This ecological community was listed under the EPBC Act on 16 July 2000. This Conservation Advice was approved by the Delegate of the Minister on 13 July 2017.

Approved Conservation Advice for Aquatic Root Mat Community in Caves of the Swan Coastal Plain

(s266B of the *Environment Protection and Biodiversity Conservation Act 1999*)

This Conservation Advice has been developed based on the best available information at the time this Conservation Advice was approved; this includes existing plans, records or management prescriptions for this ecological community.

1 CONSERVATION OBJECTIVE

To mitigate the risk of extinction (or collapse) of the **Aquatic Root Mat Community in Caves of the Swan Coastal Plain** and help recover its biodiversity and function; through protecting it as a matter of national environmental significance under national environment law, particularly to avoid further loss; and by guiding implementation of management and recovery through the recommended priority conservation and research actions set out in this advice.

2 DESCRIPTION OF THE ECOLOGICAL COMMUNITY

The **Aquatic Root Mat Community in Caves of the Swan Coastal Plain** ecological community is listed as **Endangered** under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act). The ecological community is an assemblage of aquatic invertebrates living in mats of fine tree rootlets and their associated microflora in caves containing previously permanent streams and pools in Yanchep National Park on the Swan Coastal Plain, Western Australia. Seven caves in Yanchep National Park were known to contain groundwater-fed streams or pools that contain root mats from *Eucalyptus gomphocephala* (tuart) trees (Table 1). These caves are defined as containing a single community type because there is considerable overlap of animal species between them, as well as very similar water chemistry (all being fed by the same groundwater source – the Gnangara Mound, a shallow unconfined aquifer that extends from Moore River to the Swan River). Aquatic root mat assemblages in four caves on the Leeuwin–Naturaliste Ridge in southwest Western Australia are considered to be different from the community at Yanchep as the species composition of each differs significantly from that of the latter, and they are part of a separate groundwater system, far to the south of the Gnangara Mound.

Table 1. Location of Known Occurrences of the Aquatic Root Mat Community in Caves of the Swan Coastal Plain

Area Number	Location and cave identifier
Area 1	Carpark Cave (YN18)
Area 2	Gilgie Cave (YN27) community destroyed
Area 3	Cabaret Stream Cave (YN30, YN394)
Area 4	unnamed cave (YN99)
Area 5	Twilight Cave (YN194)
Area 6	Water Cave (YN11)
Area 7	Unnamed cave (YN555 Carabooda)

Source: English et al. (2003).

A total of 100 species of fauna have been located in the seven caves at Yanchep known to contain the root mat community. About a third of these were newly discovered in the original studies of the 1990s (Jasinska 1997) and, of these, at least six crustacean species are relicts from when Australia was part of the supercontinent of Gondwana. The fauna that inhabit the caves (cavernicoles) include night fish, segmented worms including leeches, roundworms, flatworms, mites, snails, insects and crustaceans. The most common species encountered in the community are:

- Phylum Rotifera (wheel animals) – *Philodina* sp. 1.
- Phylum Platyhelminthes (flatworms) – *Stenostomum* sp., *Dalyellioida* sp. 1.
- Phylum Nematoda (roundworms) – *Chromadorida* sp. 1, *Iotonchus* sp. 1, *Ironus* sp. 1.
- Phylum Annelida (segmented worms) – *Aeolosoma tracanvorense aiyer*.
- Phylum Arthropoda:
    - Class Arachnida – Acarina (mites and ticks) – *Lobohalacarus* sp. nov. 1 (eyeless), *Soldanellonyx* sp. 1.
    - Class Crustacea (shrimps, copepods, etc) – *Cherax quinquecarinatus* (Gray), *Janiridae* sp. nov. 1, *Gomphodella* aff. maia de dekker.

Some of the species appear to be endemic to these cave streams, and some are confined to a single cave (Jasinska 1996, 1997). **Appendix A** contains a list of fauna collected from the caves.

3 CONSERVATION STATUS

The **Aquatic Root Mat Community in Caves of the Swan Coastal Plain** ecological community is listed as **Endangered** under the EPBC Act. It was listed because of its restricted area and limited distribution: there are a very small number of occurrences, each of which is small and/or isolated; and a high level of threat facing the known occurrences. The listing is based on data collected prior to the EPBC Act, though this conservation advice uses available updated information about distribution and threats. In Western Australia it is listed as critically endangered, under the name Aquatic Root Mat Community Number 1 of Caves of the Swan Coastal Plain.

4 DISTRIBUTION AND HABITAT

The **Aquatic Root Mat Community in Caves of the Swan Coastal Plain** ecological community occurs in caves of the Swan Coastal Plain in southwest Western Australia. Known occurrences are in seven caves in Yanchep National Park (Table 1). As of April 2017, the ecological community occurs within the Perth Natural Resources Management (NRM) region and the Swan Coastal Plain bioregion (Interim Biogeographic Regionalisation for Australia (IBRA) Version 7).

The habitat for the aquatic root mat community is within the seven individual caves, where there are cave streams, and the roots of tuart trees that extend into each of the caves and streams, plus the catchments for the streams that flow through the caves. This includes areas of the Gnangara mound catchment between the caves and the top of the mound, and the superficial water table that supplies the water to the cave-streams. Caves containing the aquatic root mat community occur where sandy soils underlie superficial limestone and where the waters of the Gnangara Mound seep through the sand to form a system of subterranean pools and streams, a few of which have been permanent in historical times.

Because of this very restricted distribution, no condition thresholds have been applied and all areas meeting the description of the ecological community are habitat areas critical to its survival.

5 THREATS

The ecological community has been subject to significant past disturbance and is subject to future threats. The immediate threats are:

- decline of the level of the water table as a result of groundwater extraction, pine plantations and climate change (DEC 2009; Government of Western Australia 2009; Steffen and Hughes 2013). In response to declining water levels, systems were established in the 2000s to supplement the water in caves. Due to issues including regional ground water decline, negative outcomes to Loch McNess, and safety issues with cave access, supplementation was not successful, and root mat health declined;
- destruction of the food source, i.e. the tree roots, by damage to the tuart trees from clearing, frequent or very hot fires, or possibly pathogens; and
- vandalism.

Longer term threats include:

- pollution of groundwater with fertilisers, fungicides or pesticides used in agricultural production, by runoff from urban uses, or by waters carrying pollutants from land uses such as rubbish tips or industrial areas;
- cave collapse caused by increased erosion and corrosion from changes in flow rates resulting from e.g. land use changes, by heavy human or vehicular traffic over the caves or by the use of explosives nearby; and
- invasion by exotic species, e.g. yabbies, introduced crayfish and gambusia, competing with other fauna in the community or altering habitat.

6 Priority Conservation and Research Actions

6.1 Principles and standards that guide the actions below

To undertake priority actions to meet the conservation objective, the overarching principle is that it is essential to maintain existing areas of the ecological community. Only a few occurrences of this ecological community remain and all occurrences are characterised by high richness and/or local endemism of native species. Therefore, retaining all sites and associated tuart trees is critical.

This principle is highlighted in the National Standards for the Practice of Ecological Restoration in Australia (Standards Reference Group SERA, 2016):

> **"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 (2016) – Appendix 2.*

The principle serves to dissuade 'offsets' or 'trade-offs' where remnants are removed with an undertaking to set aside and/or restore other sites. The destruction of remnants always represents a net loss of the functional ecological community because there is no guarantee all

the species and ecological functions of the remnant can be replicated elsewhere. It is not feasible to replicate the Aquatic Root Mat Community in Caves of the Swan Coastal Plain.

Previous efforts to restore ecological function have proved unsuccessful to date, but restoration efforts may be worthwhile in the future if carefully planned and managed to avoid damage. The Standards Reference Group also identify six principles as 'key principles of ecological restoration practice', the details of which are provided by the Standards Reference Group SERA (2016):

1. **Ecological restoration practice is based on an appropriate local indigenous reference ecosystem.**
2. **Restoration inputs will be dictated by level of resilience and degradation.**
3. **Recovery of ecosystem attributes is facilitated by identifying clear targets, goals and objectives.**
4. **Full recovery is the goal of ecological restoration but outcomes may take long time frames.**
5. **Science is essential to good practice but the two processes are synergistic.**
6. **Social aspects are critical to successful ecological restoration.**

6.2 Priority actions

Priority actions are recommended for the abatement of threats and to support recovery of the ecological community. Actions inconsistent with these recommendations that are likely to significantly affect the ecological community should not be undertaken. In assessment of activities that may have a significant impact on the ecological community, incorporate relevant actions listed below when determining recommendations including conditions of approval. Applications to Australian Government or other funding programs should also consider prioritising the recommended research and restoration activities below.

The four key approaches to achieve the conservation objective are:

PROTECT the ecological community to prevent further loss of extent and condition;

RESTORE the ecological community within its original range by active abatement of threats, recovering natural biological and non-biological attributes of the sites and the current area covered by the ecological community, and other conservation initiatives;

COMMUNICATION – 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 methods for restoration and protection over the long term.

These approaches are overlapping in practice and form part of an iterative approach to management that should include research, planning, management, monitoring and review. Key groups to engage with include: landholders, land managers, land use planners, researchers, community members, and the Indigenous community.

Specific management, research and other conservation priorities for Aquatic Root Mat Community in Caves of the Swan Coastal Plain are described below.

6.2.1 HIGH PRIORITY THREAT ABATEMENT, RESEARCH AND RECOVERY ACTIONS

Implement recommendations in Management Plans for Yanchep National Park likely to benefit root mat communities

- Establish a Cave Management Committee to recommend on cave management.

- Draft specific local-level regulations for cave management and protection.
- Implement a cave permit system for visitors and establish conditions to be linked to permits.
- Classify caves for management.
- Establish Cave Protection Zones.
- Prepare a code of practice regarding management activities (particularly fire, dieback hygiene, use of heavy vehicles and road repairs).
- Monitor water levels in some caves to establish long term trends.
- Minimise impacts of current and future management practices in State Forest 65 on water levels in caves.
- Liaise with other authorities regarding works that may affect the caves.

Manage water levels and quality in likely catchment areas for cave streams

- Continue to reduce water loss through transpiration from pine plantations in State Forest 65, ensuring that the impact that planned harvesting/clearing has on flow rates, water depths and erosion of banks is monitored and managed, and that the pines are replaced with suitable vegetation at an appropriate density.
- Continue to manage public and private abstraction in the Gnangara Water Reserve, Ridges area and other parts of Gnangara State Forest (State Forest 65).
- Manage the use of fertilisers, fungicides or pesticides used in agricultural production, runoff from urban uses, and waters carrying pollutants from land uses such as rubbish tips or industrial areas in the cave catchments, if and as necessary to protect water quality in the caves.

Manage threatening processes and avoid impacts on the ecological community

- Manage fire regimes (frequency, intensity and timing) to avoid fires that kill mature trees that are the source of the root mats.
- Maintain buffers between the caves and any tracks/trails, in particular keeping any unused/superfluous tracks closed and rehabilitating them where that has not already been done.
- Ensure land use planning and development control processes seek to safeguard against potentially adverse impacts upon the cave systems:
    - Proposed developments close to the seven caves that contain this ecological community are likely to require assessment.
    - No developments should be approved unless the proponent can demonstrate that they will have minimal impact on one or more of the caves, its hydrology or its faunal community, or on the trees that have roots in the caves.
- Maintain tuart regeneration as necessary as an integral part of park management.
- As a priority, complete assessment of Tuart (*Eucalyptus gomphocephala*) Forest and Woodland for listing as a threatened ecological community under the EPBC Act.

Research and monitoring

- Survey likely areas for additional occurrences of the community.
- If further caves containing the ecological community are located, identify and liaise with relevant landholders/managers.
- To the extent not already done, determine the location of trees with roots in caves, and monitor survival and recruitment of tree populations above the caves and protect them.
- Monitor the condition of all known occurrences of the ecological community.
- Continue research into the effects of changes in the groundwater catchment on water regimes in the caves; and the source of water that enters cave streams.
- Maintain ongoing assessment of the adequacy of the bore network.

- Reassess the conservation status of the ecological community.

The above list does not necessarily encompass all actions that may be of benefit to the **Aquatic Root Mat Community in Caves of the Swan Coastal Plain** ecological community, but highlights those that are considered to be of highest priority at the time of preparing the Conservation Advice.

6.3 Criteria for success

- No further reductions of root mats in caves.
- Maintenance of trees that are currently supplying or are likely in future to supply roots to the caves that contain the aquatic root community.
- The Pinjar Pine Plantation to achieve the target basal area set by the WA Government with the aim of reducing the water usage of the pine plantation to a level comparable to that of native vegetation.

6.4 Criteria for failure

- Significant loss or further modification of the ecological community, including the complete drying up of the root mats in any single cave.
- Loss of individual faunal species from the ecological community.

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Appendix A. Fauna collected from six caves with aquatic root mat habitats and a surface stream in close proximity to YN 99 (Boomerang Gorge stream) in the Yanchep National Park (from English et al., 2003).

Data for Water Cave are for one sampling period only and were sourced from Knott and Storey (2001). Data for other locations were sourced from Jasinska (1997).

TAXON	Boomerang Gorge stream	Cabaret Cave	Carpark Cave	Gilgie Cave	Twilight Cave	YN 99 cave	Water Cave	Total occur.
CNIDARIA: Hydrozoa [Hydras]								
Hydra sp. 1						1		**1**
Hydra sp. 2						1*		**1**
PLATYHELMINTHES [Flatworms]: Turbellaria								
Catenulida								
Stenostomum sp. 1		1	1	1	1	1		**5**
Stenostomum sp. 2		1	1		1	1		**4**
Macrostomida								
Macrostomum sp. 1		1				1		**2**
Macrostomum sp. 2				***1***	1			**2**
Macrostomum sp. 3	1	1				1		**3**
Rhabdocoela								
Dalyellioida sp. 1	1		1	1	1	1		**5**
Gyratrix hermaphroditus			1		1			**2**
Temnocephala sp. 1		1						**1**
Typhloplanidae sp. 1		1						**1**
ROTIFERA [Wheel animals]								
Bdelloidea sp. 1	1						1	**2**
Philodina sp. 1		1	1	***1***	1	1		**5**
Rotifera spp.	1			***1***	1			**3**

TAXON	Boomerang Gorge stream	Cabaret Cave	Carpark Cave	Gilgie Cave	Twilight Cave	YN 99 cave	Water Cave	Total occur.
TARDIGRADA [Water bears]: Eutardigrada								
Hypsibius sp. 1			1			1		**2**
NEMATODA [roundworms]								
Araeolaimida								
Aphanolaimus sp. 1		1						**1**
Araeolaimida sp. 1			1					**1**
Chromadorida								
Chromadorida sp. 1		1	1	***1***	1	1		**5**
Chromadorida sp. 2			1		1			**2**
Chromadorida sp. 3			1					**1**
Dorylaimida								
Amphidelus sp. 3		1	1	1				**3**
Iotonchus sp. 1		1	1	***1***	1	1		**5**
Mesodorylaimus sp. 1		1		1				**2**
Mesodorylaimus sp. 2					1	1		**2**
Alaimoidea sp. 1		1	1					**2**
Dorylaimidae sp. 1			1					**1**
Enoplida								
Ironus sp. 1	1	1	1	1	1	1		**6**
Tobrilus sp. 1	1		1					**2**
Tobrilus sp. 2			1					**1**
Monohysterida								
Monohystera sp. 1								
Monohysterida sp. 1								
Tylenchida								
Atylenchus sp. 1			1		1			**2**

TAXON	Boomerang Gorge stream	Cabaret Cave	Carpark Cave	Gilgie Cave	Twilight Cave	YN 99 cave	Water Cave	Total occur.
Hemicycliophora sp. 1		1	1	1				**3**
Nematoda sp. 1							1	**1**
Nematoda sp. 2		1						**1**
Nematoda sp. 3		1						**1**
MOLLUSCA: Gastropoda [snails]								
Hydrobiidae sp. 1	1			1		1		**3**
ANNELIDA [segmented worms]								
Hirudinea [leeches]								
Erpobdellidae sp. 1		1				1		**2**
Oligochaeta [earthworms]								
Aeolosomatidae sp. 1				1				**1**
Aeolosoma sp. 1				1		1		**2**
Aeolosoma aff. *leidyi*					1			**1**
Aeolosoma tracanvorense		1	1	***1***	1	1		**5**
Aeolosoma sp. 2					1			**1**
Pristina longiseta		1	1	***1***		1		**4**
Pristina aequiseta						1		**1**
Pristina sp. 1				1		1		**2**
Pristina sp. 2			1					**1**
Pristina sp. 3				1				**1**
Enchytraeidae sp. 1		1		***1***	1			**3**
Enchytraeidae sp. 2				1		1		**2**
Enchytraeidae sp. 3			1					**1**
Phreodrillidae sp. 1		1	1		1		**1**	**4**
Phreodrillidae sp. 2				1				**1**
Insulodrilus ?lacustris		1	1		1			**3**

TAXON	Boomerang Gorge stream	Cabaret Cave	Carpark Cave	Gilgie Cave	Twilight Cave	YN 99 cave	Water Cave	Total occur.
Tubificidae ("group A") sp. 1		1		1		1		**3**
Tubificidae (?*Aulodrilus*) sp. 2	1	1**		1				**2**
ARTHROPODA [insects, arachnids, crustaceans, millipedes, centipedes]								
Arachnida [arachnids]: Acarina [mites and ticks]								
Acaridida								
Acaridae sp. 1		1*						**1**
Prostigmata								
HALACARIDA								
Lobohalacarus sp. nov 1 (eyeless)	1	1	1		1	1		**5**
Soldanellonyx sp. 1	1	1	1	***1***	1	1		**6**
HYDRACARINA								
Tillia sp. nov. 1						1*		**1**
ORIBATIDA								
Hydrozetes sp. 1		1				1		**2**
Trimalaconothrus sp. 1 (eyeless)	1					1		**2**
Trhypochthoniellus sp. 1		1*	1	***1***	1			**4**
Oribatida sp. 1		1*			1*			**2**
Oribatida sp. 2				1*				**1**
Oribatida sp. 3				1*				**1**
Crustacea [crustaceans]								
Amphipoda [amphipods]								
Austrochiltonia subtenuis (Sayce)	1	1		1		1		**4**
Paramelitidae (gen. nov.) sp. nov. 1			1*		1			**2**
Hurleya sp. 1		1	1		1			**3**
Perthia sp. nov. 1		1*			1			**2**
Perthia sp. nov. 2					1			**1**

TAXON	Boomerang Gorge stream	Cabaret Cave	Carpark Cave	Gilgie Cave	Twilight Cave	YN 99 cave	Water Cave	Total occur.
Copepoda [copepods]								
CYCLOPOIDA								
Ectocyclops rubescens Brady	1							**1**
Eucyclops sp. 1	1							**1**
Eucyclops linderi Lindberg		1**						**1**
Macrocyclops sp. 1						1*		**1**
Paracyclops sp. 1	1				1	1		**3**
Paracyclops sp. 2		1	1	***1***	1		**1**	**5**
HARPACTICOIDA								
Attheyella sp. 1 (largest harpacticoid)	1					1		**2**
Bryocamptus (*Limnocamptus*) sp. 1		1	1	***1***	1			**4**
Elaphoidella sp. 1	1					1		**2**
?gen. nov. aff. *Elaphoidella / Bryocamptus* sp. 1				***1***	1	1		**3**
Parastenocaris sp. 1			1	***1***	1			**3**
?gen. nov. aff. *Epactophanes* sp. 2					1			**1**
Harpacticoida sp. 1				1				**1**
Harpacticoida sp. 2			1		1			**2**
Decapoda [crayfish]								
Cherax quinquecarinatus (Gray)	1	1	1	***1***	1	1		**6**
Isopoda [woodlice]								
Janiridae sp. nov. 1	1	1	1	1	1	1	**1**	**7**
Ostracoda [ostracods]								
Darwinula sp. 1	1					1		**2**
Gomphodella aff. maia De Dekker		1	1	1	1	1		**5**
Candona sp. 1			1		1			**2**

TAXON	Boomerang Gorge stream	Cabaret Cave	Carpark Cave	Gilgie Cave	Twilight Cave	YN 99 cave	Water Cave	Total occur.
Candoniidae sp. 1		1*						**1**
Cyprididae sp. 1	1							**1**
Entognatha [pseudo insects]								
Hexapod sp. 1		1*						1
Insecta [insects]								
Coleoptera [beetles]								
Sternopriscus sp. 1	1	1	1	1	1	1		**6**
Diptera [flies/maggots]								
CHIRONOMIDAE								
Corynoneura sp. 1						1		**1**
Paramerina levidensis (Skuse)	1					1		**2**
Polypedilum sp. 1		1				1		**2**
CERATOPOGONIDAE								
Ceratopogonidae sp. 1	1				1	1		3
CULICIDAE								
Anopheles sp. 1	1							**1**
Tipulidae sp. 1		1*		1*	1*			**3**
Trichoptera [caddis flies]								
Leptoceridae sp. 1		1*						**1**
CHORDATA: Osteichthyes [bony fishes]: PERCICHTHYIDAE								
Bostockia porosa		1						**1**

Bold = Gilgie Cave stream fauna collected both before and after the drying
* = rare species (fewer than four individuals collected in total)
# = Gondwanan relicts
Total occur = Total number of sites at which the species occurred