Department of **Biodiversity, Conservation and Attractions**

GOVERNMENT OF WESTERN AUSTRALIA

Section 1 – Eligibility for Listing

1. Name of the ecological community

Stromatolite community of stratified hypersaline coastal lakes (Lake Thetis)

2. Listing Category for which the ecological community is nominated

	Current rank under WA Minister ESA list in policy	EPBC Act (wholly or as a component)
Current listing category (Please check box)	☐ Critically endangered ☐ Endangered ☒ Vulnerable ☐ Priority 1-4 ☐ Data Deficient ☐ None – not listed	Name: ☐ Critically endangered ☐ Endangered ☐ Vulnerable ☒ None – not listed
Proposed listing category under BC Act (Please check box)	☐ Collapsed ☒ CR: Critically endangered ☐ EN: Endangered ☐ VU: Vulnerable ☐ Priority 1-4	
Select one or more of the following criteria under which the community is to be nominated for BC Act listing. (Please check box). For further details on these criteria please refer to the Attachment to this form. The information you provide in Section 3 should support the criteria you select here.	☐ Criterion A – Reduction in geographic distribution ☒ Criterion B – Restricted geographic distribution ☐ Criterion C – Environmental degradation based on change in an abiotic variable ☐ Criterion D – Disruption of biotic processes or interactions based on change in a biotic variable ☐ Criterion E – Quantitative analysis that estimates the probability of ecosystem collapse	

Section 2 – Description, Condition, Threats & Recovery

Please answer all the questions, providing references where applicable. If no or insufficient information exists to answer a question, you must indicate this instead of leaving the question blank. The answers may be provided within this form or as attachments, ensuring that responses clearly indicate which question number they refer to.

Classification

3. What is the name of the ecological community?

Note any other names that have been used recently, including where different names apply within different jurisdictions. For example, is it known by separate names in different States or regions?

Stromatolite community of stratified hypersaline coastal lakes (Lake Thetis) (commonly referred to as Lake Thetis stromatolites).

4. What authorities/surveys/studies support or use the name?

Grey *et al*. (1990), Moore (2003) and other publications refer to the stromatolite community. The community type was endorsed as a vulnerable TEC by the WA Minister for Environment in 2001. It was ranked using ranking criteria developed in WA, that differ from those used for the IUCN RLE. The community is not nominated or listed under the EPBC Act.

5. How does the nominated ecological community relate to other ecological communities that occur nearby or that may be similar to it?

Does it intergrade with any other ecological communities and, if so, what are they and how wide are the intergradation zones?
Describe how you might distinguish the ecological community in areas where there is overlap (also see Description section below).

Other microbial structures occur in Western Australia at Hamelin Pool, Shark Bay. Living microbialites in the south west of the State that are not as well known also occur at Pink Lake (Esperance), Sea Cliffs (Augusta), Lake Clifton, Pamelup Pond - Lake Preston (Yalgorup); Government House Lake and other lakes on Rottnest Island; and Lake Richmond (Rockingham) (Moore 1993). Each of these constitutes a distinct and very significant community in terms of composition, history, structure, and morphology (Moore 1993). For example, the microbialites of Lakes Clifton and Richmond lack distinct laminations and have been classified as thrombolitic, whereas those in Lake Thetis exhibit well defined laminae and are considered stromatolitic. Compared to the stromatolites of Hamelin Pool, which are formed by the trapping and binding of sediment, those of Lake Thetis are the result of biologically-influenced carbonate precipitation (Grey *et al*. 1990).

Description

6. List the main features that distinguish this ecological community from all other ecological communities.

Characteristic (or diagnostic) features can be biological (e.g. taxa or taxonomic groups of plants and animals characteristic to the community; a type of vegetation or other biotic structure), or associated non-biological landscape characteristics (e.g. soil type or substrate, habitat feature, hydrological feature). Please limit your answer to those features that are <u>specific</u> to the ecological community and can be used to distinguish it from other ecological communities.

The community occurs in Lake Thetis, in Cervantes. It comprises a distinctive and diverse group of benthic microbial assemblages, each producing a mat that is associated with one specific zone within the lake. Crenulate cyanobacterial mats occur in the low-lying areas adjacent to the lake. Lithified stromatolites, resembling those at Shark Bay, with patches of living cyanobacterial mats and nodular mats characterise the littoral areas. Filamentous mats reside in cavities and coat the surface of the flocculant mat in the basin, a mobile diatomaceous mat occurs in the shallows, and thick flocculant mats of phototrophic prokaryotes, other microbes or diatoms (or microbes and diatoms) occur in the central basin. Lake Thetis has benthic microbial mats adjacent to the lithified stromatolites and well-developed flocculant mats in the basin. Under current conditions microbial reef-forming communities and flocculant mat communities are both scarce. Some stromatolites have branching columns (DEC 2012).

7. Give a description of the biological components of the ecological community.

For instance, what species of plants and animals commonly occur in the community; what is the typical vegetation structure (if relevant).

Lake Thetis is characterised by a diverse assemblage of benthic microbial communities, each producing a distinctive mat type including: crenulate, nodular, filamentous, diatomaceous and flocculent mats. The mats are confined to specific zones that are determined by environmental controls (Grey *et al*. 1990; Grey and Plavansky 2009). The stromatolites are just one expression of the diverse microbial assemblage that occurs in the lake (DEC 2012).

Crenulate mats grow in seasonally flooded high foreshore areas around Lake Thetis. They consist of a few millimetres of organic-rich sediment intercalated with lake sediments comprising mainly calcareous mud, underlain by coarse calcareous sand. The mat contains the filamentous cyanobacteria identified as Calothrix and Scytonema as well as small colonies of the coccoid cyanobacterium, Gloeocapsa (DEC 2012).

Nodular mats are generally restricted to splash zones around the sides of stromatolite domes along the south-western shoreline of Lake Thetis. The nodular mat consists of coccoid cyanobacteria, principally Gloeocapsa, with variable quantities of diatoms depending on seasonal lake level. These organisms secrete mucilage which, along with the layer of living mat, forms a thin coating on the lithified nodules. Copious mucilage production provides a matrix for sediment accumulation and carbonate precipitation. Domes are one form of microbial mat in the lake and are marked by a thin outer rind that is dominated by coccoid cyanobacteria (Gloeocapsa and also Entophysalis (Arp *et al*. 2001)) and deeper layers that are dominated by filamentous cyanobacteria (Scytonema) and by branching and tufts (DEC 2012).

Filamentous mats occur in areas of reduced light penetration where they mainly consist of oscillatorian cyanobacteria including chasmoliths. In the deeper part of the lake, and within cracks of lithified plates and angular fragments on the lower marginal shelf, it forms a thin, fragile, often incomplete film comprising the uppermost layer of flocculent mat (DEC 2012).

Diatomaceous mats form an orange-brown gelatinous band in the shallow parts of Lake Thetis, usually just below or sometimes coating the nodular mat. Diatom frustules are a significant component of the lithified surface of many of the Lake Thetis stromatolites. Diatoms as well as cyanobacteria are consistently associated with carbonate particles and may have a role in trapping or precipitating carbonate sediments (DEC 2012; Grey *et al*. 1990).

Floating flocculant mats comprise a relatively thin (1-2mm) surface mosaic of brown-to-blue-green patches over a massive pinkish-red accumulation of biogenic sediment and colonise the bottom of the central, submerged basin, of Lake Thetis. The upper film is made up of several species of oscillatoriacean cyanobacteria and other non-phototrophic filamentous bacteria such as Beggiatoa sp., a boundary species that tolerates oxygen and oxidises hydrogen sulphide (H_2S). Other major contributors to biomass in this community include several pennate (long tapering) and naviculoid (boat shaped) diatom species and a small unicellular, coccoid cyanobacterium (Synechocystis). The underlying bulk of the mat lacks oxygen and has red–purple organic material mainly comprising purple sulfur bacteria (anoxygenic, H_2S utilizing photosynthetic bacteria, Thiocystis/Thiocapsa group) (Grey *et al*. 1990). The massive sediment in the lake basin is also likely home to sulphur reducing bacteria and other chemautotophs (DEC 2012).

Purple tides typical of bacteria, including sulphur-reducing bacteria and other chemautotrophs, have been observed at the lake (Bauld *et al*. 1986; Grey *et al*. 1990). These bacteria play an integral role in adjusting the alkalinity of the brine in the lake water and within microbial structures at the macro and micro scales (Burns *et al*. 2008; DEC 2012; Goh *et al*. 2009).

The rate of growth of the thrombolites at Lake Clifton is about 0.1mm per year, and the growth rate of the stromatolites in Lake Thetis is likely to be similarly low (Moore 1993; Moore and Burne 1994). Changes to physical parameters, such as salinity and nutrients, may cause a shift in the microbes that dominate the microbial community possibly replacing these with a different microbial assemblage that does not facilitate carbonate deposition and stromatolite formation.

8. Give a description of the associated non-biological landscape characteristics or components of the ecological community.

For instance, what is the typical landscape in which the community occurs? Note if it is associated with a particular soil type or substrate; what major climatic variables drive the distribution of the ecological community (e.g. rainfall). Note particular altitudes, latitudes or geographic coordinates

Lake Thetis is a small, permanent, hyper-saline lake located on the coastal plain east of Cervantes. It occupies a deflation basin with limestone pavement situated between Holocene parabolic and nested parabolic dunes, and is separated from the ocean by a relict fore-dune plain (Gozzard 1985). The lake is underlaid by the Superficial Aquifer, an unconfined aquifer system constituted with sediments from sand and limestone (Tamala limestone) (Rutherford *et al*. 2005). The lake waters are typically alkaline and nutrient-poor which means they are ideal for the growth of benthic microbial communities (Grey *et al*. 1990). The regional climate is Mediterranean, with hot, dry summers and cool, wet winters and the mean annual rainfall for Cervantes is 569.4mm (BOM WA data; DOW 2008; Moore *et al*. 1984).

9. Provide information on the ecological processes by which the biological and non-biological components interact (where known).

Lake Thetis is fed by direct rainfall, surface water, and possibly by groundwater bearing calcium and carbonates. It loses water by evaporation and no rivers or creeks discharge into it. There is no evidence for active subterranean water exchange with the sea (Por 1985). Water level fluctuates seasonally with rainfall, rather than with the tides, around mean sea level due to the proximity of the lake to sea level (Grey *et al*. 1990). Salinity varies from 39 to 59 gL^{-1} (>35gL^{-1} is classified as brine), and the ionic proportions of the lake water reflect seawater origins (Arp *et al*. 2001; DEC records 2009, 2010; Grey *et al*. 1990). The lake is apparently down-gradient in regional superficial flow. The salinity of groundwater in close proximity to the lake has not been investigated, apart from a shallow bore on the lake edge where it simply intercepted lake salinity. The slightly elevated sulphate levels and an anoxic boundary dominated by sulphur bacteria may in part indicate concentration of incoming groundwater bearing hydrogen sulfide and/or sulphate (DEC 2012). Aragonite saturation tends to correlate fairly strongly to the ratio of magnesium/calcium (Mg/Ca), which likely reflects depletion of calcium ions in solution. To maintain the current status of the lake and general conditions that foster calcification, the open water aragonite saturation needs to be within the general range of lake water-body values (l - series) of 5.6 to 9.1 aragonite saturation and 5.3 to 7.2 Mg/Ca.

Table 1. Hydrological data for Lake Thetis.

Source	**Mean temperature (°C)**	**Mean salinity (gL^{-1})**	**Mean pH**	**Mean calcium (mgL^{-1})**
Seawater	~20	35		412
1985 (Grey *et al*. 1990)	21	47.5	8.3	434
1986 (Grey *et al*. 1990)		43.5		
1987 (Grey *et al*. 1990)		53		478
1989 (Grey *et al*. 1990)	20.8	48	8.3	432
DEC sampling 2009	21.1	49	8	
DEC sampling 2010	24.9	53	8.6	585.6

10. Does the ecological community show any consistent regional or other variation across its extent, such as characteristic differences in species composition or structure?

If so, please describe these.

The benthic microbial assemblages of Lake Thetis are distinctive and diverse, each producing a mat that is associated with one specific zone within the lake. Crenulate cyanobacterial mats occur in the low-lying areas adjacent to the lake; nodular mats characterize the littoral areas (domes being the most obvious forms); filamentous mats reside in cavities and coat the surface in the basin; a mobile diatomaceous mat occurs in the shallows, and thick flocculant mats of phototrophic prokaryotes, other microbes and/or diatoms occur in the central basin (DEC 2012).

11. Does the ecological community provide habitat for any listed threatened species and/or endemic species?

If so, please note the species and whether the species is listed on State and/or national lists and the nature of their dependence on the ecological community.

No

12. Identify major studies on the ecological community (authors, dates, title and publishing details where relevant).

Department of Environment and Conservation (2012) Stromatolite community of stratified hypersaline coastal lake – Lake Thetis. Interim Recovery Plan No. 325, 2012-2017. Department of Environment and Conservation, Western Australia.

Grey, K, Moore, LS, Burne, RV, Pierson, BK and Bauld, J. (1990) Lake Thetis, western australia: an example of saline lake sedimentation dominated by benthic microbial processes. *Australian Journal of Freshwater Resources*, vol. 41, pp. 275-300.

Grey, K. and Plavansky, N.J. (2009) Microbialites of Lake Thetis Cervantes, Western Australia – a field guide. Geological Survey of Western Australia Record 2009/11.

Moore, L. (1991) Lake Clifton - An internationally significant wetland in need of management. Land and Water Research News. Issue No 8; 37-41.

Moore, L. (1993) The Modern Thrombolites of Lake Clifton South Western Australia. Unpublished PhD Thesis. University of Western Australia.

Distribution

13. Describe the distribution across WA and nationally.

State the appropriate bioregions where the ecological community occurs. Attach or provide any maps showing its distribution with details of the source of the maps, or explain how they were created and the datasets used.

Lake Thetis is located on the coastal plain 1.25km inland from the Indian Ocean and less than 1km due east of the coastal township of Cervantes (Appendix 1). The waterbody is approximately 300m wide, 400m long and 2m deep but varies with season.

The benthic microbial mats occur throughout Lake Thetis, the most visibly distinct being the domes which occur in the fringing shallows around much of the lake (DEC 2012).

14. What is the area of distribution of the ecological community?

For answers to parts a, b, c & d: please identify whether any values represent extent of occurrence or area of occupancy (as described in the Attachment); provide details of the source(s) for the estimates and explain how they were calculated and the datasets used.

14 a. What is the current known area (in ha)? 9ha

14 b. What is the pre-industrialisation extent or its former known extent (in ha)? An ecological community is considered to be naturally restricted if it has a pre-industrialisation area of occupancy that is less than 10 000 ha or a pre-industrialisation extent of occurrence that is less than 100 000 ha (refer to the Attachment A) 9ha

14 c. What is the estimated percentage decline of the ecological community?

It is estimated that 20% of the community has declined as a result of damage from recreational activities.

14 d. What data are there to indicate that future changes in distribution may occur?

Observations of stromatolite condition made at Lake Thetis in 2010, 2017 and 2019 noted the damage to the structures from recreational users of the lake. Based on historic evidence it can be assumed this will likely continue in the future.

National Climate Change Adaptation Research Facility (NCCARF) website (accessed 2019) is indicative of climatic trends that are likely to result in reduced groundwater inflows.

Patch size

15. What is the typical size (in ha) for a patch of the ecological community (if known)?

Explain how it was calculated and the datasets that are used. Relevant data includes the average patch size, the proportion of patches that are certain sizes, particularly proportions below 10 ha and below 100 ha, (but also below 1 ha and above 100 ha, for example). This could be presented as the range of patch sizes that comprise 90% of the occurrences.

There is only one location of this ecological community, that covers approximately 9 hectares.

16. Quantify, if possible, the smallest percentage or area required for a patch of the ecological community to be considered viable.

This refers to the minimum size of a remnant that can remain viable without active management. It may be determined through the requirements for dominant native species, level of species diversity, or the nature of invasive weeds.

There is only one location known therefore this question is not relevant.

Functionality

17. Is the present distribution of the ecological community severely fragmented?

If so, what are likely causes of fragmentation?
If fragmentation is a natural or positive characteristic of this ecological community, please explain this and state the reason.
Severely fragmented refers to the situation in which increased extinction risk to the ecological community results from most remnants being found in small and relatively isolated patches.

NA

18. Has there been a loss or decline of functionally important species?

This refers to native species that are critically important in the processes that sustain or play a major role in the ecological community and whose removal has the potential to precipitate change in community structure or function sufficient to undermine the overall viability of the community.

Changes to physical parameters, such as an increase or decrease in salinity and nutrient concentrations, are likely caused a shift in the microbes that dominate the stromatolites possibly replacing these with a different microbial community that may not facilitate carbonate deposition and stromatolite formation. As no recent monitoring of the hydrological conditions of the lake and the benthic community has been completed there is no evidence that such a shift has occurred.

18 a. If yes, which species are affected?

The benthic microbial community dominated by the filamentous cyanobacteria ('blue-green algae') and diatoms is likely to be affected by major shifts in lake chemistry.

18 b. How are the species functionally important and to what extent have they declined?

Photosynthetic and metabolic activity of the benthic microbial community facilitates carbonate deposition and stromatolite formation are likely to be affected by significant changes to lake chemistry.

Reduction in community integrity

19. Please describe any processes that have resulted in a reduction in integrity and the consequences of these processes, e.g. loss of understorey in a woodland. Include any available information on the rate of these changes.

This recognises that an ecological community can be threatened with extinction through on-going modifications that do not necessarily lead to total destruction of all elements of the community. Changes in integrity can be measured by comparison with a benchmark state that reflects as closely as possible the natural condition of the community with respect to the composition and arrangement of its abiotic and biotic elements and the processes that sustain them. Please provide a description of the benchmark state where available. For further information please refer to the Guidelines.

The microbialite community of Lake Thetis has been subject to historical disturbance by crushing from vehicles and uncontrolled pedestrian access; high level disturbance to the buffering vegetation, including from mining and refuse dumping to the north that resulted in an increase in weed invasion, more frequent fire and input of sediment. The microbialites are also likely to be subject to future threats, mainly from hydrological, chemical and physical changes (DEC 2012).

Survey and Monitoring

20. Has the ecological community been reasonably well surveyed?

Provide an overview of surveys to date, including coverage of different land tenure, and the likelihood of the ecological community's current known distribution and/or patch size being a true reflection of its actual distribution (consider area of occupancy and area of extent, including any data on number and size of patches).

Grey *et al*. (1990) monitored lake levels and microbial mat distribution from 1980 and 1989.

A baseline survey of the domal structures, including counting, geolocating and plotting, was completed at the macro scale by DBCA in 1995.

Surveys of the general health and distribution of the stromatolites were made in 2010, 2017 and 2019 by DBCA staff.

21. Where possible, please indicate areas that haven't been surveyed but may add to the information required in determining the community's overall viability and quality.

Include commentary on issues to do with accessing different land tenures within the area of distribution, including private property, and the likelihood that these areas may include occurrences.

NA

22. Is there an ongoing monitoring program? If so, please describe the extent and length of the program.

Monitoring has consisted of the following:

- Lake levels and microbial mat distribution monitored in 1980 and 1989 (Grey *et al*. 1990).

- Twenty samples of microbial material were collected by DBCA in 2011 from a variety of the microbial assemblages and have been prepared and stored for DNA analysis of microbial composition. Water samples were also collected at the same time to link water and composition data.
- Samples of microbial assemblages were monitored in 1998 by Pache *et al*.
- Water monitoring has been taken spasmodically from the lake since 1985. There has also been sampling from two bores in surface water and the saline fringe at the lake (Grey *et al*. 1990) and from the shallow aquifer to the east (Kerns 1997).
- Water monitoring by DWER from a bore less than 1km away from the lake on the western side from 2010 to 2014 (data from DWER website http://www.water.wa.gov.au/maps-and-data/monitoring/water-information-reporting).
- Monitoring is opportunistic and there is no strategic ongoing monitoring program.

Condition Classes and Thresholds

23. Do you think condition classes/thresholds apply to this ecological community? If not, give reasons.

The Committee recognises that ecological communities can exist in various condition states. In reaching its decision the Committee uses condition classes and/or thresholds to determine the patches that are included or excluded from the listed ecological community (see the Guidelines for details of the process of determining condition classes). Relevant here is recognition of different states following disturbance and the natural recovery of the occurrence towards a higher condition class.

Due to their distinctness, the dome-like structures can be used for assessing the condition of the community on a whole. However, while the rock-like domes are persistent, it is not necessarily evident from visual cues to determine whether the structure-building communities are active, inactive, or deceased. This requires use of specialist techniques and knowledge to establish the status of the microbial assemblage. Therefore a condition class can be applied to the community as a whole based on:

- the presence/absence and species composition of the benthic microbial community and whether this will contribute to growth (accretion);
- hydrological changes within the lake;
- a visual survey of the physical condition of the dome structures.

24. If so, how much of the community would you describe as in relatively <u>good condition</u>, i.e. likely to persist into the long-term with minimal management?

Using the criteria above as a baseline for 'good condition' then it can be inferred that 80% of the community is in 'good condition'. A brief survey of the condition of the dome structures in 2019 noted that 80% of the stromatolites were in good condition, the remainder impacted by recreational activities. It is not known whether the current conditions of the lake are suitable for structure growth/accretion.

25. What features or variables do you consider to be most valuable for identifying a patch of the ecological community in relatively <u>good condition</u>?

Variables for establishing the highest condition class may include: patch size; connectivity; native plant species composition; diversity and cover (for example in overstorey; mid-shrub and/or understorey layers); recognised faunal values; and cover of weeds or other invasive species.

A 'good' condition class can be described as presence of specific benthic microbial community that contributes to accretion, specific hydrological conditions within the lake that promote accretion and intact condition of dome-like structures.

26. How much of the community would you describe as in relatively <u>medium condition</u>, i.e. likely to persist into the long-term future with management?

Based on observations made of the condition of the dome-like structures in 2019, it is inferred that none of the stromatolites were in medium condition.

27. Please describe how you would identify areas in <u>medium condition</u> using one or a combination of indicators such as species diversity, structure, remnant size, cover of weeds or other invasive species, etc.

A 'medium' condition class can be described as some presence of specific benthic microbial community which contributes to accretion, minimal changes to hydrological conditions within the lake that promote accretion, and mostly intact condition of dome-like structures.

28. How much of the community would you describe as in relatively poor condition, i.e. unlikely to be recoverable with active management?

It is inferred that 20% of the community is in poor condition, based on recent observations of the condition of the dome-like structures within the lake in 2019 where 20% of the stromatolites had been crushed by walkers and collectors.

29. Please describe how you would identify areas in poor condition using one or a combination of indicators such as species diversity, structure, remnant size, cover of weeds or other invasive species, etc.

A 'poor' condition class can be described as the absence of the specific benthic microbial communities that contribute to accretion; altered hydrological conditions that do not support accretion, or significant physical damage to the dome structures.

Threats

Note: If you plan to identify climate change as a threat to the ecological community, please refer to the Guidelines for information on how this should be addressed.

30. Identify PAST threats to the ecological community indicating whether they are *actual* or *potential*.

The microbialite community of Lake Thetis has been subject to actual historical disturbance by crushing from vehicles and uncontrolled pedestrian access; high level disturbance to the buffering vegetation, including from mining and refuse dumping to the north that resulted in an increase in the risk of weed invasion and contaminants, more frequent fire and input of sediment and ash (DEC 2012).

31. Identify CURRENT threats to the ecological community indicating whether they are *actual* or *potential*.

The microbialite community of Lake Thetis is subject to recent and ongoing disturbance by physical crushing; suspected hydrological changes; and disturbance of the native vegetation buffer around the lake.

32. Identify FUTURE threats to the ecological community indicating whether they are *actual* or *potential*.

It is predicted that in the future the microbialite community of Lake Thetis will continue to be threatened by physical crushing; changes to lake level and other water quality parameters; and disturbance of the native vegetation buffer around the lake.

For each threat describe:

32 a. How the threat has impacted on this ecological community in the past.

Physical crushing and active recreation

Crushing due to recreational activities, including pedestrian access and four-wheel drives is estimated to have impacted approximately 20% of the stromatolite community in the past. General impacts are likely to increase as the population of the area and tourist visitation increases. Other activities such as canoeing and fishing, and dog-walking, have also had significant impact on the stromatolites through crushing, abrasion, and contamination. Although this has been moderated by the buffering vegetation, the lake sediment, and even the limestone structures acting as a barrier, it still likely to have resulted in an additional sustained input to a low nutrient catchment. In 2008/2009 the following were undertaken to reduce the impact on the community: installation of signs to indicate the significance of the stromatolites; a loop-walk and boardwalk, bird hides, a lookout, and a day-use area with parking and picnic facilities; track closure, and revegetation of the buffer.

Introduced fauna (fish)

Black bream are most likely a modern introduction to Lake Thetis as they were not noticed until recently (Grey *et al*. 1990) and have been observed at other lakes in the vicinity of Lake Thetis. Besides the bream there are also tentative identifications of other exotic fish including Gambusia and of Yellowtail Grunter. Introductions of exotic fish have the potential to directly and indirectly alter the ecosystem dynamics and may consume microbial assemblages, invertebrates, and indigenous fish, and so also alter native fish diversity and/or abundance, and affect nutrient pools and cycling rates. Data from Lake Thetis indicate that the water quality may at times be unfavourable for black bream but have not been found to be sufficient to exclude them outright as yet.

Erosion and sedimentation

Vehicle use by visitors to Lake Thetis has contributed to the compaction of soils occurring over many years which has prevented growth of peripheral vegetation (Gillen 2007). The removal of vegetation may have inadvertently allowed more nutrients to enter the lake because of a reduction in filtering capacity of fringing vegetation. Construction activities adjacent to the lake may have also resulted in increased sedimentation thereby physically affecting microbes via burial and/or blocking light penetration and hence photosynthesis (DEC 2012).

Alterations to surrounding vegetation

Surrounding land use including dumping of garden waste, and a shell grit quarry directly north of the lake, have resulted in the introduction of grassy weeds and subsequent changes to the vegetation buffer. This has the potential to increase nutrient and contaminant runoff into the lake as well as the risk of fire. In 2008/2009, a rehabilitation program was undertaken and included a survey of the vegetation bordering the lake, in particular adjacent to the stromatolites to determine priorities for weed control; and selective spraying of grassy weeds in the quarry and other disturbed areas with glyphosate-based spray.

Increased nutrients and contaminants

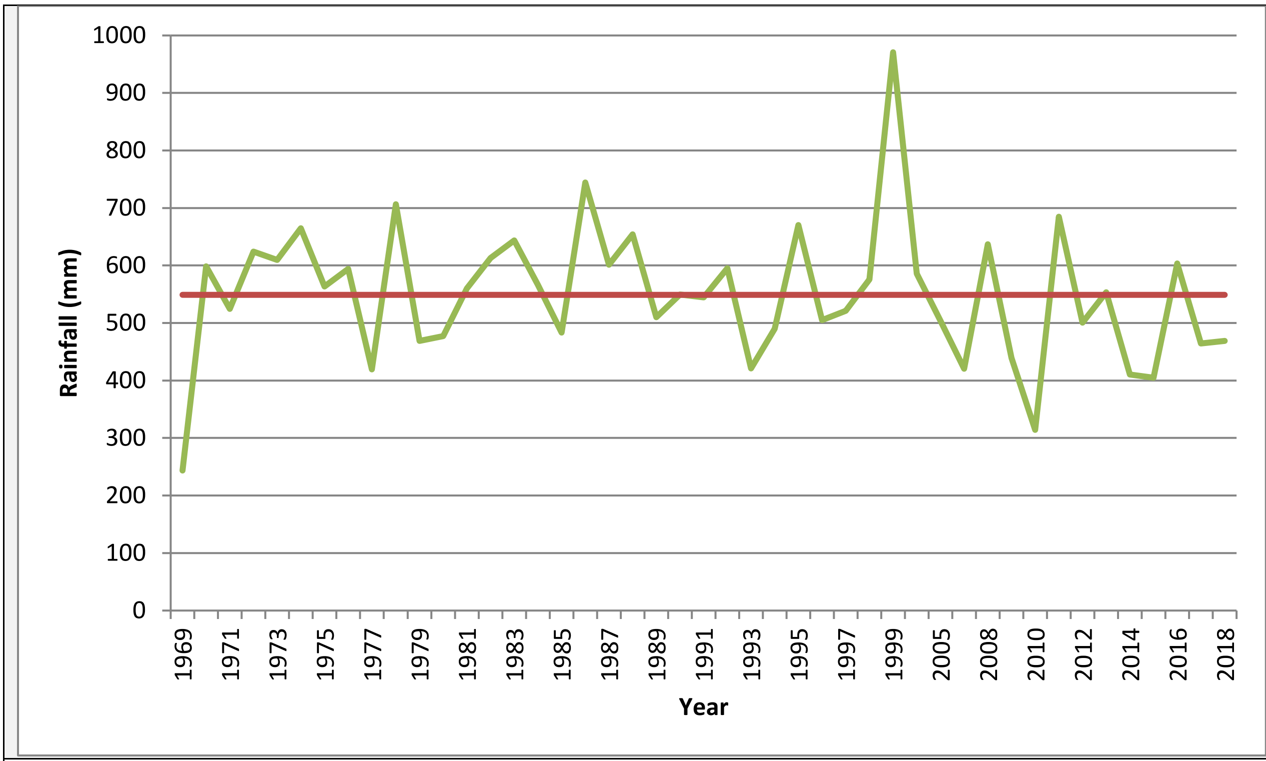
With the increasing population within the town of Cervantes and subsequent rise in land use for agricultural practices, the concomitant rise in runoff of nutrients and other pollutants from properties that are up-gradient may potentially be a threat to the growth and survival of the stromatolites. Pollution may have already intercepted the shallow groundwater in the nearby disused limestone marl pit and garden refuse site (to the north), an adjacent light industrial area, the car park servicing Lake Thetis, and during boardwalk construction activities (DEC 2012).

Hydrological changes

The yearly rainfall for the Jurien region has declined since 2000 (Figure 1). From 1969 to 1999 the average was 571mm, and from 2000 to 2018 was 499mm (from BOM data accessed for Jurien Bay), a 13% reduction.

It is not known whether this has impacted on the lake level, but it is likely to have resulted in less surface water runoff into the lake. A decline in lake level may expose the stromatolites for longer periods of time, altering the seasonality and timing of the hydrological regime required for accretion to occur. The existing Cervantes town water supply scheme consists of four production bores (2/72, 1/76, 1/85 and 7/91). The average production capacity of the existing Cervantes water supply scheme was restricted to about 260,000kL/year in 1999 (WRC 1999). Abstraction in 1994/95 was approximately 184,092kL/year (WAWA 1995) and in 2010 was increased to 30,000,000kL/year (DOW 2010).

Figure 1. Yearly rainfall totals for Jurien (green line) from 1969 to 2018. Total average rainfall (red line) is 549mm for this period (accessed from BOM WA).



32 b. What its expected effects are in the future. Include or reference supporting research or information.

Physical crushing and recreational activities

Despite the installation of the boardwalk and signage, recreational users continue to damage the stromatolites, with 2019 monitoring observing approximately 20% of the visible dome structures had been damaged (personal observations [redacted][1]). With increasing numbers of visitors to the lake, it is likely this will continue in the future, resulting in ongoing decline of the structures. It is likely that the compaction of soils from recreational users will also continue despite the installation of the boardwalk.

Changes associated with buffer vegetation

Herbicides used in the catchment or aquifer may tend to concentrate around the domes as foam. The toxic effects of a common herbicide have been demonstrated on stromatolite microbes (Falcon *et al*. 2006). A sustained plume of dissolved nutrients could potentially affect calcium carbonate saturation, and phosphates and sulphates could affect the total alkalinity (DEC 2012). It is likely that the concomitant rise in runoff of nutrients and other pollutants from properties that are up gradient will continue to be a threat to the stromatolites.

Weeds are likely to persist in the vegetation buffer surrounding the lake.

Various regulatory controls now mean that any future mining adjacent the lake is unlikely.

Drying climate

Drying climate is likely to result in declining rainfall in the south west of the state (from NCCARF website accessed 27 March 2019); https://www.nccarf.edu.au/sites/default/files/attached_files_publications/PDF%20Report%20Card%20Low%20Res.pdf). This will likely result in declining groundwater levels, influx of fresh groundwater, and subsequent change in water quality as follows:

- Reduction in rainfall by 2030 by 2-14% (median 8%). Southwest to predicted to experience some of the largest reductions in rainfall in all of Australia;
- Reduction in runoff by 10-42% (median 25%) by 2030;
- Decline in groundwater levels by 2030 (extractive yields may decrease by a third to a half in some areas).

Hydrological changes

[1] [redacted] Principal Ecologist, DBCA

A reduction in rainfall of 2 to 14% (median 8%) by 2030 (from NCCARF)(as listed in 33c) combined with an increase in groundwater abstraction may result in a decline in lake water level and increase in stromatolite exposure, potentially retarding their development. A potential, very long-term, risk is that the pH of the lake may move from its current bicarbonate equivalence point in the carbonate-bicarbonate series, with major consequences for structural deposition. Under likely drying/concentrating conditions the concentration of calcium carbonate will simply remain above the threshold that the cyanobacteria prefer and will rise in step with the Mg/Ca ratio until they precipitate or are left as an evaporite. The main threat under drying conditions would be the ultimate exposure of the lakebed, with the collapse of the buffering input of the sediment, and the potential for the development of acid sulphate soils. Rewatering a drying lake would be problematic as matching current water quality and screening out foreign biota would be difficult. An understanding of these processes would require monitoring of total alkalinity, salinity, pH and other CO2 system parameters (DEC 2012).

Changes to the salinity of the brine

Hydrological changes to the lake are likely to lead to rapid and/or sustained changes to the salinity of the brine in the future. Under likely drying/concentrating conditions the main threat is loss of microbes with moderate salinity tolerances from the community and so alteration to the community composition and dynamics including structural processes. Alternatively, dilution of the lake is unlikely because the resident chemicals would simply re-dissolve if freshwater inflow increased. There is only a short-term record of the salinity range, which from 1985 to 2010 was 39 to 59 g/L (field conductivity and absolute salinity values; Grey *et al*. 1990; DEC records 2009, 2010). The long-term fluctuations will only emerge with prolonged monitoring across the lake. This is linked to also establishing the quality, quantity and rate of inputs and outputs of water to the lake and the interaction with issues such as such as declining rainfall, and if the lake is groundwater dependent, groundwater abstraction. The impact of changes in salinity and other water quality parameters on the stromatolites may be dependent on the level of stratification and mixing of inputs such as groundwater and lake water. Lake Thetis does not appear to experience a strong level of stratification within the water column, although this has not been closely studied (DEC 2012).

32 c. Identify whether the threat only affects certain portions or occurrences. Give Details.

The threats listed above have impacted on the lake as a whole.

33. Identify any natural catastrophic event/s

Explain its likely impact and indicate the likelihood of it occurring (e.g. a drought/fire in the area every 100 years). Catastrophic events are those with a low predictability that are likely to severely affect the ecological community.

Drought has the potential to reduce lake water levels, and increase nutrient and salinity levels, affecting the microbial assemblage and hence stromatolite growth/accretion.

Major fires can occur any time and have potential for major impacts to the vegetation buffer surrounding the lake, and for increasing nutrient and sediment inputs to the lake.

34. Additional biological characteristics

Identify and explain any additional biological characteristics particular to the community or species within it that are threatening to its survival (e.g. low genetic diversity). Identify and explain any models addressing survival or particular features.

34 a. How does it respond to disturbance?

Physical disturbance such as by walkers can damage the stromatolites through crushing.

Fire in the vegetated buffer increases weed levels, and produces a short-term flush of nutrients into the lake, both because of the removal of the retentive vegetation barrier, and due to release of nutrients from the burnt vegetation. Stromatolites are likely to be impacted by the release of nutrients into the lake, and by the release of sediment immediately following fire in the remnant buffer near the lake. Chemicals used for weed control may impact on the stromatolites if used adjacent to the structures, as they are photosynthetic.

34 b. How long does it take to regenerate and/or recover?

The minimum net growth rate of the stromatolites at Lake Clifton is around 0.1mm per year (Moore 1993; Moore and Burne 1994) and those at Lake Thetis may be similarly low. Therefore the microbialite structures would take many years to regenerate following impacts such as crushing.

The surrounding vegetation buffer will recover from occasional fire.

Threat Abatement and Recovery

35. Identify key management documentation available for the ecological community, e.g. recovery plans, biodiversity management programmes, or site specific management plans (e.g. for a reserve).

Department of Environment and Conservation (2012) Stromatolite community of stratified hypersaline coastal lake – Lake Thetis. Interim Recovery Plan No. 325, 2012-2017. Department of Environment and Conservation, Western Australia.

Department of Conservation and Land Management (1998) Nambung National Park Management Plan 1998-2008. Management Plan Number 37 for the National Parks and Nature Conservation Authority. Perth, Western Australia.

36. Give an overview of how threats are being/potentially abated and other recovery actions underway and/or proposed. Identify who is undertaking these activities and how successful the activities have been to date.

Regulations that control land clearing under the WA *Environmental Protection Act 1986* and the *Environment Protection and Biodiversity Conservation Act 1999* have reduced vegetation clearing.

Other key measures required to mitigate risks to the ecological community include ensuring adjacent landowners are aware of the significance of the stromatolite community; the construction of a boardwalk on the edge of the lake to allow visitors to view the stromatolites without crushing them; and control of weeds in the rehabilitation areas on the lake edge.

37. What portion of the current extent of the ecological community is protected in a reserve set aside for conservation purposes, and what proportions are private land, or other tenure? Give details including the name of the reserves, and the extent the ecological community is protected within these reserves.

Lake Thetis stromatolite community occurs within Nambung National Park (R24522).

38 a. Which of the reserves are actively managed?
Note which, if any, reserves have management plans and if they are being implemented.

The Lake Thetis stromatolite community occurs on lands managed by DBCA.

Department of Conservation and Land Management (1998) Nambung National Park Management Plan 1998-2008. Management Plan Number 37 for the National Parks and Nature Conservation Authority. Perth, Western Australia.

38 b. Give details of any other forms of protection, such as conservation covenants, and whether the protection mechanisms are permanent.

Tenure: national park (R24522) vested with the Conservation and Parks Commission.

38 c. Indigenous interests
Is the nominated ecological community or parts thereof known to occur on any culturally significant sites? If so comment on any issues with respect to aboriginal interests, in particular with regard to management of the ecological community.

No general significance to indigenous people has been identified for the ecological community.

38 d. Native Title
Do Native Title or Indigenous Protected Areas apply to any parts of the community? If so comment on any issues with respect to exclusive possession and rights to plants and animals, in particular with regard to management of the ecological community.

NA

39. Give details of recovery actions that are or could be carried out at the local and regional level, e.g. develop and implement management plan for the control of specific weed species (regional), undertake weeding of known sites (local).

The following major actions are recommended (mainly from DEC 2012):

- Clarify and monitor composition, extent and health
- Conduct research to clarify biological threats and ameliorate threats
- Protect from physical damage
- Design and implement monitoring to link health, extent and composition of the microbialites with water quality and levels
- Monitor and protect native vegetation buffer.

40. Is there an existing support network for the ecological community that facilitates recovery? e.g. an active Landcare group, Conservation Management Network.

The recovery of the Lake Thetis stromatolites community is covered by DBCA's Moora District Threatened Flora and Communities Recovery Team.

41. Describe methods for identifying the ecological community including when to conduct surveys.

For example, season, time of day, weather conditions; length, intensity and pattern of search effort; and limitations and expert acceptance; recommended methods; survey-effort guide. Include references.

The microbial community of Lake Thetis was originally described by Moore (1993) and Grey *et al*. (1990). The structures can be identified by their internal organisation which is laminated rather than clotted which are thrombolitic. They are formed through precipitation of calcium carbonate within the microenvironment of microbes, a complex association of photosynthetic cyanobacteria and purple sulphur bacteria, eukaryotic microalgae and what are known as 'true bacteria', as a result of photosynthetic and metabolic activity. The assemblages are identified through the collection of samples which are placed in plastic whirl packs and refrigerated at 4°C. Fresh material can be decalcified at room temperature in 5% ethylenediaminetetraacetic acid (EDTA) before examination by light microscopy of microbial comparison (from Moore 2003).

Visual inspection are indicative of persistence and physical damage to microbialite structures.

42. Are there other any aspects relating to the survival of this ecological community that you would like to address?

No

Section 3 - Justification for this nomination

In order for the nomination to be considered further, one or preferably more of the following criteria need to be fulfilled and substantiated. A clear case for why the ecological community is eligible for listing under the criteria is required, including evidence as to how it meets the requirements for listing under a particular listing category, e.g. 'David *et al*. (1999) finding of 95% decline in geographic distribution suggests it should be listed as critically endangered'. The type of data available will determine which criteria will be used to justify the application of a listing category.
At least one criterion must trigger the thresholds of a listing category as indicated in the Attachment. Criteria may be of different levels of listing category e.g. Criterion 1 = CR and Criterion 3 = VU.

43. Provide data that demonstrates why the ecological community meets at least one of the following criteria for the nominated listing category.

Please use data provided in previous sections to demonstrate how it specifically meets at least one of the following criteria. Advice on how to interpret the listing criteria is in Attachment A. Provide a response for every sub-criterion.

Criterion A: Reduction in geographic distribution.

Criterion A	
☐ CR ☐ EN ☐ VU ☒ not eligible	☐ **A1** ☐ **A2a** ☐ **A2b** ☐ **A3**

Justification for assessment under Criterion A:

For criteria A and B, the ecosystem was assumed to collapse when the mapped distribution declines to zero.

Crushing due to recreational activities is estimated to have impacted approximately 20% of the microbialite structures (stomatolites). Given the limited growth rate of the structures any recovery from physical damage is likely to be very long-term. The estimated loss of a maximum of 20% of the visible extent of the microbialite structures refers to crushing of stromatolite structures that are near the board walk, and those that are visible and above the lake surface. It is likely an over-estimate. The maximum 20% reduction in geographic distribution, that is inferred to have occurred in the last 50 years, does not meet the ≥30% reduction in geographic distribution over any 50-year period, or a ≥50% reduction since ~1750 (ie. the minimum requirements to meet the category VU under criterion A).

Does not meet Criterion A

Criterion B: Restricted geographic distribution.

Criterion B	
☒ CR ☐ EN ☐ VU ☐ not eligible	☒ **B1** (specify at least one of the following) ☐**a)(i)** ☐**a)(ii)** ☐**a)(iii)** ☒**b)** ☒**c);** ☒ **B2** (specify at least one of the following) ☐**a)(i)** ☐**a)(ii)** ☐**a)(iii)** ☒**b)** ☒**c);** ☐ **B3** (only for Vulnerable Listing)

Justification for assessment under Criterion B: B1: The extent of a minimum convex polygon enclosing the Lake Thetis stromatolite community is 0.1km^2 (≤2,000km^2, which is less than the threshold for CR). B2: The Lake Thetis stromatolite community is estimated to occupy one 10 × 10km square grid cell (threshold for EN is 20 and for CR is two grid cells). The impacts of physical crushing, introduced fauna, erosion and sedimentation, alterations to surrounding vegetation, increased nutrients and contaminants; and inferred from future changes to the hydrological regime are considered to be 'trivial' as there is no evidence linking decline of the community to any factor except physical crushing and potentially sedimentation. The level of crushing has now been minimised through access controls that prevent vehicles accessing the lake. Physical crushing of stromatolites relates to areas accessible to walkers. a): Inadequate data are available to support a measure of observed or inferred decline in spatial extent, environmental quality or disruption to biotic interactions. b): Impacts of physical crushing, introduced fauna, erosion and sedimentation, alterations to surrounding vegetation, increased nutrients and contaminants, and from future changes to the hydrologic regime are considered 'trivial'. c): Ecosystem exists at one threat-defined location as there is only one occurrence and it is impacted by physical impacts from recreational users and potentially sedimentation (threshold for CR is one and for EN is five threat-defined locations). B3: Known from one threat-defined location and prone to effects of human activities or stochastic events within a very short time period in an uncertain future and thus capable of collapse or becoming CR within a very short time period (meets VU as <5 threat defied locations). **Meets CR B1c; B2c** **VU B3**	
Criterion C: Environmental degradation based on change in an abiotic variable.	
Criterion C ☐ CR ☐ EN ☐ VU ☒ not eligible	☐ **C1** ☐ **C2** ☐ **C3**

Justification for assessment under Criterion C:

Lake salinity is an abiotic variable affecting the community. Collapse of the community is defined under criterion C as a change in salinity such that net carbonate accretion of the microbialites is no longer supported and is unlikely to be supported in future. Due to lack of required information it is not possible to determine thresholds in salinity that would no longer support the assemblages that accrete and form the stromatolites or therefore to determine the proportional extent of decline or the relative severity of decline in relation to the specified collapse state. There is no evidence that the minimum threshold for proportion of the extent (≥30%) of the community or relative severity of degradation (≥30%) over the past 50 years, or any 50-year period, has been met, to meet Vulnerable (VU) under criteria C1 and C2.

C1: Hydrological monitoring has been undertaken spasmodically since 1985, with the most recent monitoring occurring in 2010. Available data are, however, inadequate to link the level of potential detrimental changes to salinity with any changes in the microbial assemblage, as parameters measured have not been consistent. That is, there is a lack of data that would allow hydrological/chemical changes to be linked to suitable numerical measures of the health of the assemblages.

C2: Drying climate predictions for the south west region of the state show a 2 to 14% reduction in rainfall by 2030 (from NCCARF).

It is expected that future changes to the hydrology of the lake from a decline in rainfall resulting from a drying climate, as well as groundwater abstraction for agricultural, urban or other purposes, will result in a change in lake levels and seasonal variation, higher water temperatures, and potentially an increase in salinity, thereby likely resulting in changes to the BMC. Groundwater allocation limits for future public water supply from the Cervantes superficial aquifer, in the area of Lake Thetis have been set by DOW (2010) at 30,000,000kL/year. Based on lack of historical monitoring data, the likely relative severity of the hydrological changes in relation to lake salinity and their impacts on the microbial assemblages is uncertain.

C3: There is a lack of long term, consistent historic data available to determine thresholds in salinity that would no longer support the assemblages that accrete and form the stromatolites or therefore to determine the proportional extent of decline or the relative severity of decline in relation to the specified collapse state. There are inadequate data to determine if the community meets the minimum threshold for proportion of the extent (≥50%) of the community or relative severity of degradation (≥50%) since ~1750, to meet VU under criterion C3.

Does not meet criterion C

Criterion D: Disruption of biotic processes or interactions based on change in a biotic variable.

Criterion D	
☐ CR ☐ EN ☐ VU ☒ not eligible	☐ **D1** ☐ **D2** ☐ **D3**

Justification for assessment under Criterion D:

There are few data available to indicate the level of any disruptions to the biotic processes of the stromatolite assemblages over any 50 year period, or since 1750.

The impacts of introduced bream on the structures is a significant biotic threat to the community. Collapse in relation to the impacts of introduced bream is a level of impact such that net carbonate accretion of the microbialites no longer occurs (eg due to bream feeding on the microbial assemblages). No data were accessed that indicate that bream have had a significant impact on the community.

As for criterion C, available data are inadequate to link the level of bream in the lake to changes in health of the microbial assemblages, as biological monitoring is opportunistic and not designed to answer such questions.

There is a lack of long term, consistent historic data available to indicate if the community meets the minimum threshold for proportion of the extent (≥50%) of the community or relative severity of disruption of biotic processes (≥50%) since ~1750, to meet VU under criterion D3.

Does not meet criterion D

Criterion E: Quantitative analysis that estimates the probability of ecosystem collapse.

Criterion E
☐ CR
☐ EN
☐ VU
☒ not eligible

Justification for assessment under Criterion E:

The ecosystem could not be assessed under Criterion E as no quantitative estimates of the risk of ecosystem collapse have been completed.

Section 4 – References/Standard of Scientific Evidence/Critical habitat

Note: The opinion of appropriate scientific experts may be cited (with their approval) in support of a nomination. If this is done the names of the experts, their qualifications and full contact details must also be provided in the reference list below. Harvard style of referencing is preferred.

44. Please provide copies of key documentation/references used in the nomination.

ANZECC (2000) National Water Quality Management Strategy. Australian and New Zealand Guidelines for Fresh and Marine Water Quality Volume 1: The Guidelines. Australian and New Zealand Environment and Conservation Council, Canberra.

Arp, G., Reimer, A. and Reitner, J. (2001) Photosynthesis-induced biofilm calcium concentrations in Phanerozoic oceans. Science 292: 1701-1704.

Department of Conservation and Land Management (1998) Nambung National Park Management Plan 1998-2008. Management Plan Number 37 for the National Parks and Nature Conservation Authority. Perth, Western Australia.

Department of Water (2010) Jurien Groundwater Allocation Plan. Water Resource Allocation Planning Series Report No. 27. State Government of Western Australia.

Department of Environment and Conservation (2012) Stromatolite community of stratified hypersaline coastal lake – Lake Thetis. Interim Recovery Plan No. 325, 2012-2017. Department of Environment and Conservation, Western Australia.

Falcon, L.I., Eguiarte, L.E. and Souza, V. (2006) Report on the proposed use of Aquamaster in Cuatro Cienegas, Coahuila, Mexico as a mechanism to control Arundo donax. Laboratorio de Evolución Molecular y Experimental, Instituto de Ecología, Universidad Nacional Autónoma de México. (Microbial Ecology - in revision?).

Gillen, K. (2007) *Lake Thetis - proposed development*, Unpublished Report, Department of Conservation and Environment.

Goh, F., Allen, M.A., Leuko, S., Kawaguchi, T., Decho, A.W., Burns, B.P. and Neilan, B.A. (2009) Determining the specific microbial populations and their spatial distribution within the stromatolite ecosystem of Shark Bay and phylogeny of stromatolite populations. The ISME Journal 3: 383-396l 2009.

Gozzard, J. R. (1985) The geology, mineral resources and land-use capability of coastal lands, Green Head to Guilderton. Geological Survey of Western Australia Environmental Geology Report No. EV34.

Grey, K, Moore, LS, Burne, RV, Pierson, BK and Bauld, J. (1990) Lake Thetis, western australia: an example of saline lake sedimentation dominated by benthic microbial processes. *Australian Journal of Freshwater Resources*, vol. 41, pp. 275-300.

Grey, K. and Plavansky, N.J. (2009) Microbialites of Lake Thetis Cervantes, Western Australia – a field guide. Geological Survey of Western Australia Record 2009/11.

Kerns, A.M. (1997) Hydrogeology of the coastal plain between Cervantes and Leeman, Perth Basin. Water and Rivers Commission Report Series. Report No. HG 3.

Moore, L. (1993) The Modern Thrombolites of Lake Clifton South Western Australia. Unpublished PhD Thesis. University of Western Australia.

Moore, L.S. and Burne, R.V. (1994) The modern thrombolites of Lake Clifton, Western Australia. In Bertrand, J. and Monty, C. (eds), Phanerozoic Stromatolites II, Kluwer Academic Publishers, Netherlands.

Moore, L., Knott, B., and Stanley, N. (1984) The Stromatolites of Lake Clifton, Western Australia. Living structures representing the origins of life. Search 14 (11-12), 309-313.

Rutherford, J.L., Roy, V.J. and Johnson, S.L. (2005) The Hydrogeology of Groundwater Dependent Ecosystems in the Northern Perth Basin. Hydrogeological Report Series. Report HG 11. Department of Environment.

Water and Rivers Commission (1999) Cervantes Water Reserve Water Source Protection Plan, Cervantes Town Water Supply. Water Resource Protection Series, Water and Rivers Commission Report WRP 8.

Water Authority of Western Australia (1995) Jurien Groundwater Area Management Plan. Report No. WG 202, August 1995.

45. Statement on the Standard of Scientific Evidence

Published data on the Lake Thetis stromatolite community was sufficient to apply some of the IUCN RLE. The assessment based on those criteria is considered robust. Lack of systematic monitoring programs that would link biotic and abiotic variables with the health of the community impeded the application of the IUCN RLE to a number of criteria.

46. Has this document been reviewed and/or have relevant experts been consulted?
If so, indicate by whom and provide their contact details.

The document was reviewed by the following people:
Nature Conservation Coordinator, DBCA Moora District; Parks and Wildlife Service.

District Operations Officer, DBCA Moora District; Parks and Wildlife Service.

Principal Ecologist, DBCA Species and Communities Program.

47. Do you wish to propose any areas of habitat for consideration as Critical Habitat for the nominated community?
If so, refer to Ministerial Guideline No 5 and attached a separate nomination proposal addressing the matters required under that guideline. Indicate location/s including a map, and attached shapefiles.

Summary assessment against IUCN RLE Criteria

Criterion	Rank indicated	Overall conclusion
A1	-	• Does not meet criterion
A2a	-	• Does not meet criterion
A2b	-	• Does not meet criterion
A3	-	• Does not meet criterion
B1a	-	• EOO is ≤2,000km^2 • Inadequate available data to indicate if decline in spatial extent, environmental quality or disruption to biotic interactions that would meet lowest thresholds of the criterion (VU) • Does not meet criterion
B1b	-	• EOO is ≤2,000km^2 • Impacts of recreational users, erosion and sedimentation, alterations to surrounding vegetation, increasing nutrients, introduced fauna; and inferred from future changes to the hydrological regime are considered 'trivial' • Does not meet criterion
B1c	CR	• EOO is ≤2,000km^2 • Ecosystem exists at one threat-defined location • Meets CR
B2a	-	• AOO is one grid cell • Inadequate information available to indicate a measure of decline in spatial extent, environmental quality and disruption to biotic interactions that would meet lowest thresholds of the criterion (VU) • Does not meet criterion
B2b	-	• AOO is one grid cell • Impacts from recreational users, erosion and sedimentation, alterations to surrounding vegetation, increasing nutrients, introduced fauna; and inferred from future changes to the hydrological regime are considered 'trivial' • Does not meet criterion
B2c	CR	• AOO is one grid cell • Ecosystem exists at one threat-defined location • Meets CR
B3	VU	• Known from one threat-defined location • Prone to the effects resulting from recreational users, erosion and sedimentation, alterations to surrounding vegetation, increasing nutrients, introduced fauna; and inferred from future changes to the hydrological regime • Meets criterion for VU
C1	-	• Inadequate evidence to indicate the community meets the minimum thresholds for proportion of the extent (≥30%) or proportional severity of degradation (≥30%) over past 50 years to meet VU.
C2	-	• Inadequate evidence to indicate the community meets the minimum thresholds for proportion of the extent (≥30%) or proportional severity of degradation (≥30%) over any 50-year period to meet VU.
C3	-	• Inadequate evidence to indicate the community meets minimum thresholds for proportion of the extent (≥50%) or proportional severity of disruption of abiotic processes (≥50%) since ~1750 to meet VU.

D1	-	• Inadequate evidence to indicate the community meets the minimum thresholds for proportion of the extent (≥30%) and proportional severity of disruption of biotic processes (≥30%) over past 50 years to meet VU.
D2	-	• Inadequate evidence to indicate the community meets the minimum thresholds for proportion of the extent (≥30%) or proportional severity of disruption of biotic processes (≥30%) over any 50-year period to meet VU.
D3	-	• Inadequate evidence to indicate the community meets minimum proportion of the extent (≥50%) or proportional severity of disruption of biotic processes (≥50%) since ~1750 to meet VU.
E	NA	• No quantitative estimates of the risk of ecosystem collapse.
		Meets CR under B1c; B2c: VU B3. *The highest risk category obtained by any of the assessed criteria will be the overall risk status of the ecosystem'* (IUCN RLE Guidelines V1.1 page 42). **Meets CR under B1c; B2c**

Section 5 - Nominator Details & Declaration

48. Contact Details

Note: Nominator details are subject to the provision of the *Privacy Act 1988*

Title/Full Name	[redacted]
Organisation or Company name	Department of Biodiversity, Conservation and Attractions
Postal address	17 Dick Perry Avenue, Kensington Post: Locked Bag 104, Bentley Delivery Centre, WA 6983.
Email	[redacted]
Phone	[redacted]
Fax	

49. Declaration

Signature (Or insert electronic signature)	***I declare that the information in this nomination form and any attachments is true and correct to the best of my knowledge.***
Date signed	

Section 6 – Completed nomination form checklist

Please check all items on this list have been completed or are included with your nomination.

- ☐ I have read and applied the further information and guidelines for completing this nomination form in Attachment A
- ☐ Nominator details including name, address contact phone number included
- ☐ Name of the EC
- ☐ Any other names it is known by
- ☐ Map included or attached
- ☐ References cited
- ☐ If questions are left unanswered, a statement indicating that insufficient information is available

A description of:

- ☐ Biological components of the ecological community
- ☐ Non biological components of the ecological community
- ☐ Key interactions and functional processes
- ☐ Characters distinguishing it from other ecological communities
- ☐ Key species (dominant, characteristic or diagnostic, threatened etc)
- ☐ Known or estimated current extent of the ecological community
- ☐ Past/current/future threats including actual/potential, how/ where, how being/how could be abated
- ☐ Which listing category/categories it should be listed under and why

How to lodge your nomination
Completed nominations may be lodged either: 1. by email to: **communities.data@dbca.wa.gov.au** ***If submitting by email, please also mail hard copies of attachments that cannot be emailed.*** OR 2. by mail to: Species and Communities Branch Department of Biodiversity, Conservation and Attractions, WA Government Locked Bag 104, BENTLEY DELIVERY CENTRE WA 6983 ***If submitting by mail, please include an electronic copy on memory stick or CD.***

Appendix 1. Lake Thetis stromatolites community