WATER TECHNOLOGY
WATER, COASTAL & ENVIRONMENTAL CONSULTANTS

APPENDIX C
ECOLOGICAL INPUTS TO THE GAWLER RIVER STORMWATER MANAGEMENT PLAN

Ecological Inputs to Gawler River Stormwater Plan by Lance Lloyd

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Stormwater management needs to consider the ecological requirements of the river and floodplain system of the Gawler River system. This information provides some context and allows various management options to be compared again how well they cater for these ecological requirements or not and if there are any ecological impacts arising from various scenarios.

Threatened Ecological Communities

The river channel downstream of the township of Gawler is dominated by River Redgum (*Eucalyptus camaldulensis*) and Black Box (*E. largiflorens*), either which are threatened but do rely on water from the river for recruitment and growth (Philpott et al 1999). The river channel is dominated by reeds and sedges (*Phragmites, Typha, Juncus, Isolepis, Schoenoplectus*) as well as those overstorey trees.

South Australia support 14 threatened ecological communities (Table 1 and Figure 1). Only two of these critically endangered communities occur within the Gawler River Floodplain and which are:

- Peppermint Box (*Eucalyptus odorata*) Grassy Woodland of South Australia, and
- Iron-grass Natural Temperate Grassland of South Australia.

Table 1: Threatened Ecological Communities of South Australia

Community	Category	Present or Endemic	Date of Listing
Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions	Endangered	Present	16/07/2000
Eyre Peninsula Blue Gum (*Eucalyptus petiolaris*) Woodland	Endangered	Endemic	13/08/2013
Giant Kelp Marine Forests of South East Australia	Endangered	Present	29/08/2012
Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia	Endangered	Present	01/04/2010
Iron-grass Natural Temperate Grassland of South Australia	Critically Endangered	Endemic	21/06/2007
Kangaroo Island Narrow-leaved Mallee (*Eucalyptus cneorifolia*) Woodland	Critically Endangered	Present	01/05/2014
Karst springs and associated alkaline fens of the Naracoorte Coastal Plain Bioregion	Endangered	Endemic	15/12/2020
Peppermint Box (*Eucalyptus odorata*) Grassy Woodland of South Australia	Critically Endangered	Endemic	21/06/2007
Plains mallee box woodlands of the Murray Darling Depression, Riverina and Naracoorte Coastal Plain Bioregions	Critically Endangered	Present	10/06/2021
Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains	Critically Endangered	Present	27/03/2012
Subtropical and Temperate Coastal Saltmarsh	Vulnerable	Present	10/08/2013
Swamps of the Fleurieu Peninsula	Critically Endangered	Endemic	21/03/2003

Community	Category	Present or Endemic	Date of Listing
The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin	Endangered	Present	04/04/2001
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	Critically Endangered	May occur	17/05/2006

Peppermint Box Grassy Woodland and Iron-grass Natural Temperate Grasslands are found between Victor Harbor and Port August in South Australia. The Gawler River flows through these communities. However, the communities nor the component species or their condition are dependent upon the river or flooding for any part of their lifecycle.

However, given these communities are listed as critically endangered under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act), any significant impact on these community are matters of national environmental significance and must be addressed. Therefore, any plan for the Gawler River, its floodplain or surround areas must consider these communities, if they occurred in these areas, especially if any scenarios resulted in any development adjacent to the river or floodplain.

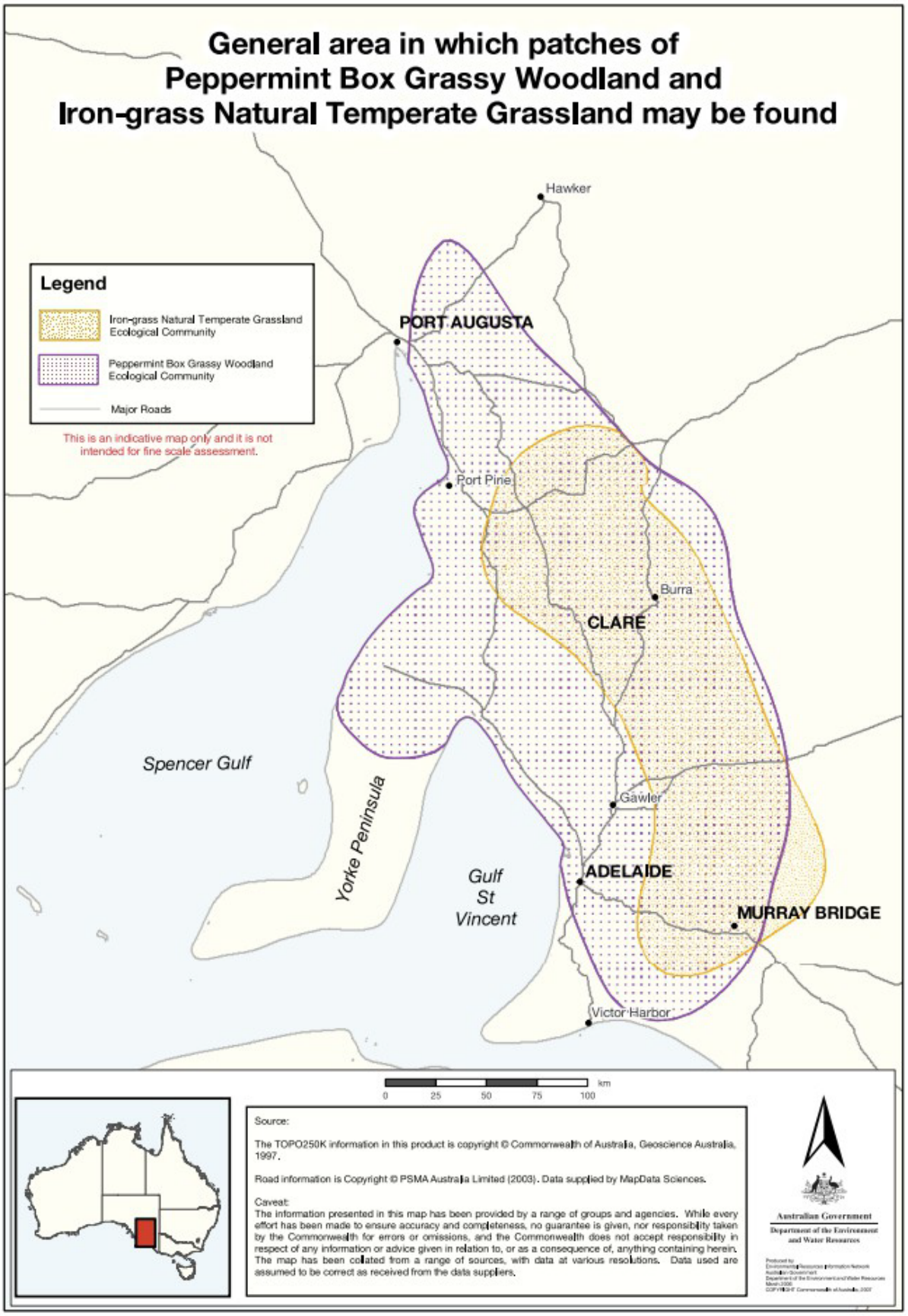

Figure 1: Distribution of Peppermint Box Grassy Woodland and Iron-grass Natural Temperate Grassland of South Australia

Ecological threats

Previous work has identified the following threats facing biodiversity and natural processes in the Gawler River:

- Alteration of stream flows (from instream structures, floodplain changes and catchment alterations; irrigation storages);
- Dam construction affecting flooding, water temperatures and life cycles of fauna and plants;
- Loss of habitat area;
- Loss of habitat diversity;
- instream barriers to fish passage;
- loss of riparian (riverside) vegetation;
- siltation;
- contaminants (insecticides and weedicides) from agricultural & forestry practices; and
- increased nutrient loads from agricultural fertilisers and sewage.

Water Quality

Water quality is important for all aquatic fauna and flora and many of the threats listed above arise from poor water quality. Table 2 shows that the Gawler River is saline, carrying heavy sediment loads and very high nutrient levels.

Table 2: Water Quality results summarised by Wilkinson et al 2005a.

Period	Source	EC	SS	TKN	NO3_N	TP
Jun 73 - Nov 74	Geometric Mean (n=6), EWS 3876		179		0.21	0.15
1978-83	Median (n=14), Glatz (1989)	1920 (n=54)	24 (n=9)	1.48	0.19	0.21
Aug-04	Geometric Mean (n=3), this study	1606	119	2.08	0.20	0.39

Pesticides and herbicides have been detected in most samples in the limited sampling undertaken within the Gawler River. This makes it hard to know if the problem is more widespread but the very high levels of suspended solids load (Figure 2) likely means that pesticides and herbicides are common (as they attached to the sediment (Wilkinson et al 2005a &b).

Figure 2: Suspended solid loads for Gawler River compared to other SA systems (Wilkinson et al 2005b.)

Fish Communities

Fish are a very important group in coastal waterways. They are strongly dependent on flows and flow regimes to complete their life cycles. Even in largely freshwater reaches, several species will have parts of their life cycles in the estuary or the marine environment and are migratory throughout the waterways. All species also only undertake local movements to find mates, food or exploit new habitats.

The fish of most southern Australian rivers, can be classified into six groups which have different requirements (Lloyd et al 2012). These types are classified based on their presence within different parts of the system, their use of the estuary and their migration patterns, all of which affect their environmental flow requirements (Figure 3).

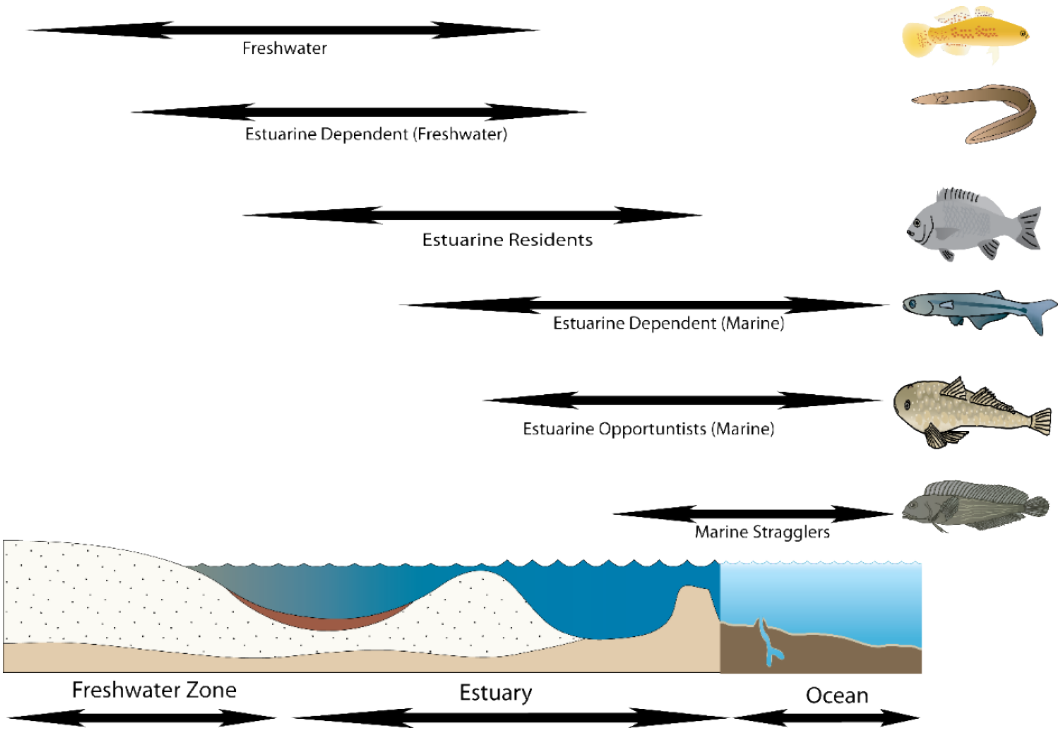

Figure 3: Classification of types of fish in Southern Australian waterways (Lloyd et al. 2012).

Estuarine Dependent (Freshwater & Marine) and Estuarine Residents fish make up the vast majority of the fish species present (>70%). These species are dependent upon the estuary and are more significantly reliant on freshwater inflows. Freshwater and Estuary Opportunists species make up the remainder of the species present (28%) and these are entirely dependent on freshwater flows. All of the fish present rely upon freshwater flow components to complete their life cycle in the upstream reaches or some of them in the estuary (or sea), but all require flushing flows to move along the river or reach the estuary. Their biology and water requirements can be found in Table 3.

The other groups of fish missing in this list are the Estuary Opportunist (Marine) and Marine Straggler groups which derive from marine environments. It is possible some of these species are present but lack of survey in the estuary (and its restricted nature) has resulted in their absence or lack of records. However, freshwater is important to all species to some degree as freshwater inflows also bring nutrients and organic matter into the estuary, and near ocean, increasing its productivity (Lloyd et al. 2012).

Table 3: Native Fish of the Gawler River

Category	Scientific Name	Common Name
Freshwater	*Galaxias olidus*	Mountain Galaxias
	Retropinna semoni	Australian Smelt
Estuary Opportunist (Freshwater)	*Philypnodon grandiceps*	Flatheaded Gudgeon
	Philypnodon macrostomus	Dwarf Flatheaded Gudgeon
Estuary Dependent (Freshwater)	*Galaxias brevipinnis*	Climbing Galaxias
	Galaxias maculatus	Common Galaxias
	Pseudaphritis urvillii	Congolli
Estuary Resident	*Pseudogobius olorum*	Bluespot Goby
	Arenigobius bifrenatus	Bridled Goby
	Atherinosoma microstoma	Smallmouth Hardyhead
Estuary Dependent (Marine)	*Geotria australis*	Pouched Lamprey
	Mugil cephalus	Sea Mullet
	Aldrichetta forsteri	Yellow-eye Mullet
	Liza argentea	Flat-tail mullet

None of the fish are listed under state or EPBC Acts but all have significant ecological roles and requirements.

Flow and ecological requirements for fish

Freshwater, Estuary Opportunist (Freshwater), Estuary Dependent (Freshwater) and Estuary Resident fish all depend on freshwater inflows and events to assist in their life history and understanding freshwater inputs is critical to designing an environmental flow regime for these species (see Table 4). While Estuary Dependent (Marine) fish depend on the presence of estuarine conditions (resulting from freshwater inflows) their biology is not tied to specific flow events so are not listed in Table 4.

In determining the environmental flow requirements for a river system, it is important to consider its fish community and the life history of key species, together with other organisms. These key characteristics include the life span, spawning season, incubation, duration, migration, and habitat requirements.

This information will also be very useful in comparing various flow scenarios arising out of future options for managing the Gawler River and its floodplain.

Table 4: Ecological requirements of key fish species present in the Gawler River system. These are based on current knowledge but these can only be considered as approximate until further research is conducted on these species [derived from www.fishbase.org; Allen *et al.* (2002); Koehn & O'Connor (1990); Lloyd (1987); Merrick & Schmida (1984); McDowall (1980); Treadwell & Hardwick (2003)].

Fish Species		Life Span	Spawning Season	Incubation Duration*	Migration	Other
Common Name	Scientific Name					
Mountain Galaxias	*Galaxias olidus*	2-4 years	July - Oct	5-7 days	Upstream, if at all	Leaf litter required
Australian Smelt	*Retropinna semoni*	1-2 years	Sept - Nov	9-10 days	Active movers between habitats and along anabranches	Aquatic vegetation required as a substrate for laying eggs
Flathead Gudgeon	*Philypnodon grandiceps*	4-7 years	Oct - Feb	4-6 days	Local only	Hard surfaces required as a substrate for laying eggs
Dwarf Flathead Gudgeon	*Philypnodon macrostomus*	3-5 years	Oct - Feb	4-5 days	Local only	Hard surfaces required as a substrate for laying eggs
Common Jollytail	*Galaxias maculatus*	2-3 years	April -June	Normally take 10-16 days between flow events or tides (in estuary	Downstream to estuary in Autumn.	Aquatic/riparian/intertidal macrophytes required as a substrates for laying eggs
Climbing Galaxias	*Galaxias brevipinnis*	2-4 years (Uncertain)	May-June	Unknown – perhaps 5-7 days (same as *G. olidus*)	Larvae are washed downstream to the sea in Winter. Juveniles return upstream in spring and early summer.	Prefer rocky streams with flowing water and good riparian vegetation however have are also found in habitats with silt substrates.

Fish Species		Life Span	Spawning Season	Incubation Duration*	Migration	Other
Common Name	**Scientific Name**					
Tupong (Congolli)	*Pseudaphritis urvillii*	>5years	Sept - Dec	Unknown (likely to be short - 3 or so days)	Adults migrate downstream to estuary for breeding April to July. Juveniles migrate upstream Oct – Feb.	Congolli are susceptible to impacts from the presence of water flow barriers
Western Blue-spot Goby	*Psuedogobius olorum*	2-3 years	Oct-Jan	4 days	Local only	Need hollow in log or burrow under rock or wood as a substrate for laying eggs.
Bridled Goby	*Arenigobius bifrenatus*	Unknown >3 years	Spring (Oct – Dec)	Unknown – assume 4 days	Local only	Burrows into soft substrate in lower saline reaches of rivers or in upper embayments. The females lay demersal eggs in their burrows.
Smallmouth Hardyhead	*Atherinosoma microstoma*	1 year	Sept - Feb	4-7 days	Local only	Breeding probably occurs in estuary or lower reaches of rivers

Pest plants and animals (water dependent)

The alien species include the predacious redfin and the invasive Eastern Gambusia as well as the two carp species (European carp and goldfish, as well as their hybrids). Alien fish species are water dependent pest animals which can proliferate and can impact on native fish communities through habitat condition or impacts through competition and predation (Lintermans 2007). The 4 species present are all hardy, have wide salinity tolerances and therefore are found throughout the system. While it is important to know which alien species exist in the system, these species' water requirements will not be considered in the project apart from their impacts and how to mitigate these. Exotic fish dominated the fish fauna in the Philpott et al. (1999) study.

Table 5: Alien fish present within the Gawler River System

Alien Fish Species	
Common Name	**Scientific Name**
Eastern Gambusia	*Gambusia holbrooki*
Redfin	*Perca fluviatilis*
European Carp	*Cyprinus carpio*
Goldfish	*Carassius auratus*
Brown trout	*Salmo trutta*
Rainbow Trout	*Onchorynnchus mykiss*

These pest species pose a threat to other aquatic values such as native fish, aquatic plants, macroinvertebrates, and water birds.

Stormwater water management plans can't really manage these species directly, but they can be mindful not to create conditions which promote these species but rather benefit native fish which can predate and control some of these invasive species.

Key Aquatic Fauna Communities

Waterbirds

Gawler River has a significant, long, narrow estuary with delta creeks at Port Gawler. The estuary is classified as a tide dominated creek (NABCWMB 2000). The extensive tidal flats consist of shelly silts, clays and sands supporting significant low mangrove woodland with small areas of samphire shrubland sitting at the mouth of the Gawler River.

The Adelaide International Bird Sanctuary represents the largest area of wetland near the mouth of the Gawler River but Gawler Estuary and Buckland Park are less well studied. The AIBS has at least 55 shorebird species recorded, including a vast majority which are internationally migratory summer visitors, and the bird sanctuary is important on a global scale (including areas nearby). In fact, around 15,000 shorebirds make this region home each year (during spring and summer) and return to breed in China and Siberia. Eastern Curlew, Bar-tailed Godwit and Great Knot are among these birds and their numbers and diversity make the area of great importance, some of the value is due to the freshwater inputs from the Gawler. The shoreline or mudflat species often do well in estuarine and saline coastal wetlands where there is a strong tidal signal resulting in a regular drying and inundation of the mudflats and shoreline twice a day. They also prefer wetlands which slowly dry out allowing birds to access the invertebrates or plants on the mudflats like found in areas like the Gawler estuary, Buckland Park and the AIBS. EPBC listed species such as Red Knot (Endangered), Great Knot (Critically Endangered), Curlew Sandpiper (Critically Endangered), Lesser Sand Plover (Endangered), Bartailed Godwit (Critically Endangered), and Eastern Curlew (Critically Endangered) and Australian Painted Snipe (Endangered) many of which are Migratory - heading north in our winters along the East Asian–Australasian Flyway.

Other resident waterbird species are also common, including:

- Royal Spoonbill (*Platalea regia*)
- Australian Pelican (*Pelecanus conspicillatus*)
- Black Swan (*Cygnus atratus*)

Many other waterbirds depend upon the aquatic ecosystems near the mouth of the Gawler River (Buckland Park, the estuary and areas within the Adelaide International Bird Sanctuary).

The bird sanctuary also provides habitat for other significant Australian birds like the Elegant Parrot and Gulf St Vincent Slender-billed Thornbill. Many bush birds are also present along the river and near the mouth and utilise the resources of the site and the wetlands presence no doubt enhances these species within the region, although these are not further discussed as they are not water dependent.

Table 6: Shore birds and conservation status at AIBS (Derived from Mehlman et al. 2018)

Common Name	Scientific Name	EPBC Listed?
Common Sandpiper	*Actitis hypoleucos*	
Ruddy Turnstone	*Arenaria interpres*	
Sharp-tailed Sandpiper	*Calidris acuminata*	
Sanderling	*Calidris alba*	
Red Knot	*Calidris canutus*	Endangered
Curlew Sandpiper	*Calidris ferruginea*	Critically Endangered
Little Stint	*Calidris minuta*	
Red-necked Stint	*Calidris ruficollis*	
Great Knot	*Calidris tenuirostris*	Critically Endangered, EPBC
Long-toed Stint	*Calidris subminuta*	
Pectoral Sandpiper	*Calidris melanotos*	
Cox's Sandpiper	*Calidris x paramelanotos*	Curlew-Pectoral Sandpiper hybrid (Christidis et al. 1996, Menkhorst et al. 2017)
White-rumped Sandpiper	*Calidris fuscicollis*	Rare vagrant
Baird's Sandpiper	*Calidris bairdii*	Rare vagrant
Inland Dotterel	*Charadrius australis*	
Double-banded Plover	*Charadrius bicinctus*	Short-distance migrant from New Zealand
Little Ringed Plover	*Charadrius dubius*	Rare vagrant
Ringed Plover	*Charadrius hiaticula*	Rare vagrant
Greater Sand Plover	*Charadrius leschenaultii*	Vulnerable, EPBC
Lesser Sand Plover	*Charadrius mongolus*	Endangered
Red-capped Plover	*Charadrius ruficapillus*	Resident
Oriental Plover	*Charadrius veredus*	
Banded Stilt	*Cladorhynchus leucocephalus*	Resident
Black-fronted Dotterel	*Elseyornis melanops*	Resident
Red-kneed Dotterel	*Erythrogonys cinctus*	Resident
Latham's Snipe	*Gallinago hardwickii*	
Oriental Pratincole	*Glareola maldivarum*	Rare vagrant
Sooty Oystercatcher	*Haematopus fuliginosus*	Resident
Pied Oystercatcher	*Haematopus longirostris*	Resident
Black-winged (Whiteheaded) Stilt	*Himantopus leucocephalus*	Resident
Broad-billed Sandpiper	*Limicola falcinellus*	
Bar-tailed Godwit	*Limosa lapponica*	Critically Endangered, EPBC (subspecies menzbieri); Vulnerable, EPBC (subspecies baueri)
Black-tailed Godwit	*Limosa limosa*	Vulnerable
Hudsonian Godwit	*Limosa haemastica*	Rare vagrant
Little Curlew	*Numenius minutus*	
Whimbrel	*Numenius phaeopus*	

Common Name	Scientific Name	EPBC Listed?
Eastern Curlew	*Numenius madagascariensis*	Critically Endangered, EPBC
Red-necked Phalarope	*Phalaropus lobatus*	
Ruff	*Philomachus pugnax*	
American Golden Plover	*Pluvialis dominica*	Rare vagrant
Pacific Golden Plover	*Pluvialis fulva*	
Grey Plover	*Pluvialis squatarola*	
Red-necked Avocet	*Recurvirostra novaehollandiae*	Resident
Australian Painted Snipe	*Rostratula australis*	Resident; Endangered, EPBC
Grey-tailed Tattler	*Tringa brevipes*	
Wood Sandpiper	*Tringa glareola*	
Common Greenshank	*Tringa nebularia*	
Common Redshank	*Tringa totanus*	Rare vagrant
Marsh Sandpiper	*Tringa stagnatilis*	
Lesser Yellowlegs	*Tringa flavipes*	Rare vagrant
Buff-breasted Sandpiper	*Tryngites subruficollis*	Rare vagrant
Australian Pratincole	*Stiltia isabella*	
Masked Lapwing	*Vanellus miles*	Resident
Banded Lapwing	*Vanellus tricolor*	Resident
Terek Sandpiper	*Xenus cinereus*	

Management recommendations

The Gawler estuary retains considerable ecological value, however the Gawler River is a highly modified system. Flow is heavily regulated due to dams, weirs and diversion from Gawler River tributaries, with up to 56% of the natural flow of the Gawler River are diverted for consumption purposes. Total volumes, durations, frequencies and seasonality of flows have all been affected (NABCWMB 2000). Environmental water requirements (EWRs) of the Gawler from the town of Gawler and the coast (at Buckland Park; NABCWMB 2000) EWRs are a description of the water regimes needed to maintain ecological values of water dependent ecosystems at a low level of risk (Table 6).

The various reports, studies and current information lead to the following recommendations:

- Improve fish migration by removal or modification (providing fish passage) of weirs and instream blockages (in Gawler and Yaldara – outside study area);
- Remove or control alien fish species;
- Remove pest plants and replant with native plants along riparian corridor;
- Reduce sediment run-ff - ensure catchment vegetation cover is high, revegetate and bare or unused ground; practice low tillage agriculture,
- Provide environmental flows with flow to the sea over an extended period late autumn to spring at least once every three years but preferably each year and as per Table 6 below:

Table 6: Environmental water requirements (EWRs) of the Gawler from the town of Gawler and the coast (at Buckland Park; NABCWMB 2000).

Flow band	Peak flow (m^3/s)	Daily flow (ML)	Average frequency	Duration (Time)	Importance	Seasonality
Pool connection	6–10	420–700	Once every 3 years as a minimum, but every year is far more beneficial.	Minimum 2–3 months	Water quality for pools. Riffle habitat available. Recharge habitat for aquifers. Paratya (freshwater shrimp) migration. Fish reproduction and migration flows.	Autumn and spring for fish migration
Mid-flow	10	350	Yearly	Minimum 2–3 months	Connection and recharge to Buckland Park (BP). BP would require water flowing into the lake for 2–3 months per year. Sediment transport.	Winter to spring
Bank-full	<300	20,300	Once every 10–20 years	Hours	Sediment and organic matter transport. Channel maintenance.	N/A
Over-bank	300+	20,300+	Once every 10–20 years	Hours	Floodplain maintenance and organic inputs to channel.	N/A

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