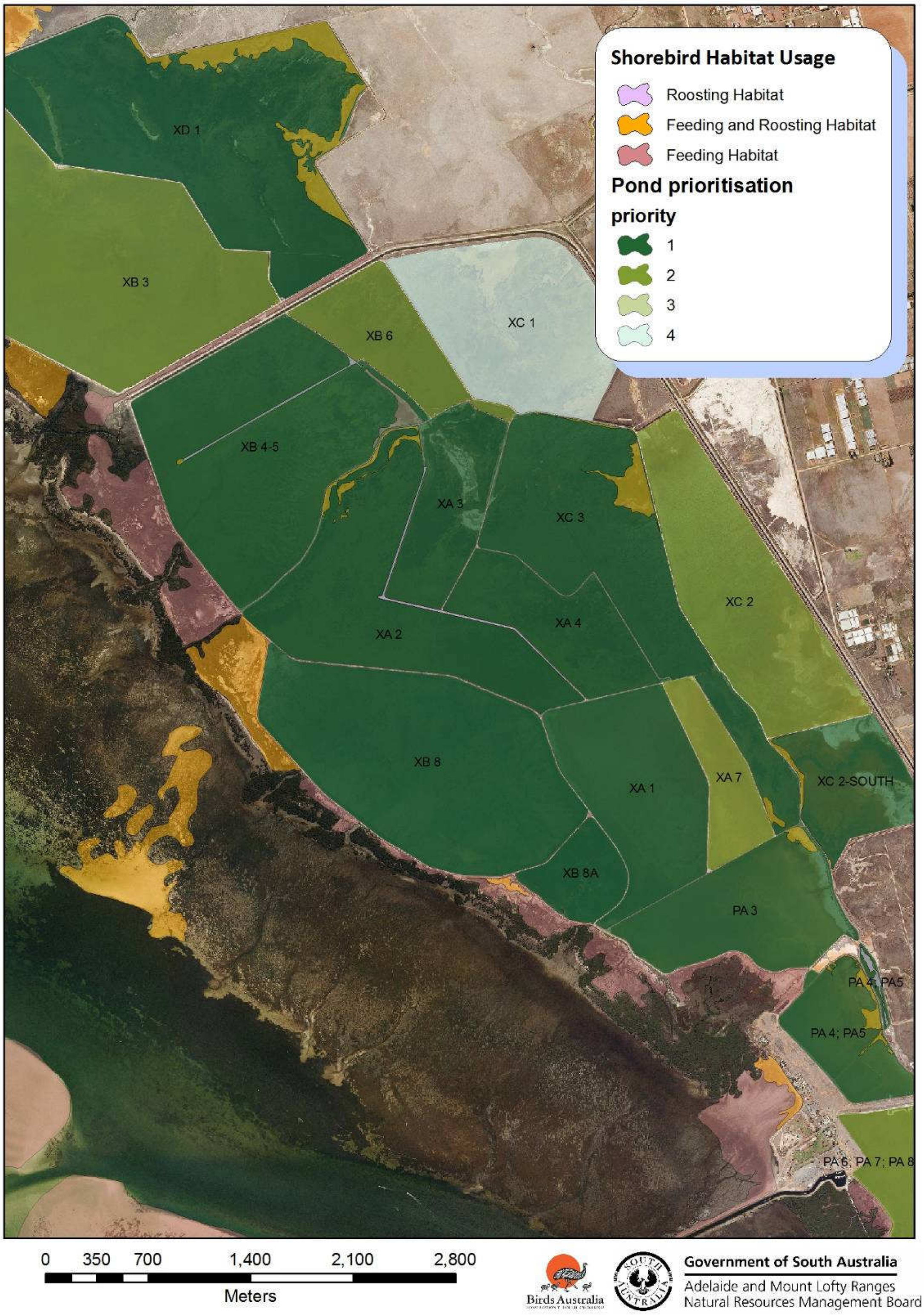
23. Re-assess the threats by computing threat scores regularly to determine whether shorebird numbers are changing in response to changes in threat levels.

Article IX. APPENDIX

Map 1. Cheetham's Dry Creek saltfields with shorebird pond prioritisation.



Map 2. The northern marine saline ponds, Pt Gawler Off-road Park and adjacent intertidal shorebird habitat (centre left). Buckland Park Lake (bottom right).



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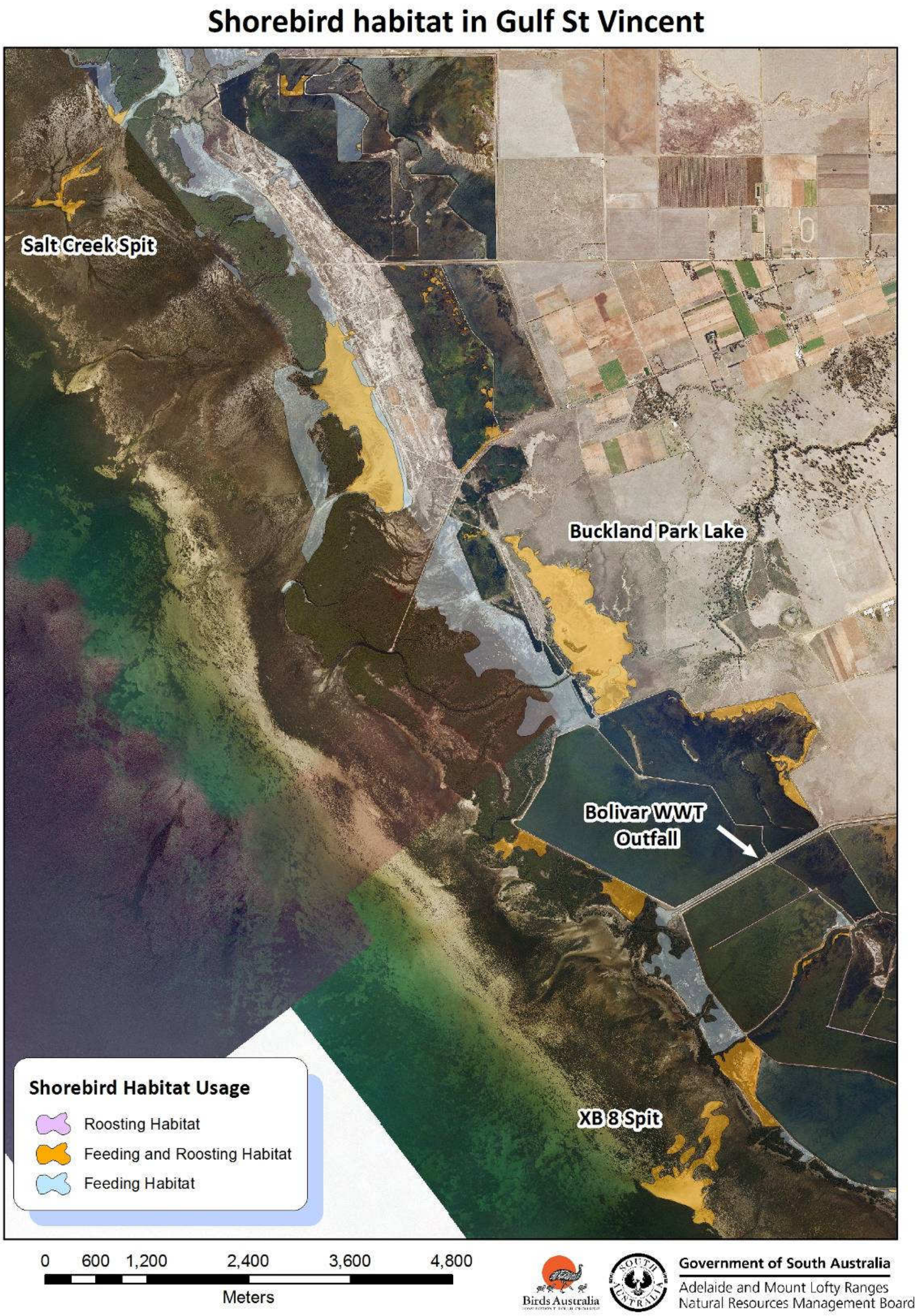
Map 3. Low, meduim and high hypersaline ponds and the sandpit to the east of pond XB 8 (centre left).

Map 4. shorebird habitat surrounding Thompson Beach, including inland feeding, roosting and breeding habitat.



Map 5. Salt Creek Spit, Buckland Park Lake, Bolivar WWT Outfall and the XB 8 Spit.

Shorebird habitat in Gulf St Vincent

Map 6. Bald Hill and the Pt Wakefield Sand Spit.

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