

**DRAFT Conservation Advice for the Karst Springs and Associated Alkaline Fens  
of the Naracoorte Coastal Plain Bioregion**



The Threatened Species Scientific Committee (the Committee) was established under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) and has obligations to present advice to the Minister for the Environment in relation to the listing and conservation of threatened ecological communities, including under sections 189, 194N and 266B of the EPBC Act.

The Committee will provide its advice on the Karst Springs and Associated Alkaline Fens of the Naracoorte Coastal Plain Bioregion to the Minister as a draft conservation advice in 2020.

The Minister will decide whether to amend the list of threatened ecological communities under Section 184 of the EPBC Act to include the Karst Springs and Associated Alkaline Fens of the Naracoorte Coastal Plain.

This draft conservation advice will be made available for public comment for a minimum of 30 business days. The Committee and Minister will have regard to all public and expert comment relevant to the consideration of the ecological community for listing.

## **1 CONSERVATION OBJECTIVE**

To mitigate the risk of extinction of the Karst Springs and Associated Alkaline Fens of the Naracoorte Coastal Plain Bioregion ecological community, and help recover its biodiversity and function through protecting it from significant impacts as a Matter of National Environmental Significance under national environmental law, and by guiding implementation of management and recovery, consistent with the recommended priority conservation and research actions set out in this advice.

This conservation advice contains information relevant to the objective by:

- describing the ecological community and where it can be found (section 2);
- identifying the key threats to the ecological community (section 3);
- summarising the existing protections for the ecological community (section 4);
- presenting evidence to explain why the ecological community merits listing as nationally threatened under national environment law (section 5); and
- outlining information to guide its conservation, including the key diagnostic features, condition thresholds and classes, and additional information to identify the ecological community, and the priority conservation and research actions to stop its decline and support its recovery (section 6).

## **2 DESCRIPTION OF THE ECOLOGICAL COMMUNITY**

The ecological community described in this conservation advice includes plants, animals and other organisms associated with a type of groundwater dependant ecosystem that occurs in association with the tertiary limestone of the Otway Basin in South Australia and Victoria.

### **2.1 Summary description and name of the ecological community**

The name of the ecological community is the **Karst<sup>1</sup> Springs and Associated Alkaline Fens of the Naracoorte Coastal Plain Bioregion**, hereafter referred to as ‘Karst Springs and Alkaline Fens’, or ‘the ecological community’. The ecological community is associated with a particular type of groundwater dependant ecosystem (GDE). Its primary defining features are the underlying limestone geology, karst fed (alkaline) freshwater springs, soaks, pools or streams and fringing fens which include herblands, peatlands, sedgeland and/or shrubland vegetation. The ecological community is part of a once extensive system of wetlands that occurred on low lying areas over Gambier limestone bedrock near the coastal zone of the Otway Basin in South Australia and western Victoria (Grimes et al 1999; Geoscience Australia 2018).

This ecological community includes flora, fauna and other organisms present in a permanent groundwater fed water component and within the emerging and fringing vegetation of adjoining fens.

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<sup>1</sup> Karst is a type of landscape with distinctive landforms that primarily result from highly soluble bedrock. Karst features include, caves, dolines, cenotes, solution pipes and tufa. Limestone is the most widespread karst rock (Jennings 1971).

## **2.2 Location and physical environment**

The Karst Springs and Alkaline Fens are located in the near-coastal zone of the Otway Basin in lower south east South Australia and south west Victoria, between latitudes 37.30°S to 38.20°S. The ecological community is scattered across the near-coastal area that is roughly east of Millicent South Australia and west of Portland Victoria.

The coastal region of south east South Australia and south west Victoria is characterised by broad plains of Tertiary and Quaternary limestone and sediments. Calcareous<sup>2</sup> sand ridges parallel to the coast are separated by inter dune swales, closed limestone depressions and bordered inland by geologically recent volcanoes such as *Berrin*<sup>3</sup>/Mount Gambier and *Budj Bim*<sup>4</sup>/Mount Eccles.

Due to the low relief landscape and the porous and highly transmissive geology, there are few major natural river systems in this region. The exception is the Glenelg River and a small number of perennial streams originating from coastal springs which flow to the coast. The majority of surface water expressed in the region results from groundwater sources.

Otway Basin groundwater discharge occurs at locations close to the coast and inland through natural springs, swamps and terminal wetlands as well as submarine discharge off the coast (Allison 1975; Wood 2011). Recharge of the upper unconfined limestone aquifer occurs via the infiltration of local and regional rainfall within the Lower South East and East Glenelg groundwater catchments of the Gambier Karst Province. The lower confined aquifer is recharged from the Dundas Highlands of Victoria and may contribute to hydrological inputs into deep karst systems.

This groundwater dependant ecological community is limited to the Gambier Limestone formation within the Bridgewater (NCP01) subregion of the Naracoorte Coastal Plain IBRA<sup>5</sup> bioregion.

The extent of the ecological community corresponds to country (the traditional lands) of the Boandik and Gunditjmara peoples.

At May 2020, the ecological community occurred within the Glenelg Hopkins Catchment Management Authority region in Victoria and the South East Natural Resources Management Authority region in SA. Local government areas known to contain the ecological community (at May 2020) include: District Council of Grant (SA), Wattle Range Council (SA) and Glenelg Shire Council (Vic).

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<sup>2</sup> Calcareous soils/sediments are composed of at least 15% calcium carbonate.

<sup>3</sup> Boandik language

<sup>4</sup> Gunditjmara language

<sup>5</sup> IBRA refers to the Interim Biogeographical Regionalisation of Australia. IBRA regions are large geographically distinct areas of similar climate, geology and landform with corresponding similarities in their vegetation and animal communities. The version current at the time of this advice is IBRA v7 (DoE, 2013), which divides Australia into 89 bioregions and 419 subregions, including offshore islands.

### 2.2.1 Climate

The climate throughout the Bridgewater subregion where the ecological community occurs is currently described as Mediterranean, with cool wet winters and mild to hot dry summers.

The western extent (South Australia) of the ecological community occurs in the E1 agro-climatic classification and the eastern extent (Victoria) of the ecological community in the D5 agro-climatic classification of Hutchinson et al. 2005 (Table 1).

**Table 1.** Agro-climatic classes associated with the Karst Springs and Alkaline fens

Agro-climate class	Agro-climate	Location and main land uses
E1	Classic “Mediterranean” climate with peaks of growth in winter and spring and moderate growth in winter	Southern South Australia: Forestry, horticulture, winter cropping, improved pastures
D5	Moisture availability high in winter-spring, moderate in summer, most plant growth in spring	Southern Victoria: Forestry, cropping, horticulture, improved and native pastures

Source: Hutchinson et al. (2005).

The coastal plains have a median annual rainfall of 714mm near Mt Gambier SA and 835mm at Portland in Victoria. Rainfall for this region is strongly seasonal, occurring predominantly in winter (Table 2). The seasonal climate predisposes the region to summer fires but fire regimes are likely to have changed substantially since non-Indigenous settlement.

Areal (potential) evapotranspiration<sup>6</sup> rates for these regions are >1000mm/year with evaporation exceeding rainfall in the non-winter months and extremely high evaporation rates in cleared areas (Paydar 2009; Sinclair Knight Merz 2009; BOM 2019). The unconfined aquifer which supplies groundwater to the ecological community is recharged when winter precipitation exceeds evapotranspiration, which is typically between May and September (Mustafa et al 2012).

**Table 2.** Evapotranspiration, mean rainfall and mean temperature across the range of the ecological community

Weather station	Period	Evapotranspiration (mm)	Rainfall (mm)	Temperature (°C)
<b>Mount Gambier Aero SA</b>				
	January	≥70mm	27.0	25.4
	July	≥30mm	100.6	13.2
	Annual	>1000mm	713.7	19.0
<b>Portland Vic</b>				
	January	≥70mm	35.6	21.8
	July	≥30mm	108.3	13.6
	Annual	>1000mm	835.1	17.8

Source: BOM (2019).

<sup>6</sup> Evapotranspiration is sometimes used interchangeably with evaporation. However, evaporation refers to open water surfaces and bare soil, and evapotranspiration refers to land surfaces with vegetation (BOM).

### **2.2.2 Geology and elevation**

The ecological community occurs over the tertiary limestone of the Otway Basin which underlays the near coastal region of south east South Australia and south west Victoria. The Otway Basin formed during the Antarctic–Australian continental separation about 65 million years ago (Paleogene) and contains the Gambier Limestone formation and minor Bridgewater formation<sup>7</sup> (Grimes 1994; Birch 2003). These Tertiary marine limestones were deposited approximately 15-35 million years ago (during the Oligocene and early Miocene) (Scholz 1987; Grimes et al 2009; Wood 2011; Bourman et al 2016). Gambier Limestone thickness ranges from several metres in the north to over 300 m at the coast (Harris 1983).

Dissolution of the underlying Gambier limestone<sup>8</sup> bedrock in combination with fluctuating sea levels and water tables from  $\approx$  2.6 million years ago (during the Quaternary) and extensive faulting has led to the formation of the karstic landscape (Grimes et al 1999; Butcher 2011; Mustafa et al 2012). Approximately one million years ago (during the Pleistocene epoch) altered sea levels and tectonic uplift further contributed to the formation of a series of calcareous sandstone dunes over the Gambier Limestone and interdunal flats. Basalt lava deposited during the Pliocene-Holocene (and as recently as 5000 years ago) overlay the onshore sediments of the Otway Basin in the newer Volcanic Province that extends through the adjacent areas of western Victoria. The present eroded upper surface of the domed Gambier Limestone is elevated approximately 80 m above sea level near Mount Gambier and extends 75 m below sea-level about 5 km offshore.

Much of the onshore Gambier limestone region is characterised by a series of stranded beach dune ridges parallel to the coastline. The low lying flat porous shallow surface soils that extend inland of the coast range from calcareous sand, fine textured saline soils, loam to localised areas of alkaline peats overlaying the Tertiary and Quaternary limestone (Payder et al 2009; White 2010; Wood 2011). Elevation of the south east South Australian and south west Victorian coastal region where the ecological community occurs is generally <60 m (Table 3) with a gradual relief and gradient toward the sea.

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<sup>7</sup> The Bridgewater Formation is a series of Quaternary formed calcareous dune ridges that run parallel to the coast and that rise up to 30 m above the adjoining plains.

<sup>8</sup> Limestones in this region fall into two groups, both relatively young: Tertiary (mainly Miocene) limestones of the Gambier Limestone and its equivalent Port Campbell Limestone (Victoria), and the younger Quaternary calcareous dune limestones of the Bridgewater Formation and associated calcareous marine and coastal sediments of the interdune flats.

**Table 3.** Elevation where the ecological community occurs in the coastal regions of south east South Australia and south west Victoria.

Location	Elevation (above sea-level)
Drik Drik Vic	48 m
Nelson Vic	20 m
Portland Vic	55 m
Lake Momebeong Vic	4-6 m
Long Swamp Vic	0-2 m
Port MacDonnell SA	5 m
Clarke Park SA	0-2 m
Eight Mile Creek SA	2-4 m
Ewens Ponds SA	4-6 m
Pick Swamp SA	2-4 m
Piccaninnie Ponds SA	0-2 m

Source: BOM (2019).

### 2.2.3 Hydrology

Groundwater<sup>9</sup> moves from the higher recharge points in the landscape towards the lowest areas, where discharge normally occurs through sedimentary aquifers. The highly transmissive, porous and permeable nature of the underlying sedimentary Gambier limestone of the south east South Australian and south west Victorian coastal region results in substantial groundwater flow rather than surface flow (Grimes 1994; Butcher et al 2011; Lewis pers comm 2018; White pers comm 2018). These regions typically have few natural surface drainage channels in the form of rivers or streams. The exception is the Glenelg River and a small number of short perennial streams originating from springs (Wood 2011). The water table is typically high near the coast and discharged at a number of locations through natural terrestrial springs that support the ecological community, as well as submarine discharge off the coast (White 2010; Wood 2011). Much of the coastal region, given the shallow depth to groundwater and relatively high winter rainfall, was historically inundated by groundwater and seasonally by surface water to form permanent and semi-permanent wetlands particularly when drainage was impeded by the coastal dunes (Butcher et al 2011).

Groundwater flow within this region of south east South Australian and south west Victorian occurs in two main regional aquifer systems: an upper unconfined Tertiary limestone aquifer (TLA), and a deeper Tertiary confined sand aquifer (TCSA). The two aquifer systems are separated by a low permeability aquitard in the south east and generally consisting of the Narrawatruk Marl formation and the upper carbonaceous clay of the TCSA (Mustafa pers comm

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<sup>9</sup> Groundwater is subsurface water that occurs beneath the watertable in soils and geologic formations that are fully saturated.

2018). The Gambier Limestone and younger overlying limestones of the Otway Basin form the main unconfined aquifer system (Grimes 1994; DEWNR 2014). Recharge of the unconfined aquifer occurs from the infiltration of regional rainfall generally between May and September when winter precipitation exceeds evapotranspiration. Direct drainage of surface water via natural sink-holes and other solution tubes also occurs in some areas and by lateral groundwater flows from northeast to southwest toward the coast (Wood 2011; Mustafa et al 2012). A proportion of groundwater within the TLA originates from the laterised Dundas Tablelands (Table 3) which occurs east of the Kanawinka fault-line in south west Victoria and is dissected by the Glenelg and Wannon Rivers and their tributaries (Costar et al 2017; DEWNR 2014).

The Karst Freshwater Springs and Alkaline Fens ecological community is intrinsically connected with the broader regional hydrology and geology. Wood (2011) and Mustafa et al (2012) noted that the source of ground water discharge for the ecological community can vary from shallow and seasonal to deep and perennial. Shallow systems have a strong dependence on seasonal groundwater discharge from the upper regional Tertiary Limestone Aquifer and can fluctuate in volume. Deep perennial systems, while having a strong dependence on the upper Tertiary Limestone Aquifer, may also be partially fed by discharge from deeper parts of the same aquifer. Many examples of flow for the ecological community would have historically discharged into the surrounding soil or terminal lakes with a few patches having small natural outlet streams to the sea. Constant groundwater discharge from the Karst Springs and Alkaline Fens inundated the surrounding landscape (Butcher et al 2011) prior to the landscape and hydrological changes that have occurred in recent times.

Groundwater in the region which supplies the ecological community is typically low in salinity but may fluctuate due to the season and proximity to the saltwater/freshwater interface near the coast. The interface occurs where fresh groundwater flowing toward the coast is diverted upwards by a wedge of dense marine saltwater at the bottom of the aquifer, contributing to aquifer discharge from the springs. Discharge volumes from the springs typically range from 20 m<sup>3</sup>/day in the less permeable parts of the aquifer to more than 25 000 m<sup>3</sup>/day. Water age discharged from springs near the coast can vary from at least 23 years, to more than 37 years (Wood 2011; Rigosi et al 2015). A study published in 1990 showed that water temperature regardless of depth typically ranged from 15-17°C depending on season (Scholz 1990).

### **2.3 Vegetation**

The Karst Springs and Alkaline Fens exhibit a range of biological components that can occur in broad interconnected habitats: An open water or aquatic zone; a transition zone which, depending on pool depth, contains an inner submergent zone and/or outer emergent zone; and a fringing zone. Due to the consistent delivery of groundwater inputs to the ecological community, these zones tend to be permanent unless hydrological flows and quality are disrupted. The adjacent hydrological influence of the springs extends into the surrounding soils of the fringing zone and results in the occurrence of rare and unique terrestrial vegetation assemblages and species.

### **2.3.1 Open water zone**

When present, the ecological community within the central permanent open freshwater / aquatic zone is restricted to aquatic species due to spring water depth such as in a drowned sinkhole (fissures in the limestone bedrock) or deep terminal lake. Although typically representing a small surface area, the presence of flooded karst systems is a key feature of the ecological community (Butcher et al 2011). The submerged assemblage of aquatic vegetation within spring pools is considered unique to this ecological community (Bonifacio and Pisanu 2013; Keith et al 2013; Bachmann et al 2015). Free-floating macrophytes<sup>10</sup> such as duckweeds, e.g. Common Duckweed (*Lemna disperna*), Floating Ivy leaf Duckweed (*Lemna trisulca*), can also be evident on the surface and extend into the emergent zone on pool fringes. However, the pools are generally dominated by Phytoplankton (algae) at depth. Phytoplankton in the aquatic zone include species such as *Batrachospermum boryanum* and *Enteromorpha intestinalis* and from the genera *Anabaena*, *Cladophora*, *Enteromorpha*, *Lyngbya*, *Oscillatoria*, and *Spirogyra*.

### **2.3.2 Submergent zone**

The vascular plant species present in this zone vary according to water depth, the degree of the pool floor slope and the substrate type they are attached to i.e. peat or silt or rock. With increasing depths beyond three metres, where species transition from the peripheral emergent zone to the submergent zone, true aquatic plant species first become evident attached to the floor and sides of pools. Macrophytic species can occur down to six metres and include helophytes<sup>11</sup> such as Water Ribbons (*Cyanogeton procerum*, *Triglochin striata*), Sea Tassel (*Ruppia polycarpa*), *Hydrocotyle* spp such as Pennywort (*Hydrocotyle verticillata*) and River Buttercup (*Ranunculus inundatus*). Other macrophytic species include Common Spike Rush (*Eleocharis acuta*) and Water Mat (*Lepilaena cylindrocarpa*). In some locations where water depth is generally less than six metres and the pool floor is quite broad, extensive beds of macrophytes can occur. However, some species may extend to greater depth due to water clarity and sediment substratum, for example, the submerged perennial macrophytes Water-Milfoil (*Myriophyllum propinquum*, *M. simulans*, *M. variifolium*) can be present to seven metres and Fennel Pondweed (*Stuckenia pectinatus*) to 15 metres in deep caverns sometimes covered by *Cladophora* sp. (Scholz 1990; Thurgate 1995; Butcher et al 2011).

Vascular (aquatic) plants generally become increasingly sparse as water depth increases beyond five metres (Butcher et al 2011). Below approximately six metres algae, such as *Batrachospermum boryanum* (a red algae), *Chaetomorpha linum*, *Chara globularis*, *Cladophora aegagropila*, *Enteromorpha intestinalis*, *E. prolifera* and the genera *Anabaena*, *Lyngbya*, *Nitella*, *Oscillatoria*, *Porphyropsis* and *Vaucheria* transition as the dominant growth form and often in dense mats (Scholz 1990; Thurgate 1995; Butcher et al 2011; Frood and Papas 2016). Mosses, such as *Cratoneuropsis relaxa*, *Distichophyllum microcarpum* and *Fissidens rigidens*, may be present on limestone outcrops and floors of submerged caverns to depths exceeding 15 metres

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<sup>10</sup> Macrophytes are plants that have adapted to living in aquatic environments.

<sup>11</sup> Helophytes are aquatic plants that are rooted in submerged substrate, but with leaves above the waterline.



(Scholz 1990; Thurgate 1995; Butcher et al 2011; Bachmann et al 2015). Epiphytic algal growth can also occur on genera such as *Ranunculus*, particularly when reduced water flow occurs.

### **2.3.3 Emergent and fringing zone (Fens)**

The central open water and/or submergent zones transition with decreasing depth into waterlogged soils in the emergent zone fringing the karst springs. The saturated alkaline soils can support a continuum of dense fen vegetation that ranges from reedbeds, sedgeland and herblands to shrublands (Jones 1978; Bachmann 2002; Ecological Associates 2009; Keith et al 2013; Bachmann et al 2015; Froud and Papas 2016). The inundated emergent zone occurs as a dense herbaceous verge of reeds, sedges and rushes which include emergent macrophytic species, such as twig-rushes (*Baumea articulata*, *B. arthropphylla*, *B. juncea*, *B. rubiginosa*), Leafy Twig-rush (*Cladium procerum*), *Cyperus laevigatus*, Slender Spike Sedge (*Eleocharis gracilis*), Common Reed (*Phragmites australis*), Swamp Weed (*Selliera radicans*), Three-square (*Schoenoplectus pungens*), Shiny Bog-sedge (*Schoenus nitens*) and Bull-rush (*Typha domingensis*).

As sedgeland transitions to shrubland, the overstorey is typically dense, particularly in wetter older stands. Silky Tea-tree/Wereo/Wiriyu/Woolly Tea-tree (*Leptospermum lanigerum*) is commonly the dominant canopy species (typically 3-6 m but up to 10 m) due to its preference for moist to wet conditions. Other species that are tolerant of waterlogging which may co-occur in the canopy include Scented Paperbark (*Melaleuca squarrosa*), Swamp Paperbark (*M. ericifolia*) and Tree Everlasting (*Ozothamnus ferrugineus*). Tree species such as Swamp Gum (*Eucalyptus ovata*) can sporadically occur. Dominant understorey species include tall tussock sedges such as Cutting Grass (*Gahnia trifida*) and Tall Saw-sedge (*Gahnia clarkei*) e.g. on the less waterlogged edges of the fringing zone.

The fringing zone provides habitat for herbaceous species including Grass Daisy (*Brachycome graminea*), *Centella cordifolia*, Variable Willow-herb (*Epilobium billardierianum* ssp. *billardierianum*), Bidgee-widgee (*Acaena novae-zelandiae*), Angled Lobelia (*Lobelia alata*), Creeping Brookweed (*Samolus repens*), Fireweed (*Senecio biserratus*), Australian Native Violet (*Viola hederacea*) and genera such as *Cotula*, *Hydrocotyle* and *Cynnogeton* (Bachmann 2002; Ecological Associates 2009; Butcher et al 2011; Keith et al 2013; Bachmann et al 2015; Froud and Papas 2016). The ecological community also provides habitat for orchids such as the vulnerable Swamp Greenhood (*Pterostylis tenuissima*) which grows exclusively under the dense canopy of Silky Tea-tree/Woolly Tea-tree in the alkaline peat fens of the ecological community. Other orchid species include the Swamp Helmet Orchid (*Corbas* sp. aff. *diemenica*), Maroon Leek-orchid (*Prasophyllum frenchii*) and Small Sickie Greenhood (*Pterostylis* sp. aff. *falcata*). As the shrub canopy density increases, the groundlayer can become sparse due to shading and competition.

### **2.3.4 Channel and riparian vegetation**

Some complexes have small natural connecting channels between spring pools, for example Ewens Ponds and Piccaninnie Ponds. In addition, many occurrences of the ecological community now have outflow streams that drain into the marine environment. These streams are typically fast flowing and can support submergent aquatic vegetation such as *Chara* and *Ruppia* species

and emergent plants such as *Hydrocotyle*, *Ranunculus*, *Schoenoplectus*, *Triglochin*, *Typha* and *Vallisneria* species. The riparian areas of the streams support similar species to the fringing zones of the spring pools i.e. sedges (*Isolepis*), rushes (*Juncus*) and reeds (*Phragmites*) and *Leptospermum* shrublands. As the outflow streams pass through coastal dunes toward the marine environment, flora species will transition to more salt tolerant species that are not considered part of the ecological community.

A list of characteristic plants of the ecological community is at Appendix A.

### **2.3.5 Variability and disturbance**

The preceding description of the vegetation generally relates to the less disturbed, or ‘reference’ occurrences of the Karst Freshwater Springs and Fens. In many locations there has been substantial disturbance to the ecological community, which is also reflected in its current state: drainage, clearance, with hydrological history and management including grazing having had a strong influence on the current structural and floristic composition of the ecological community (Foulkes and Heard 2003; Taylor 2006; Bachmann et al 2016; Butcher and Brookes 2018).

Australia typically has a low annual rainfall, high evaporation and high rainfall variability. As a result, many freshwater wetlands are ephemeral with few having relatively stable water levels and permanence such as the Karst Spring and Alkaline Fens (Briggs 1981). Wetland dependant plants within the ecological community range from aquatic, emergent to fringing terrestrial species. Obligate aquatic species such as free floating and submergent flora require permanent inundation while emergent to fringing species such as shrubs experience intermittent inundation.

The terrestrial vegetation structure of the Karst Springs and Alkaline Fens varies from closed shrubland to sedgeland and aquatic herbland. The local expression of the ecological community is influenced by the quality and quantity of permanent groundwater and surface water, salinity and pH, history of inundation, disturbance regimes and both local and regional land management. Many remnant patches of the ecological community contain regrowth from past clearance, hydrological disruptions or other disturbances. Some occurrences, for example where natural hydrological regimes have been re-established e.g. where drainage has been impeded, may initially be expressed primarily as sedgeland with very sparse shrub canopy (<10% crown cover). Other areas may occur as dense shrublands of predominantly Silky Tea-tree (*Leptospermum lanigerum*) with sparse understorey.

Not all zones will necessarily be present within the same location due to variations in local hydrology, elevation, substrate and landscape position. In low relief, low altitude areas where karst pools may be present, for example Piccaninnie Ponds and Ewens Ponds, the biological associations can include all zones. However, in elevated areas with higher relief, such as the riparian areas in western Victoria, large aquatic pools are not necessarily present, and the ecological community may only contain an emergent and/or fringing zone in and/or adjacent to a seep. With the continual discharge of groundwater from the ecological community into fringing zones, other adjacent wetland types and riparian vegetation near watercourses can be contiguous due to their proximity and hydrological connection.

The structure and composition of the ecological community varies in response to groundwater or disturbance. High water tables stimulate emergence of native wetland species that leads to development of a sedgeland and/or dense shrubland layers. Increased and prolonged water levels may also temporarily remove or reduce a Tea-tree canopy but can also stimulate their regeneration from lignotuber resprouts in areas fringing the new emergent zone. The diversity in the shrubland can decrease over time, as species with short to medium generation lengths and high light requirements progressively decline as overstorey density increases. Eventually a lower diversity mature form establishes.

Other disturbances such as hydrological variability, in combination with grazing, also lead to shifts in vegetation structure and composition. These potentially lead to changes in plant species composition away from the ecological community; for instance, through the conversion of fens into native and/or exotic pasture (Butcher et al 2011).

## **2.4 Faunal components**

The Karst Spring and Alkaline Fens occurs near the boundary between two major Australian biogeographic regions: the temperate southern and eastern Australia Bassian region and the semi-arid inland Eyrean region. This area, which occurs across the South Australian south-east and Victoria's south-west border, is recognised as a national biodiversity hotspot. The Karst Springs and Alkaline Fens provides diverse habitats for a range of aquatic, terrestrial and volant vertebrates and invertebrates that rely on permanent or near permanent wetlands. The Karst Springs and Alkaline Fens provide food, shelter, breeding, nesting habitats and other resources for fauna over all or part of their life cycles. Some characteristic species such as the White-faced Heron (*Egretta novaehollandiae*) and Tiger Snake (*Notechis scutatus*) are widely distributed, while others, such as the Swamp Antechinus (*Antechinus minimus maritimus*) and the Glenelg Spiny Freshwater Crayfish (*Euastacus bispinosus*), have specialised habitat niches and more restricted ranges. Most fauna species that are a part of the ecological community also use adjacent or nearby habitats, such as other kinds of wetlands, sedgelands, shrublands and woodlands.

### ***Mammals***

The closed shrub canopy and sedge layers of the ecological community support a range of mammal species. Volant species such as microbats typically forage for insects over a variety of habitats including shrubland canopy and edge zones, over pools, outflow creeks and fens. The south east region has the highest bat species richness for South Australia (Foulkes and Heard 2003). Microbat species include the critically endangered Southern Bent-wing Bat (*Miniopterus schreibersii bassanii*) which prefers wetland foraging habitat, the Lesser Long-eared Bat (*Nyctophilus geoffroyi*), South-eastern Free-tailed Bat (*Ozimopus planiceps*) and Gould's Wattled Bat (*Chalinolobus gouldii*). The Karst Springs and Alkaline Fens is also known to provide habitat for the Large-footed Myotis (*Myotis macropus*) which forages for small fish, prawns and aquatic insects by trawling water surfaces with its feet.

Mammals, dependant on damp or wet habitats such as the Karst Springs and Alkaline Fens, include the carnivorous Swamp Antechinus (*Antechinus minimus maritimus*) and the

predominantly carnivorous and amphibious Rakali/Water Rat (*Hydromys chrysogaster*). Other mammal species likely to occur in the ecological community are the herbivorous Swamp Rat (*Rattus lutreolus*) and the omnivorous Bush Rat (*Rattus fuscipes*). These mammals utilise the clumping and dense aquatic and terrestrial ground cover of the ecological community for foraging and shelter. The nocturnal Bush Rat is likely to also pollinate flowers while feeding on nectar. The Swamp Antechinus is particularly reliant on Silky Tea-tree (*Leptospermum lanigerum*), a key dominant in the fringing component of wetlands such as the Karst Spring and Alkaline Fens.

### *Birds*

The continual discharge of fresh groundwater from the Karst Springs into the associated Alkaline Fens supports habitat for roosting, foraging and breeding for at least 140 bird species. The ecological community occurs across diverse habitats ranging from deep expanses of freshwater, floating vegetation in lakes, flowing water in outlet channels, shallow water sedgeland, herblands and grasslands to dense shrublands. The ecological community includes numerous bird groups from coastal shrublands, open woodlands and grasslands, sedgelands and wet shrublands, migratory waders and waterbirds (Foulkes and Heard 2003, Butcher et al 2011, DELWP 2017).

The Karst Springs and Alkaline Fens provides habitat for at least 79 waterbird species including at least 19 migratory species listed under international agreements with China - CAMBA (9), Japan - JAMBA (9), the Republic of Korea - ROKAMBA (10) and the Bonn Convention - BONN (9) (Butcher et al 2011, DELWP 2017).

Various waterbird feeding and dietary guilds are present within the ecological community and include brolga, coots, ducks, egrets, grebes, herons, ibis, rails, spoonbills and waterfowl. The fresh water and dense cover of Cutting Grass (*Gahnia trifida*) also attracts cryptic waterbirds such as the Australian Spotted Crake (*Porzana fluminea*), Australasian Bittern (*Botaurus poiciloptilus*) and Latham's Snipe (*Lewinia pectoralis*) (Butcher et al 2011). The Karst Springs and Alkaline Fens also acts as an important refuge for birds from more arid regions, during drought in other parts of south east Australia as well as a stopover for migratory waders (Foulkes and Heard 2003).

Waterbird breeding patterns are closely tied to seasonal patterns for water availability, food resources and nesting habitat. The consistent flooding patterns of the aquatic component of the Karst Springs and Alkaline Fens provide resources to support breeding for at least ten waterbird species including: Black Swans (*Cygnus atratus*), Brolga (*Grus rubicunda*), Magpie Geese (*Anseranas semipalmata*), Masked Lapwings (*Vanellus miles*) and Musk Ducks (*Bizura lobata*). Black Swans and Brolgas build their nests from grass and reedy material on small islands or directly on shallow waters (Brolgas), or deeper water (Black Swans). Brolgas are listed as threatened in South Australia and Victoria with populations in Victoria estimated at between 600 – 700 individuals (DELWP 2017b).

The high invertebrate abundance and diversity within the ecological community supports insectivore species such as the Beautiful Firetail (*Stagonopleura bella*), Southern Emu-wren (*Stipiturus malachurus*), Superb Fairywren (*Malurus cyaneus*) and thornbills (*Acanthiza* spp). The terrestrial and aquatic vegetation supplies seeds, fruit and other material for herbaceous

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species such as the Australian Wood Duck (*Chenonetta jubata*), Buff-banded Rail (*Gallirallus philippensis*), Lewin's Rail (*Lewinia pectoralis*) and Purple Swamphen (*Porphyrio porphyrio*). The aquatic macrophytes within the ecological community provide breeding and shelter for macroinvertebrates, frogs and fish (Harding and de Jong (2007). These support omnivore bird species such as the Australian Shelduck (*Tadorna tadornoides*), Grey Teal (*Anas gracilis*) and Pacific Black Duck (*Anas superciliosa*). The Karst Springs and Alkaline Fens was also at least previously a winter roosting and feeding habitat for the critically endangered Orange-bellied Parrot (*Neophema chrysogaster*) after migration from breeding sites in Tasmania (Foulkes and Heard 2003, Butcher et al 2011).

### ***Amphibians***

The Karst Spring and Alkaline Fens provide diverse breeding and foraging habitat for at least nine frog species including the Common Eastern Froglet (*Crinia signifera*), Smooth Frog (*Geocrinia laevis*), Spotted Grass Frog (*Limnodynastes tasmaniensis*) and Painted Frog (*Neobatrachus pictus*). *Litoria raniformis* (Growling Grass Frog), listed as nationally vulnerable, breeds in spring and summer in this part of its range. The species' preference for permanent still or slow flowing freshwater bodies is important for its long tadpole phase while thick vegetation allows the species to overwinter close to these water components. Favoured sites frequently have a large proportion of emergent, submerged and floating vegetation, which is a characteristic of some examples of the ecological community such as Piccaninnie and Ewens Ponds (Clemann and Gillespie 2012). Amphibians provide food for cryptic bird species such as the Australasian Bittern (*Botaurus poiciloptilus*) and Lewin's Rail (*Rallus pectoralis pectoralis*), as well as for other birds, reptiles and mammals.

### ***Reptiles***

The Karst Springs and Alkaline Fens ecological community includes many snakes, lizards and turtles. Lizards that are commonly a part of the ecological community include the Eastern Three-Lined Skink (*Acritoscincus duperreyi*), Southern Water Skink (*Eulamprus tympanum*) and White's Skink (*Liopholis whitii*). Lizards currently listed as threatened at the state level include the Eastern Mourning Skink (*Lissolepis coventryi*) and Glossy Grass Skink (*Pseudomoia rawlinsoni*) which is at its western extent and favours sedgelands dominated by Cutting Grass (*Gahnia trifida*) tussocks. The common Eastern Long-Necked Turtle (*Chelodina longicollis*) feed on frogs and macroinvertebrates within the various flooded components of the ecological community such as sedgeland and outlet streams. Snakes present in many patches of the ecological community include the Lowland Copperhead (*Austrelaps superbus*) and Tiger Snake (*Notechis scutatus*). These species are top predators that feed on frogs, lizards, eggs, small and juvenile birds and other animals present in the ecological community.

### ***Fish***

The Karst Springs and Alkaline Fens provide important resources for fish such as food and migration pathways, spawning grounds and nursery areas. When present, the aquatic zones of the ecological community provide habitat for up to 24 fish species (Hammer et al 2009; Hammer et al 2011; Veale and Whiterod 2014). Several functional groups are present ranging from obligate freshwater specialists such as the Southern Pygmy Perch (*Nannoperca australis*) and Dwarf

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Galaxias (*Galaxiella pusilla*), estuarine species such as the Tamar River goby (*Afurcagobius olorum*), Western Bluespot Goby (*Pseudogobius olorum*), to estuarine/marine species such as Black Bream (*Acanthopagrus butcheri*) and Jumping Mullet (*Liza argentea*). Several diadromous species, including the Southern ShortFin Eel (*Anguilla australis*), Pouched Lamprey (*Geotria australis*), Grayling (*Prototroctes maraena*) and Congolli (*Pseudaphritis urvillii*) migrate between the freshwater springs and marine systems to complete their lifecycles (Hammer et al 2008; Butcher et al 2011). Four fish species in the ecological community are currently classified as nationally vulnerable: Australian Grayling (*Prototroctes maraena*), Dwarf Galaxias (*Galaxiella pusilla*), Yarra Pygmy perch (*Nannoperca obscura*) and Variegated Pygmy Perch (*Nannoperca variegata*). Veale and Whiterod (2014) described eight species as regionally threatened.

The ecological community includes short lived fish species such as the Dwarf Galaxias, Common Galaxias (*Galaxias maculatus*) and Small Mouthed Hardyhead (*Atherinosoma Microstoma*), which reach maturity within one year. The ecological community also contains longer-lived species such as the Southern Pygmy Perch which can live up to five years and the Southern Short Fin Eel up to 24 years.

Many fish species within the ecological community have particular habitat preferences. For example, Yarra Pygmy Perch has a strong preference for highly vegetated habitats such as the dense zones fringing springs and outlet streams. The Spotted/Trout Galaxias (*Galaxias truttaceus*), prefers cool flowing freshwater at lower altitudes and the Australian Grayling (*Prototroctes maraena*), prefers deep clear pools. Both of these fish species are at the western edge of their South Australian range in the ecological community. Areas with shallow water (~ 0.1 m) provide habitat for small-bodied native fish, notably Dwarf Galaxias.

### ***Invertebrates***

The persistence of permanent freshwater in the Karst Spring and Alkaline Fens and the various terrestrial and aquatic zones around them provide habitat for a diverse invertebrate fauna.

Typically the aquatic components of the community are dominated by amphipods (*Austrogammarus*, *Paracalliope*, Corophiidae and *Austrochiltonia*), blackflies (*Simulium*), caddisflies (*Notalina* and *Triplectides*), damselflies (*Austroagrion* and *Austrolestes*), dragonflies, dytiscid beetles, chironomids, marsh flies, mayflies (*Atalophlebia*, *Centroptilum* and *Nousia*), native snails (*Angrobia* and *Glyptophysa*), pea mussels (Sphaeriidae), stone flies (*Austrocerca* and *Dinotoperla*), water mites (*Oxus*) and waterbugs and beetles (Coleoptera) (Foukes and Heard 2003; EPA 2014a).

The shallower ponds of the ecological community also provide habitat for crustaceans and macro-invertebrates that use submerged and emergent aquatic macrophytes such as *Myriophyllum* spp., *Triglochin* spp. and *Juncus kraussii*. Crustaceans include the Burrowing Crayfish (*Engaeus strictifrons*), freshwater shrimp (*Paratya*), freshwater crabs (*Amarinus*), Swamp Yabby (*Charax*) and the nationally endangered Glenelg Spiny Freshwater Crayfish (*Euastacus bispinosus*) (Ecological 2009; EPA 2014a). The Glenelg Spiny Freshwater Crayfish is at its most western extent and the ecological community provides its main habitat in south Australia.

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The Karst Springs and Alkaline Fens provides preferential habitat for butterflies in the family Nymphalidae (brush-footed butterflies). Sedges, especially *Gahnia* species, are an important flora component within the ecological community and are the dominant food plant for *Hesperillini* Skippers and several brown butterflies (Caton et al 2011; Grund 2019). Other skippers that are dependent on *Gahnia* sedgelands as food plants for their larvae include *Hesperilla chrysotricha* and *Hesperilla idothea* (Bachman 2002). Other butterfly species present include: Bright-eyed Brown (*Heteronympha cordace wilsoni*), Silver Xenica (*Ori xenica lathoniella herceus*), Striped Xenica (*Ori xenica kershawi kanunda*), Sword-grass Brown (*Tisiphone abeona albifascia*), White-banded Grass-dart (*Taractrocera papyria papyria*) and Flame Sedge-skipper (*Hesperilla idothea idothea*). Some butterfly species are indicators of good wetland health such as the Varied Sedge-Skipper (*Hesperilla donnysa*) and Golden-Haired Sedge-Skipper (*Hesperilla chrysotricha chrysotricha*) (Bachman 2002).

A list of characteristic fauna of the ecological community is at Appendix A.

### 3 SUMMARY OF THREATS

#### 3.1 Primary threats to the ecological community

The Karst Springs and Alkaline Fens have been primarily impacted by historic drainage and clearing for agriculture and forestry (conversion to monoculture plantation), and the remnant areas that remain continue to be under threat from ongoing degradation.

Table 4 summarises the key factors that impact upon the Karst Springs and Alkaline Fens and why this ecological community is considered threatened. This information supports the assessment against the criteria at section 4. Although each threat is presented separately as a list, these threats often interact and can have synergistic impacts upon components of the ecological community.

**Table 4: Summary of threats facing the ecological community**

Threat factor	Threat Status/Impact	Summary
Natural system modifications (hydrological changes)	Timing: Mostly Past/Some Ongoing	<p>Aproximately 55% of the lower south east of South Australia was covered by seasonal and permanent wetland vegetation including the Karst Springs and Alkaline Fens. These interconnecting wetland complexes were extensively modified by a combination of private and government drainage schemes and water extraction from the 1860s. Only about 6% of mixed quality wetlands remain across the Bridgewater subregion.</p> <p>Changes in land use and hydrology have significantly altered the ecology of remaining wetlands, resulting in lower aquifer flows and shallow water table depths. In the Bridgewater Bioregion there has been a shift from dryland agriculture to irrigated cropping and orchards/vineyards. This increases groundwater usage reducing the water table and aquifer flow rates. Expansion of plantation forestry can also contribute to declining water tables and reduced aquifer recharge.</p> <p>Current hydrological groundwater impacts to the ecological community are associated with ongoing drainage and irrigation (such as centre pivots).</p> <p>Historical and ongoing groundwater management practices can facilitate detrimental nutrient levels, algal blooms, eutrophication, chemical pollution and salinity levels. For example, increasing salinity levels have been noted within some components of the ecological community at Spencer Pond (Mustafa et al 2012).</p>
Agriculture (Vegetation clearance and fragmentation)	Timing: Mostly Past/Some Ongoing	<p>The vegetation component of the ecological community has been progressively cleared since European settlement primarily for agricultural use. Forest plantations have been established from about 1900. The ecological community's</p>



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		<p>location on relatively fertile soils, high rainfall and on flats and lower slopes made it a prime target for clearance.</p> <p>Habitat fragmentation and loss of landscape-level connectivity influences the ability of patches to function as habitat. Isolation and poor connectivity of many fragments can make the ecological community highly susceptible to small-scale, cumulative threats that impact either directly on fauna species or indirectly through their resources (e.g. availability of seeds, nectar, prey).</p> <p>Smaller patches of intact vegetation are less likely to support the range of resources required to maintain diverse flora and fauna species. Isolated smaller patches may show lower abundance, diversity and a decline in the number of fauna species detected. Fragmentation can result in populations being broken up into many smaller populations which are at greater risk of local extinctions. For example, Whiterod et al (2015) noted that previously relatively abundant subpopulations of Glenelg Spiny Freshwater Crayfish in the Cress Creek occurrence of the ecological community had substantially reduced. Whiterod and Hammer (2012) found that juvenile crayfish were not detected in three sub-populations at Bones Pond, Jerusalem Creek and Clarke Park occurrences.</p> <p>Smaller remnants are more susceptible to 'edge effects' such as higher levels of weed and feral animal invasion, encroachment of adjoining land use impacts such as spray drift and livestock grazing, resulting in potentially reduced diversity and abundance of native species. Edge effects may arise from activities such as maintenance of access tracks; grazing; weed invasion; and herbicide and chemical drift.</p>
Agriculture (grazing and trampling)	Timing: Ongoing	<p>The Karst Springs and Alkaline Fens ecological community occurs on relatively productive soils, much of which has been converted to pasture and developed for intensive farming industries such as dairy farming. Browsing, preferential grazing and trampling by stock can rapidly damage or change the structure, composition and functionality of the ecological community. Similarly, removal of vegetation affects microclimate, including humidity levels, at ground level.</p> <p>Pugging can alter soil structure, surface drainage and infiltration, impede vegetation regrowth, lead to weed spread and density, and exacerbate the leaching of potassium and nitrogen from the soil.</p> <p>Removal of riparian habitats through unrestricted grazing and trampling can have long-term impacts as it can affect underlying peat layers and bank stability of the ecological community leading to erosion, sedimentation, reduced water quality and increased water temperature. The silting up of</p>

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		<p>outflow streams and drainage beds can have negative consequences for the dispersal and habitat quality of aquatic fauna species.</p>
<p>Invasive and other problematic species, genes and diseases</p>	<p>Timing: Ongoing</p>	<p>The ecological community now typically occurs as isolated occurrences adjacent to heavily disturbed and modified land and drainage channels. As a result, invasive weeds often associated with agricultural and pastoral areas have invaded occurrences. Weed dispersal into the aquatic and/or terrestrial components of the ecological community can occur through numerous vectors including livestock and feral animals, machinery, water, wind and native birds and animals. For example, bird dispersed species such as Arum Lilly (<i>Zantedeschia aethiopica</i>) invade both dry and wet areas of the ecological community.</p> <p>The ecological community is impacted by Weeds of National significance such as African Boxthorn (<i>Lyceum ferocissimum</i>), Blackberry (<i>Rubus fruticosus</i> spp. agg.) and Bridal Creeper (<i>Asparagus asparagoides</i>).</p> <p>In areas where a drying hydrological regime occurs, particularly for long periods, Coastal Wattle (<i>Acacia longifolia</i> var. <i>sophorae</i>) and the introduced native Sallow Wattle (<i>Acacia longifolia</i> var. <i>longifolia</i>) and their hybrids can colonise sites (NVC 2014). Dense infestations of Coastal Wattle may cause up to 75% of indigenous species to be lost from the terrestrial vegetation layer (Butcher et al 2017). The Spiny Rush (<i>Juncus acutus</i>) can quickly invade watercourses and other damp areas and forms dense monocultures which exclude other native species and is indicative of changing hydrological and salinity levels.</p> <p>Several feral animal species, for example foxes, cats, deer, goats, mice, rabbits and rats, have been recorded in and adjacent to the Karst Springs and Alkaline Fens. These invasive species subject the ecological community and the broader landscape to individual and compounding impacts such as predation of native animals, competition for resources, habitat disturbance, weed spread and direct transmission of disease and parasites.</p> <p>Feral herbivores such as rabbits alter the structure and composition of native vegetation communities by selectively removing the most palatable vegetation and removing large amounts of biomass. They compete with native fauna and stock for grasses, herbs and seeds, affect the regeneration of woody trees and shrubs and spread weed seeds.</p> <p>Goats (<i>Capra hircus</i>) and deer (<i>Cervus dama</i> and <i>Cervus elaphus</i>) occur in the region. These species exert high grazing pressure on native vegetation and can impede woody species regeneration by grazing on seedlings and young saplings.</p>

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		<p>They also disperse weeds through their droppings and can cause considerable soil disturbance, and trample ground layer plants, causing changes to the structure of remnant vegetation.</p> <p>Populations of invasive fish species such as Mosquito Fish/Gambusia (<i>Gambusia holbrooki</i>), Marron (<i>Cherax tenuimanus</i>) and Redfin (<i>Perca fluviatilis</i>) are present in the region and have the potential to directly predate on native species, compete for resources and introduce disease and parasites. Predatory fish such as Brown Trout (<i>Salmo trutta</i>) have previously been detected and removed from the ecological community.</p>
Climate change and severe weather	Timing: Ongoing	<p>Changes to climate are likely to impact upon the ecological community through seasonal shifts in temperature and rainfall. This may result in issues such as:</p> <ul style="list-style-type: none"> <li>• decreased recharge of the unconfined aquifer;</li> <li>• reduced groundwater discharge into springs and seeps;</li> <li>• loss of resilience to degradation and fragmentation;</li> <li>• structural and compositional changes of terrestrial and aquatic species;</li> <li>• predominance of exotic plant species and reduced native forb diversity;</li> <li>• higher rainfall areas under increased pressure for cropping;</li> <li>• cascading changes in ecological interactions; and</li> <li>• rising sea-levels leading to inundation and/or increasing groundwater salinity levels.</li> </ul> <p>More extreme climate events such as heat waves and drought will have greater impact upon those native species with limited dispersal ability.</p>
Natural system modifications (Fire-driven habitat change)	Timing: Ongoing	<p>The ecological community can carry fire, even when there is surface water present with some native species such as <i>Leptospermum</i> and <i>Typha</i> species providing major fuel components. Wetland remnants with a high woody weed component, or surrounded by land with high woody weed loads, are particularly susceptible to fire. Fire may contribute to species loss and structural changes to the Karst Springs and Alkaline Fens. For example, a known population of Swamp Antechinus within the ecological community at Cress Creek Bubbling Spring, had its habitat substantially burnt in 2013 (Sweeney 2013).</p> <p>The ecological community contains substantial deposits of peat in some areas that can be many metres deep. Drainage has exposed and dried these peat layers in many areas leading to subsidence. Gill et al (2014) noted that in south east</p>

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		Australia, peat-substrate fires have also been ignited by prescribed and/or unplanned fires. Peat fires have slow rates of spread but can burn for long time periods (up to months) and can have multiple ignition points due to spread of fire in the above ground vegetation.
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### **3.2 Key threatening processes**

Key threatening processes have been defined at the national level under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), and for Victoria under the *Flora and Fauna Guarantee Act 1988*. Those most relevant to the Karst Springs and Alkaline Fens (at May 2020) are listed in Table 5:

**Table 5.** Potentially relevant key threatening processes identified in the *Flora and Fauna Guarantee Act 1988* (VIC) and the EPBC Act.

<b>VIC FFG Act</b>	<b>EPBC Act</b>
<ul style="list-style-type: none"> <li>Alteration to the natural flow regimes of rivers and streams</li> </ul>	
<ul style="list-style-type: none"> <li>Alteration to the natural temperature regimes of rivers and streams</li> </ul>	
	<ul style="list-style-type: none"> <li>Land clearance</li> </ul>
<ul style="list-style-type: none"> <li>Degradation of native riparian vegetation along Victorian rivers and streams</li> </ul>	
<ul style="list-style-type: none"> <li>Habitat fragmentation as a threatening process for fauna in Victoria</li> </ul>	
<ul style="list-style-type: none"> <li>Inappropriate fire regimes causing disruption to sustainable ecosystem processes and resultant loss of biodiversity</li> </ul>	
<ul style="list-style-type: none"> <li>Increase in sediment input into Victorian rivers and streams due to human activities</li> </ul>	
<ul style="list-style-type: none"> <li>Infection of amphibians with Chytrid Fungus, resulting in chytridiomycosis</li> </ul>	<ul style="list-style-type: none"> <li>Infection of amphibians with chytrid fungus resulting in chytridiomycosis</li> </ul>
<ul style="list-style-type: none"> <li>Input of toxic substances into Victorian rivers and streams</li> </ul>	
<ul style="list-style-type: none"> <li>Introduction of live fish into waters outside their natural range within a Victorian river catchment after 1770</li> </ul>	<ul style="list-style-type: none"> <li>Novel biota and their impact on biodiversity</li> </ul>
<ul style="list-style-type: none"> <li>Invasion of native vegetation by Blackberry <i>Rubus fruticosus</i> L. agg</li> </ul>	<ul style="list-style-type: none"> <li>Novel biota and their impact on biodiversity</li> </ul>
<ul style="list-style-type: none"> <li>Invasion of native vegetation by ‘environmental weeds’</li> </ul>	<ul style="list-style-type: none"> <li>Novel biota and their impact on biodiversity</li> </ul>
<ul style="list-style-type: none"> <li>Invasion of native vegetation communities by Tall Wheat-grass <i>Lophopyrum ponticum</i></li> </ul>	<ul style="list-style-type: none"> <li>Novel biota and their impact on biodiversity</li> </ul>

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VIC FFG Act	EPBC Act
	<ul style="list-style-type: none"> <li>Loss and degradation of native plant and animal habitat by invasion of escaped garden plants, including aquatic plants</li> </ul>
<ul style="list-style-type: none"> <li>Loss of biodiversity as a result of the spread of Coast Wattle (<i>Acacia longifolia</i> subsp. <i>sophorae</i>) and Sallow Wattle (<i>Acacia longifolia</i> subsp. <i>longifolia</i>) into areas outside its natural range</li> </ul>	<ul style="list-style-type: none"> <li>Novel biota and their impact on biodiversity</li> </ul>
<ul style="list-style-type: none"> <li>Loss of terrestrial climatic habitat caused by anthropogenic emissions of greenhouse gases</li> </ul>	<ul style="list-style-type: none"> <li>Loss of climatic habitat caused by anthropogenic emissions of greenhouse gases</li> </ul>
<ul style="list-style-type: none"> <li>Predation, habitat degradation, competition and disease transmission by feral pigs (<i>Sus scrofa</i>)</li> </ul>	<ul style="list-style-type: none"> <li>Predation, habitat degradation, competition and disease transmission by feral pigs</li> </ul>
<ul style="list-style-type: none"> <li>Predation of native wildlife by the cat, <i>Felis catus</i></li> </ul>	<ul style="list-style-type: none"> <li>Predation by feral cats</li> </ul>
<ul style="list-style-type: none"> <li>Predation of native wildlife by the introduced Red Fox <i>Vulpes vulpes</i></li> </ul>	<ul style="list-style-type: none"> <li>Predation by European red fox</li> </ul>
<ul style="list-style-type: none"> <li>Prevention of passage of aquatic biota as a result of the presence of instream structures</li> </ul>	
<ul style="list-style-type: none"> <li>Reduction in biomass and biodiversity of native vegetation through grazing by the Rabbit <i>Oryctolagus cuniculus</i></li> </ul>	<ul style="list-style-type: none"> <li>Competition and land degradation by rabbits</li> </ul>
<ul style="list-style-type: none"> <li>Removal of wood debris from Victorian streams</li> </ul>	
<ul style="list-style-type: none"> <li>Soil degradation and reduction of biodiversity through browsing and competition by feral goats (<i>Capra hircus</i>)</li> </ul>	<ul style="list-style-type: none"> <li>Competition and land degradation by unmanaged goats</li> </ul>
<ul style="list-style-type: none"> <li>The spread of <i>Phytophthora cinnamomi</i> from infected sites into parks and reserves, including roadsides, under the control of a state or local government authority</li> </ul>	<ul style="list-style-type: none"> <li>Dieback caused by the root-rot fungus (<i>Phytophthora cinnamomi</i>)</li> </ul>
<ul style="list-style-type: none"> <li>Threats to native flora and fauna arising from the use by the feral honeybee <i>Apis mellifera</i> of nesting hollows and floral resources</li> </ul>	<ul style="list-style-type: none"> <li>Novel biota and their impact on biodiversity</li> </ul>
<ul style="list-style-type: none"> <li>Use of <i>Phytophthora</i>-infected gravel in construction of roads, bridges and reservoirs</li> </ul>	<ul style="list-style-type: none"> <li>Dieback caused by the root-rot fungus (<i>Phytophthora cinnamomi</i>)</li> </ul>
<ul style="list-style-type: none"> <li>Wetland loss and degradation as a result of change in water regime, dredging, draining, filling and grazing</li> </ul>	

Source: DELWP (2019); DotE (2019).

The following approved EPBC threat abatement plans<sup>12</sup> are considered relevant to the Karst Springs and Alkaline Fens (at May 2020):

- Threat abatement plan for competition and land degradation by unmanaged goats;
- Threat abatement plan for competition and land degradation by rabbits;

<sup>12</sup> The threat abatement plan for beak and feather disease affecting endangered psittacine species ceased on 1 October 2015. A non-statutory threat abatement advice is being developed.

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- Threat abatement plan for disease in natural ecosystems caused by *Phytophthora cinnamomi*;
- Threat abatement plan for infection of amphibians with chytrid fungus resulting in chytridiomycosis;
- Threat abatement plan for predation by European red fox;
- Threat abatement plan for predation by feral cats; and
- Threat abatement plan for predation, habitat degradation, competition and disease transmission by feral pigs.

DRAFT

#### 4 THREATENED SPECIES SCIENTIFIC COMMITTEE RECOMMENDATIONS

##### 4.1 Eligibility for listing against the EPBC Act criteria

On the basis of available information, it is recommended that the Karst Springs and Associated Alkaline Fens of the Naracoorte Coastal Plain is eligible for listing as endangered. This was the highest conservation category met at the time of assessment.

##### 4.1.1 Criteria 1 – decline in geographic distribution

Criterion 1. Decline in geographic distribution			
Category	Critically Endangered	Endangered	Vulnerable
Its decline in geographic distribution is <b>either</b> :	very severe	severe	substantial
<b>a)</b> Decline relative to the longer-term (beyond 50 years ago e.g. since 1750); <b>or</b> ,	≥90%	≥70%	≥50%
<b>b)</b> Decline relative to the shorter-term (past 50 years).	≥80%	≥50%	≥30%

##### **Vulnerable**

The ecological community historically occurred as a series of wetland complexes fed by permanent springs connected hydrologically by high water tables and constant freshwater flows from the unconfined tertiary aquifer. Much has been drained and terrestrial peat fens cleared. Published data of the pre-European extent, current distribution and decline are incomplete for the Victorian extent of the ecological community. However, the pre-European extent of the ecological community in South Australia has been estimated to have been about 2058 ha and to have declined to approximately 912 ha (Keith et al 2013, Bachmann et al 2016, Butcher and Brooks 2018). This represents a **substantial** decline of 55% since pre-1750.

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4.1.2 Criteria 2 – limited geographic distribution coupled with demonstrable threat

<b>Criterion 2 - Limited geographic distribution coupled with demonstrable threat</b>			
Its geographic distribution is:	<b>Very restricted</b>	<b>Restricted</b>	<b>Limited</b>
2.1. Extent of occurrence (EOO)	< 100 km <sup>2</sup> = <10,000 ha	<1,000 km <sup>2</sup> = <100,000 ha	<10,000 km <sup>2</sup> = <1,000,000 ha
2.2. Area of occupancy (AOO)	< 10 km <sup>2</sup> = <1,000 ha	<100 km <sup>2</sup> = <10,000 ha	<1,000 km <sup>2</sup> = <100,000 ha
2.3. Patch size <sup>#</sup>	< 0.1 km <sup>2</sup> = <10 ha	< 1 km <sup>2</sup> = <100 ha	-
<b>AND</b> the nature of its distribution makes it likely that the action of a threatening process could cause it to be lost in:			
the Immediate future [within 10 years, or 3 generations of any long-lived or key species, whichever is the longer, up to a maximum of 60 years.]	<b>Critically endangered</b>	<b>Endangered</b>	<b>Vulnerable</b>
the Near future [within 20 years, or 5 generations of any long-lived or key species, whichever is the longer, up to a maximum of 100 years.]	<b>Endangered</b>	<b>Endangered</b>	<b>Vulnerable</b>
The Medium term future [within 50 years, or 10 generations of any long-lived or key species, whichever is the longer, up to a maximum of 100 years.]	<b>Vulnerable</b>	<b>Vulnerable</b>	<b>Vulnerable</b>

<sup>#</sup> A number of patch size measures may be applied here, depending on what data are available.

1) The mean or the median patch area. In cases where the ecological community is highly fragmented and the patch data distribution is skewed towards mostly small patches, the median would be a more appropriate measure. Otherwise, the smaller of the mean or median should be referred to.

2) The proportion of patches that fall within each size class.

3) Changes in patch size and distribution between the modelled pre-1750 and currently mapped occurrences.

**Vulnerable to Endangered**

The ecological community has a **limited** Extent of Occurrence of 361 992 ha (3620 km<sup>2</sup>) and a **restricted** Area of Occupancy of 912 ha (9.1 km<sup>2</sup>). Available size data for individual occurrences (Table 6) indicate the majority (84%) are less than 100 ha (1 km) in size, a threshold that is also indicative of a **restricted** geographic distribution.



**Table 6.** Indicative size distribution for the Karst Springs and Alkaline Fens ecological community in South Australia.

Thresholds		Size range (ha)	No. occurrences	% total occurrences	Cumulative %
Restricted	Very Restricted	≤ 10	10	40	84
		> 10 - ≤100	11	44	
		> 100 - <1000	4	16	
		<b>Total</b>	<b>25</b>	<b>100</b>	

Source: (Keith et al (2013), Bachmann et al (2016); Butcher and Brooks (2018).

The ecological community is faced with a number of demonstrable threats to its long-term viability (Table 4). Remnant wetlands in this region are impacted by ongoing drainage, weed invasion and falling aquifer levels. Occurrences of the ecological community were hydrologically linked seasonally and were part of a complex of intergrading woodlands and wetlands (Stephens 1943; Bachmann 2002; Whiterod et al 2015). The now highly fragmented distribution of the community lies within an agricultural landscape and is very susceptible to edge effects and the cumulative actions of various threats, particularly declining water table, reduced aquifer outputs, increasing nutrient loads and sea-level rise.

The ecological community has a **restricted** distribution; and the nature of its distribution and available evidence suggests that the collective actions of these threatening processes have the potential to cause significant decline in extent and function in the **near to medium term future**.

#### 4.1.3 Criteria 3 – decline of functionally important species

Criterion 3 - Loss or decline of functionally important species			
Category	Critically Endangered	Endangered	Vulnerable
For a population of a native species likely to play a major role in the community, there is a:	very severe decline	severe decline	substantial decline
Estimated decline over the last 10 years or three generations, whichever is longer of:	at least 80%	at least 50%	at least 20%
to the extent that restoration of the community is not likely to be possible in:	the immediate future	the near future	the medium-term future
restoration of the ecological community as a whole is <i>unlikely</i> in	10 years, or 3 generations of any long-lived or key species, whichever is	20 years, or 5 generations of any long-lived or key species, whichever is	50 years, or 10 generations of any long-lived or key species, whichever

	the longer, up to a maximum of 60 years.	the longer, up to a maximum of 100 years.	is the longer, up to a maximum of 100 years.
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### **Insufficient information to determine eligibility**

Healthy occurrences of the ecological community contain aquatic macrophytes, terrestrial shrubland and sedgeland, and peat fen components. Changes in species composition have been driven by changes to freshwater flows from the unconfined tertiary aquifer, in addition to clearance of aquatic and terrestrial vegetation and fragmentation of patches. Although some iconic species such as the Glenelg Spiny Crayfish, Swamp Antechinus and Swamp Greenhood have a strong association with the Karst Springs and Alkaline Fens, there is uncertainty about the functional roles of these species within the ecological community. *Leptospermum lanigerum*, is only one of a mix of species associated with the formation of the alkaline peat fens. Although this species occurs in dense patches, it is mainly restricted to the terrestrial component which fringes the aquatic component.

Whilst there has been significant overall loss of area and degradation of the ecological community, data to support analysis against this criterion, and its indicative thresholds, for loss of particular functionally important species of flora or fauna within remnants is not available. No quantitative analysis has been undertaken that show the removal of any particular aquatic or terrestrial species will result in ecosystem collapse. Therefore, there is insufficient information to determine eligibility for this criterion.

#### **4.1.4 Criteria 4 – reduction in community integrity**

<b>Criterion 4 - Reduction in community integrity</b>			
<b>Category</b>	<b>Critically Endangered</b>	<b>Endangered</b>	<b>Vulnerable</b>
The reduction in its integrity across most of its geographic distribution is:			
as indicated by degradation of the community or its habitat, or disruption of important community processes, that is:	very severe	severe	substantial

### **Endangered**

Many occurrences have been impacted by the degradation or removal of either the aquatic and/or terrestrial peat fen components of the ecological community. There have been substantial losses in extent of the ecological community and most remaining fragments are degraded and continue to be impacted by various threats. For example, freshwater macrophytes within the aquatic component are particularly susceptible to increased nutrient levels, increased salinity and reduced freshwater flows. Historically, the ecological community occurred as a series of springs and associated fens that formed complexes. These complexes would seasonally amalgamate, facilitating broad distribution of many aquatic flora and fauna species. Fragmentation due to

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drainage and clearance has caused a reduction in wetland size, increased the distance between individual occurrences and complexes, exposed more edges and led to greater susceptibility to further disturbances and degradation. For example, Ewens Ponds was part of Eight Mile Creek Complex prior to drainage commencing in the 1940s. The pre-1750 extent of the site was approximately 1400-1700 ha and currently totals only about 29 ha (98% reduction) and has been fragmented into six sites (Stephens 1943; Sweeney 2012; Bachmann et al 2016).

The integrity of the ecological community has been significantly compromised, at both patch and landscape scales through various types of local degradation and past broad scale vegetation clearing and ongoing landscape changes. Continued drainage of springs and decreased groundwater discharge due to changed landuse, reduced rainfall, increased drawdown and reduced aquifer recharge has caused flows within all occurrences to substantially decline. Many occurrences have freshwater flows that have transitioned from permanent to seasonal resulting in declining water quality. Coastline aquifer vulnerability in general is likely to increase due to the sea-level rises and increase in storm surges. Rising salinity levels have been noted in the lower south-east coastal region with Piccaninnie Pond/Pick Swamp complex and Spencers Pond showing evidence of high salinity in some aquifer flows (Mustafa et al 2012).

There has been a reduction in integrity through hydrological changes, increased fragmentation and weed invasion. This has affected ecological processes and resulted in a subsequent decline and/or change to flora and fauna within the ecological community, consistent with a **severe** reduction in integrity across most of its geographic distribution. If these changes are ongoing, it could lead to the eventual loss of the ecological community within the **near future**.

### 4.1.5 Criteria 5 – rate of continuing detrimental change

Criterion 5 - Rate of continuing detrimental change			
Category	Critically Endangered	Endangered	Vulnerable
Its rate of continuing detrimental change is:	very severe	severe	substantial
as indicated by a) degradation of the community or its habitat, or disruption of important community processes, that is:			
or b) intensification, across most of its geographic distribution, in degradation, or disruption of important community processes, that is:			
5.1 An observed, estimated, inferred or suspected <i>detrimental change</i> over the <i>immediate</i> <sup>#</sup> past or projected for the <i>immediate</i> future of at least:	80%	50%	30%

<sup>#</sup>The immediate timeframe refers to 10 years, or 3 generations of any long-lived or key species believed to play a major role in sustaining the community, whichever is the longer, up to a maximum of 60 years.

### **Vulnerable to Endangered**

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The ecological community is undergoing continuing detrimental change arising from threats outlined in Section 3, Description of key threats. Threats associated with human disturbance are likely to increase with growing agricultural and forestry developments and landuse changes. In addition, natural disturbances, such as changes in rainfall volumes and seasonality, are likely to continue impacting the ecological community, including increasing storm severity due to climate change.

The ecological community has undergone a substantial decline in geographic distribution, decline in condition of the ecological community continues and a significant investment in ongoing management is required, in the form of weed control and in some cases supplementary planting and water, to avoid a further increase in the rate of continuing detrimental change.

There is a general trend of reductions in groundwater volumes in the Bridgewater bioregion and the ecological community. The majority of the ecological community is located at the lowest point of the landscape and downstream of agricultural and forestry activities. Groundwater extraction is the primary source for irrigation in the region. During the period 1990-2015, disruption to flow (from permanent to seasonal) within seven (28%) occurrences of the ecological community systems has occurred with subsequent decline in the aquatic component and loss of aquatic species (Bachmann et al 2016; Veale and Whiterod 2018; Harding pers comm). For example, Glenelg Spiny Freshwater Crayfish, which require flowing and well-oxygenated water, have experienced population declines in at least two remnants due to reduced spring flow (Whiterod et al 2015). Monitoring of spring discharge at Piccaninnie Ponds indicates that a critical threshold for the site is likely to be 30-38 megalitres a day (Butcher et al 2011). Similar monitoring at Ewens Ponds also supports the importance of high flow and water quality. Projected spring output indicates that the aquatic component of the ecological community can shift from a macrophyte to algae dominated system when flow declines beyond a critical level.

Changes in landuse in the Bridgewater Bioregion for 1990–2015 include an 8.6% reduction in dryland agriculture, at least a 305% increase in irrigated land and a 33% decrease in wetland area. Given the intensification of irrigation and groundwater demand in the immediate past and actual and projected seasonal shifts in rainfall combined with the continued drainage of areas adjacent to the ecological community and associated subsidence, **serious to severe** ongoing degradation to the ecological community is likely across most of its range.

### **4.1.6 Criteria 6 – quantitative analysis showing probability of extinction**

<b>Criterion 6 - Quantitative analysis showing probability of extinction</b>			
<b>Category</b>	<b>Critically Endangered</b>	<b>Endangered</b>	<b>Vulnerable</b>
A quantitative analysis shows that its probability of extinction, or extreme degradation over all of its geographic distribution, is:	at least 50% in the immediate future.	at least 20% in the near future.	at least 10% in the medium-term future.

**Insufficient information to determine eligibility**

***Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)***

At least 54% of remnant patches are estimated to be at  $\leq 2$  m elevation above current sea-level. Although the estimated 2070 sea-level rise for this location is 0.30 (low) – 0.40 (high) metres, the impacts from direct overland seawater inundation is not likely for the majority ( $< 10\%$ ) of the ecological community due to landscape position, structure of outflow streams and stream volume (CSIRO and Bureau of Meteorology 2015; Coastal Risk Australia 2019).

Direct flooding from sea-level rise can be projected for the ecological community. However, there is little data available for salinity levels and its origins, for example seawater intrusion of groundwater, for most remnant areas. As such, there is insufficient information for the relevant timeframes to determine the eligibility of the ecological community for listing under this criterion.

## **5 CONSERVATION OF THE ECOLOGICAL COMMUNITY**

### **5.1 Identification of the ecological community**

The Karst Springs and Alkaline Fens ecological community intergrades with other vegetation types and ecological communities. Key diagnostic characteristics are used to identify whether the Karst Springs and Alkaline Fens ecological community is present at a particular time and place and define the features that distinguish it from other ecological communities. Additional information to assist with identification is also provided in the other sections of this document, particularly the description (section 2) and Appendix A - Species lists.

In order to be protected as a matter of national environmental significance areas of the ecological community must meet both:

- key diagnostic characteristics (section 5.1.1) AND
- at least the minimum condition thresholds (section 5.2.1)

#### **5.1.1 Key diagnostic characteristics**

The key diagnostic characteristics are designed to allow identification of the ecological community irrespective of the season.

Areas of vegetation that do not meet the key diagnostics are not the nationally listed ecological community.

The ecological community is defined as meeting the following key diagnostic characteristics:

##### Location

The ecological community occurs within the Bridgewater subregion of the Naracoorte Coastal Plain IBRA bioregion and is likely to occur at  $\leq 60\text{m}$  above sea level (ASL).

##### Hydrology

The ecological community is associated with a range of wetland types that are inundated on a permanent to semi-permanent basis depending on their hydrological connection to the unconfined aquifer. This also covers bodies of open water such as spring pools, shallow fens<sup>13</sup>/swamps and outflow channels.

The main groundwater source is from the Gambier Tertiary Limestone unconfined aquifer which includes the Green Point Member, Camelback Member and Greenways Member. Groundwater from limestone aquifers is neutral to alkaline.

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<sup>13</sup> Fens are characterised by pH neutral to alkaline water chemistry usually dominated by grasses and sedges. Bogs are characterised by pH acidic water chemistry and typically dominated by shrubs and mosses.

### Salinity

Water salinity is typically fresh<sup>14</sup>, less than 1000 µS/cm but may range up to 3000 µS/cm due to seasonal influences and may periodically rise to 5000 µS/cm in some patches e.g. during drought. Any occurrences consistently  $\geq 5000$  µS/cm is considered too saline to be part of the ecological community.

### Soil/substrate

Typically silt/loam/peat with some sites containing calcareous sand overlying permeable Tertiary limestone bedrock.

The alkaline hydrological inputs support the formation and retention of peat. Typically peat depth is a function of the persistence of the overlying vegetation and permanent alkaline freshwater inputs.

### Biological assemblages

Generally contains species dependant on habitat that is reliant on the presence of neutral to alkaline freshwater at some stage to complete their life cycle. The assemblages of species present may vary with the landscape position, hydrological regime and water quality. A complex of vegetation types may occur that varies with degree of inundation, including one or more of the following:

Floating aquatic vegetation on open water (e.g. Azolla);

Submergent aquatic vegetation (e.g. milfoil and ribbon weed);

Emergent vegetation and peat fens (e.g. rushes, reeds, sedges). Peat fens can include:

- Aquatic grassland, herbland, sedgeland, reedland, notably
  - Freshwater open aquatic herbland
  - *Gahnia trifida* tussock sedgeland
  - Typha/Phragmites tall aquatic grassland
- Shrublands on peat or fringing the wetlands
  - *Leptospermum lanigerum* tall wet shrubland (SA); Swamp Scrub (Victoria)
  - *Melaleuca squarrosa* wet heathland

Flora species from these vegetation types are part of the ecological community. Historically, Silky Tea-tree/Wereo/Wiriyu/Woolly Tea-tree (*Leptospermum lanisgerum*) was a characteristic species of the fringing vegetation and remains so at many sites. Cutting Grass (*Gahnia trifida*) is also characteristic at many sites. Other characteristic flora species are outlined in Appendix A1 and A2.

The complex of vegetation types within the ecological community provides habitat for numerous fauna notably small mammals, reptiles, aquatic invertebrates, fish and various birds, including waterbirds. The latter includes migratory and colonially-breeding species such as egrets, ibis,

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<sup>14</sup> Salinity refers to total salt concentration and is described using electrical conductivity and measured in microseimens per centimetre (µS/cm). Freshwater is defined as being under 3 000 µS/cm; brackish is defined as between 3 000 and 10 000 µS/cm.

cormorants, herons, spoonbills and ducks. Characteristic fauna species for many sites include the Common Eastern Froglet (*Crinia signifera*), Eastern Long-Necked Turtle (*Chelodina longicollis*), Rakali/Water Rat (*Hydromys chrysogaster*) and Tiger Snake (*Notechis scutatus*). Other characteristic fauna species are outlined in Appendix A3.

While most fauna are not diagnostic for the ecological community, other characteristic animal species that are indicative of good condition include: Swamp Antechinus (*Antechinus minimus maritimus*), Australasian Bittern (*Botaurus poiciloptilus*), Brolga (*Grus rubicunda*), Dwarf Galaxias (*Galaxiella pusilla*), Glenelg Spiny Freshwater Crayfish (*Euastacus bispinosus*), Golden-Haired Sedge-Skipper (*Hesperilla chrysotricha chrysotricha*), Growling Grass Frog (*Litoria raniformis*), Latham's Snipe (*Lewinia pectoralis*), Southern Pygmy Perch (*Nannoperca australis*), Southern Water Skink (*Eulamprus tympanum*), Swamp Rat (*Rattus lutreolus*) and Varied Sedge-Skipper (*Hesperilla donnysa*).

## **5.2 Regulated areas of the ecological community**

National listing focuses legal protection on occurrences or areas of the ecological community that are the most functional, relatively natural and in comparatively good condition. These areas are identified through *minimum condition thresholds*.

*Condition classes* are also used to distinguish between Karst Springs and Alkaline Fens of different qualities, to aid environmental management decisions. The minimum condition thresholds are designed to identify those patches that retain sufficient conservation values to be considered a matter of national environmental significance, to which the referral, assessment, approval and compliance provisions of national environment law apply.

Occurrences or areas of the ecological community that do not meet the minimum condition thresholds (that do not at least meet Class C) are excluded from protection under national environment law. In many cases, the loss and degradation are irreversible because natural characteristics have been permanently removed. However, although not protected under national environment law, many of these patches may still retain some important natural values and may be protected through state and local laws or planning schemes.

In many cases the restoration of wetland ecosystems can be effective as long as water regimes are reinstated. In addition, patches that can be restored should not be excluded from recovery and other management actions. Suitable recovery and management actions may improve a patch's condition, such that it subsequently can be included as part of the ecological community fully protected under national environment law. Management actions should be designed to restore patches to highest quality condition where practical.

When assessing condition of the ecological community it is important to also consider the key diagnostics (section 5.1.1). Table 7 outlines the condition classes that apply to the ecological community. All patches in Classes A, B and C of Table 7 are part of the community.



### 5.2.1 Condition classes and thresholds

The Bioregion and EVC Benchmark for Vegetation Quality Assessment (DSE 2019) provide a framework for assessing the condition of ecological communities in Victoria. Evaluations by Ecological Associates (2009), Deane et al (2015), Gehrig et al (2015) provide a framework for assessing the condition of ecological communities in South Australia. These frameworks provides the basis of the condition classes and thresholds that apply to this ecological community.

**Table 7.** Condition categories and thresholds for the Karst Springs and Alkaline Fens ecological community. Note the key diagnostic features also apply. Condition Classes A, B and C are the defined ecological community.

Condition class	Site components	Minimum patch size
Class A – high quality	Sites with 6 or more site components rated as Category 3	10 ha
Class B – moderate quality	Sites with 4 or more site components rated as Category 2 or 3	0.5 ha
Class C – low quality	Sites with 2 or more site components rated as Category 2 or 3	0.1 ha

  

Site components	Category 1	Category 2	Category 3
Pool depth	≥ 0.1 m	≥ 1 m	≥ 6 m
Flow <sup>1</sup>	Seasonal	Permanent moderate	Permanent high
Nutrient <sup>1</sup>	High	Moderate	Low
Aquatic macrophyte % cover of all standing water <sup>2</sup>	≥ 5%	≥ 20%	≥ 75%
Filamentous algae (Phytoplankton) % cover	≤ 80%	≤ 50%	≤ 10%
Fringing shrub canopy <sup>3</sup> cover %	≥ 5%	≥ 10%	≥ 75%
Woody and herbaceous weed – exotic <sup>4</sup> cover %	≤ 70%	≤ 50%	≤ 5%
Grassy weed – exotic <sup>4</sup> cover %	≤ 70%	≤ 50%	≤ 5%
Peat	Seasonally damp	Constantly damp	Constantly saturated
Characteristic and indicative fauna species <sup>5</sup>	< 3	≥ 3	≥ 9

Notes:

<sup>1</sup>For guidance on flow and nutrients see Ecological Associates (2009), Butcher et al 2011 and Rigosi et al 2015.

<sup>2</sup>Exclude areas with reeds, sedges and other emergent flora, and where depth exceeds 6 m.

<sup>3</sup>Canopy cover is measured as projective foliage cover.

<sup>4</sup>Exotics are measured as projective foliage cover of all non-indigenous species.

<sup>5</sup>See 5.1.1 (Biological assemblages). Many of these fauna species are threatened at the state and/or national level and need to be considered in their own right (Table A3 in Appendix A).

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## **6 PRIORITY RESEARCH AND CONSERVATION ACTIONS FOR KARST SPRING AND ALKALINE FENS**

### **6.1 Principles and standards**

The overarching principle underlying the Conservation Objective and these Priority Actions is that it is preferable to maintain existing areas of the ecological community that are relatively intact and of high quality. There are good, practical reasons to do so. It is typically more cost effective to retain an intact remnant than to allow degradation and then attempt to restore it or another area. The more disturbed and modified a patch of the ecological community, the greater the recovery effort that is required. Also, intact remnants are likely to retain a fuller suite of native plant and animal species, and ecological functions. Certain species may not be easy to recover in practice, if lost from a site.

This principle is highlighted in the National Standards for the Practice of Ecological Restoration in Australia (Standards Reference Group SERA, 2017):

**“Ecological restoration is not a substitute for sustainably managing and protecting ecosystems in the first instance.**

The promise of restoration cannot be invoked as a justification for destroying or damaging existing ecosystems because functional natural ecosystems are not transportable or easily rebuilt once damaged and the success of ecological restoration cannot be assured. Many projects that aspire to restoration fall short of reinstating reference ecosystem attributes for a range of reasons including scale and degree of damage and technical, ecological and resource limitations.”

*Standards Reference Group SERA (2017) – Appendix 2.*

The principle discourages ‘off-sets’ where intact remnants are removed with an undertaking to set aside and/or restore other, lesser quality, sites. The destruction of intact sites represents a net loss of the functional ecological community because there is no guarantee all the species and ecological functions of the intact site can be replicated elsewhere.

Where restoration is to be undertaken, it should be planned and implemented with reference to the *National Standards for the Practice of Ecological Restoration in Australia*. These Standards guide how ecological restoration actions should be undertaken and are available online from the Standards Reference Group SERA (2017)<sup>15</sup>. They outline the principles that convey the main ecological, biological, technical, social and ethical underpinnings of ecological restoration practice.

Conservation and research efforts should also involve members of the Boandik and Gunditjmarra community in the process of planning research, monitoring and conservation actions.

### **6.2 Priority actions**

Priority actions are recommended for the abatement of threats and supporting recovery of the ecological community. As the Karst Spring and associated Alkaline Fens is typically located low in the landscape, actions to protect it often need to consider hydrology and be undertaken both

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<sup>15</sup> Society for Ecological Restoration: [www.seraustralasia.com/standards/contents.html](http://www.seraustralasia.com/standards/contents.html)

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upstream and upslope of the ecological community. These recommended actions are designed to provide guidance for:

- planning, management and restoration of the ecological community by landholders, NRM and community groups and other land managers;
- conditions of approval for relevant controlled actions under national environment law; and,
- prioritising activities in applications for Australian Government funding programs.

Detailed advice on actions may be available in specific plans, such as management plans for weeds, fire or certain parks or regions. The most relevant are listed in section 6.3 below.

This conservation advice identifies priority conservation actions under the following key approaches:

- **PROTECT** the ecological community to prevent further losses;
- **RESTORE** the ecological community by active abatement of threats, appropriate management, restoration and other conservation initiatives;
- **COMMUNICATE, ENGAGE WITH AND SUPPORT** people to increase understanding of the value and function of the ecological community and encourage their efforts in its protection and recovery; and
- **RESEARCH AND MONITORING** to improve our understanding of the ecological community and the best methods to aid its management and recovery.

These approaches overlap in practice and form part of an iterative approach to management that includes research, planning, management, monitoring and review.

The actions below do not necessarily encompass all actions in detail that may benefit the Karst Springs and associated Alkaline Fens of South East Australia ecological community. They highlight general but key actions required to at least maintain survival of the ecological community at the time of preparing this Conservation Advice.

### ***6.2.1 PROTECT the ecological community***

This key approach includes priorities intended to protect the ecological community by preventing further losses to extent and integrity.

- Remnants should be properly taken into account during the early stages of zoning and development planning decisions, including strategic planning documents at state, regional and local levels.
- Liaise with local councils and State authorities to ensure that cumulative impacts on the ecological community are reduced as part of broader strategic planning or large projects (e.g. drainage maintenance, road works, developments, land use changes, groundwater allocation).
- Undertake activities to mitigate and reduce detrimental hydrological impacts to spring flows and water quality.
- Undertake activities to mitigate and reduce detrimental hydrological impacts to outflow creeks and drains.
- Undertake activities to mitigate future climate change and therefore reduce the impacts of climate stress on this ecological community.

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### ***Conserve remaining patches***

- Protect and conserve remaining areas of the ecological community, including protecting potential areas of natural or managed regeneration (e.g. former fen occurrences).
- Avoid hydrological changes that disrupt natural patterns of inundation, overland flows and water table levels, or that increase salinity, nutrient loads, algal blooms, sedimentation/turbidity, peat subsidence or pollution.
- Protect patches identified as the most intact wildlife refuges or of regional importance in formal conservation reserves. Consider other remnants for less formal conservation tenures, preferably ones that aim for protection over the long-term. This includes investigating formal conservation arrangements, management agreements and covenants to protect patches on private land. This is particularly important for larger occurrences or areas that link to other patches of native vegetation and are part of wildlife corridors or migration routes.
- Where regrowth is occurring, provide measures that will support regrowth to maturity (e.g. provide fencing around rather than through wetlands to minimise damage risk).
- Retain other native vegetation remnants, near patches of the ecological community, where they are important for connectivity, diversity of habitat and act as buffer zones between the ecological community and threats or intensive land use zones.
- Retain habitat features for fauna, noting species requirements or particular vegetation structure. For example, a continuous canopy or sub canopy, particularly of *Leptospermum lanigerum* is important for Swamp Antechinus (*Antechinus minimus maritimus*) and Swamp Greenhood (*Pterostylis tenuissima*).

### ***Planning to minimise hydrological impacts and further clearing***

- Liaise with local councils and state authorities to ensure that cumulative impacts on the ecological community are reduced as part of broader strategic planning or large projects (e.g. drainage, weirs, bridges, road works, developments, changes in land use).
- Liaise with planning authorities to promote the inclusion of Karst Springs and Alkaline Fens protection and projected tidal inundation zones in their plans/responses to climate change, sea-level rise, coastal erosion and in coastal zone management generally.

### ***Manage actions to minimise impacts***

Apply the mitigation hierarchy to avoid, then mitigate potential impacts on the ecological community from development or other actions. The priority is to avoid detrimental hydrological changes and further clearance and fragmentation of remnants.

- Plan projects to avoid the need to offset, by avoiding significant impacts to the ecological community.
- In circumstances where impacts cannot be totally avoided, then they should be minimised by:
  - retaining and avoiding damage to high quality patches, which should be managed to retain their benchmark state;
  - protecting groundwater quality and levels;
  - protecting important habitat features, such as dense *Leptospermum lanigerum* shrubland as these take many years to develop and cannot be quickly replaced; and

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- protecting important habitat for threatened species, such as orchids which require particular hydrological regimes and light conditions.
- Avoid activities that could cause significant hydrological change to patches of the ecological community:
  - Avoid constructing levees, culverts, floodgates etc that will lead to permanent detrimental hydrological restrictions to occurrences of the ecological community, or that will otherwise adversely alter existing inundation regimes.
  - Avoid constructing outlets/drains that detrimentally alter the saturation of peat layers in or near occurrences of the ecological community.
  - Avoid building roads, causeways, weirs, bridges and other structures in a way that alters the natural hydrology.
  - Avoid draining of coastal wetlands.
- Minimise the risk of indirect impacts to the ecological community from actions outside but near to patches of the ecological community, for example avoid constructing outlets/drains adjacent to occurrences of the community that will detrimentally alter the saturation of peat layers.

### ***Apply buffer zones***

- Protect and apply appropriate buffers, particularly of other native vegetation, around patches of the ecological community to minimise off-site impacts. A buffer zone is a contiguous area adjacent to an occurrence that is not part of the ecological community but is important for protecting its integrity. As the risk of indirect damage to an ecological community is usually greater where actions occur close to a patch, the purpose of the buffer zone is to minimise this risk by guiding land managers to be aware that the ecological community is nearby and take extra care. For instance, the buffer zone will help protect the ecological community from spray drift (fertiliser, pesticide or herbicide sprayed in adjacent land), weed invasion, polluted water runoff and other damage. The best buffer zones are typically comprised of intact remnants of other native vegetation. Fire breaks and other asset protection zones do not typically provide a suitable buffer and should be additional to a vegetated buffer.
- The recommended buffer zone is 1220 m from the outer edge of the patch as this distance accounts for likely influences upon the broader hydrology (SENRM 2019). A larger buffer zone should be applied, as practical, to protect patches that are of very high conservation value. Or where hydrological impacts to the unconfined aquifer are likely.

### ***Prevent the introduction and spread of exotic species***

- Prevent planting of known or potentially invasive species in gardens, developments and landscaping near the ecological community (DoTE 2010).
- Avoid the sale of known invasive species in areas where the ecological community occurs.
- When conducting activities in or around the ecological community, practice good biosecurity hygiene to avoid spreading weeds or pathogens (DoTE 2015).
- Minimise unnecessary soil disturbance that may facilitate weed establishment.
- Prevent dumping of garden and other waste into bushland, especially in or near occurrences of the ecological community.

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- If new incursions do occur, detect and control them early, as small infestations are more likely to be eradicated. This applies to weeds already present in the bioregion but new to a site, for example, spread of Tall Fescue (*Festuca arundinacea*). It also applies to weeds not yet present within the bioregion but likely to become an environmental problem if introduced.
- Limit or prevent access of grazing animals to occurrences of the ecological community (e.g. construct fences) where practicable.
- Prevent further introduction of feral animals and, where possible, contain stock and pets in nearby residential and agricultural areas.

### ***6.2.2 RESTORE and MANAGE the ecological community***

Because of the limited extent and remnant nature of this ecological community, some occurrences cannot be considered to be viable in the long term without active management. The majority of stands of closed *Leptospermum lanigerum* shrubland (fens) are remnant, but with appropriate management and protection, regrowth areas can develop into dense thickets in the future.

This key approach includes priorities to restore and maintain the remaining occurrences of the ecological community by active abatement of threats, appropriate management, restoration and other conservation initiatives.

- Liaise with landholders and undertake and promote programs that ameliorate threats such as drainage, clearance, grazing, degrading water quality and human disturbance.
- Identify and prioritise other specific threats and undertake appropriate on-ground site management strategies where required.
- Identify and prioritise areas where saturation of peat soils will improve the persistence of the ecological community and carbon sequestration for the medium to long term.

#### ***Manage hydrology***

- Implement/reinstate the original or other appropriate hydrological management regimes for the ecological community and the landscapes surrounding the ecological community, taking into account results from research:
  - Use available ecological information to understand how water regimes may impact on key species in the ecological community; for instance, do not allow detrimental groundwater levels to occur in areas adjacent to the ecological community when key, threatened or functionally important flora and fauna are reproducing.
  - Use available information to appropriately manage groundwater levels in agricultural and forestry areas adjacent to occurrences of the ecological community.
  - Consider levels and duration of nutrient loads when establishing new flooding regimes and water levels in occurrences of the ecological community; for instance, vegetation in new flood zone may need to be removed prior to raising water levels to prevent a spike of nutrients being released from decomposition.

#### ***Manage weeds, pests and diseases***

## ***Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)***

Implement effective integrated control and management techniques for weeds, pests and diseases affecting the ecological community and manage sites to prevent the introduction of new, or further spread of, invasive species.

- Prioritise weeds and patches for which management is most urgent.
- Target control of key weeds that threaten the ecological community using appropriate methods that avoid impacts to non-target species.
- Encourage appropriate use of local native plant species in the region through local government and industry initiatives and best practice strategies.
- Ensure chemicals, or other mechanisms used to manage weeds, do not have significant adverse, off-target impacts on the ecological community.
- Control introduced pest animals through coordinated landscape-scale control programs.

### ***Manage tramplng, browsing and grazing***

- Any grazing which may be occurring in the ecological community should cease and fencing, using minimal clearance envelopes, may be required for exclusion of stock.
- Grazing, firewood cutting and other uses which may be acceptable in other grassy and woodland systems are not appropriate in this ecological community.
- Dense shrublands may be valuable for shelter of stock in some situations. Heavy grazing can open up the canopy and allow the invasion of weeds, such as Blackberry (*Rubus* spp) and African Boxthorn (*Lycium ferocissimum*), that impact both the ecological community and adjacent agricultural land.

### ***Manage fire***

- Implement/reinstate appropriate fire management regimes for the ecological community and the landscapes surrounding the ecological community, taking into account results from research:
  - Use available ecological information to understand how fire may impact on key species in the ecological community; for instance, do not burn areas adjacent to the ecological community when key, threatened or functionally important flora and fauna are reproducing.
  - Apply mosaic burning patterns, where feasible, during controlled burning of natural vegetation associated with the ecological community to increase habitat variability.
  - Do not burn adjacent to the ecological community if soil moisture is very low, or dry conditions are predicted for the coming season as recovery will be too slow and erosion may occur or weeds become established while the ground is bare.

### ***Undertake restoration***

- Undertake restoration, including bush regeneration and revegetation, of poorer and moderate quality patches to restore them to high quality, including restoration of patches that don't currently meet the condition thresholds for protection to a condition that does (see Table 5).
  - Plan and implement restoration with reference to the *National Standards for the Practice of Ecological Restoration in Australia* (Standards Reference Group SERA, 2017).



- Use local native species in restoration/revegetation projects for the ecological community and restore understorey vegetation to a structure and diversity appropriate to the site.
- In general, use locally collected seeds, where available, to revegetate native plant species. However, choosing sources of seed closer to the margins of their range may increase resilience to climate change.
- Ensure commitment to follow up after planting, such as the care of newly planted vegetation including maintaining appropriate hydrological needs, weeding and use/removal of tree guards.
- Consider the landscape context and other relevant species and communities when planning restoration works. For example, ensure adjacent ecological communities and threatened species (such as Glenelg Spiny Freshwater Crayfish, Swamp Greenhood) and migratory species are not adversely impacted by tree planting or other restoration activities for Karst Springs and Alkaline Fens.
- Increase the area and improve ecological function of existing patches, for example by enhancing groundwater quality, landscape connectivity, habitat diversity and condition.
- Consider the restoration of lower quality patches of the ecological community to achieve high quality condition (see Table 7).
- Develop a collection program and collect seed from the ecological community for the Australian Seedbank Partnership<sup>16</sup> and/or other relevant programs.
- Implement effective adaptive management regimes using information from available research and management guidelines, for example, see the *National Standards for the Practice of Ecological Restoration in Australia*, relevant research or advice from local authorities.
- Develop a collection program and collect arbuscular mycorrhizal fungi from the ecological community for use in revegetation programs.
- Investigate options to restore natural hydrological regimes to patches of the ecological community that have been adversely impacted and implement wetland restoration where appropriate. This may include removing or altering weirs, causeways, drains or other structures, where feasible.

### ***6.2.3 COMMUNICATE, engage with and support***

This key approach includes priorities to promote the ecological community to build awareness and encourage people and groups to contribute to its recovery. This includes communicating, engaging with and supporting the public and key stakeholders to increase their understanding of the value and function of the ecological community and to encourage and assist their efforts in its protection and recovery. Key groups to communicate with include landholders, land managers, land use planners, researchers, community members and Indigenous communities.

#### ***Raise awareness***

- Communicate with landholders/managers, relevant agencies and the public to emphasise the value of the ecological community, the key threats, its significance, and appropriate

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<sup>16</sup> Australian Seedbank Partnership: [www.seedpartnership.org.au](http://www.seedpartnership.org.au)

## ***Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)***

management. Encourage landholders to talk with local NRM organisations, state agencies and other knowledgeable groups, such as Landcare/Wetland care.

- Undertake effective community engagement and education to highlight the importance of minimising disturbance (e.g. during recreational activities) and of minimising pollution (e.g. via signage).
- Inform landholders about incentives, such as conservation agreements, stewardship projects, funding and government NRM programs etc. that may apply to help look after sites on private lands.

### ***Provide information***

- Develop and enhance education programs, information products and signage to help the public recognise the presence and importance of the ecological community, and their responsibilities under the EPBC Act and state and local regulations.
- Install signage to discourage damaging activities such as removal and disturbance of native vegetation, dumping agricultural waste and other rubbish, creating informal paths and tracks, and the use of off-road vehicles in/near occurrences of the ecological community.
- Install significant vegetation markers along access roads and drainage channels and access tracks to designate area of the ecological community to protect and prevent inappropriate maintenance from occurring.
- Promote knowledge about local weeds and what garden plants to avoid planting. Recommend local native species for revegetation and landscaping or safe alternative plants.

### ***Coordinate efforts***

- Encourage local participation in restoration and ‘landcare’ efforts through local conservation groups, creating ‘friends of’ groups, field days and planting projects, etc.
- Liaise with local fire management authorities and agencies and engage their support in fire management of the ecological community. Ensure land managers are given information about how to manage fire risks to conserve any threatened species and ecological communities.
- Support opportunities for Traditional Owners or other members of the Indigenous community to manage the ecological community.
- Promote awareness and protection of the ecological community with relevant agencies and industries. For example:
  - State and local government planning authorities, to ensure that planning takes the protection of remnants into account, with due regard to principles for long-term conservation;
  - Land owners and developers, to minimise threats associated with land conversion and development;
  - Local councils and state authorities, to ensure infrastructure or development works involving substrate, vegetation or hydrological disturbances do not adversely impact the ecological community. This includes avoiding the introduction or spread of weeds.

#### ***6.2.4 RESEARCH and monitoring***

## ***Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)***

This key approach includes priorities for research into the ecological community, and monitoring, to improve understanding of the ecological community and the best methods to aid its recovery through restoration and protection. Relevant and well-targeted research and other information gathering activities are important in informing the protection and management of the ecological community.

### ***Mapping***

- Collate existing vegetation and hydrological mapping information and associated data for this ecological community and identify knowledge gaps.
- Comprehensively map the extent and condition of the ecological community across its range:
  - Support field survey and interpretation of other data such as aerial photographs and satellite images to more accurately document current extent, condition, threats, function, presence and use by regionally significant or threatened species.
  - Support and enhance existing programs to model pre-1750 extent across the entire range of the ecological community to inform restoration.
  - Identify the most intact, high conservation value remnants and gain a better understanding of variation across the ecological community.
  - Conduct targeted field surveys and ground-truth to fill data gaps and clarify the presence and condition of remnants.
  - Identify where the best, high quality remnants of the ecological community occur.

### ***Options for management***

- Investigate key ecological interactions, such as the role of fauna and invertebrates in pollination, seed dispersal and nutrient cycling.
- Research the appropriate and integrated methods to manage pests and weeds that affect the ecological community.
- Assess the vulnerability of the ecological community to climate change and investigate ways to improve resilience through other threat abatement and management actions.
- Support and enhance research into effective landscape-scale restoration techniques for the ecological community. Investigate the interaction between disturbance types, such as invasion by weeds and feral animals and fire, to determine how an integrated approach to threat management can be implemented.
- Investigate the most cost-effective options for restoring landscape function and hydrology, including re-vegetation or assisted regeneration of priority areas, potentially buffering, connecting and protecting existing occurrences and enhancing carbon sequestration.

### ***Monitoring***

- It is important that any monitoring is planned before management commences and considers what data are required to address research questions. Monitoring must also be resourced for management activities, especially for those using a novel approach, and applied during and following the management action.
  - Monitor changes in the composition, structure and function of the ecological community, including response to all types of management actions and use this

## ***Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)***

information to increase understanding of the ecological community and inform recommendations for future management.

### ***Modelling sea-level rise impacts***

- Identify and map areas of the ecological community most vulnerable to sea-level rise, coastal erosion and saline groundwater intrusion to inform planning that will protect areas containing the ecological community.

### ***Monitor water quality and regimes***

- Establish/maintain monitoring wells in the vicinity of known occurrences of the ecological community.
- Monitor aquifer water levels, nutrient levels, salinity and spring volume thresholds (i.e. water regimes) for the ecological community and determine trends over time.
- Determine aquifer water age for areas containing the ecological community.
- Determine any freshwater-saltwater interface for areas containing the ecological community.

### ***Options for managing weeds***

- Research appropriate and integrated methods to manage weeds that affect the ecological community.

### ***Understanding fire***

- Research to gain a better understanding of the ecological consequences of fire in the ecological community including identifying intensities, intervals and critical thresholds in the process of canopy closure and ground-layer displacement.
- Research the population dynamics of *Leptospermum lanigerum* in remnants with no flammable ground-layer.

### ***Understanding regrowth***

- Research to gain a better understanding of how regrowth stands develop and how they can best be managed alongside other ecological communities, particularly those typically dominated by *Leptospermum* species in the canopy.
- Research the types of arbuscular mycorrhizal fungi and the associations with flora species within the ecological community.
- Research the development of regrowth stands of the ecological community to improve understanding of their rate and trajectory of development and evaluate convergence with undisturbed reference states.

## **6.3 Existing Plans/Management Prescriptions that are relevant to the Ecological Community**

Existing plans relevant to this ecological community exist in the form of recovery plans for threatened species within the community, threat abatement plans for threats acting upon this community, regional natural resource management plans, conservation plans and plans of management for National Parks estate that include areas of Karst Spring and Alkaline Fens, as well as regional planning documents.

*Recovery plans, threat abatement plans and wildlife conservation plans*

***Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)***

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## APPENDICES

### Appendix A – Species lists

**Table A1. Characteristic plant species of the Karst Springs and Alkaline Fens**

This is a characteristic rather than comprehensive list of plant species that may be present in the ecological community. Individual occurrences may not include all species on the list (only a low proportion of listed species are expected to be found at any one site) and may include other species not listed. Scientific names were checked and updated by ABRS as at October 2019.

Source: Scholz 1990; Bachmann 2002; Foulkes and Heard 2003; Ecological 2009; Aldridge et al 2011; Butcher et al 2011; DSE 2012; Bachmann et al 2015

Scientific name	Common name
<b>Upper layer (<i>canopy trees and shrubs &gt;1m; typically &gt; 5m</i>)</b>	
<i>Eucalyptus ovata</i>	Swamp Gum
<i>Leptospermum lanigerum</i>	Silky Tea-tree, Wereo, Wiriya, Woolly Tea-tree
<i>Leucopogon parviflorus</i>	Coast Beard-heath
<i>Melaleuca halmaturorum</i>	Blistered Paper-Bark
<i>Melaleuca squarrosa</i>	Scented Paper-bark
<i>Ozothamnus ferrugineus</i>	Tree Daisy
<b>Groundlayer (<i>herbs and shrubs typically &lt;1m</i>)</b>	
<i>Acaena novae-zelandiae</i>	Bidgee-widgee
<i>Brachycome graminea</i>	Grass Daisy
<i>Centella cordifolia</i>	Centella
<i>Cotula</i> spp.	
<i>Epilobium billardierianum</i> ssp. <i>billardierianum</i>	Variable Willow-herb
<i>Epilobium pallidiflorum</i>	Showy Willow-herb
<i>Hydrocotyle laxiflora</i>	Stinking Pennywort
<i>Hydrocotyle</i> spp.	
<i>Hydrocotyle verticillata</i>	Pennywort
<i>Lilaeopsis polyantha</i>	Australian Lilaeopsis
<i>Lobelia alata</i>	Angled Lobelia
<i>Lobelia anceps</i>	Lobelia
<i>Persicaria</i> sp.	Smartweed, Knotweed

***Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)***

Scientific name	Common name
<i>Prasophyllum frenchii</i>	Maroon leek-orchid
<i>Pterostylis tenuissima</i>	Swamp Greenhood
<i>Ranunculus amphitrichus</i>	Water Buttercup
<i>Ranunculus inundatus</i>	River Buttercup
<i>Ranunculus papulentus</i>	Large River Buttercup
<i>Ranunculus pentandrus</i> var. <i>pentandrus</i>	Inland Buttercup, Smooth Buttercup
<i>Ranunculus sessiliflorus</i>	Smallflower Buttercup
<i>Ranunculus</i> spp.	Buttercups
<i>Samolus repens</i>	Creeping Brookweed
<i>Senecio biserratus</i>	
<i>Tetragonia implexicoma</i>	Bower spinach
<i>Urtica incisa</i>	Scrub Nettle
<i>Viola hederacea</i>	Native Violet
<b>Grasses, sedges and rushes</b>	
<i>Baumea articulata</i>	Jointed Twig-rush
<i>Baumea arthropphylla</i>	
<i>Baumea juncea</i>	Bare Twig-rush
<i>Baumea laxa</i>	Lax Twig-rush
<i>Baumea rubiginosa</i>	Soft Twig-rush
<i>Carex fascicularis</i>	Tassel Sedge
<i>Cladium procerum</i>	Twig-rush
<i>Crassula helmsii</i>	Swamp Stonecrop
<i>Eleocharis acuta</i>	Common Spikerush
<i>Eleocharis gracilis</i>	Slender Spike-sedge
<i>Eleocharis sphacelata</i>	Tall Spikerush, Ma-bil, Kaya
<i>Gahnia clarkei</i>	Tall Saw-sedge
<i>Gahnia trifida</i>	Cutting Grass
<i>Isolepis fluitans</i> syn. <i>Scirpus fluitans</i>	Floating Club-rush



***Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)***

<b>Scientific name</b>	<b>Common name</b>
<i>Isolepis platycarpa</i>	Flatfruit Clubsedge
<i>Juncus procerus</i>	Tall Rush
<i>Juncus</i> spp.	
<i>Persicaria</i> spp.	
<i>Phragmites australis</i>	Common Reed
<i>Schoenoplectus pungens</i>	Sharpleaf Rush, Sharp Club-rush, Three-Square
<i>Schoenoplectus</i> spp.	
<i>Schoenoplectus validus</i>	River Club-rush
<i>Schoenus</i> spp.	
<i>Triglochin striata</i>	Streaked Arrowgrass
<i>Typha domingensis</i>	Bulrush, Narrowleaf Cumbungi
<i>Typha orientalis</i>	Bulrush, Broadleaf Cumbungi
<b>Aquatic</b>	
<i>Callitriche</i> spp.	Water-starwort
<i>Cycnogeton procerum</i> syn. <i>Triglochin procerum</i>	Water Ribbons
<i>Cycnogeton</i> spp. syn. <i>Triglochin procera</i> s.l.	Water Ribbons
<i>Isolepis inundata</i>	Swamp Club-rush
<i>Lemna disperma</i>	Common Duckweed
<i>Lemna minor</i>	Lesser Duckweed, Common Duckweed
<i>Lemna trisulca</i>	Ivy Leaf Duckweed
<i>Lepilaena australis</i>	Austral Water-mat
<i>Lepilaena cylindrocarpa</i>	Water Mat
<i>Myriophyllum propinquum</i>	Water Milfoil
<i>Myriophyllum salsugineum</i>	Amphibious Water Milfoil
<i>Myriophyllum simulans</i>	Water Milfoil
<i>Myriophyllum variifolium</i>	Varied Water Milfoil
<i>Myriophyllum verrucosum</i>	Red Water Milfoil
<i>Myriophyllum</i> spp.	Water Milfoils

***Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)***

Scientific name	Common name
<i>Potamogeton ochreatus</i>	Blunt Pondweed
<i>Ruppia polycarpa</i>	Water Tassel
<i>Spirodela</i> sp.	Duckweed
<i>Stuckenia pectinata</i> syn. <i>Potamogeton pectinatus</i>	Fennel Pondweed, Sago Pondweed
<i>Vallisneria spiralis</i>	Ribbon Weed
<i>Wolffia</i> sp.	Duckweed
<b>Phytoplankton (algae)</b>	
<i>Abaena</i> spp.	
<i>Anabaena</i> spp.	
<i>Batrachospermum boryanum</i>	
<i>Chaetomorpha linum</i>	
<i>Chara globularis</i>	
<i>Cladophora aegagropila</i>	
<i>Enteromorpha intestinalis</i>	
<i>Enteromorpha prolifera</i>	
<i>Lyngbya</i> spp.	
<i>Oscillatoria</i> spp.	
<i>Porphysiphon</i> spp.	
<i>Spirogyra</i> spp.	
<i>Vaucheria</i> spp.	

**Table A2. Threatened plant species that may occur in the Karst Springs and Alkaline Fens**

Source: SA: National Parks and Wildlife Act 1972; VIC: Flora and Fauna Guarantee Act 1988; National: Environment Protection and Biodiversity Conservation Act 1999.

Scientific name	Common name	SA	Victoria	National
<i>Myriophyllum variifolium</i>		Near threatened		
<i>Prasophyllum frenchii</i>	Maroon Leek-orchid	Endangered		Endangered
<i>Pterostylis tenuissima</i>	Swamp Greenhood	Vulnerable		Vulnerable
<i>Ranunculus inundatus</i>	River Buttercup	Near threatened		
<i>Triglochin procerum</i> syn <i>Cycnogeton procerum</i>	Water Ribbons	Near threatened		

**Table A3. Native fauna that may occur in the Karst Springs and Alkaline Fens**

Some species may be resident in Karst Springs and Fens and use it as key habitat while other species may only be transient within the ecological community. The scientific and common names and national distributions of species were checked using The Atlas of Living Australia website and were current as at October 2019.

B – Bonn, C – CAMBA, CE – Critically Endangered, E – Endangered, J – JAMBA, M – Migratory, T – Threatened, NT – Near Threatened, R – ROCAMBA, Ra – Rare, V = Vulnerable

Source: Bachmann 2002; Foulkes and Heard 2003; Churchill 2008; Bachmann et al 2015; Wilson and Swan 2010; Aldridge et al 2011; Whiterod and Hammer 2012; Veale and Whiterod 2014; Atlas of Living Australia 2018.

Scientific name	Common name	Conservation status		
		EPBC Act	SA	VIC
Mammals				
<i>Antechinus minimus maritimus</i>	Swamp Antechinus	V	E	T
<i>Austronomus australis</i>	White-striped Freetail Bat			
<i>Chalinolobus gouldii</i>	Gould’s Wattled Bat			
<i>Chalinolobus morio</i>	Chocolate Wattled Bat			
<i>Hydromys chrysogaster</i>	Water Rat/Rakali			
<i>Isoodon obesulus obesulus</i>	Southern Brown Bandicoot (eastern)	E	V	
<i>Macropus fuliginosus</i>	Western Grey Kangaroo			
<i>Miniopterus orianae bassanii</i>	Southern Bentwing Bat	CE	E	CE
<i>Myotis macropus</i>	Large-footed Myotis			
<i>Nyctophilus geoffroyi</i>	Lesser Long-eared Bat			
<i>Ozimopos planiceps</i> syn <i>Mormopterus planiceps</i>	South-eastern Free-tailed Bat/Little Mastif Bat			
<i>Potorous tridactylus tridactylus</i>	Long-nosed Potoroo	V	E	T
<i>Rattus fuscipes</i>	Bush Rat			
<i>Rattus lutreolus</i>	Swamp Rat			
<i>Tachyglossus aculeatus</i>	Short-beaked Echidna			
<i>Wallabia bicolor</i>	Swamp Wallaby		V	

***Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)***

Scientific name	Common name	Conservation status		
		EPBC Act	SA	VIC
Birds				
<i>Acanthagenys rufogularis</i>	Spiny-cheeked Honeyeater			
<i>Acanthiza chrysorrhoa</i>	Yellow-rumped Thornbill			
<i>Acanthiza lineata</i>	Striated Thornbill			
<i>Acanthiza pusilla</i>	Brown Thornbill			
<i>Accipiter cirrocephalus</i>	Collared Sparrowhawk			
<i>Accipiter fasciatus</i>	Brown Goshawk			
<i>Acrocephalus australis</i>	Australian Reed-Warbler	B		
<i>Alauda arvensis</i>	Eurasian Skylark			
<i>Anas castanea</i>	Chestnut Teal			
<i>Anas gracilis</i>	Grey Teal			
<i>Anas superciliosa</i>	Pacific Black Duck			
<i>Anseranas semipalmata</i>	Magpie Goose		E	NT
<i>Anthochaera carunculata</i>	Red Wattlebird			
<i>Anthochaera chrysoptera</i>	Little Wattlebird			
<i>Anthus novaeseelandiae</i>	Australasian Pipit			
<i>Apus pacificus</i>	Fork-tailed Swift	C, J, R		
<i>Aquila audax</i>	Wedge-tailed Eagle			
<i>Ardea alba</i>	Great Egret			
<i>Ardea pacifica</i>	White-necked Heron			
<i>Arenaria interpres</i>	Ruddy Turnstone	M, B, C, J, R	Ra	V
<i>Aythya australis</i>	Hardhead			V
<i>Biziura lobata</i>	Musk Duck		Ra	V
<i>Botaurus poiciloptilus</i>	Australasian bittern	E	V	E
<i>Bubulcus ibis</i>	Cattle Egret			
<i>Cacatua tenuirostris</i>	Long-billed Corella			

***Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)***

Scientific name	Common name	Conservation status		
		EPBC Act	SA	VIC
<i>Cacomantis flabelliformis</i>	Fan-tailed Cuckoo			
<i>Calamanthus fuliginosus</i>	Striated Fieldwren			
<i>Calidris acuminata</i>	Sharp-tailed Sandpiper	M, B, C, J, R		
<i>Calidris alba</i>	Sanderling	M, B, C, J, R	Ra	NT
<i>Calidris ferruginea</i>	Curlew Sandpiper	CE, M, B, C, J, R		E
<i>Calidris ruficollis</i>	Red-necked Stint	M		
<i>Caligavis chrysops</i>	Yellow-faced Honeyeater			
<i>Cereopsis novaehollandiae</i>	Cape Barren Goose		Ra	
<i>Ceyx azureus</i>	Azure Kingfisher		E	NT ( <i>Alcedo azurea</i> )
<i>Chalcites basalis</i>	Horsfield's Bronze-cuckoo			
<i>Chalcites lucidus</i>	Shining Bronze-cuckoo			
<i>Charadrius bicinctus</i>	Double-banded Plover	B		
<i>Charadrius ruficapillus</i>	Red-capped Plover			
<i>Chlidonias hybrida</i>	Whiskered Tern	M		
<i>Chlidonias leucopterus</i>	White-winged Black Tern	M, C, J, R		NT
<i>Chroicocephalus novaehollandiae</i>	Silver Gull			
<i>Cincloramphus cruralis</i>	Brown Songlark			
<i>Cincloramphus mathewsi</i>	Rufous Songlark			
<i>Circus approximans</i>	Swamp Harrier	M		
<i>Cisticola exilis</i>	Golden-headed Cisticola			
<i>Colluricincla harmonica</i>	Grey Shrike-thrush			
<i>Coracina novaehollandiae</i>	Black-faced Cuckoo-shrike			
<i>Cormobates leucophaea</i>	White-throated Treecreeper			

**Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)**

Scientific name	Common name	Conservation status		
		EPBC Act	SA	VIC
<i>Corvus coronoides</i>	Australian Raven			
<i>Corvus mellori</i>	Little Raven			
<i>Corvus tasmanicus</i>	Forest Raven			
<i>Cygnus atratus</i>	Black Swan			
<i>Dacelo novaeguineae</i>	Laughing Kookaburra			
<i>Dasyornis broadbenti</i>	Rufous Bristlebird			T
<i>Egretta garzetta</i>	Little Egret		Ra	T
<i>Egretta novaehollandiae</i>	White-faced Heron			
<i>Elanus axillaris</i>	Black-shouldered Kite			
<i>Elseyornis melanops</i>	Black-fronted Dotterel			
<i>Eolophus roseicapilla</i>	Galah			
<i>Eopsaltria australis</i>	Eastern Yellow Robin, Pulun potj (G)			
<i>Epthianura albifrons</i>	White-fronted Chat			
<i>Erythronys cinctus</i>	Red-kneed Dotterel			
<i>Falco berigora</i>	Brown Falcon			
<i>Falco cenchroides</i>	Nankeen Kestrel			
<i>Falco longipennis</i>	Australian Hobby			
<i>Falco peregrinus</i>	Peregrine Falcon		Ra	
<i>Falcunculus frontatus</i>	Crested Shrike-tit		Ra	
<i>Fulica atra</i>	Eurasian Coot			
<i>Gallinago hardwickii</i>	Latham's Snipe	B, J, R	Ra	NT
<i>Gallinula tenebrosa</i>	Dusky Moorhen			
<i>Gallirallus philippensis</i>	Buff-banded rail			
<i>Gavicalis virescens</i>	Singing Honeyeater			
<i>Grallina cyanoleuca</i>	Magpie-lark			
<i>Grus rubicunda</i>	Brolga		V	V

***Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)***

Scientific name	Common name	Conservation status		
		EPBC Act	SA	VIC
<i>Gymnorhina tibicen</i>	Australian Magpie			
<i>Haematopus fuliginosus</i>	Sooty Oystercatcher		Ra	NT
<i>Haematopus longirostris</i>	Australian Pied Oystercatcher		Ra	
<i>Haliastur sphenurus</i>	Whistling Kite			
<i>Hieraaetus morphnoides</i>	Little Eagle			
<i>Himantopus leucocephalus</i>	Black-winged Stilt			
<i>Hirundapus caudacutus</i>	White-throated Needletail	V, C, J, R		V
<i>Hirundo neoxena</i>	Welcome Swallow			
<i>Hydroprogne caspia</i>	Caspian Tern	J		NT
<i>Larus pacificus</i>	Pacific Gull			
<i>Lewinia pectoralis</i>	Lewin's Rail		V	T
<i>Malurus cyaneus</i>	Superb Fairy-wren			
<i>Melithreptus brevirostris</i>	Brown-headed Honeyeater			
<i>Microcarbo melanoleucos</i>	Little Pied Cormorant			
<i>Mirafra javanica</i>	Horsfield's Bushlark			
<i>Morus serrator</i>	Australasian Gannet			
<i>Neochmia temporalis</i>	Red-browed Finch			
<i>Neophema chrysogaster</i>	Orange-bellied Parrot	CE	E	CE
<i>Neophema chrysostoma</i>	Blue-winged Parrot		V	
<i>Neophema elegans</i>	Elegant Parrot		Ra	
<i>Nesoptilotis leucotis</i>	White-eared Honeyeater			
<i>Nycticorax caledonicus</i>	Nankeen Night-Heron			
<i>Ocyphaps lophotes</i>	Crested Pigeon			
<i>Oriolus sagittatus</i>	Olive-backed Oriole		Ra	
<i>Pachycephala olivacea</i>	Olive Whistler		V	



**Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)**

Scientific name	Common name	Conservation status		
		EPBC Act	SA	VIC
<i>Pachycephala pectoralis</i>	Golden Whistler			
<i>Pachycephala rufiventris</i>	Rufous Whistler			
<i>Pelecanus conspicillatus</i>	Australian Pelican	M		
<i>Petrochelidon ariel</i>	Fairy Martin			
<i>Petrochelidon nigricans</i>	Tree Martin			
<i>Phalacrocorax carbo</i>	Great Cormorant			
<i>Phalacrocorax sulcirostris</i>	Little Black Cormorant			
<i>Phalacrocorax varius</i>	Pied Cormorant			NT
<i>Phaps elegans</i>	Brush Bronzewing			
<i>Phylidonyris novaehollandiae</i>	New Holland Honeyeater			
<i>Platalea flavipes</i>	Yellow-billed Spoonbill			
<i>Platalea regia</i>	Royal Spoonbill			NT
<i>Platycercus elegans</i>	Crimson Rosella			
<i>Podiceps cristatus</i>	Great Crested Grebe		Ra	
<i>Poliocephalus poliocephalus</i>	Hoary-headed Grebe			
<i>Poodytes gramineus</i>	Little Grassbird			
<i>Porphyrio porphyrio</i>				
<i>Porphyrio porphyrio</i>	Purple Swamphen			
<i>Porzana fluminea</i>	Australian Spotted Crake			
<i>Psephotus haematonotus</i>	Red-rumped Parrot			
<i>Ptilotula penicillata</i>	White-plumed Honeyeater			
<i>Rhipidura fuliginosa</i>	Grey Fantail			
<i>Rhipidura leucophrys</i>	Willie Wagtail			
<i>Sericornis frontalis</i>	White-browed Scrubwren			

**Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)**

Scientific name	Common name	Conservation status		
		EPBC Act	SA	VIC
<i>Spatula rhynchotis</i>	Australasian Shoveler			
<i>Stagonopleura bella</i>	Beautiful Firetail		Ra	
<i>Sternula albifrons</i>	Little Tern	B, C, J, R	E	T
<i>Stictonetta naevosa</i>	Freckled Duck		V	E
<i>Stipiturus malachurus</i>	Southern Emu-wren		V	
<i>Streptopelia chinensis</i>	Spotted Dove			
<i>Synoicus ypsilophora</i>	Brown Quail			
<i>Tachybaptus novaehollandiae</i>	Australasian Grebe			
<i>Tadorna tadornoides</i>	Australian Shelduck	M		
<i>Thalasseus bergii</i>	Crested Tern	J		
<i>Threskiornis moluccus</i>	Australian White Ibis			
<i>Threskiornis spinicollis</i>	Straw-necked Ibis			
<i>Todiramphus sanctus</i>	Sacred Kingfisher			
<i>Tribonyx ventralis</i>	Black-tailed Nativehen			
<i>Tringa glareola</i>	Wood sandpiper	M, B, C, J, R	Ra	V
<i>Vanellus miles</i>	Masked Lapwing			
<i>Vanellus tricolor</i>	Banded Lapwing			
<i>Zapornia tabuensis</i>	Spotless Crake			
<i>Zosterops lateralis</i>	Silvereye			
<b>Amphibians</b>				
<i>Crinia signifera</i>	Common Eastern Froglet			
<i>Geocrinia laevis</i>	Smooth Frog		NT	
<i>Limnodynastes dumerilii</i>	Eastern Banjo Frog			
<i>Limnodynastes peronii</i>	Brown-Striped Frog			
<i>Limnodynastes tasmaniensis</i>	Spotted Grass Frog			

***Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)***

Scientific name	Common name	Conservation status		
		EPBC Act	SA	VIC
<i>Litoria ewingii</i>	Brown Tree Frog			
<i>Litoria raniformis</i>	Growling Grass Frog, Southern Bell Frog	V	V	
<i>Neobatrachus pictus</i>	Painted Frog			
<i>Neobatrachus sudellae</i>	Sudell's Frog			
<b>Reptiles</b>				
<i>Acritoscincus duperreyi</i>	Eastern Three-Lined Skink			
<i>Amphibolurus muvicaus</i>	Jacky Lizard		NT	
<i>Anepischetosia maccayi</i> syn <i>Nannoscincus maccayi</i>	Highlands Forest Skink		E	
<i>Austrelaps superbus</i>	Lowland Copperhead			
<i>Bassiana duperreyi</i>	Eastern Three-lined Skink			
<i>Chelodina longicollis</i>	Eastern Long-Necked Turtle			
<i>Drysdalia coronoides</i>	White-Lipped Snake		NT	
<i>Eulamprus tympanum</i>	Southern Water Skink		NT	
<i>Hemiergis peronii</i>	Lowlands Earless Skink			NT
<i>Lerista bougainvillii</i>	South-Eastern Slider			
<i>Liopholis whitii</i>	White's Skink			
<i>Lissolepis coventryi</i>	Eastern Mourning Skink		E	V
<i>Notechis scutatus</i>	Tiger Snake, Wangaluk (W)			
<i>Pseudemoia entrecasteauxii</i>	Southern Grass Skink			
<i>Pseudomoia rawlinsoni</i>	Glossy Grass Skink		E	NT
<i>Pseudonaja textilis</i>	Eastern Brown Snake			
<i>Tiliqua nigrolutea</i>	Blotched Blue-Tongue			

**Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)**

Scientific name	Common name	Conservation status		
		EPBC Act	SA	VIC
<i>Tiliqua rugosa</i>	Sleepy Lizard			
<b>Fish</b>				
<i>Acanthopagrus butcheri</i>	Black Bream			
<i>Afurcagobius tamarensis</i>	Tamar River Goby			
<i>Aldrichetta forsteri</i>	Yelloweye Mullet			
<i>Anguilla australis</i>	Southern Shortfin Eel			
<i>Atherinosoma microstoma</i>	Smallmouth Hardyhead			
<i>Gadopsis marmoratus</i>	River Blackfish			
<i>Galaxias brevipinnis</i>	Climbing Galaxias			
<i>Galaxias maculatus</i>	Common Galaxias			
<i>Galaxias truttaceus</i>	Trout Galaxias			
<i>Galaxiella pusilla</i>	Dwarf Galaxias	V		T
<i>Galaxiella toourtkoourt</i>	Little Galaxias			
<i>Geotria australis</i>	Pouched Lamprey			
<i>Mordacia mordax</i>	Shorthead Lamprey			
<i>Nannoperca australis</i>	Southern Pygmy Perch			
<i>Nannoperca obscura</i>	Yarra Pygmy Perch	V		T
<i>Nannoperca variegata</i>	Ewen Pygmy Perch	V		T
<i>Neochanna cleaveri</i>	Australian Mudfish			T
<i>Prototroctes maraena</i>	Australian Grayling	V		T
<i>Pseudaphritis urvillii</i>	Congolli			
<i>Pseudogobius olorum</i>	Bluespot Goby			
<i>Tasmanogobius lasti</i>	Scary's Tasmangoby			
<b>Arthropods (See Bachmann 2002)</b>				
<i>Amarinus lacustris</i>	Freshwater Crab			
<i>Amarinus</i> spp.	Freshwater Crab			
<i>Angrobia</i> spp.	Freshwater snail			

***Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)***

Scientific name	Common name	Conservation status		
		EPBC Act	SA	VIC
<i>Arrenurus</i> spp.				
<i>Atalophlebia aurata</i>	Mayfly			
<i>Atalophlebia australis</i>	Mayfly			
<i>Atriplectides dubius</i>	Caddisfly			
<i>Austroagrion</i> spp.	A damselfly			
<i>Austrocerca tasmanica</i>	A stonefly			
<i>Austrogammarus</i> spp.	An amphipod crustacean			
<i>Austrolestes</i> spp.	A damselfly			
<i>Austrosimulium furiosum</i>	Blackfly			
<i>Chironomus</i> spp.	Midges			
<i>Centroptilum elongatum</i>	Baetid mayfly			
<i>Dinotoperla brevipennis</i>	A stonefly			
Dixidae family	Midges			
<i>Engaeus strictifrons</i>	Burrowing crayfish			
<i>Erina acasta</i>	Blotched Dusky-blue			
<i>Erina hyncinthina</i> form <i>josephina</i>	Common Dusky Blue		Ra	
<i>Erina hyacinthina hyacinthina</i>			Ra	
<i>Euastacus bispinosus</i>	Glenelg Spiny Freshwater Crayfish	E	Cr	
<i>Geitoneura klugii</i>	Klug's Xenica			
<i>Geocharax</i> spp.	A swamp yabby			
<i>Haliphus gibbus</i>	A water beetle			
<i>Hellyethira simplex</i>	A caddisfly			
<i>Hemiphlebia mirabilis</i>	Ancient Greenling		E	
<i>Hesperilla chrysotricha cyclospila</i>	Golden-Haired Sedge-Skipper			

***Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)***

Scientific name	Common name	Conservation status		
		EPBC Act	SA	VIC
<i>Hesperilla donnysa</i>	Varied Sedge-Skipper			
<i>Hesperilla idothea idothea</i>	Flame Sedge-Skipper			
<i>Heteronympha merope merope</i>	Common Brown			
<i>Heteronympha cordace wilsoni</i>	Bright-eyed Brown			T
<i>Hydrodroma</i> spp.	A freshwater crab			
<i>Hygrobia</i> spp.	An aquatic beetle			
<i>Junonia villida calybe</i>	Meadow Argus			
<i>Lampides boeticus</i>	Long-tailed Pea-blue			
<i>Lingora aurata</i>	A caddisfly			
<i>Lingora</i> spp.	Caddisflies			
<i>Nacaduba biocellata biocellata</i>	Doublespotted Lineblue			
<i>Notalina spira</i>	A caddisfly			
<i>Nousia fuscula</i>	A mayfly			
<i>Nousia pilosa</i>	A mayfly			
<i>Ocybadistes walkeri hypochlora</i>	Dart			
<i>Offadens</i> spp.	Mayflies			
Oribatidae order	Moss mites			
<i>Ori xenica kershawi kanunda</i>	Striped Xenica		V	
<i>Ori xenica lathoniella herceus</i>	Silver Xenica			
<i>Oxus</i> spp.	A water mite			
<i>Paracalliope</i> spp.	An amphipod crustacean			
<i>Paratya australiensis</i>	Australian Paratya, Glass Shrimp			

***Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)***

Scientific name	Common name	Conservation status		
		EPBC Act	SA	VIC
<i>Rheotanytarsus</i> spp.	Chironomid midge			
<i>Simulium ornatipes</i>	A blackfly			
<i>Taractrocera papyria papyria</i>	White-Banded Grass-Dart		Ra	
<i>Taschorema</i> Complex	Caddisflies			
<i>Theclinessthes serpentata serpentata</i>	A butterfly			
<i>Thraulophlebia conspicua</i>	A mayfly			
<i>Thraulophlebia inconspicua</i>	A mayfly			
<i>Tisiphone abeona albifascia</i>	Sword-Grass Brown		V	
<i>Trapezites symmomus soma</i>	Symmomus Rush-skipper			
<i>Triplectides australis</i>	A caddisfly			
<i>Ulmerophlebia pipinna</i>	A mayfly			
<i>Vanessa itea</i>	Australian Admiral			
<i>Vanessa kershawi</i>	Australian Painted Lady			
<i>Zizina labradus labradus</i>	A butterfly			
<b>Molluscs</b>				
<i>Ascorhis tasmanica</i>				
<i>Ferrissia (Pettancylus) gibbosa</i>				
<i>Glyptophysa</i> spp.	A freshwater snail			
<i>Glyptophysa gibbosa</i>	Narracan River corrugated mussel			
<i>Hyridella narracanensis</i>	Southern River Mussel			
<i>Laomavix collisi</i>	Collis' pinhead snail			
<i>Magilaoma penolensis</i>	Penola pinhead snail			

***Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)***

Scientific name	Common name	Conservation status		
		EPBC Act	SA	VIC
<i>Musculium (Sphaerinova) tasmanicum tasmanicum</i>				
<i>Paralaoma caputspinulae</i>	Prickle pinhead snail			
<i>Pisidium (Euglesa) etheridgei</i>				
<i>Posticobia</i> spp.	A freshwater snail			
<i>Potamopyrgus antipodarum</i>				
Sphaeriidae family	A pea mussel			

**Table A4. Weed species that may occur in or adjacent to the Karst Springs and Alkaline Fens**

Source: Bachmann 2002; Foulkes and Heard 2003; Taylor 2006; Butcher et al 2011; Sweeney 2013; Bachmann et al 2015; DELWP 2018.

Scientific name	Common name
<i>Anagallis arvensis</i> syn <i>Lysimachia arvensis</i>	Pimpernel
<i>Asparagus asparagoides</i>	Bridal Creeper (WONS)
<i>Berula erecta</i>	Lesser Water-parsnip
<i>Centaureum erythraea</i>	Common Centaury
<i>Cirsium vulgare</i>	Spear Thistle
<i>Coprosma repens</i>	Mirror Bush
<i>Cotoneaster glaucophyllus</i>	Cotoneaster
<i>Dipogon lignosus</i>	Dolichos Pea
<i>Euphorbia paralias</i>	Sea Spurge
<i>Festuca arundinacea</i>	Tall Fescue, Williams Grass
<i>Holcus lanatus</i>	Yorkshire Fog Grass
<i>Hypochoeris radicata</i>	Cat's Ear
<i>Juncus acutus</i>	Spikey Rush
<i>Juncus articulata</i>	Jointleaf Rush



***Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)***

Scientific name	Common name
<i>Leontodon taraxacoides</i> ssp. <i>Taraxacoides</i>	Hairy Hawkbit
<i>Lolium rigidum</i>	Rye Grass
<i>Lycium ferocissimum</i>	African Boxthorn (WONS)
<i>Lysimachia arvensis</i> syn <i>Anagallis arvensis</i>	Scarlet Pimpernel
<i>Phalaris aquatica</i>	Bulbous Canary-grass
<i>Poa pratensis</i>	Kentucky Blue Grass
<i>Polygala myrtifolia</i>	Polygala
<i>Polypogon monspeliensis</i>	Annual Beard Grass
<i>Prunella vulgaris</i>	Self-heal
<i>Rhamnus alaternus</i>	Italian Buckthorn
<i>Rorippa nasturtium-aquaticum</i> syn. <i>Nasturtium officinale</i>	Watercress
<i>Rosa rubiginosa</i>	Briar Rose
<i>Rubus fruticosus</i>	Blackberry (WONS)
<i>Sonchus oleraceus</i>	Common Sow-thistle
<i>Trifolium fragiferum</i> var. <i>fragiferum</i>	Strawberry Clover
<i>Trifolium subterraneum</i>	Subterranean Clover
<i>Ulex europaeus</i>	Gorse
<i>Zantedeschia aethiopica</i>	Arum Lilly

## **Appendix B - Relationship to other vegetation classification and mapping systems**

Ecological communities are complex to classify. Each state and territory apply different systems and to classify vegetation communities and types. Reference to vegetation and mapping units as equivalent to a national ecological community, at the time of listing, should be taken as indicative rather than definitive. A unit that is generally equivalent may include elements that do not meet the key diagnostics and minimum condition thresholds. Conversely, areas mapped or described as other units may sometimes meet the key diagnostics for the Karst Springs and Alkaline Fens. Judgement of whether the ecological community is present at a particular site should focus on how the site meets the description (section 2), the key diagnostic characteristics (section 5.1.1) and minimum condition thresholds (section 5.2.1).

State vegetation mapping units are not necessarily the ecological community being listed. However, for many sites (but not all) certain vegetation map units will correspond sufficiently to provide indicative mapping for the national ecological community, where the description matches.

On-ground assessment is essential to finally determine if any site is part of the ecological community.

### **Relationships to the National Vegetation Information System (NVIS)**

Under the National Vegetation Information System (NVIS), vegetation associated with the Karst Rising Springs can be classified within:

#### **Major Vegetation Group (MVG)**

- 17 – Other Shrublands
- 21 – Other Grasslands, Herblands, Sedgeland and Rushlands

#### **Major Vegetation Subgroup (MVS)**

- 32 – Other shrublands
- 38 – Wet tussock grassland with herbs, sedges or rushes, herblands or ferns
- 58 – *Leptospermum* forests and woodlands
- 63 – Sedgeland, rushes or reeds
- 64 – Other grasslands

### **Relationship to South Australian vegetation classifications that may correspond to the ecological community**

There are no vegetation types formally recognised as threatened in South Australia which correspond with the national ecological community. However, the Karst Springs and Alkaline Fens corresponds best to the following vegetation types noted in the Provisional List of Threatened Ecosystems in South Australia (Native Vegetation Council 2019):

- *Gahnia trifida* Sedgeland in drainage lines and depressions – Endangered
- *Leptospermum lanigerum* Closed Shrubland in non-saline wetlands – Endangered

## ***Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (s266B)***

The national ecological community may also include the following wetland vegetation components (WVC) (Ecological Associates 2009; Harding unpublished):

- WVC 1.6 – *Leptospermum lanigerum* tall wet shrubland
- WVC 1.9 – *Gahnia trifida* tussock sedgeland
- WVC 1.11 – Freshwater emergent sedgeland
- WVC 2.16 – *Melaleuca squarrosa* wet heathland
- WVC 2.17 – Typha/Phragmites tall aquatic grassland
- WVC 2.18 – Karst rising spring – open water component
- WVC 2.20 – Freshwater open aquatic herbland

### **Relationship to Victorian vegetation classifications that may correspond to the ecological community**

The Karst Springs and Alkaline Fens corresponds best to the Victorian wetland Ecological Vegetation Class (EVC):

- Swamp Scrub (EVC 53) - Bioregional conservation status of Endangered in the Bridgewater Bioregion

The ecological community may also include:

- Calcareous Sedgy Shrubland (EVC A106)
- Aquatic Sedgeland (EVC 308)
- Calcareous Wet Herbland (EVC 591)
- Aquatic Herbland (EVC 653)
- Sink-hole Wetland (EVC 908)
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