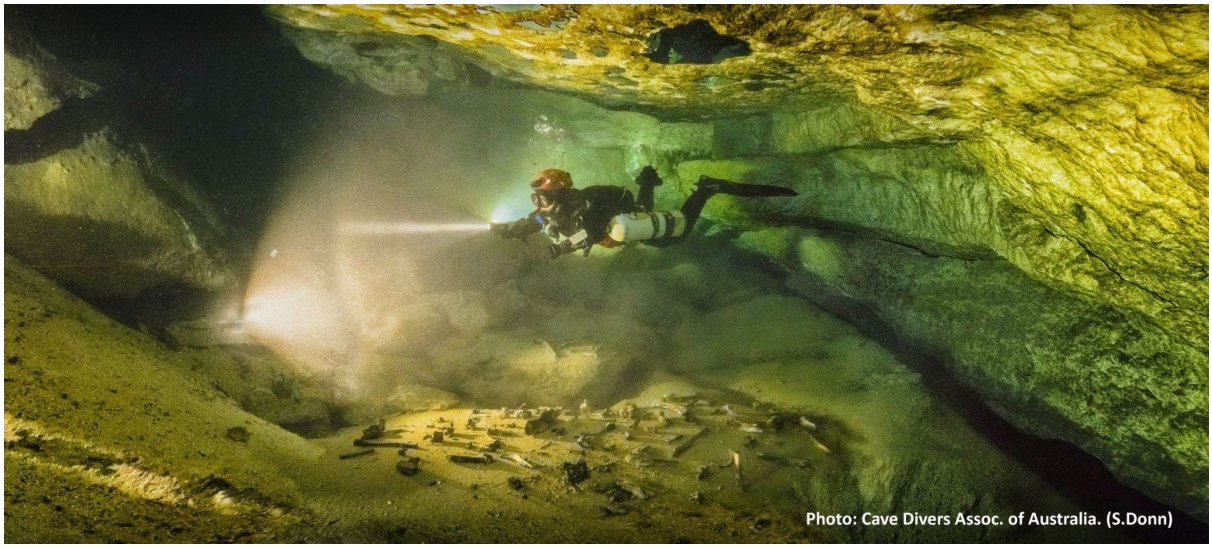
HERITAGE ASSESSMENT REPORT

NAME:	Green Waterhole – Tank Cave Fossil Complex	**PLACE:**	26530
ADDRESS:	Green Waterhole Water Reserve (L81), Allotment 550, Princes Highway, Tantanoola SA, 5280		

This heritage assessment considers that the place meets criteria b, c and g. Refer to Summary of State Heritage Place for final approved wording, including criteria statements.



ASSESSMENT OF HERITAGE SIGNIFICANCE

Statement of Heritage Significance:

The Green Waterhole – Tank Cave Fossil Complex contains the only known extensive underwater vertebrate fossil deposits in Australia. This unique freshwater depositional environment has ensured the preservation of extinct species not found anywhere else, with several additional species new to science recovered and awaiting description.

The underwater deposits have also resulted in a completeness and preservation of fossil assemblies almost unique for Australia. This provides an important opportunity to investigate the evolution of South Australian mammals and birds. The impacts of this type of site on the age and nature of the fossil remains have yet to be fully studied.

The complex represents unusual geological formations including the occurrence of a shallow fresh waterhole not usually found in sinkholes in the South East, and evidence of rare volcanogenic influences in the formation of the cave system.

The cave complex also demonstrates rare speleological features, including length of cave passageways, clarity of water, underwater speleothems, and being a type locality for stygofauna. The complex also holds importance for the development of cave diving in the country and is closely associated with the Cave Divers Association of Australia.

It is also acknowledged as a place of significance for the Boandik people.

Statements of Designation:

Designated Place of Palaeontological Significance

The Green Waterhole – Tank Cave Fossil Complex is highly significant for palaeontology in three important ways.

First, it is the best example of underwater Pleistocene vertebrate deposits anywhere in Australia. Although fossils of this age are found in underwater settings throughout the Mt Gambier region, fossils in the Green Waterhole – Tank Cave Fossil Complex are incredibly numerous, very well preserved, and found in situ.

Second, the site contains fossil species found nowhere else in Australia, or else are incredibly rare. These include both bird and kangaroo species.

Third, the site offers the rare opportunity to study the taphonomy of underwater deposits. Evidence for at least one wetting and drying phase in the cave has the potential to provide important information for understanding how fossil deposits are formed and preserved in cave settings.

The significant palaeontological features contained within the complex are:

- Oligo-Miocene marine species throughout the cave walls and ceilings
- Incredibly well-preserved and diverse underwater vertebrate fossil deposits
- Type site for extinct kangaroo *Simosthenurus newtonae*
- Type site for extinct birds *Centropus colossus* and *Orthonyx hypsilophus*
- Untouched* fossil and sedimentary deposits in Green Waterhole/Tank Cave
- Presence of rare megafauna taxa such as *Propleopus*
- Underwater taphonomic processes including microbial activity, mineral dissolution and deposition, weathering, fragmentation, and disarticulation
- Diverse and rich avifaunal deposits

*Several sites within the complex are almost untouched, in particular some sedimentary beds. Sedimentary deposits are a well-known source of palaeoenvironmental information that can inform on precipitation and vegetation histories. Science recognises the intrinsic value of preserving important elements of the

caves in their original (pre-human) condition. This provides a significant undisturbed record of the State's palaeoenvironment. Science also recognises that such preservation may enable future examination and enhanced interpretation using techniques not yet devised or invented for understanding our State's past environment.

Designated Place of Speleological Significance

The Green Waterhole – Tank Cave Fossil Complex is situated at the Western end of the longest underwater cave system in South Australia, widely acclaimed as one of the premier cave diving localities in Australia. The Green Waterhole - Tank Cave system has a long history in the development of the sport of cave diving in Australia. In addition to the 10 kms of passageways that can be explored by divers, the complex preserves important speleological formations, features, and fauna that are rare or not found in other caves in the area.

The significant speleological features contained within the complex are:

- Extensive phreatic joint-controlled maze cave system with outstanding exploration potential
- Twilight and dark underwater zones accessible by divers
- Cave collapse features and boulders in Green Waterhole
- Underwater speleothem formations
- Calcite raft deposits
- Undisturbed mud cracks and significant sediment accumulations
- Marine and vertebrate fossils in the walls and on the floor, respectively
- Preservation of stromatolites around the cave entrance
- Type locality for *Koonunga crenarum* (a *syncarid* crustacean)
- Habitat for over 40 other species of stygofauna
- Scalloping and phreatic erosion above the current water table

Designated Place of Geological Significance

The broad Gambier Limestone Plain extends from the coastline to the Bordertown/Kingston area and is a raised sea floor, elevated over 1-2 million years by tectonic forces associated with the volcanic activity across the region. Fresh groundwater from rainfall percolates through the limestone from inland to the coast, dissolving cave systems particularly along major fracture lines (geological faults). Volcanoes also have also erupted along two large regional faults in the Mount Gambier region. Many large deep sinkholes ('cenotes') have developed south of Mount Gambier reaching the water table and extending deep below them (50-120m).

The combined Green Waterhole-Tank Cave system is shallow by comparison (20m) with other sinkholes in the region, and is the longest underwater cave system by far in South Australia, developed by solution in a large complex grid system (see site map overlay). Initiation and enlargement of the cenotes and possibly the Green Waterhole-Tank Cave system itself has been assisted by volcanic CO2 gases rising up fault lines and acidifying the groundwater, stimulating large-scale solution of passages in the limestone (Webb et al 2010). This is a rare process in global cave development known as 'volcanogenesis' and requires the coexistence of volcanoes, extensive limestone and abundant groundwater, which occurs at this location. Ongoing research will establish if this process has been applied throughout the development of the Green Waterhole-Tank Cave system.

Green Waterhole is a *shallow* cenote that is attractive to animals and humans, being more accessible for drinking during dry periods than most other sinkholes in the region. The waterhole made water available in a pool perched above the regional water table during low sea levels. The cave complex provides an excellent opportunity to study the relationship between changing sea-levels, ground water, and environment, and their effects on the evolution and extinction of fauna in the region over a long time period.

The significant geological features contained within the complex are:

- Soft limestone caves including connections between doline and dissolution passages
- Exposure of the regional water table and associated freshwater semi-troglobitic aquatic life
- Untouched sedimentary deposits preserving pollen and spores over thousands of years
- Solutional/Erosional features indicative of higher and lower water levels in the past and their various effects upon cave development in the limestone mass
- Capacity for examination in detail of possible impact of rare 'volcanogenic' influences
- Excellent example of soft limestone caves and the connection between doline and dissolution passages

Relevant South Australian Historical Themes

The Green Waterhole – Tank Cave Fossil Complex demonstrates the following themes and subthemes in *Historic Themes for South Australia* (Draft 29 May 2020).

1. Natural Environment

1.1 Tracing climatic and topographical change

1.2 Tracing the evolution of plants and animals

1.5 Appreciating South Australia's natural environment

6. Developing Social and Cultural Life

6.5 Participating in sport, leisure and recreation

6.9 Innovating and advancing knowledge

Comparability / Rarity / Representation:

Dry cave fossil deposits preserving Pleistocene vertebrates are relatively common in Australia, and South Australia is no exception. Significant fossil sites are found in several regions in the State including the Southeast Limestone Coast. The World Heritage Naracoorte Caves are located nearby and preserve similar large mammal fossils as the Green Waterhole – Tank Cave Fossil Complex of the same broad geological period – the Pleistocene. However, several important temporal gaps exist in the Naracoorte Caves fossil sequence which may be preserved in the Green Waterhole – Tank Cave Fossil Complex. Comparisons between these cave complexes will therefore provide better chronological and geographic understanding of the Pleistocene megafauna of the Southeast, and any potential links between the sites.

The Green Waterhole – Tank Cave Fossil Complex differs in two important ways from the Naracoorte deposits. First, the mode of deposition and preservation of the fossils are very different as Naracoorte contains no underwater fossil deposits. Examination of the fossils from Green Waterhole – Tank Cave Fossil Complex will provide important new information on site formation processes not possible from Naracoorte. Second, taxonomic representation of smaller species is very different between the two sites. This is especially the case for birds, with the Green Waterhole – Tank Cave Fossil Complex hosting bird species either rare or not present in Naracoorte. These provide important information regarding the biodiversity of the State, and the evolution of the Australian avifauna.

Other caves within the Mt Gambier region also preserve occasional fossils of a similar age and under similar underwater conditions as Green Waterhole – Tank Cave Fossil Complex. Major differences exist in the number (diversity and richness) and state of the fossils. Fossils are highly concentrated in Green Waterhole – Tank Cave Fossil Complex, unlike fossil remains within the other caves in the Mt Gambier region which are usually loose and isolated elements without any obvious association. Preservation in Green Waterhole – Tank Cave Fossil Complex is also excellent, both in terms of the skeletal elements and in the anatomical features preserved.

Other caves across South Australia also sample similar time periods as Green Waterhole – Tank Cave Fossil Complex, e.g. Kelly Hill Caves (not listed) and Emu Bay Caves (SHP 14548) on Kangaroo Island. However, like Naracoorte these deposits are in dry sections of the caves.

Comparatively, the Green Waterhole – Tank Cave system provides an outstanding experience for cave divers due to its accessibility, water quality, level of difficulty, length of passageways, and the natural features that are preserved underwater. As such, it has been an integral part of the CDAA's training programs and focal point for the CDAA's research, conservation, and exploration activities for several decades (see discussion under criterion (g)).

Geologically, Green Waterhole and Tank Cave are part of the same cave system that cave divers eventually connected through a submerged linking passage. The resulting 10 kilometers of passages, however, with only one substantial entrance at its extreme north-western end (Green Waterhole itself), is an extraordinary exception to any of the other approximately 1,000 caves recorded across the Gambier Limestone region that covers the entire South East of South Australia.

Only one other cave of similar character and dimensions is known on the Australian continent, namely Olwolgin Cave, located under the Nullarbor Plain. This is in similar limestone but has quite different hydrogeological circumstances, principally that the Nullarbor Plain has no volcanic evidence and the groundwater, though just as clear, is brackish with a salinity one-third that of seawater. Thus the Green Waterhole-Tank Cave system has developed to an extraordinary length and complexity under the influence of freshwater and is likely to be continuing to do so, whereas the Olwolgin Cave system on the Nullarbor lacks the volcanic input, and solution of the limestone is no longer possible due to salinity, so the cave development process has long been arrested.

Victoria Fossil Cave (SHP 26459) in the World Heritage Caves at Naracoorte, 100 kms north of Mount Gambier, is a multi-linear dry cave system 4 kms long with some strong similarities to Green Waterhole–Tank Cave as well as some intriguing essential differences. Both caves contain extensive outstanding megafauna fossil remains, but groundwater activity in their development has taken different pathways. A research comparison between these two lengthy cave systems has the potential to reveal groundwater processes and characteristics not examinable in any of the many short or deep cave systems throughout the Gambier Limestone Plain or indeed across the State of South Australia.

Assessment against Criteria under Section 16 of the *Heritage Places Act 1993*. All Criteria have been assessed using the 2020 Guidelines.

(a) it demonstrates important aspects of the evolution or pattern of the State's history.

The Green Waterhole – Tank Cave Fossil Complex demonstrates important aspects of the State's natural history, including representing several periods of evolution. However, the place not only demonstrates this significance, but also has considerable potential to demonstrate many more aspects of our history, which means it could be said to meet both criterion (a) and criterion (c) for similar reasons.

Criterion (a) focuses on the 'State's history'. The first test asks which 'historic theme' is demonstrated by the place. In this case, the theme is 'natural history', which is a theme. However, criterion (c) talks about the 'history, including its natural history'. Given that the Green Waterhole – Tank Cave Fossil Complex is considered to meet criterion (c) because of its significant associations with natural history as well as its *potential* to demonstrate important aspects of our natural history, it seems more relevant to consider the place meets (c) because of its historical significance and potential, rather than meeting criterion (a) using a similar argument.

Therefore, it is recommended that this place **does not fulfil** criterion (a).

(b) it has rare, uncommon or endangered qualities that are of cultural significance.

The Burra Charter states: "Cultural significance means aesthetic, historic, scientific, social or spiritual value for past, present or future generations. Cultural significance is embodied in the place itself, its fabric, setting, use, associations, meanings, records, related places and related objects."

The primary qualities of cultural significance for the Green Waterhole – Tank Cave Fossil Complex relate to its exceptional scientific value. These qualities are significant to South Australia, as they contribute to an understanding of the progress of life on earth over multiple periods of geological time.

In terms of specific scientific qualities, the complex has a number of rare and even unique characteristics in the context of South Australia. The complex is the type location for a number of fossil and living species, i.e., the place from where the holotype of a species was collected from and so the population therein best represents those species, e.g. *Koonunga crenarum* (Zeidler, 1985). Relevant fossil type species are listed in the palaeontological designation statement above.

The cave complex is an unusual example of an underwater cave containing Pleistocene/Holocene fossils, including non-marine specimens. Marine fossils are

common in limestone walls, but this cave has fossils of creatures that lived in the cave. Being located underwater helps to preserve these fossils in a way that is different to dry air caves.

The cave complex is a notable location for megafauna in Australia, including *Propleopus oscillans*, a rare species of carnivorous kangaroo. Only a few representatives have been found in Australia, two from Fossil Cave. The fossil deposits also contain diverse avifauna including species either rare or not present at other sites in South Australia (including Naracoorte), providing important information regarding the evolution of Australian birds.

The complex has an unusually high concentration of fossils, whereas other caves in the Mt Gambier region generally have loose and isolated elements without any obvious associations. It also has an extremely rare taphonomy, where the way the fossils have accumulated is exceptional in the context of an underwater setting. The Tank Cave Bone Room and Elephant Room also include pristine areas of fossils, providing a rare opportunity to study undisturbed in situ deposits.

Geologically, the cave complex has rare qualities, including calcite rafts, extensive underwater passages, untouched mud cracks (Tank Cave), and underwater speleothem formations (Tank Cave). It is also one of few underwater cave sites that is easily accessible to cave divers, and is recorded as one of the earliest places for cave diving in South Australia.

It is recommended that the nominated place **fulfils** criterion (b).

(c) it may yield information that will contribute to an understanding of the State's history, including its natural history.

The Green Waterhole – Tank Cave Fossil Complex has yielded and will continue to yield significant information contributing to an understanding of South Australia's palaeontological, speleological and geological history.

Palaeontologically, the complex is significant both for the types of fauna preserved as well as the mode by which they came to be preserved. Green Waterhole is the type site (i.e. site of origin) of two named fossil bird species and fourteen other birds. Of the birds, three are extinct and representative of the Pleistocene 'megafauna', while the rest are extant. The complex also hosts a considerable mammalian fossil fauna, comparable in diversity of 'megafauna' to some of the caves in the World Heritage Naracoorte Caves. It is the type site of one species of extinct short-faced kangaroo, and of particular note is the presence of *Propleopus oscillans*, a nationally rare 'carnivorous'/scavenging kangaroo from the Pleistocene.

The mode of preservation of the fossils in this complex is unique for Australia. The presence of many small bird fossils in the cave may be a result of the standing water, which may have attracted and helped preserve the remains of flocks of birds in an otherwise relatively arid period. The cave is also one of the very few caves in Australia that preserve fossils in an underwater setting. Being submerged allows for the preservation of the fossils in an exceptional physical state as well as level of completeness, with several extinct kangaroos represented by complete or near-complete skeletal representation and undamaged elements.

Although the majority of surface mammal fossils have already been extracted, the fossils from deposits situated in the Western-end of Tank Cave have been minimally disturbed and remain largely unexamined. There are also several significant areas within Green Waterhole that have been left untouched. Moreover, the development of new diving equipment, underwater excavation methods and technologies, and increased access to techniques for dating and environmental analysis provide additional means of developing a sophisticated and holistic understanding of the deposits. Such information will be critical for contextualising previous finds and to better understand ecosystem responses to environmental change and the conservation of biodiversity.

As a submerged Quaternary fossil deposit, the site represents an almost unique type of fossil site in Australia. Despite its importance, it has been subject to relatively little study, owing in large part to difficulty in accessing the site by non-cave divers. Many important questions concerning the site and its formation remain to be answered. This includes: the age of the site; the chronology of formation; the impact of the submerged environment on the preservation of the bone; the conflicting preservation data coming from the bird versus the mammal fossils; the true species richness of the site; and the types of habitats that were present during site formation.

Altogether, the significance of the site lies in the presence of several unique bird species, the rareness of this level of fossil completeness and preservation, and the unique depositional environment for Australian megafauna sites. Many undisturbed areas in the complex preserves in situ deposits representing an important natural history resource. The contributions of the site for understanding the evolution of South Australia's mammal and bird faunas, environmental change, and how fossil systems form and are preserved is unmatched in Australia.

Geologically and hydrologically, this lengthy cave system has the potential to reveal groundwater processes and developmental characteristics not examinable in any of the many short or deep cave systems throughout the Gambier Limestone Plain or indeed across the State of South Australia.

The site hosts numerous speleological and geological features that are either rare or non-existent in other caves of Mt Gambier, including a doline entrance with high talus cone, calcite rafts, extensive underwater passages, untouched mud cracks, and underwater speleothem formations. Its scalloped and phreatic erosional features and stromatolite deposits have been little studied but are likely to provide important information regarding changing water table levels tied to sea-level fluctuations.

The complex, as a largely submerged cave system, has also provided important habitat for stygofauna - animals that live in the phreatic zone, i.e., below the water table, and which are normally only accessible via bore holes or cave diving. Green waterhole is the type locality for *Koonunga crenarum*, a species endemic to the local region.

It is recommended that the nominated place **fulfils** criterion (c).

(d) it is an outstanding representative of a particular class of places of cultural significance.

This place is defined as a cave system, or could be more specifically defined as an underwater cave system. There are a large number of caves and underwater caves throughout South Australia, including the adjacent Tank Cave.

The specific place defined as 'Green Waterhole Tank Cave Fossil Complex' is just one portion of a larger cave system, therefore does not fully represent the class of place, and does not demonstrate enough of the elements of the class of place to be considered outstanding.

The main aspect of this part of the cave system that is considered outstanding in comparison other cave systems is its rare fossil assemblage. However, aspects of rarity are considered more applicable to criterion (b).

If the cave system was defined more specifically as a fossil site, there are several features of the place that could be described as outstanding in the context of the state, including the quantity of fossils, the type and rarity of the fossils, and the quality and diversity of the fossil record preserved there. However, as those features are already identified under the criterion (b) arguments, it is considered that there is not sufficient additional evidence to justify listing this place under both (b) and (d). As the rarity aspects are considered particularly notable for this place, it is recommended that this place is not listed under criterion (d) as well.

It is recommended that the nominated place **does not fulfil** criterion (d).

(e) it demonstrates a high degree of creative, aesthetic or technical accomplishment or is an outstanding representative of particular construction techniques or design characteristics.

The wording of this criterion implies human-manufactured design or accomplishment. The cave complex is a natural formation, and its aspects of physical significance have not been designed or constructed by humans. Therefore, it is recommended that the nominated place **does not fulfil** criterion (e).

(f) it has strong cultural or spiritual association for the community or a group within it.

The cave complex is likely to have strong cultural or spiritual associations for the Boandik people. However, this heritage assessment is only considering "non-Aboriginal cultural heritage" under the *Heritage Places Act 1993*. Therefore, no assessment of Aboriginal Heritage values is included in this report.

It is recommended that the nominated place **does not fulfil** criterion (f).

(g) it has a special association with the life or work of a person or organisation or an event of historical importance.

The Cave Divers Association of Australia (CDAA) is the not-for-profit incorporated body responsible for establishing and maintaining specialised cave diving standards for Australia, liaising with landowners and facilitating safe access to approximately 60 diveable caves and sinkholes across South Australia's Limestone Coast and the Nullarbor Plain in Western Australia, as well as a number of individual sites in other regions of Australia.

Between 1969 and 1973 there were 11 fatalities in submerged cave systems in the Limestone Coast region of South Australia. Widespread concern throughout the community regarding cave diving activities forced the government to intervene and, for a time, access to submerged cave systems in South Australia was prohibited. Following a formal inquiry and under State Government direction, the CDAA was established in September 1973 as a means to regulate cave diving activities in South Australia. Since this time, the CDAA has trained over 5,400 cave divers, hosted many International cave-diving visitors, and currently consists of 750 current members. The Association's aims are to foster the development, advancement, promotion, mapping, education, exploration, conservation, safety and research of underwater caves and related features.

The Green Waterhole – Tank Cave system has a special association with the Association and it has been an integral part of the CDAA's training programs and

focal point for the CDAA's research, conservation and exploration activities for several decades.

Green Waterhole (known colloquially as "Fossil Cave") is one of the key sites utilised by CDAA Instructors for the CDAA's "Cave" level diver training. It is the only "Cave" level site in Australia where cave divers are able to witness aspects of such palaeontological and speleological significance, and it thereby underpins the Association's "Cave" level educational programs around conservation and site preservation and the importance of implementing minimal-impact diving techniques.

Tank Cave, which lies predominantly to the East of Green Waterhole is equally significant to the CDAA's aims. Featuring 10 kilometres of intersecting phreatic passages, it is by far the longest underwater cave system in South Australia and the second-longest in the nation, Access is restricted to "Advanced-Cave" level divers, and it is used for the final assessment dives for "Advanced-Cave" diver candidates. Ongoing exploration of Tank Cave in recent years has resulted in the discovery of several kilometres of additional cave passage, including, in 2018, the connection to Green Waterhole, and the fossil deposits at the systems Western extremity, located in the designated Green Waterhole – Tank Cave Fossil Complex.

The importance of Tank Cave to the CDAA resulted in the Association purchasing the land where the primary entrance to the system is located in 2010. Access via this entrance is managed by the CDAA. The only other known natural entrance to the system is via Green Waterhole, which is currently managed by the Department for Environment and Water [DEW]. In 1998, government recognition of the CDAA's modern training programs and strict access protocols resulted in the responsible Minister reinforcing the State Government's 1973 findings, with an ongoing directive reiterating that access to these sites be limited to members of the CDAA.

While the Green Waterhole – Tank Cave system lacks some of the spectacular attributes synonymous with the region's other world-renowned sites such as Piccaninnie Ponds, the Shaft, and Kilsby Sinkhole, it is nonetheless one of Australia's most popular and frequently dived cave systems. Recognition of the subtle and sensitive nature of significant features, such as the unique speleology and outstanding fossil assemblages located in the Western end of the system have resulted in the identification of the Green Waterhole – Tank Cave Fossil Complex. The CDAA considers these potentially vulnerable areas within the Complex to be worthy of higher legislative protection, in order to secure the CDAA's role in future research, training, education and conservation initiatives.

As the Green Waterhole – Tank Cave Fossil Complex has special associations with the work of the CDAA, it is recommended that the nominated place **fulfils** criterion (g).

PHYSICAL DESCRIPTION

Green Waterhole Cave (5L81, aka Fossil Cave) is located within the Gambier Limestone 25 kms west of the city of Mt Gambier. The entrance is a shallow and relatively small oval-shaped collapse doline (sinkhole), with a rounded, cemented upper edge which indicates that it is considerably older than the large sharp-edged sinkholes in the region. This age difference is likely to be significant and invites further research.

To the southeast and, to a lesser extent northwest, caverns extend underwater at a gross average incline of approximately 22° to a maximum depth of approximately 16 m. The presence of at least three phreatic (honeycombed) solution zones in the doline walls indicate substantial water level changes of several metres in the geological past, likely tied to rainfall recharge variations from past climate change phases, and with periodic impacts from global sea level changes and/or tectonic movement.

The Green Waterhole sinkhole entrance and underwater chamber contains Pleistocene animal and avian fossils within in-washed volcanic silt. The cave contains evidence of three significant past underwater fossil excavations in 1979, 1987-88 and 2006.

A surrounding buffer covers adjacent underwater chambers in the Tank Cave system which also contain similar fossils and encompasses an area of land to the north where the cave is geologically extended with further possible buried entrances where fossils have accumulated.

Elements of Significance:

Elements of heritage significance include (but are not necessarily limited to):

- Historic entrance
- Fossil beds and body fossils
- Speleothems (Stalactites, stalagmites, stromatolites and rafts)
- Undisturbed sediments (naturally deposited)
- Natural collapses and rockfall formations
- Connection between Green Waterhole and Tank Cave
- Location of grid posts marking fossil collection areas
- Cave walls, floors and roof
- Quality and clarity of water, including low silt levels (maintain 'natural' water quality of site)

- Stygofauna habitat

Elements not considered to contribute to significance of place include (but are not necessarily limited to):

- iron posts, ropes, guidelines
- modern faunal material (e.g. sheep, goats)
- non-perishable rubbish or other refuse
- fence, stairs, and benches near Green Waterhole entrance
- underwater signage
- all above-ground development on land above the cave system

HISTORY

Geological time (dates approximate)

Approximately 30-15 million years ago, an extensive limestone sea floor developed offshore of south-eastern SA after Australia separated from Antarctica. Between 15 and 10 million years ago, this limestone sea floor emerged from the sea due to regional tectonic uplift, becoming the large Gambier Limestone Plain (extending to the Bordertown/ Kingston area). The Tartwaup Fault (hingeline) developed along the Mount Gambier-Tantanoola-Millicent region.

Around 5 million years ago, extensive volcanics (termed the 'Newer Volcanics') commenced in the region. Then, between 1-2 million years ago, the Mount Burr Range volcanoes erupted along the Tartwaup Fault, adjacent to the Green Waterhole-Tank Cave complex locality.

Approximately 528 thousand years ago, the oldest dated megafauna fossils in the region began accumulating in the World Heritage Naracoorte Caves, located 100 kms north on the Gambier Limestone Plain. Nearer to Mt Gambier, the oldest dated megafauna (from 134 thousand years ago) have been found in Kilsby's Sinkhole.

The Green Waterhole - Tank Cave system is believed to have been formed around 125 thousand years ago. This was later followed by lowering of regional water table and subsequent cave collapse forming Green Waterhole Cave entrance. The earliest dated megafauna in the system dates to approximately 65 thousand years ago.

First Nations interactions (overview)

First Nations Peoples have lived in the Limestone Coast region for tens of thousands of years. Archaeological evidence places people in the northern Flinders Ranges around

49,000, so it is possible people were in the Limestone Coast region around that time. Several caves in the Mount Gambier region contain non-figurative rock art. There is also evidence of chert mining from some caves. This is the traditional land of the Boandik (Bunganditj language) People.

The Green Waterhole was probably an important water source for Boandik People, particularly as it is one of only three such dolines (sinkholes) within a 20km radius with easily accessible fresh water. It is also the most obvious of the three sinkholes, being located at the edge of the original forest country near the foot of 'The Bluff' – a large nearby volcano in the Mount Burr Range. A number of bone and stone tools have been recovered from the Green Waterhole cave during scientific excavations.

Colonial settlement and early survey

Boandik People probably showed the Green Waterhole to the early European explorers/settlers who began arriving in the region from 1836. The waterhole was strategically located halfway between the developing settlements of Mount Gambier and Millicent alongside the most direct route between them, also following the foothills of the Mount Burr range. Having such easily accessible fresh water made the waterhole an important stock and domestic watering stop along the journey.

An early survey map dated 1859 identifies a waterhole at that location. Although not named Green Waterhole at that time, it was clearly surveyed as a Government Water Reserve, similar to other easily accessible water points across the State; whether caves or otherwise. The site was used as a stock watering reserve as part of the travelling stock route system. These stock routes probably originated from traditional pathways used by First Nations People.

In addition to the natural formation of the waterhole, early settlers dug a one-metre diameter well that penetrated the roof of the south-eastern water chamber to make bucketing easier and more efficient. This is presumed to have been created prior to the survey of the waterhole.

Green Waterhole is currently a Water Reserve under Crown Lands and under the proxy management of SA National Parks.

Scientific investigation and collecting

The first fossils were recovered from the cave in 1964, followed by several expeditions mounted by divers in the 1960s and 1970s to recover mammal fossil skulls belonging to extinct 'megafauna' kangaroos. Starting in 1979, divers and researchers began systematic excavations at the site using a grid system of pickets set up in the south-

eastern portion of the cave. A considerable amount of fossil material was recovered from these excavations, with divers collecting visible surface bones first, followed by reaching into the unconsolidated sediment and feeling for further finds.

Current collections in the SA Museum

As a result of excavations at the site, 1,258 specimens are currently registered at the South Australian Museum representing 38 genera and containing over 35 species. Avifauna makes up the majority of the collection with 958 registered specimens, comprising 26 genera and around 20 species. This is followed by 187 registered macropodoids containing 4 genera and 6 species. Of the order Rodentia, 57 specimens are registered with the remaining fauna representing members of the order Dasyuromorphia, Peramelemorphia, Anura, Chiroptera, the family Phalangeridae, Palorchestidae and the class Reptilia.

A History of fossil collection at Green Waterhole Cave (5L81, formerly S123)

By TH Worthy, RT Wells and P Horne

1964

First specimens collected in 1964 by Mr. G. McKenzie (included some possum bones and a palate from the extinct kangaroo genus *Sthenurus*. This material was passed on to a local amateur palaeontologist and caver, Mr F. W. Aslin, who sought advice from Dr Brian Daily, Geology Dept, University of Adelaide, and later gave it to the South Australian Museum (Pledge 1980, Horne 1988).

1968-1969

Brian Brawley/G. McKenzie. Collection in January included many *Sthenurus* bones, including six extremely well-preserved skulls and jaws, now in SA Museum as the 'Aslin Collection'. A subsequent expedition took place in November 1968 (Pledge 1980, Horne 1988).

1969 (long weekend). Brian Brawley et al. dived, collecting many specimens.

An article reporting collections of fossils appeared in Australia Post Magazine Pix 15th February, 1969 by New South Wales divers Ron and Valerie Taylor, apparently based on The Pines sinkhole, but photographs in the article were from Green Waterhole (Pledge 1980). Fossils in the Australian Museum labelled Gambier Sinkholes coll. R & V Taylor 1968 derive from these exploits.

June 1974. Neville Pledge (SA Museum) and Brian Brawley diving. Collection included mostly postcranial bones, 3 mandibles (2 of S. gilli), Macropus vert column, and limb bones of sthenurine. Sketch maps made, with sites tagged as e.g., A, 4, 5, 12, 10.

The 1979 Expeditions (Rod Wells, Flinders University)

Cave divers from Flinders University Underwater Caving Club recovered more bones in 1978, passing them to Rod Wells. During Christmas break 1978, cave divers Keith Evans, Martin Garrad, Robin Garrad, Jenny Hiscock, Clive Mills and Richard Stanton spent a week installing "star-droppers" hammered into the boulders and silt in the main chamber linked by dive lines. An A-line, B-line, C-line, D-line and N-line were thus installed and created a roughly rectangular grid with sectors about two metres wide and anywhere between 4 and 15 metres in length (Horne 1988). Material was collected thereafter from locations defined by this grid.

Expedition 1, 19/01/1979. The party included Rod Wells and Dominic Williams along with divers Robin and Martin Garrard, Jenny Hiscock, Richard Stanton, Keith Evans, and Peter Rogers. Collections were made at Sites identified as C1, 03, 04, 05, 08, 09, 10, 11, 12, 13. Divers mapped the site and the line-grid system around the star-dropper line-system and sites related to this.

Expedition 2, March 1st – 6th 1979. Rod Wells, D. Williams, and divers Jenny Hiscock, Robin and Martin Gerard, Clive Mills, Donna Satterthwaite and Richard Stanton. Further collections made (Sites 5, 9 [=A2], 14, details and photographs available at Flinders from Rod Wells).

The first complete skeleton of *Sthenurus occidentalis* was recovered in the January expedition from near C1; moulds of all bones were made and from these casts that resulted in articulated skeletons in Victoria Fossil Cave, SA Museum and many museums elsewhere including overseas. Fossils were reported in scientific literature from the site by Pledge (1980), Williams (1980), and Rich and Van Tets (1982). The fossil birds from this site were studied by Robert Baird as part of his PhD and later published (Baird 1985) wherein 16 species were reported, two named as new (*Centropus colossus, Orthonyx hysilophus*), from fossils from this site and that material deposited in SA Museum; *Genyornis* is not present contra Williams (1980).

1987-1988 work

South Australian Underwater Speleological Society (SAUSS) was incorporated in late 1986, and following Cate Newton (Flinders University) expressing an interest in continuing the study of the deposits, a combined mapping/bone recovery project was organised with Flinders and SAUSS shortly afterwards. Detailed mapping of the site began in February 1987,

Fossil collection trip, 12/09/1987. Rod Wells, Cate Newton (Hons student), Dave Cowan and divers Christopher Hales, Peter Horne, Terry Reardon, Mark Keane, Mark Nielson,

Andrew Cox, Greg Bulling, and Peter Blackmore. Large collections of fossils made, detailed by Rod Wells and Cate Newton.

Further dives on 18 October, with bone recovery on 31 October and 14-15 November. Surveying continued November 1987 through January 1988 and in May 1988 when a few more fossils were collected (Horne 1988).

This work resulted in the detailed map drafted by Peter Horne in 1988. The map detailed the main floor features, the grid/peg system on which the fossils were collected, and the location of old tags from earlier expeditions. It therefore is the key to the location of the majority of fossils from the site.

Fossils from the 1979 and 1987 expeditions were described by Cate Newton for her Honours Thesis (Newton 1988).

2006 Expeditions

Initiated by T.H. Worthy and A. Camens (University of Adelaide), Permit C25151-2.

27/28 May 2006. Diving team: Peter Horne (Team Coordinator), Neville Skinner, David Albano and Mark Nielsen; with Ian Lewis providing surface support. Aimed to collect from around Site 07 on the 'N' line of the 1979 survey in an attempt to gather more samples of the Green Waterhole Eagle. Collected sediment and micro-vertebrates, including a tibiotarsus (bird leg bone) of the extinct Iogrunner *Orthonyx hysilophus* which had been named on a pelvis from this site (Baird 1985).

28-29 October 2006. Peter Horne (team leader), Dave Fielder, Andrea Gordon, Katrin and Gerret Springer. Collections were made along the N-line as follows: A, area south side N4-N3; B, between N6 and N5; C, area from N5 towards C5; and D, around Site 07. A coracoid of the Green Waterhole Eagle individual, first collected in 1979 from 'near site 07' was recovered.

All bones are catalogued in the SA Museum. The birds (303 bones) P.42422-P.42440; P.42460-42536, and the mammals P.42556-42655. An unsuccessful attempt was made to extract DNA from extinct macropodid bones by ACAD researchers.

Hume 2015

Julian Hume visited the site on 23 February 2015 and found fossil bones lying about on the surface apparently derived from sediments excavated where divers had installed a new dive-line attachment post. Fossils catalogued in SA Museum collections.

Aquatic fauna in Green Waterhole-Tank Cave

Stygofauna, is the term for animals inhabiting groundwater environments, such as in bore holes and caves or sinkholes. Australia is recognised as a regional centre of stygofaunal diversity with 238 taxa recognised in eastern areas with the crustaceans (amphipods, syncarids) and hydrobiid gastropods the dominant and most widespread groups (see Thurgate et al. 2001). These authors report that the Naracoorte Coastal Plain (Naracoorte to the Mount Gambier area) has more than 40 taxa, mostly epigean species in springs and cenotes with the following taxa having more than five species Ceinidae, Paramelitidae, Koonungidae, Hydrobiidae, Planorbidae.

The amphipod *Uronyctus longicaudus* (Neoniphargidae) has a very localised distribution in hypogean (underground) habitats in the Mt Gambier area (Stock & Iliffe 1990). At least four genera from three families of molluscs occur in groundwaters of the Naracoorte Coastal Plain Region but none are obligate stygobitic species (Thurgate et al. 2001). However, it is very likely that multiple stygobitic species occur in the Green Waterhole – Tank Cave complex. Remko Leijs (SA Museum) has sampled the site for stygofauna finding other stygobitic taxa, but these remain unpublished (Remko Leijs pers. comm. to TH Worthy 8 Sept 2012).

Two notable species are the syncarid crustaceans in the genus *Koonunga,* of the Family Koonungidae, Order Anaspidacea. Green Waterhole Cave is the type locality for *Koonunga crenarum* Zeidler, 1985 which was described following discovery of the species by Peter Horne on 8 March 1981 (Zeidler 1983, 1985). The types (holotypes and paratype specimens) are in the SA Museum. *Koonunga crenarum* is most commonly found in the large water filled collapsed caves which are exposed to daylight and are relatively large (10-20 mm long), partially pigmented and lack eyes (Leijs et al. 2015). This species is only found in the Tantanoola – Mt Gambier region where it has been recorded from numerous caves and sinkholes (Zeidler 1985; Leijs et al. 2015).

A second smaller (~ 7 mm) species of syncarid, *Koonunga hornei*, is also found in phreatic waters in groundwater monitoring bores and submerged caves in the Penola and Mt Gambier region. It was reported from the Pines sinkhole at Tantanoola (Leijs et al. 2015) and is likely to occur in the Fossil – Tank Cave system. It lacks body pigment and eyes. Leijs et al. (2015) suggested that *K. crenarum* occupies the larger cavities in the Mount Gambier limestone karst aquifer while *K. hornei* also occupies the smaller fissures. Both species are suggested to have evolved from epigean (surface water dwelling) species in the last 1 million years.

The freshwater Glenelg Spiny Crayfish *Euastacus bispinosus* has been recorded at the Pines Sinkhole in Tantanoola and Gouldens Waterhole nearer Mt Gambier (Whiterod

et al. 2014) and has also been found at from the Fossil – Tank Cave complex (Pete Wolf pers observ.).

While, there are no comprehensive faunal surveys from this single cave, the diverse regional stygofauna makes it likely that numerous species remain to be reported from the complex. In addition, it is significant that the cave is the type locality (ie, the place from which the characteristics of the species is defined) for at least one stygofaunal species.

Chronology

Year	Event
37-15 Ma	Limestone floor develops offshore in south-eastern SA.
15-10 Ma	Neogene Tectonics - limestone floor begins to be lifted from the sea due to large regional tectonic uplift, becoming the Gambier Limestone Plain. The large Tartwaup Fault (hingeline) develops along Mount Gambier-Tantanoola-Millicent region.
5 Ma	Extensive volcanics (termed the 'Newer Volcanics') commenced in the region.
1-2Ma	Mount Burr Range volcanoes erupt along Tartwaup Fault, adjacent to Green Waterhole-Tank Cave complex locality.
528 ka	Oldest dated megafauna fossils in the region at Naracoorte Caves.
134 ka	Oldest dated megafauna from Mt Gambier region (Kilsby's Sinkhole).
125 ka	Possible inception of Green Waterhole – Tank Cave system, followed later by lowering of regional water table and subsequent cave collapse forming Green Waterhole cave entrance.
~65 ka	Dates for megafauna from Green Waterhole.
60-65 ka	First arrival of people on the continent of Sahul (Australia and New Guinea).
~50 ka	Probable arrival of Bunganditj (Boandik) people in Green Waterhole region (before 50 ka).
6-5 ka	Mt Shank and Mt Gambier erupt creating Blue Lake crater. Both events feature in local indigenous oral histories.
Pre-1836	Green Waterhole well-known to local Bunganditj (Boandik) people as it is located adjacent to the nearest volcano ('The Bluff", part of the Mount Burr volcanic range) making it very accessible to obtain drinking water from.
Post 1836	First located by European explorers/settlers and identified as best water access for horses, bullocks and other stock.
Pre-1859	Likely period when the hand-dug well over the south-eastern water chamber was dug to service passing traffic, leading to eventual Government Water Reserve designation .
1859	Enclosed by survey as a Government Water Reserve and indicated on surveyor's map. No name was ascribed to it on the map at that time.

1930s	Regional pine forestry industry established utilising rich volcanic soils of the Mount Burr Range and the plains surrounding Green Waterhole – Tank Cave area.
1964	The first fossils were recovered from the cave by early local scuba divers.
1968–1969	Aslin collection and Ron and Valery Taylor collection are made.
1979	First expedition by Flinders University led by RT Wells & DLG Williams.
1987	Second expedition by Flinders University led by RT Wells & C Newton.
1988	P Horne compiles detailed speleological report on the cave diving gridding and fossil recovery operation.
2006	Expeditions led by TH Worthy and A Camens of Adelaide University.
2015	Julian Hume visits site.
2020	Julien Louys gives a presentation to a forum including DEW staff, SA Museum representatives and CDAA on the significance of the fossil cave.

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- Dr Julien Louys, Griffith University
- Pete Wolf and Peter Horne, Cave Divers Association of Australia
- Dr Liz Reed and Dr Diego Garcia-Bellido, University of Adelaide and SA Museum
- Dr Mary-Anne Binnie, Ben McHenry and Neville Pledge, SA Museum
- Dr Trevor Worthy, Dr Rod Wells and Dr Gavin Prideaux, Flinders University
- Ian D Lewis, Steve Bourne and Anna Pope, SA Department for Environment and Water

SITE RECORD

NAME:	Green Waterhole – Tank Cave Fossil Complex	**PLACE NO.:**	26530

FORMER NAME:	Green Waterhole, Fossil Cave. Tank Cave name unchanged since discovery in 1980's.	
DESCRIPTION OF PLACE:	North-western section of Green Waterhole/Tank Cave system containing significant fossil deposits.	
DATE OF CONSTRUCTION:	~125ka	
REGISTER STATUS:	Not applicable - Gap identified 2020 [Date of Provisional Entry]	
LOCAL HERITAGE STATUS:	Nil	
CURRENT/PREVIOUS USE:	Pre-1836: First Nations access to natural drinking water as evidenced by stone tools recorded in thesis research. 1836–1940's: Government Water Reserve used by European settlers for stock and domestic freshwater supplies. 1964–present: Recreational cave diving and discovery/ongoing recovery of Pleistocene fossil remains of animals and birds.	
LOCAL GOVERNMENT AREA:	Wattle Range	
LOCATION:	**Street No.:**	Lot 550
	Street Name:	Princes Highway
	Town/Suburb:	Tantanoola
	Post Code:	5280
LAND DESCRIPTION:	**Title**	CR/5762/955
	Plan No.:	H420600
	Section:	550
	Hundred:	Hindmarsh
	Encumbrance:	Native Title claim: First Nations of the South East #1 Mining Licences, exploration (petroleum): PEL 680
MAP REFERENCE (Centre of entrance)		37° 43' 54.68" S, 140° 31' 49.34" E

PHOTOS

NAME:	Green Waterhole – Tank Cave Fossil Complex	**PLACE NO.:**	26530

Entrance sinkhole (doline) to Green Waterhole, 2017.
Rounded upper rim of sinkhole indicates older age of entrance

Excavation party from Flinders University at Green Waterhole; Photo: Rod Wells 1979

PHOTOS

NAME:	Green Waterhole – Tank Cave Fossil Complex	**PLACE NO.:**	26530

Cave Diver Peter Blackmore in Green Waterhole cave;
white calcite flakes draped over boulders (source of creamy coloured bones);
three stakes and fossil search reference gridlines in foreground
Photo: Ian Ploenges 1987

Fossil bed in Green Waterhole cave. Photo: Ian Ploenges 1987

PHOTOS

NAME:	Green Waterhole – Tank Cave Fossil Complex	**PLACE NO.:**	26530

Green Waterhole cave entrance lake showing a line of grid marker stakes
Photo: Peter Rogers 1979

In situ fossil femur in 'Elephant room', Jane Bowman, 2018

PHOTOS

NAME:	Green Waterhole – Tank Cave Fossil Complex	**PLACE NO.:**	26530

Honours student Cate Newton viewing bones being collected during 1987 dives, Rod Wells

Fossilised snake skeleton near H11 in the Cave Complex. Toby Passauer, 2018

PHOTOS

NAME:	Green Waterhole – Tank Cave Fossil Complex	**PLACE NO.:**	26530

'Bone Room' in Green Waterhole/Tank Cave system - Photo: Stewart Don, 2019

'Dark Room' fossils, Green Waterhole-Tank Cave system - Photo: Pete Wolf 2019

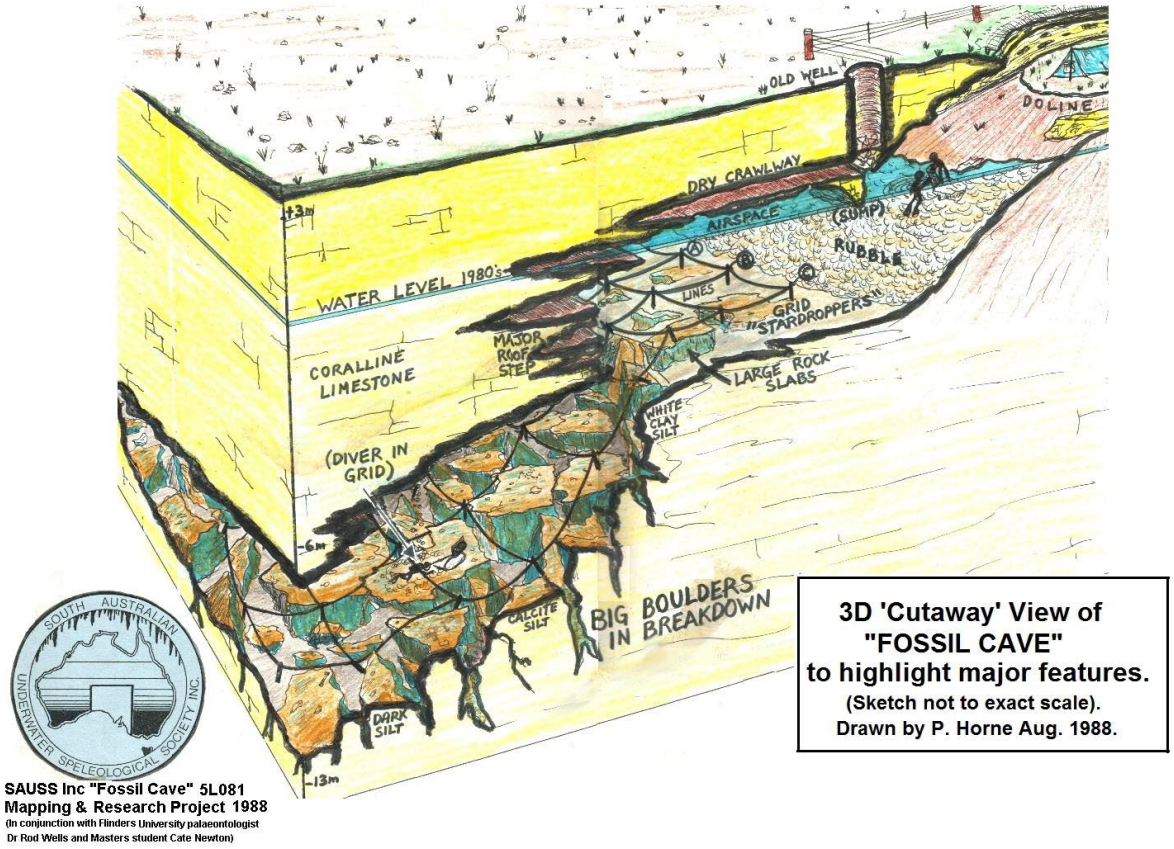
PHOTOS

NAME:	Green Waterhole – Tank Cave Fossil Complex	**PLACE NO.:**	26530

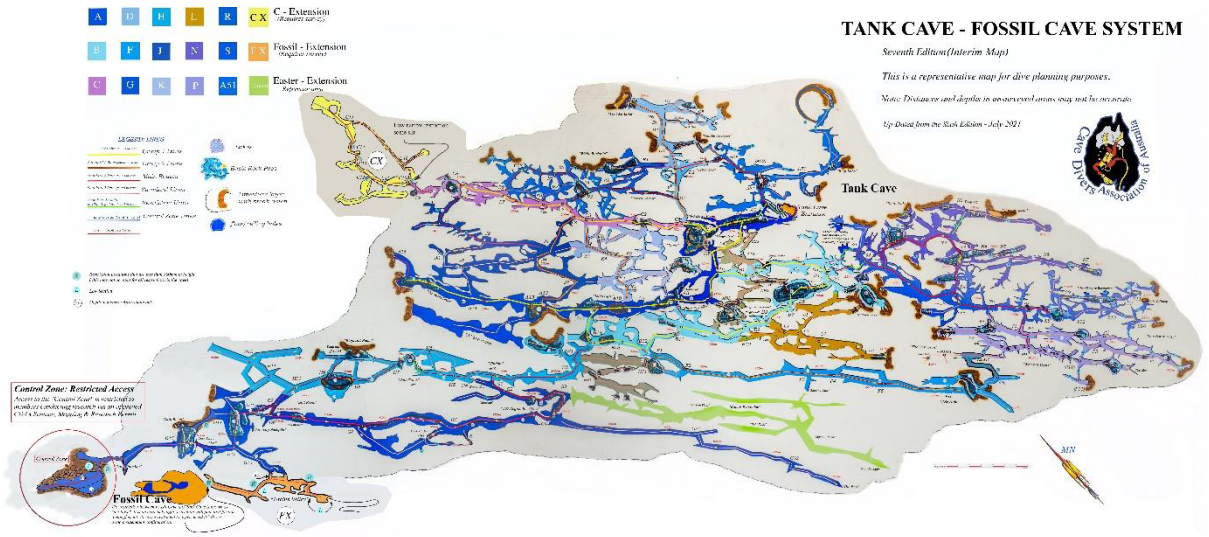
Green Waterhole fossil find: *Simosthenurus occidentalis* - Photo: Rod Wells 1979
(semi-articulated skeleton as found on first day of diving)

Green Waterhole fossil finds, Flinders University - Photo: Rod Wells 2021

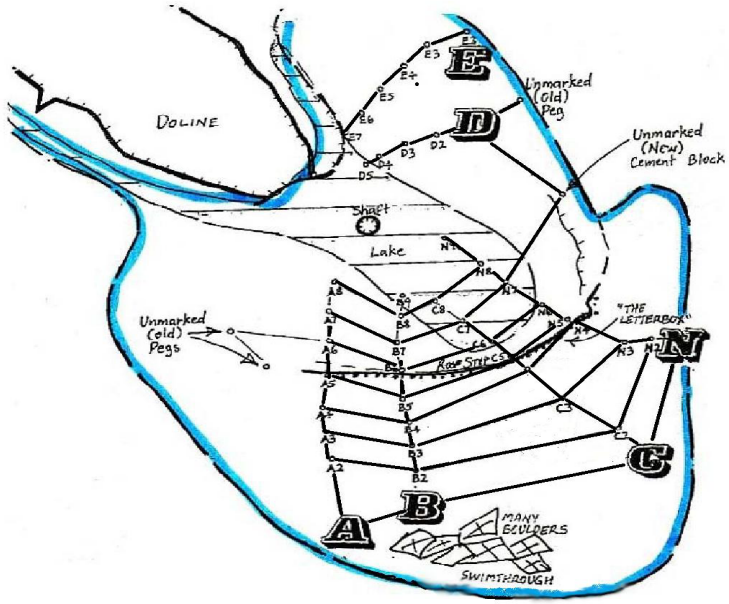
NAME:	Green Waterhole – Tank Cave Fossil Complex	**PLACE NO.:**	26530



3D Cutaway diagram of Green Waterhole indicating entrance (doline), submerged boulder-strewn chamber floor and portion of underwater grid system installed by cave divers for systematic fossil recovery from the dark sediment distributed throughout the chamber. The view is from the north-east. The artist is Peter Horne, coordinator of the South Australian Underwater Speleological Society Inc. (SAUSS), whose members formed the diver recovery team for the fossil excavation. This diagram is also Figure 28 in the reference report Horne P, 1988.



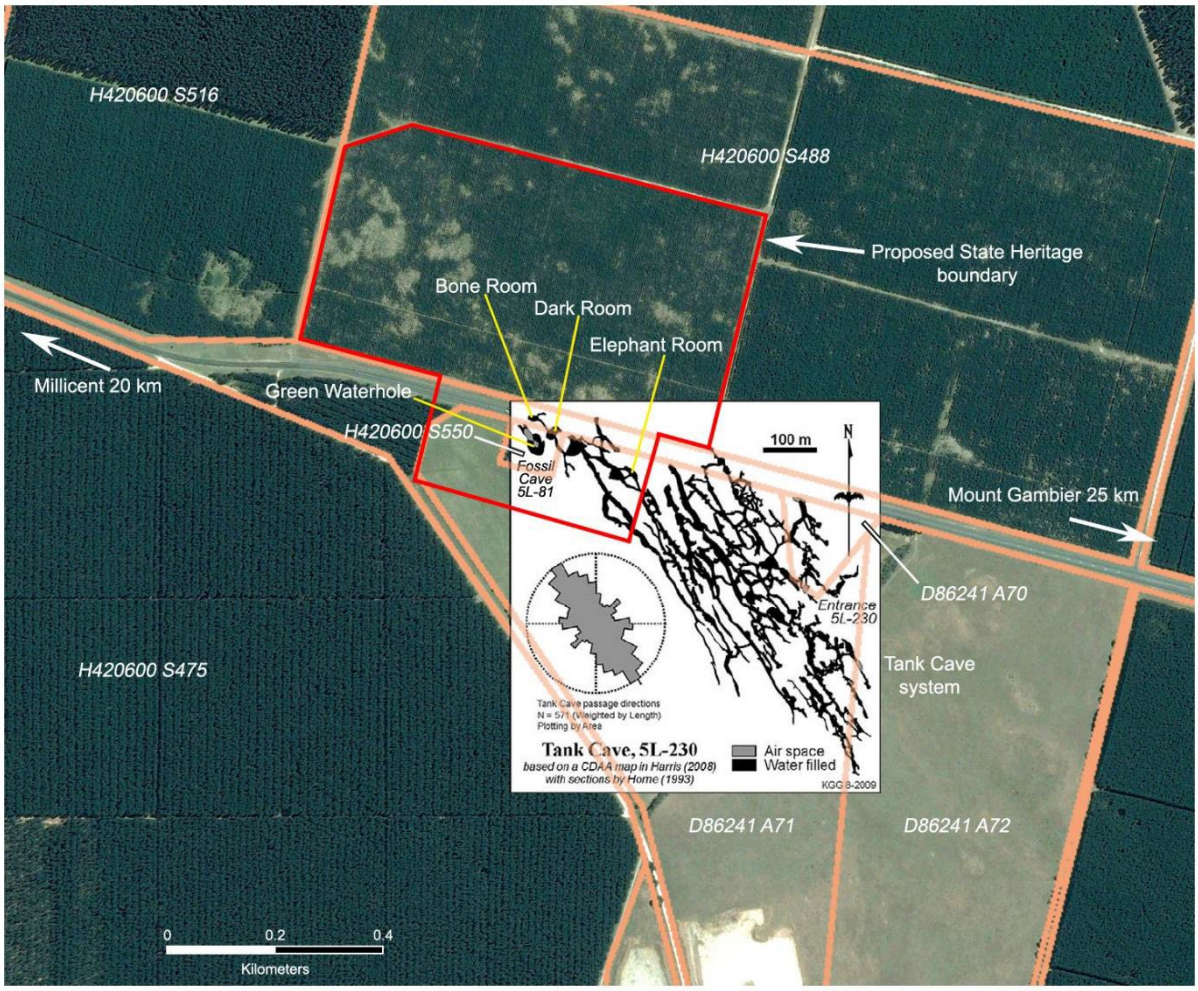
Map showing full extent of Tank Cave system as currently known
Cave Divers Association of Australia, 2021



Original plan view of Green Waterhole showing grid pattern and reference system installed by cave divers in 1978. This allowed accurate recording of locations of individual fossils to enable researchers to assess distribution patterns and bone associations. Map and artwork by Peter Horne. This diagram is Figure 22 in the reference report Horne P, 1988.

SITE PLAN

NAME:	Green Waterhole – Tank Cave Fossil Complex	**PLACE NO.:**	26530



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LEGEND

Parcel boundaries (Indicates Extent of Listing)

Outline of Elements of Significance for State Heritage Place

Extent of Listing *includes* (all within Hundred of Hindmarsh, SE South Australia):

- Whole of land parcel H420600, Section 550, (Government Water Reserve)
- North-western sector (approx 10%) of land parcel D8241, Allotment 71 (private land)
- South-western sector (approx 25%) of land parcel H420600, Section 488 (pine forest – boundary coincides with firebreaks around forest compartment)
- 0.45kms of Princes Highway separating Sections 488 and 550

Extent *excludes* the large proportion (approx 90%) of the Tank Cave complex to E and SE of boundary as this system does not contain fossils in either of its dry or underwater areas.