Murrawijinie & Koonalda Caves, Nullarbor National Park:

Review of Natural & Cultural Resources, & Strategies for Visitor Management

by Stefan Eberhard & Robyn McBeath

Report prepared for the
Parks and Wildlife Service (Far West Region),
Department of Environment and Heritage, South Australia

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Cover:
Aerial photograph of Murrawijinie 2 and Murrawijinie 3 Caves. Note the de-vegetated areas within the doline catchments, and the proximity of vehicle tracks, car parks and camping areas, to the cave entrances. Phot by S. Eberhard 2003.

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EXECUTIVE SUMMARY

Koonalda and Murrawijinie Caves are located in the Nullarbor National Park, managed by the Parks and Wildlife Service, Department of Environment & Heritage, South Australia.

The Nullarbor Plain is popularly known for it's many caves, however very few of these are accessible to the general public. Koonalda and Murrawijinie Caves are amongst the most accessible and well known caves on the Nullarbor Plain, and probably amongst the most frequently visited. They are an important natural asset attracting tourists travelling across the Nullarbor Plain.

The caves contain significant natural and cultural resources (including Aboriginal art) that have suffered impacts resulting from many years of unregulated visitation. Visitor numbers are expected to increase in the future as regional tourism strategies continue to promote the Nullarbor Plain, including Koonalda and Murrawijinie Caves in particular. Increased visitation has the potential to further damage sensitive cave values unless protective measures are taken.

The purpose of this report is:

(1) To review the natural and cultural resources of Koonalda and Murrawijinie Caves;

(2) Assess the existing impacts and potential impacts of visitation to the caves;

(3) Develop strategies for facilitating public access and appreciation of the caves, whilst ensuring the conservation of natural and cultural resources.

For improved protection of water catchments and conservation of landscape values at both locations, vehicle tracks and parking areas could be relocated outside the immediate catchment areas of the dolines and caves. Alternatively, the existing carparks and roads could be better contained and delineated, whilst avoiding slopes prone to erosion. Access to the caves may be maintained along defined walking trails whilst impacted areas are rehabilitated.

To evaluate visitor impacts and resource conservation, photo-monitoring of selected key sites in the caves needs to be undertaken, which can be used as a baseline against which to assess changes. Visitor numbers need to be monitored by installing logbooks at strategic locations, and vehicle counters to monitor traffic circulation.

Liason with local, regional and state tourism agencies and operators is required to ensure accurate and appropriate promotion and marketing of the caves.

Murrawijinie Caves

It is recommended that Murrawijinie Caves continue to be managed to allow self-guided visitation, however development of some visitor support facilities, information and interpretation is required to adequately protect natural and cultural resources, and to enhance the visitor experience. There is a need to provide appropriate pre-visit information, directional signage, and on-site explanatory and interpretive information.

It is recommended that elevated boardwalks be constructed in the caves to facilitate visitor access, and to protect sensitive natural and cultural features. Infrastructure and signage should be kept low profile and visually unobtrusive, be totally removable and involve minimal modification of existing landscape features.

Site development and interpretation should include Aboriginal heritage sites within the caves, and, European pastoral era heritage sites located en-route to the caves. Archaeological survey and assessment of both is required to determine their conservation requirements prior to site development.

The local Aboriginal community should be encouraged to give support to and participate in the development and delivery of interpretation associated with Aboriginal sites in Murrawjinie Caves.

Visitor interpretation programs and/or commercial tour operations should be supported, where these are consistent with protection of the caves.

Koonalda Cave

Koonalda Cave contains Aboriginal cultural heritage and archaeological values of outstanding national and international significance. The significance of Koonalda is attributable to the demonstrable antiquity of Aboriginal use of the cave, which involved an elaborate flint mining industry, and engravings that represent some of the earliest known ‘art’. Koonalda Cave also contains important heritage values associated with early pastoralism on Koonalda Station, which involved pumping of water from the cave for stock. An archaeological survey and heritage conservation plan needs to be undertaken for Aboriginal and pastoral era heritage in Koonalda Cave.

In view of the outstanding importance of Koonalda Cave, it’s proper protection must be a paramount aim in all management planning and future actions. In consideration of this, there exist two key conservation and management issues that need to be urgently addressed:

(1) Control of unauthorized entry into the cave;

(2) Conservation of archaeological and cultural heritage values.

The existing gate across the entrance of the cave is not effective in controlling unauthorized entry, and, irreparable graffiti damage is continuing to occur to the Aboriginal engravings. The Art Passage should be managed as a special area separate to other parts of the cave, and excluded from any future show cave developments.

The interior of the cave should remain closed to unsupervised public access. Access and viewing of the entrance from the surface should continue, but with provision of more explanatory and interpretive information.

Ranger patrols need to be increased, and it is recommended that a permanent full-time ranger base be established in the Nullarbor National Park.

Wider recognition and appreciation of the outstanding heritage values and conservation issues at Koonalda must be pursued with relevant bodies, and heritage funding and support sought from the appropriate organisations. It is recommended that World Heritage nomination for the Nullarbor Region be pursued.

Koonalda Cave has previously been considered suitable, and recommended, for development as a show cave for the public. Future development as a guided show cave is considered appropriate, subject to the recommendations made in this report. These include, amongst other, adequate resource protection in the interim, and preparatory research and monitoring.

Any development must appropriately reflect the importance of the site, by aiming for best practise standards in show cave development. Unless adequate security can be assured, development as a self-guided show cave is not recommended.

To prepare for future show cave development, and to meet interim resource conservation requirements, the following actions are recommended, listed below in approximate order of importance and priority:

1. Resolve the gate problems;
2. Provide interim signage explaining the reasons for cave closure;
3. Increase ranger patrols (establish permanent ranger base in Nullarbor NP);
4. Monitor visitor numbers (surface and illegal cave entry);
5. Pursue heritage conservation funding and support;
6. Seek wider recognition and appreciation of site values and conservation issues, through appropriate dissemination of information;
7. Prepare conservation plan for archaeological and cultural heritage (Aboriginal and pastoral era, surface and inside cave);
8. Undertake development and interpretation plan (surface sites only);
9. Relocate the carpark, control erosion and rehabilitate impacted areas;
10. Business and development feasibility study (for show cave development);
11. Development and interpretation plan (for show cave development);

1 PART ONE - INTRODUCTION

1.1 Background

Koonalda and Murrawijinie Caves are located in the Nullarbor National Park. The management authority is the Parks and Wildlife Service, Department of Environment & Heritage, South Australia.

The Nullarbor Plain is popularly known for it's many caves (eg. Thomson 1947, 1952; Woolf 1936; Wright 1956), however very few of these are accessible to the general public. Koonalda and Murrawijinie Caves are amongst the most accessible and well known cave sites on the Nullarbor Plain, and probably amongst the most frequently visited. They are an important natural asset attracting tourists travelling across the Nullarbor Plain.

The Nullarbor region is being promoted as part of "The Nullarbor – Australia's Great Road Journey", which traverses the Great Australian Bight from Ceduna in South Australia to Norseman in Western Australia. In addition to the caves, other important attractions are the treeless plain, coastal cliffs and whale watching at the Head of the Bight.

The caves contain significant natural and cultural resources that have suffered impacts resulting from many years of unregulated visitation. Visitor numbers are expected to increase in the future as regional tourism strategies continue to promote the Nullarbor Plain, including Koonalda and Murrawijinie Caves in particular.

In reporting on the management of karst features of the Nullarbor, Davey and Spate (1990) advocated the need for improved public access and interpretation of a few selected sites to cater for the considerable number of self-drive visitors who are looking for adventure and/or different experiences with an environmental or cultural dimension. Koonalda Cave and Murrawijinie Caves were recommended as suitable for this purpose, with the former recommended for development as a 'show' cave and the latter as 'adventure' caves.

Increased visitation has the potential to further damage sensitive cave values unless protective measures are taken. Tourism can provide the incentive to protect both the natural and cultural heritage. Through sound interpretation, tourism can inspire greater appreciation of the natural environment and hence stimulate awareness of, and willingness to contribute to, conservation.

Within this context there is a need to review visitor services (facilities and information), environmental impacts, and conservation requirements for these sites.

1.2 Purpose & scope of this report

The purpose of this report is:

1. Review and assess the natural and cultural resources of Koonalda and Murrawijinie Caves;

2. Assess the existing impacts and potential impacts of visitation to the caves;

3. Develop strategies for facilitating public access and appreciation of the caves, whilst ensuring the conservation of natural and cultural resources.

The report includes a digitized photographic inventory (attached as separate pdf files on CD Rom) of identified natural and cultural resource values, and examples of existing impacts and management issues.

1.3 Significance of the Caves

Koonalda and Murrawijinie Caves contain geologic, geomorphic, biological, anthropological, archaeological and heritage resources of regional and national significance. Koonalda Cave contains Aboriginal cultural heritage values of outstanding international significance.

Both sites also have important tourism and recreation values.

Significant features of the Caves are listed below:

1.3.1 Natural values

- The natural landscape and catchment surrounding the caves;
- Within the caves, examples of geologic structures and materials, including fossils and flint nodules formed within the Nullarbor and Wilson Bluff Limestone;
- Unusual geomorphic features and processes associated with cave and karst development in an arid environment;
- Koonalda cave contains important groundwater resources;
- Cave deposits, including rich sub-fossil bone deposits preserving a record of faunal history in the region;
- Foci for biodiversity, providing important habitat for vertebrate and invertebrate fauna, including rare or threatened species, and/or forms endemic to the Nullarbor region;

1.3.2 Cultural values

- Archaeological and anthropological material that provides insight into human occupation of the region (listed on State Heritage Register and Register of the National Estate);
- Aboriginal hand stencils, engravings, stone arrangements, and flint mining activities.
- European pastoral era equipment and constructions.

1.3.3 Tourism & recreation values

- Established destinations for tourism and recreation;
- Opportunities to experience 'wild' caves;
- Opportunities to interpret natural cave and cultural values;
- Aesthetic appeal of the cave entrances, dolines, passages and chambers;
- Potential to add further value to local and regional tourism.

1.4 Strategic Directions

In view of the sensitive natural and cultural resources within Murrawijinie and Koonalda Caves, and their importance to both conservation and tourism, the suggested goals for management of the caves are:

Goal 1: Conservation of natural resources

To conserve the natural values of the caves by minimizing human modification of natural processes and features and interpreting the natural values of the cave.

Goal 2: Conservation of cultural resources

To conserve, record and interpret the cultural heritage of the caves.

Goal 3: Tourism & Recreation

To facilitate public enjoyment of the caves in a manner compatible with the primary goals of conserving the natural and cultural heritage values.

2 PART TWO - MURRAWIJINIE CAVES

2.1 BACKGROUND

Murrawijinie Caves are located 10 km north of the Nullarbor Hotel/Motel on the Eyre highway (Figure 1), which is 14 km west of the turnoff to Head of the Bight, and 297 km west of Ceduna. There are three caves referred to as Murrawijinie 1 (N7), Murrawijinie 2 (N8) and Murrawijinie 3 (N9).

Murrawijinie Caves have a long history of human visitation and usage. The name Murrawijinie is reported to mean "bloody hand" (Woolf 1936). Two of the caves contain Aboriginal hand stencils and stone arrangements. Murrawijinie 1 and Murrawijinie 2 are listed on the State Heritage Register.

The caves were also known to the pastoralists on Nullarbor Station, which was established in the 1880's when Tom Brown built a homestead, shearing shed and other outbuildings near Robert's Well (Angas & Reynolds 1991; Beattie 1993). The caves were visited by Captain Maitland Thomson on his caving expeditions during the 1930's and 1940's. They have remained a well known and popular destination with travelers crossing the Nullarbor, and have suffered from graffiti and rubbish. The caves continue to be promoted as an attraction from the Nullarbor Hotel/Motel, and regionally via the Nullarbor brochure. Visitor numbers and impacts resulting from visitation are expected to increase in the future.

The aim of this section is to document the natural and cultural resources in Murrawijinie Caves, define the management issues, assess existing and potential impacts, and make recommendations for future management.

2.2 NATURAL RESOURCES

2.2.1 Surface environment, hydrology and catchment

The natural character and aesthetic appeal of the cave entrances and dolines, which are spectacular in the otherwise flat Nullarbor landscape, is compromised by the nearness of vehicular access and associated impacts. The landscape and catchment surrounding the caves has been degraded by vegetation and soil loss caused by vehicular access tracks which lead to parking areas and campsites in very close proximity to the caves.

The parking areas are situated on the lip of cave entrances or dolines, and within the catchment area where localized surface runoff flows into the caves. The carparks at

Caves 1 and 2 lie directly above underlying cave passages, thus likely affecting diffuse infiltration in these areas (Figures 2, 3).

Eroded sediment from the de-vegetated surfaces, and potential contaminants from vehicles and camping activities within the catchment area, may be transported into the caves by surface runoff. Soil erosion is evident on slopes within the dolines, for example Cave 3.

Protection of the surrounding surface environment and cave catchment area could be improved by relocating vehicle parking a short distance back from the doline and catchment perimeters (ca. 100 m), whilst rehabilitating impacted areas. Alternatively, the existing carparks and roads could be better contained and delineated, whilst avoiding slopes prone to erosion. In relocating the carparks and developing walking trail access, four options are presented for consideration in the later section on visitor management (Figures 4 to 7). The options differ primarily in the amount of new road, surface walking trails, and rehabilitation required.

The feasibility of achieving any of these options needs to be considered in relation to the costs, impacts, and the practical difficulty of controlling vehicle movements in this remote location and open landscape with no natural constraints to vehicle access.

Management Aim

To maintain the natural integrity of the surface environemnt and catchment area surrounding the caves.

Recommendations

1. Relocate vehicle access tracks and parking areas outside the surface catchment areas of the dolines and caves.

2. Discourage camping near the caves by providing alternative campsites in a suitable location.

3. Provide access to the caves by defined walking trails from the parking areas.

4. Rehabilitate impacted areas.

2.2.2 Geology and Geomorphology

The caves are significant geologic and geomorphic features within the regional context of the Nullarbor Plain. They contain large-scale and small-scale features of scientific and public appreciation value, that potentially may be damaged by visitors or compromised by inappropriate structures.

Geologically, the caves are developed within the Nullarbor Limestone of Early to Middle Miocene age (Lowry 1970; and references cited in Davey et al. 1992). The caves provide a 'window' through which a cross-sectional sequence of the limestone can be viewed. Horizontal bedding structures and fossils are clearly exposed in the cave walls and ceilings, and could be readily interpreted to the public. There is a risk however that some visitors may attempt to souvenir fossils.

Geomorphologically, the caves are examples of collapse dolines leading into shallow caves developed within the near-surface zone in which the rock is highly perforated by small anastomosing tubes and cavities of various types. The perforated zone is attributed to various geomorphic explanations for different cavity types, including phreatic preparation when the regional watertable lay close to the surface, perched water bodies, salt weathering, and corrosion by tree root exudates (Lowry & Jennings 1974). Good examples of anastomosing tubes and spongework cavities occur, which could be readily interpreted (Plate M11).

Management Aim

To protect geologic and geomorphic features and processes.

Recommendations

1. Plan access routes and structures so as to protect geologic and geomorphic features.

2. Facilitate protection of geologic and geomorphic features through appropriate interpretation.

2.2.3 Cave deposits

Cave deposits include secondary minerals, speleothems, sediments, and bones.

Caves on the Nullarbor Plain are known to contain secondary mineral deposits of great scientific significance, although such mineral deposits have not so far been identified in Murrawijinie Caves (references cited in Davey et al. 1992). The Nullarbor caves are also important for containing speleothems formed of halite and gypsum, in addition to the more usual calcite, all of which have great value in interpreting palaeo-environments on the Nullarbor Plain. The Murrawijinie Caves are not generally renowned for their speleothems, although Cave 3 contains calcite stalagmites and stalactites that may prove important for palaeo-environment studies.

Sediments include materials derived from in situ weathering and collapse of the limestone bedrock, ranging from fine silt-sized particles to large blocks several metres across. In addition, water-borne and air-borne sediments of fine calibre materials from

outside have been deposited on cave floors. Sediments may contain palaeontological and archaeological material.

Like many Nullarbor Caves, all three of the Murrawijinie Caves contain rich deposits of bone material. Much of the bone material in Murrawijinie Caves belongs to small animals, and thus is inconspicuous and easily trampled underfoot inadvertantly. The bone material is largely derived from the prey of owls and kestrels, where it is concentrated in mounds beneath roost sites, or scattered more diffusely within the twilight zones. Mounds of small mammal bones derived from the decomposition of owl pellets occur below roost sites in avens, probably once occupied by the Masked Owl (*Tyto novaehollandiae*) which has recently become extinct across much of it's former range on the Nullarbor Plain. Accumulations of larger bone material (in Cave 3) may be attributed to mammalian carnivores such as dingo or fox, whilst other skeletal remains are the result of accidental pitfall into vertical entrances.

The bone deposits in Murrawijinie Caves have not yet been subject to detailed study, but as such they represent a potentially valuable record of faunal assemblages in the local area, including species which may no longer occur in the Nullarbor region. The bone deposits are fragile and vulnerable to damage or destruction by inadvertent trampling underfoot, which occurs because of their small size and inconspicuous appearance. Bones are widely distributed on the cave floors, especially in Caves 1 and 2. If the deposits are to be protected from ongoing degradation then visitors must not be encouraged to wander freely throughout the caves. Protection of the deposits could be enhanced by providing a defined route, combined with explanatory interpretation.

Management Aim

To protect and conserve cave deposits.

Recommendations

1. Define routes through the caves that protect and conserve cave deposits, especially bone material.

2. Utilise interpretive signage to increase public awareness and appreciation of cave deposits, including bone deposits.

3. Support scientific investigation and assessment of the bone deposits.

2.2.4 Wildlife

The caves and dolines are foci for biodiversity and provide critical habitats not otherwise present on the flat arid surface of the plain. They provide shelter, moisture and nutrients for both native and introduced fauna and flora.

The sheltered moist microclimate within dolines and cave entrances supports a vegetation community that is distinct from the bluebush /saltbush shrubland of the plain surface. The vegetation communities in the Murrawijinie Caves have been extensively colonised by invasive weeds, including Blackberry Nightshade (*Solanum nigrum*),Wild Hops (*Acetosa vesicaria*), Smooth Mustard (*Sisymbium erysimoides*), Wards Weed (*Carrichtera annua*), New Zealand Spinach (*Tetragonia tetragonoides*), Twining Glycine (*Glycine cladestina*), and Bedstraw (*Galium* sp.) (Plates M18, 25).

The rock overhangs and caves provide critical roost and nesting sites for birds, including Australian Kestrel (*Falco cenchroides*), Welcome Swallow (*Hirundo neoxena*) and unidentified species of owl. The Masked Owl (*Tyto novaehollandiae*) is listed as endangered under Schedule 7 of the SA National Parks & Wildlife Act 1972. Although no owls or fresh owl pellets was observed during this survey, these caves were clearly used extensively by owls in the past. These caves therfore represent important habitat for possible future recovery of this species. During breeding periods of birds, nesting adults and young may be inadvertently disturbed by visitors with consequent risk of some mortality to young.

The caves and dolines may also provide shelter for mammals, including kangaroo, dingo, fox and rabbit. Although these species were not observed at the time of this survey, bones and scats indicate previous use. The caves may also provide shelter for other small native mammals, including bats, although none were observed during the brief survey visit. Caves and rocky overhangs are a habitat for Stick-Nest Rats (*Leporillus* spp.), which may have remained extant in the region up until the 1930's (Copley 1999). *L. apicalis* is listed as endangered and *L. conditor* as vulnerable under the the SA National Parks & Wildlife Act 1972. No stick nests were observed in Murrawijinie Caves.

The Nullarbor karst contains a highly significant fauna of cave-adapted invertebrates, although no specialised troglobitic species have been recorded from Murrawijinie Caves. Their occurrence in these caves is considered unlikely due to the the shallow, open structure of these caves, which do not otherwise support the stable, humid environmental conditions characteristic of the deep cave zone where troglobites mostly occur.

Eight invertebrate species are recorded from Murrawijinie Caves by Richards (1971) and listed in Appendix 1. All are arthropods, including 6 insects (beetles, crickets, two-winged flies), one crustacean (slater), and one arachnid (pseudoscorpion). One species, the cave cricket, Pallidotettix nullarborensis, is endemic to the Nullarbor Plain. No special requirements for protection of invertebrate fauna are considered necessary at these sites.

Reptiles, including snakes, frequently occur near cave entrances and dolines on the Nullarbor Plain. Visitors may benefit from a warning in this regard.

Management Aim

To protect and conserve fauna and flora.

Recommendations

1. In developing Murrawijinie Caves for visitor access consider habitat and conservation requirements of fauna including threatened species.

2.3 CULTURAL RESOURCES

2.3.1 Aboriginal Heritage

Murrawijinie Cave 1, and Cave 3 in particular, are well known for the Aboriginal art they contain, consisting of hand stencils in ochre (eg. Cane 1992). Murrawijinie 1 (5035-625) and Murrawijinie 2 (5035-626) are listed on the State Heritage Register, and as such are subject to the South Australian *Development Act 1993* and *Heritage Act 1993.* These two caves are mentioned in the description for the listing of the Nullarbor National Park (6046) on the Register of the National Estate, although the caves themselves are not separately listed.

Caves 1 and 3 also contain stone arrangements that may be Aboriginal. No Aboriginal cultural material has yet been identified in Cave 2.

In Cave 1 a small group of faded stencils occurs under the overhang at the northwestern end of the doline, close to the normal entry point. The stencils are not obvious, and without prior knowledge of their existence or location, most visitors probably wouldn't notice them. Visitors entering the doline are instinctively drawn towards the southeastern end of the doline, where the main cave is. Four sites containing different types of stone arrangements were identified beneath the overhang towards the northwestern end. These consist of two rock cairns, a pile of stones at one side of the stencil gallery, and an enigmatic arrangement of stones forming a line and possibly a circle (Plates M8, 9, 10).

Cave 3 is better known and appreciated for its good display of Aboriginal hand stencils beneath the southern overhang (Plates M34, 35). Unfortunately some of the stencils have been damaged by graffiti. An identified stone arrangement consists of a boulder originating from just below the caprock zone, positioned deeper inside the cave and propped with a smaller stone in such a position that a natural hollow within the boulder is oriented in such a manner that would allow it to be used as a receptacle (Plates M31, 32. Whether or not this arrangement is Aboriginal or Euorpean in origin remains to be determined.

Both caves clearly have significant value as cultural heritage sites, but they remain vulnerable to damage and degradation resulting from visitation. Some of the artwork has already been damaged by graffiti. The site conservation strategy report for the west coast and Nullarbor by Walshe et al. (1997) recommended for these two caves that signage be considered, and that access be restricted where possible. At the same time these authors noted that it would be unrealistic to restrict access to these sites, which already experience high visitation. Educational signage, combined with defined routes, may therefore offer the best strategy for ongoing protection.

The Aboriginal art is one of the principal attractions for visitors to the Murrawijinie Caves. By provision of appropriate interpretation and defined access to selected cultural site(s), it is argued that this may assist in site protection by encouraging appropriate visitor behaviour. In the absence of such measures it is argued there remains a greater likelihood of undesirable visitor behaviour, such as touching the artwork and writing graffiti. The artwork in Cave 3 provides the best display, is more accessible, and appears to be better known and more regularly visited than the art site in Cave 1. It is recommended that the art site in Cave 3 be the primary focus for Aboriginal cultural interpretation and protection.

It is beyond the scope of this report to provide a qualified and complete record of archaeological sites within these caves, however the location of stencils and stone arrangements observed during this survey are shown in Figures 2 and 3. It is probable that other sites occur within these caves, and the surrounding terrain. It is recommended that an archaeological survey be undertaken in all three caves, as a prerequisite to any further development for visitor access and interpretation.

Management Aim

To protect and manage aboriginal cultural heritage sites and artifacts appropriately; and where appropriate, to provide access to, and interpret, selected aboriginal cultural heritage sites, consistent with the protection of these sites.

Recommendations

1. Undertake an archaeological survey of Murrawijinie Caves.

2. Involve the local Aboriginal community in identifying and protecting the Aboriginal cultural sites.

3. Manage and conserve cultural heritage sites according to the guidelines of the Burra Charter (ICOMOS 1988).

2.3.2 Pastoral Era Heritage

In addition to the Aboriginal cultural heritage in the Murrawijinie Caves, there also exists a number of European pastoral era heritage sites linked with pastoralism in the late nineteenth century. These sites, which include old stock yards, Roberts Well, Horse Tank and No. 1 Bore, are located along the track to the caves from Nullarbor Hotel/Motel. (Plates M40, 41, 42). The distance to these sites is presently indicated on the sign at the start of the route near Nullarbor Roadhouse, however these sites have considerable potential to be further developed and interpreted for public appreciation, which could be used to complement and enhance the visitor experience en-route to the caves. Visitor safety needs to be considered in the further development of these sites, particularly No. 1 Bore where there is a deep shaft. At present there is no signage at any of these sites.

Management Aim

To protect and manage pastoral era heritage sites and artifacts appropriately; and where appropriate, to provide access to, and interpret, selected heritage sites, consistent with the protection of these sites.

Recommendations

1. Undertake survey and assessment of pastoral era heritage sites en-route to the caves, including the old stock yards, Roberts Well, Horse Tank and No. 1 Bore.

2. Develop conservation and interpretation plans for the pastoral era heritage sites, with interpretation planning linked as appropriate, with that for the caves.

3. Manage and conserve cultural heritage sites according to the guidelines of the Burra Charter (ICOMOS 1988).

4. Ensure that conservation work is supervised by qualified heritage conservation practitioners.

2.4 VISITOR MANAGEMENT

In discussing the management of archaeological sites in caves on the Nullarbor Plain, and the possible presentation of these sites to the public, Cane (1989) makes the following general recommendations:

- All visits by guided tours only, no unsupervised visits;
- Tours to be strictly controlled with small numbers (10-15 people);
- Access to sites only by constructed, minimal impact, walkways that allow "look but not touch";
- Prior detailed archaeological survey to identify, document and interpret sites, and establish a reference baseline against to which to measure future changes;
- Conservation and rehabilitation as required;
- Involvement of an archaeologist in development of interpretation and site plans.

Whilst guided supervision of all visits to the many Nullarbor cave sites containing Aboriginal heritage would be impossible using present management resources, it might be a more realistic management aim to improve the general level of protection through provision of on-site information that encourages appropriate conduct. In consideration of the practical difficulties involved in managing the many archaeological and anthropological sites on the Nullarbor Plain (92 recorded sites, cave and surface, Cane 1989) we believe that unsupervised visitation to some cave sites, including Murrawijinie Caves, is appropriate so long as adequate on-site information and protective infra-structure (trails and boardwalks) are provided as necessary. Unsupervised visitation is already well established at Murrawijinie Caves anyway, where it will continue whatever attempts are made to regulate and control access. Some other sites however, are far less robust than Murrawijinie Caves, and of such importance, that unsupervised visitation should not be encouraged.

2.4.1 Contribution to tourism

The Nullarbor Plain is popularly known (and promoted) for it's many caves, however very few of these are accessible to the general public. Together with the treeless plain, coastal cliffs and whale watching at the Head of the Bight, caves are one of the few scenic attractions for visitors to the Nullarbor Plain. Murrawijinie Caves are one of the few accessible caves.

Murrawijinie Caves are important for local and regional tourism, and they are an identified, actively promoted component within the regional tourism strategy - The Nullarbor brochure and map promotes the caves. The caves are an attraction on scenic flights operated from the Nullarbor Hotel/Motel, and the Hotel/Motel also promotes the caves as a local self-drive destination.

Visitor numbers (approx. 15,000) to this area increase during the whale watching season (July to October) at the Head of the Bight. Murrawijinie Caves represent a potential secondary attraction for visitors in the area during this period. However, the proportion of visitors to this area who also include a visit to the caves appears to remain relatively low.

Tourist value could be added by seeking to have visitors extend their stay in the region through further promotion, marketing and pre-visit information on Murrawijinie Caves. However, this should not be undertaken until necessary cave conservation actions, on-site visitor facilities and information, and monitoring programs have been developed to cater for increased visitation.

Management Aim

Ensure Murrawijinie Caves are appropriately integrated into local and regional tourism strategies, consistent with conservation and management objectives.

Recommendation

1. Liase with regional tourism agencies to ensure appropriate integration with regional tourism strategies, consistent with conservation and management objectives.

2.4.2 The cave visitor

The number of visitors to Murrawijinie Caves is unknown as no statistics have been collected, however they are amongst the most accessible and well known cave sites on the Nullarbor Plain, and probably amongst the most frequently visited.

The proximity of the caves to the Eyre Highway and the Nullarbor Hotel/Motel has facilitated regular visitation over many years.

The caves attract a diverse range of visitors including:

- Staff and visitors from the Nullarbor Hotel/Motel;
- 'Local' residents from the west coast and Eyre Peninsula;
- Adventure travellers engaged in private, 4WD based holiday;
- Adventure travellers with commercial 4WD tours;
- Travellers commuting along the Eyre Highway;

- Tourists during the whale watching season at the Head of the Bight;
- Cavers.

Most are day-visitors who stop for a brief look at the caves before continuing on to other destinations. Some visitors camp overnight at the caves. The Nullarbor Hotel/Motel is one of the major entry / exit points for adventure travellers visiting the Nullarbor National Park and Nullarbor Regional Reserve (DEHAA 1999), though this visitor componant in all probability only represents a small proportion of total visitation to the caves.

Some visitors exhibit inappropriate conduct such as leaving behind graffiti, rubbish and faeces. Due to the accessibility of the caves to relatively large numbers of visitors there is the potential for ongoing degradation to occur.

Management Aim

Educate visitors in appropriate minimum impact conduct in caves.

Recommendations

1. Provide pre-visit and onsite information that encourages appropriate conduct in caves.

2.4.3 Providing for the visitor

Visitor support for Murrawijinie Caves presently consist of:

- Vehicle access via 10km of rough dirt track, with discrete directional signage, from the Nullarbor Hotel/Motel;
- Car parking areas and camping (both undesignated) at the cave entrances;
- Cliff warning signs at each entrance.

No other visitor support, including structures to assist cave entry, defined routes to protect cave resources, explanatory or interpretive information are presently provided. The caves are illuminated by natural light and torches are not required.

For improved visitor support, and cave protection, there is an explicit need for explanatory and interpretive information to be provided on site, combined with defined trails within the caves which visitors are expected to adhere to. The visitor support information and facilities would be best coordinated and integrated through a site development and interpretation plan, for which this report provides the initial framework for development and interpretation options.

Management Aim

To provide day visit facilities to enhance visitor enjoyment and realize the tourist potential of the caves, consistent with protecting cave values.

Recommendations.

1. Initiate a site development and interpretation plan for the caves and pastoral era heritage sites en-route to the caves.

2.4.4 Cave trails

Defined routes or trails are required to protect vulnerable cave features, including extensive bone deposits on the floors in Caves 1 and 2. The location of defined trails needs to be planned with due consideration to the protection and interpretation of natural and cultural features, and only after an archaeological survey has been completed.

To maintain, so far as possible, the natural character of the surface landscape and cave environment, structures to assist cave entry, or visitor safety, should be kept to a minimum. Where such structures are deemed necessary, they should have a low profile and be visually unobtrusive, be totally removable and involve minimal modification of existing landscape features.

The methods and materials used to for cave trails needs to be determined and should consider:

- Public safety;
- Utilization of natural surfaces where appropriate;
- Pre-manufacturing of structures;
- Avoidance of toxins & pollutants.

In consideration of the small size of the caves, and the aim of maintaining their natural character, all visitor support structures, trails and signage should be kept as discrete and minimal as possible. Some principles in heritage presentation, engineering and appropriate materials for use in cave environments are detailed by Spate et al. (1998).

Entry to Cave 1 and Cave 2 involves climbing short vertical sections of a few metres in height, whilst entry to Cave 3 is straightforward via an inclined boulder slope. The vertical climbs into Caves 1 and 2 may deter some visitors, although fixing short ladders would facilitate entry. Access to Cave 1 is presently gained by climbing a wooden log propped against the wall (Plate 5). The entrances to all three caves contain vertical cliffs and daylight holes where a fall is possible. The hazards are generally obvious although the location of the daylight holes is not apparent until one is directly atop them (Plate M27).

Management Aim

To develop and maintain a defined cave trail which protects the natural and cultural values.

Recommendations

1. Develop a site plan showing cave trails.
2. Install ladders into caves 1 & 2.
3. Install an elevated walkway throughout with handrails used only where necessary.

2.4.5 Surface trails

It is recommended that defined walking trails be constructed which lead to the cave entrances from vehicle parking areas located > 100 m beyond the immediate doline catchments. Existing vehicle tracks and parking areas within the doline catchments should be rehabilitated.

Cave 1 is located 700 m distance away from Caves 2 and 3 that are situated next to each other (Figures 1, 2, 3, Plates M1, 12). Currently visitors drive to Cave 1 before driving on to Caves 2 and 3. In relocating the carparks outside the doline catchment areas, and developing walking trail access, three options are presented below. The options differ primarily in the amount of new road, surface walking trails, and rehabilitation required. A fourth option, which does not involve relocation outside the doline catchments, would be to better constrain and delineate the existing roads and carparks, whilst stabilizing and rehabilitating eroded and impacted areas. The feasibility of achieving any of these options needs to be considered in relation to the costs, impacts, and the practical difficulty of controlling vehicle movements in this remote location and open landscape with no natural constraints to vehicle access.

Option 1

Develop new road alignments (about 500 to 600 m) to bypass the doline catchment areas (Figure 4). Rehabilitate impacted areas and develop walking trails from relocated carparks.

Option 2

Develop 700m walking trail linking the three caves. Requires rehabilitation of 700-800 m of existing road and construction of a major new link road (about 800 m) between relocated carparks at each end (Figure 5).

Option 3

Modify, only slightly (< 50 m), the existing road alignments and carparks so they are not directly on top of underlying cave passages, or encroaching upon the doline slopes prone to erosion. Involves minimal rehabilitation, new road and carpark development, but still within the doline catchments (Figure 6).

Option 4

No new roads or carparks, but confine and delineate the existing roads and carparks, whilst stabilizing and rehabilitating eroded and impacted areas (Figure 7).

Management Aim

To improve the condition of the surface environment of the caves by providing access by walking trails and rehabilitating impacted areas.

Recommendations

1. Develop surface walking trails to cave entrances from carparks relocated outside doline catchments.
2. Rehabilitate impacted areas.

2.4.6 Camping

Most visitors to Murrawijinie Caves come for a brief look and then move on to other destinations. A few camp overnight at the caves, although this practise should be discouraged for purposes of cave and catchment protection. Camping should not be permitted within the immediate catchment area of the dolines and caves (> 100 m), nor should it be encouraged within easy walking distance of the caves as this will exacerbate visitor impacts, including rubbish, toilet paper and faeces deposited within the caves. The no camping policy near the caves should be conveyed to visitors in pre-visit information and on-site signage, together with alternative camping locations.

Management Aim

To discourage camping adjacent to the caves.

Recommendations

1. Ensure pre-visit information and on site signage conveys the no camping policy, including alternative camping areas.

2.4.7 Vehicle access and parking

Access to the caves is via a rough track leading north 10.4 km from the Nullarbor Hotel/Motel. The track is most suited to 4WD vehicles, but becomes difficult or nearly impassible for brief periods after heavy rain. The track is also accessible by 2WD vehicles under dry conditions, however it's rough nature probably deters some visitors.

Upgrading of the vehicle track would improve access and probably encourage more visitors to the caves. This would also increase pressure and impacts on the caves and surrounding area however, and would need to be carefully managed with appropriate controls and monitoring.

For visitor safety, protection of cave catchments and conservation of surface landscape values, it is recommended that vehicle parking areas be relocated further away from the cave entrances as already described. The carparks at Caves 1 and 2 lie directly above underlying cave passages, including a site with very thin caprock beside the Cave 2 carpark (Figure 3).

Management Aims

To provide vehicle access and parking consistent with management and visitor support.

Recommendations

1. Relocate parking areas as indicated in Figures 4, 5.
2. Improve the vehicle track and directional signage ex Nullarbor Hotel/Motel.

2.4.8 Visitor Information and Interpretation

Visitor information and interpretation for Murrawijinie Caves is a vital part of providing both visitor support and conservation of cave values. Presently there is no on-site information or interpretive signage, and directional signage is minimal.

Visitor information and interpretation includes:

- Pre-visit information
- Directional signage
- On-site information, orientation, safety, codes of conduct, etc
- On-site interpretation

It is important that visitor information and interpretation conveys appropriate conservation messages, a minimal impact code of conduct in caves for example.

It is recommended that an interpretation plan be developed for Murrawijinie Caves inclusive of cultural heritage sites en-route to the caves, that is consistent with DEH regional planning, and coordinated with local and regional tourism promotion strategies.

Management Aim

To enhance visitor enjoyment and appreciation of the caves through education and high quality interpretation.

Recommendations

1. Improve directional signage, pre-visit and on-site information, on-site interpretation.

2.4.9 Interpretation themes (and sites):

- ***Nullarbor Plain***
  Landscape – flat
  Climate - arid
  Vegetation - treeless, chenopod shrubland

- ***European cultural heritage***
  nineteenth century pastoralism -old stock yards, Roberts Well, Horse Tank, No. 1 Bore

- ***Caves***
  Geology - limestone, fossils
  Geomorphology (features and processes - caves, anastomosing tubes, salt weathering)
  Deposits - bones, sediments, speleothems

- ***Wildlife***
  kestrels, swallows, owls, threatened species, introduced species

- ***Aboriginal cultural heritage***
  hand stencils and stone arrangement in Cave 3

- ***Conservation***
  Caves and cave features, bones, wildlife habitat, cultural heritage

2.4.10 Promotion and marketing

Murrawijinie Caves are currently promoted by:

- Nullarbor Hotel/Motel;
- Parks & Wildlife Service, Ceduna;
- Tourism Eyre Peninsula (via The Nullarbor brochure).

To optimize visitor experience and enhance the benefit to local and regional tourism economies, it is essential to ensure that the Parks & Wildlife marketing plan for Murrawijinie Caves is integrated with the marketing plans of local tour operators (including whale watching at Head of the Bight, scenic flights ex. Nullarbor Hotel/Motel), regional and state tourism agencies (Tourism Eyre Peninsula, South Australian Tourism Commission).

The promotion of Murrawijinie Caves is consistent with the marketing and development objectives and strategies of Tourism Eyre Peninsula (de Bruyn 2003), which include the Nullarbor brochure, development and promotion of geological attractions, and development of the backpacker market. 'Soft adventurers' and 'guided ecotourists' are forecast growth markets for the Eyre Peninsula. This market component is suited to Murrawijinie Caves, where visitors can get close to nature, engage with and potentially learn about nature, while minimizing impact.

Significant promotion and marketing potential for Murrawijinie Caves already occurs via The Nullarbor brochure produced by Tourism Eyre Peninsula, however, opportunity exists to expand this. Thus pre-visit information should convey accurate information with appropriate emphasis on minimal impact, nature-based tourism.

It is essential that promotion and marketing of the caves is rigorously controlled and integrated with conservation management objectives. If increased promotion and marketing is not synchronized with site development there is potential for increased impacts to occur before protective structures and information have been placed.

Management Aims

Coordinate promotion and marketing of the caves with local tourism operators and regional tourism agencies, which is consistent with conservation management objectives.

Recommendations

1. Liaise with local, regional and state tourism agencies and operators to ensure accurate and appropriate promotion and marketing of the caves.

2.4.11 Visitor programs

Interpretive programs may add significantly to visitors' understanding and enjoyment, particularly in caves which are an unfamiliar environment to many people. Such programs may also contribute to conservation of resource values through on-site guidance and education of visitors.

Potential exists for development of a visitor interpretive program, based from the Nullarbor Hotel/Motel, with guided tours run to Murrawjinie Caves which include other cultural heritage sites en-route. Such a program could be developed in collaboration with the local Aboriginal community.

Management Aim

Provide opportunities for visitor interpretation programs

Recommendations

1. Consider proposals for visitor interpretation programs on their merits, particularly addressing value to visitors and potential environmental impacts.

2. Encourage the local Aboriginal community to participate in the development and delivery of interpretation associated with Aboriginal sites in Murrawjinie Caves.

2.4.12 Commercial tourism operations

There exists an opportunity to develop an eco-tourism experience visiting Murrawjinie Caves and other cultural heritage sites in the vicinity. A tour could potentially be developed which taps into the existing visitor market at Head of the Bight and the Nullarbor Hotel/Motel. A coordinated effort between tour operators and park management would ensure the provision of high quality services while protecting park values.

Management Aims

Provide opportunities for commercial tourism services, consistent with park management aims.

Recommendations

1. Consider proposals for commercial visitor services on their merits.

2. Encourage commercial tour operators to assist in protection of the caves and management faciltities.

2.4.13 Public safety

The caves and sites en-route contain potential safety hazards or risks to visitors. It is beyond the scope of this report to assess the risks to visitors, however a number of potential safety hazards are listed below for consideration in future planning and risk assessment.

Site and associated risks and hazards:

- ***Murrawijinie Caves:***
  vertical cliffs - falling
  unstable cliff edges, rocks dislodged, falling
  daylight holes, falling
  thin caprock, collapse
  unstable boulders, boulder movement
  low roofs, head injury
  confined dark spaces
  venomous snakes

- ***No. 1 Bore:***
  deep open hole

- ***Horse Tank:***
  open tank containing water

- ***Robert's Well:***
  open tank containing water
  deep open hole

Management Aims

The aim is provide for the safety of visitors and to promote safe practices by visitors.

Recommendations

1. Undertake safety audits where appropriate.
2. Undertake regular safety inspections of sites and facilities; ensure that they are maintained in a safe condition.
3. Maintain safety and indemnity provisions in all leases and permits. Require lessees and permitees to explain relevant risks to their members and visitors.
4. Maintain or install warning signs where necessary.
5. Encourage safe practices by visitors through appropriate on-site information.
6. Develop an accident response plan in collaboration with Nullarbor Hotel/Motel.

2.4.14 Research and Monitoring

To assist management planning and conservation actions, it is important to have a reliable source of environmental data from which environmental conditions and changes can be monitored, and appropriate responses determined.

There is a need for monitoring visitor numbers, visitor satisfaction, visitor impacts and resource conservation. A logbook installed in the caves could be used to monitor visitor numbers and visitor satisfaction, whilst a vehicle counter could be used to monitor traffic circulation. Visitor impacts and resource conservation could be evaluated through a systematic monitoring program (eg. photo-monitoring) of key sites that are likely to show signs of change at the earliest possible time, thus allowing remedial action before further damage is suffered. This monitoring system could result in establishment of Limits of Acceptable Change for the caves.

Management Aim

To establish a program to monitor visitor numbers and visitor satisfaction, visitor impacts and traffic circulation, as a basis for the future research and planning of visitor facilities and conservation actions.

Recommendations

1. Install a logbook in the caves for recording visitor numbers and visitor satisfaction.

2. Install a vehicle counter to monitor traffic circulation.

3. Instigate a systematic photo-monitoring program to evaluate visitor impacts and resource conservation, and establish Limits of Acceptable Change for the caves.

4. Support bona-fide scientific research, particularly when it assists in management.

3 PART THREE - KOONALDA CAVE

3.1 BACKGROUND

Koonalda Cave (N4) is located 88 km east of Border Village and 395 km west of Ceduna. The cave is situated 32 km north from the Eyre Highway, and 7 km north of the Koonalda Station homestead (Figure 8). The cave was explored by Captain Maitland Thomson in 1934 and 1936 (Thomson 1952). Thomson's reports of water in the cave led Gurney to test it and then install an engine in the cave to pump water for stock. Koonalda Station was South Australia's most western pastoral property for 50 years, until it became part of the Nullarbor National Park in 1989. It has a high heritage significance as a remote dry land pastoral property, which relied totally on pumping water from Koonalda Cave for stock survival (Angas & Reynolds 1991). The cave contains water pumping equipment and other historical relics from the pastoral era. During this era, the underground lakes in the cave were polluted by leachates from pump engines and sheep droppings.

Koonalda Cave and the Koonalda homestead complex are both listed on the State Heritage Register, whilst the cave is also listed on the Register of the National Estate, as a 'Prohibited Area' under 'Aboriginal Places South Australia'. The cave was subject to intensive archaeological investigations between 1956 and 1968, when it was found to contain Aboriginal cultural heritage and archaeological values of outstanding national and international significance, including evidence of occupation, flint mining, and engravings more than 20,000 years old.

Since inclusion in the national park the cave has been closed to general public access although the large and spectacular entrance can still be viewed from the top. However, there exists serious ongoing management problems involving unauthorized entry into the cave, and irreversible graffiti damage being done to the Aboriginal engravings.

Koonalda Cave has a long history as an attraction for visitors to the Nullarbor, Captain Maitland Thomson referring to it in 1947 as, "one of the show caves on Nullarbor". Koonalda Cave has previously been recommended as suitable for development as a show cave for the public. This is only considered possible however if rigorous controls are in place to ensure protection of the natural and cultural values. Visitation is expected to increase as the cave is being promoted as a tourism attraction (view from top only) in the Nullarbor brochure and map.

The aim of this section is to document the natural and cultural resources in Koonalda Cave, define the management issues, assess existing and potential impacts, and define strategies for future visitor management.

3.2 NATURAL RESOURCES

3.2.1 Surface environment, hydrology and catchment

Koonalda Cave is situated in the topographic low point of an enclosed depression which forms a catchment basin of approximately 1.8 km ^{2}, where internal drainage is directed into the cave entrance via a radial system of drainage channels (Figure 9). The catchment basin and the cave have been strongly impacted by previous pastoral activities, when stock watering troughs were located in the catchment and even on the lip of the cave entrance. The concentration of stock in this area resulted in nearly complete de-vegetation within the basin, as clearly evident in earlier photographs (eg. Wright 1971). This condition allowed increased surface runoff to transport massive quantities of soil and sheep droppings into the cave, which were deposited in the cave lakes. The first lake (Lake 1) has been severely affected by this sedimentation and organic pollution (Plate K82).

Since de-stocking of the property in 1989 vegetation in the basin has recovered (Plates K1, 2) although sheet and gully erosion continue to occur on steeper slopes where a proliferation of vehicle tracks converge at the cave entrance (Plates K3 to K6). Research undertaken here and elsewhere on the Nullarbor by Gillieson (pp. 81-83 *in* Gillieson 1992) suggests that the soil surface crust of lichens and mosses and associated micro-topography are of crucial importance in preserving hillslope hydrology and in reducing erosion by both water and wind. These crusts are destroyed by vehicle tracks and sheep grazing.

Ongoing gully erosion could be prevented by moving vehicle tracks off the steep slopes on the sides of the catchment basin. For best protection of the catchment basin, it is recommended that the parking area and all vehicle tracks be moved outside the basin. Impacted areas should be rehabilitated, and access provided by a walking trail.

Koonalda Cave is an important site for recharge to the karst aquifer, and, for water supply. The cave lakes support a thin layer or 'cream' of 'fresh' water that rests on top of the more brackish/saline waters of the Eucla Basin aquifer. Woolf (1936) recorded a clay-lined pocket in the upper part of the cave floor beside the lakes, which hydrometer test showed contained 1.8 ounces of dissolved solids to the gallon, compared with 2,2 to 3 ounces per gallon in the main lakes. Thomson (1947) reported 18 feet (5.5 m) more water in the cave than when he saw it in 1934 and 1936.

Pastoralism on Koonalda Station depended entirely on the cream of fresh water, which was pumped from the cave for stock watering. The fresh water cream is recharged when surface runoff in the catchment basin flows into the cave entrance. Serious degradation of the groundwater lakes in Koonalda Cave occurred during the pastoral period which continued for 50 years until 1989. In Lake 1 the impacts included extreme sedimentation and organic pollution derived from soil and sheep droppings washed in from the surface. This and other lakes in the West Passage were also contaminated with diesel oil and grease leaked from pump engines installed in the cave. Since pastoral activities halted 14

years ago, sedimentation and contamination of the lakes has largely ceased, and partial recovery of groundwater quality appears to have occurred, at least in respect of reduced odour.

In view of it's importance for recharge to the karst aquifer, and as a potential water supply, groundwater resources in Koonalda Cave need to be protected. This requires protection of water quality and maintenance of the natural hydrologic regime in the surface catchment and inflow waters. Potential sources of contamination should be assessed, including the decaying pump engines that remain in situ in the cave. Scientific investigation and monitoring of water quality and leachates should be supported, and remedial actions undertaken where appropriate.

Some aspects of the hydrology, water chemistry and water quality in the Nullarbor aquifer, including Koonalda Cave, is covered in James, Rogers and Spate (1989) James et al. (1991), James and Spate (1993), Smith (1989), Spate and Ward (1980).

Management Aim

To maintain the natural integrity of the surface environment in the catchment area, hydrologic processes, water quality and groundwater resources.

Recommendations

1. Relocate all vehicle tracks and parking areas away from the cave entrance and slopes within the catchment basin. Alternatively, the existing carparks and roads could be better contained and delineated, whilst avoiding slopes prone to erosion.

2. Control erosion and rehabilitate impacted areas

3. Provide access to the cave by a defined walking trail from the parking area.

4. Support scientific investigation and monitoring of groundwater quality and potential sources of leachate within the cave. Undertake remedial actions where appropriate.

3.2.2 Geology and Geomorphology

The upper levels of Koonalda Cave are developed within the Nullarbor Limestone of Miocene age, whilst the lower levels are developed within chalky Wilson Bluff Limestone of Eocene age.

Koonalda Cave is a very significant geomorphic feature, at both regional and national levels. It's most apparent and spectacular attribute is the very large size of it's passages and chambers (up to 60 m wide and 50 m high), which rank among the largest in the Nullarbor karst, and in Australia (Figure 10).

The cave is one of only a few known examples of the 'deep cave' type which intersect the regional watertable approximately 85 m below the surface of the Nullarbor Plain. The cave is laterally extensive, containing 1.6 km of surveyed passages, including a series of watertable lakes.

The cave is important for understanding processes of cave development on the Nullarbor. The geology and geomorphology of Koonalda Cave is covered by Lowry (1970), Lowry & Jennings (1974), and references cited in Davey et al. 1992.

Management Aim

To protect geologic and geomorphic features and processes.

Recommendations

1. Plan access routes and structures that do not impinge upon geologic and geomorphic features and processes.

3.2.3 Cave deposits

Cave deposits include secondary minerals, speleothems, sediments, and bones.

The sediments in Koonalda Cave include precipitates and clastic sediments, described by Frank (1971). Decorative carbonate precipitates are rare within the Wilson Bluff Limestone, but chloride and sulphate precipitates are present, the latter occurring as gypsum flowers. Clastic deposits include extensive accumulations of breakdown from collapse of the cave roof and walls, which dominate the cave floors (Plate K74). In addition, there is sporadic dumping of soil derived material brought into the cave by short-lived streams. An 8 m deep sedimentary sequence exposed in Trench III (Figure 11, Plates K54, 55) consists of three distinct units: (1) comprising the top white unit (0 – 1.8 m) composed of breakdown with Aboriginal hearths containing charcaoal dated to ca. 20, 000 years BP; (2) intermediate unit (1.8 – 1.95 m); (3) the lower red unit (3.5 to 4 m thick) composed mostly of water-borne and ponded soil derived material (Plate K57). Older soil derived sediment fills occur in truncated bedding plane cavities within the Wilson Bluff Limestone, and, in cavities in the Nullarbor Limestone exposed in the doline walls (Frank 1971).

Despite the size of the archaeological excavations in Koonalda, little faunal material was recovered, none of which was associated with the archaeological material. Bones collected from the red unit in Trench III by Thorne (1971) are listed in Appendix 2.

In the entrance doline, as well as inside the cave, there are numerous heaps of small bones which are the disintegrated remains of owl pellets (Plate K33). These inconspicuous deposits, representing a valuable record of local faunal assemblages, are

vulnerable to damage from trampling by visitors. Any future development works in the cave should consider the protection of these deposits.

Management Aim

To protect and conserve cave deposits.

Recommendations

1. Trails and other developments in the cave should consider the conservation and protection of cave deposits.

2. Support scientific investigation and assessment of cave deposits.

3.2.4 Flora and Fauna

Koonalda Cave has a distinctive flora due to the increased shelter and moisture within the large doline, which includes species not otherwise found in the area. The flora recorded by Symon (1971) and listed in Appendix 3, includes many alien species of herbs and fruit trees. The fruit trees were planted in the doline during the pastoral era, and thus have heritage conservation significance (Plate K20).

The doline and cave provides critical roost and nesting sites for birds, including Australian Kestrel (*Falco cenchroides*), Welcome Swallow (*Hirundo neoxena*) and an unidentified species of owl, either a Barn Owl (*Tyto alba)* or Masked Owl (*Tyto novaehollandiae*). The latter species is listed as endangered under Schedule 7 of the SA National Parks & Wildlife Act 1972.

A small colony of bats roost in the chamber where the north and west passages diverge. The species remains undetermined but it may be the Chocolate Wattled Bat (*Chalinolobus moriae*) which commonly roosts in other Nullarbor caves (Hall 1970). Dead specimens of *Nyctophilus geoffroyi* have been collected in Koonalda Cave (Hamilton-Smith 1967). Any future developments undertaken in Koonalda Cave should consider the potential disturbance which may be caused to roosting bats. Gate designs should allow for continued bird and bat movements.

Koonalda Cave is important habitat for cave dwelling invertebrates, eighteen species are listed in Appendix 4. A number of these species are endemic to the Nullarbor, including the rare troglobite, *Trogloblatella nullarborensis* (Nullarbor cave cockroach) recorded from deep cave habitats in only a few caves (Plate K86). Any future developments undertaken in Koonalda Cave should consider the protection of this species, and other cave dwelling invertebrates.

No aquatic fauna is known from the lakes in Koonalda Cave, although searches by cave diving have been made for the microbial mantles which are found in other Nullarbor cave lakes (Contos et al. 2002).

Management Aim

To protect and conserve native fauna and flora.

Recommendations

1. Any future development works in Koonalda Cave should consider the habitat and conservation requirements of fauna, including birds, bats and invertebrates. (Gate designs should allow for continued bird and bat movements).

3.3 CULTURAL RESOURCES

3.3.1 Aboriginal Heritage

Koonalda Cave contains Aboriginal cultural heritage and archaeological values of outstanding national and international significance. The cave was subject to intensive archaeological investigations between 1956 and 1968 (Gallus 1968a, b, 1971; Pretty & Gallus 1967; Sharpe and Sharpe 1976; Wright 1971a, b). These early investigations established Koonalda Cave as one of the most important archaeological sites on the Nullarbor Plain, and amongst the world's most important sites for studies in human prehistory (Cane1992).

The significance of Koonalda is attributable to the demonstrable antiquity of Aboriginal use of the cave, which involved an elaborate flint mining industry, and engravings that represent some of the earliest known 'art'. Radiocarbon dates indicate an occupational sequence in the range 16,000 to 27,000 years ago (Wright 1971a), although the cave may have been visited earlier than this since OSL dates from Allens Cave indicate occupation of the region by about 40, 000 years (Roberts 1996). Numerous other caves and rockholes on the Nullarbor Plain have important archaeological and Aboriginal heritage values, described by Cane (1989) and Walshe et al. (1997).

Koonalda Cave (14250) and the Koonalda Homestead Complex (14248) are both listed on the State Heritage Register, and as such are subject to the South Australian *Development Act 1993* and *Heritage Act 1993.* Koonalda Cave (6013) is also listed on the Register of the National Estate, as a 'Prohibited Area' under 'Aboriginal Places South Australia'. A low density scatter of artifacts on the surface pavement outside Koonalda Cave is a registered site (4835-502) (Walshe et al. 1997).

The archaeological sites in Koonalda Cave (Figure 11) are located in the *Northwest Passage*, which can be divided into two sections comprising the *Gallus Site,* and, the *Art Passage* which includes *The Squeeze* (Plate K65). In both these sections there exist

management issues relating to the ongoing protection and conservation of the art, and other Aboriginal heritage sites. These issues stem from:

1. The archaeological excavations undertaken between 1956 and 1968 resulted in considerable impacts to the cave, and the work was never suitably concluded. Impacts are most evident at the Gallus Site where there remain deep open pits, spoil heaps, rusting equipment and extensive areas of compacted floor.

2. Inadequate protection of identified cultural heritage sites (flint mining, stone arrangements, hearths, art), which has contributed to ongoing degradation of the sites since archaeological work ceased approximately 1968. Whilst there was a sign installed to warn of the deep pits, no protective measures were provided for the flint mining sites, stone arrangements and hearths in the near vicinity. These sites are not readily apparent to visitors unfamiliar with them, and thus they have remained vulnerable to ongoing degradation by inadvertent trampling.

In consideration of the outstanding importance of this site, it's adequate protection must be the paramount aim in all management planning and future developments. Prior to any development or increase in visitation to Koonalda Cave it is imperative that a conservation and rehabilitation plan for the archaeological and cultural heritage sites in the Northwest Passage be developed. This needs to be done in consultation with an archaeologist.

Management Aim

To protect and manage aboriginal cultural heritage sites and artifacts appropriately.

Recommendations

1. Restrict access to the Art Passage, and manage this section separately to other sections of the cave. Monitor visitor numbers and impacts in this section.

2. Develop and implement a conservation and rehabilitation plan for the archaeological and cultural heritage sites in the Northwest Passage.

3. Seek increased understanding and wider recognition of the cultural heritage and archaeological values within Koonalda Cave, through appropriate research and information programs.

4. Manage and conserve cultural heritage sites according to the guidelines of the Burra Charter (ICOMOS 1988).

3.3.2 Pastoral Era Heritage

Koonalda Cave played a critical role in pastoralism on Koonalda Station, which was South Australia's most western pastoral property for 50 years, until it became part of the Nullarbor National Park in 1989. The lease for the station was not granted until December 1941, until after the applicants, Frederick and Cyril Gurney, had proved that they could water stock with water pumped from the cave (Angas & Reynolds 1991).

As Koonalda Station relied totally on pumping water from the cave for stock survival, the history of the property is strongly linked with Koonalda Cave, which still contains pumping equipment and other structures dating from this period. The dominant role played by the water pumping operation in the life of the pastoral property can nowadays only be appreciated from inside the cave, where there remains heavy machinery, deep excavated pits, and a long stairway constructed from local timber. Whilst some components of the water pumping infrastructure, including the pipeline, have been removed from the cave, the infrastructure that remains *in situ* has important historical relevance to Koonalda Station.

Koonalda Station itself has high heritage significance as a remote dry land pastoral property (Angas & Reynolds 1991). A survey of the buildings and infrastructure at the former Koonalda homestead complex, undertaken by the State Heritage Branch in 1991, provided recommendations for stabilization and maintenance, future use and interpretation values. This survey acknowledged the heritage significance of Koonalda Cave in it's own right, but made no assessment or recommendations in relation to the infrastructure contained therein.

In further consideration of the association between the homestead complex and water pumping activities in Koonalda Cave, it is important that this historic relationship be recognized and integrated in future heritage planning actions. In this respect it is argued that the pumping equipment and other related structures that remain in the cave have high heritage significance. This significance is best appreciated and interpreted with the few remnants that still remain in the cave, where their installment deep underground bears testimony to the efforts and resourcefulness of the pastoral settlers of the outback.

The State Heritage Branch survey (Angas & Reynolds 1991) recommended that a conservation plan be prepared for the homestead complex. We recommend that this should also be done for the related infrastructure and features within Koonalda Cave. Some components of this infrastructure are vulnerable to degradation and present, variously, heritage conservation (stairway in entrance chamber), public safety (bore casing), or environmental contamination (pump engine leachate) issues.

The location of infrastructure and features identified as having heritage significance are shown in Figure 11, and listed below:

- Fruit tree grove in doline (Plate K20);
- Wood post and wire structure (part of a winch or windlass?) near top of boulder slope in entrance chamber (Plate K35);
- Long stairway in entrance chamber, constructed using local timber (Plates K38, 39);
- Pump engine at base of ladder (Plate K70);
- Pump engine and pits in North Passage (Plates K75, 76);
- Bore casing in West Passage (Plates K77, 78).

Management Aim

To protect and conserve pastoral era heritage sites and artifacts appropriately, where this is consistent with the conservation of other cave values, and public safety.

Recommendations

1. Prepare a conservation plan for pastoral era heritage sites and artifacts in Koonalda Cave.

2. Integrate Koonalda Cave with the Koonalda homestead complex in future heritage conservation efforts, planning and interpretation.

3. Manage and conserve cultural heritage sites according to the guidelines of the Burra Charter (ICOMOS 1988).

4. Ensure that conservation work is supervised by qualified heritage conservation practitioners.

3.4 VISITOR MANAGEMENT

In view of the outstanding importance of Koonalda Cave, it's proper protection must be a paramount aim in all management planning and future actions. In consideration of this, there exist two key conservation and management issues which need to be urgently addressed:

1. Control of unauthorized entry into the cave;
2. Conservation of archaeological and cultural heritage values;

It is imperative that these issues be accorded the highest priority for action as unauthorized entry and irreversible graffiti damage to the Aboriginal engravings continues to occur under the present conditions of access and inadequate control of entry.

3.4.1 Access and Control of Entry

Since inclusion in the National Park, Koonalda Cave has been closed to general public access although permits for entry may be granted to bona fide groups or individuals, for purposes of research, mapping, exploration and cave diving. Visitation to Koonalda by these cave user groups has involved only limited numbers over the last few years, although this situation could change in the future, if research interest is rekindled or new passages are discovered for example. Continued visitation of Koonalda Cave by responsible groups is considered appropriate, however, visitor credentials, visitor numbers, impacts and adherence to permit conditions should be strictly monitored. The number of access permits issued each year should be limited, and the efficacy of the permit system reviewed periodically.

Unregulated visitor access during the pastoral period resulted in graffiti damage to the Aboriginal engravings. Unfortunately, damage continues to be sustained despite official closure of the cave to general public access following annexure to the National Park in 1989. The graffiti has been placed, either by people making unauthorized entry, or the permit conditions of authorized entry not being respected. Whatever the case, these breaches are clearly unacceptable as they are causing irreparable damage to the Aboriginal engravings. Davey and Spate (1990) commented on this same problem previously, whilst noting that most of the vandalism was caused by a relatively small number of individuals resident in the west coast region (based on the names and dates). Unfortunately the practise is continuing, the recent graffiti includes, amongst other marks, the surnames of local residents from the west coast that is dated 2000 and 2001. This evidence should be further investigated as matter of priority.

Proper protection of the cultural heritage and other values in Koonalda Cave can only be assured, in the first instance, by effective control of entry into the cave, including

prevention of unauthorized entry. Damage continues to occur because the gate in the cave entrance is not completely effective in preventing unauthorized access. Improved measures for controlling entry into the cave need to be implemented as the highest priority management action. It is considered that the most effective means of controlling unauthorized entry will be by placing barriers across all openings into the cave, and combining this with regular monitoring and repairs as required.

Part of the access control problem lies in the large size of the cave which makes effective sealing of the cave from determined efforts at unauthorized entry quite difficult. The first gate structure, situated on the lip of the doline, was clearly ineffective in controlling unauthorized entry, and was replaced by another gate lower down (Plate K21). Unfortunately this gate is not completely effective either, as it can be easily bypassed by climbing underneath or over the top (Plates, 23, 24, 27). Comments in the visitor book from the Shearer's Hut at the homestead complex clearly imply this to be the case.

The existing gate could be easily improved by blocking the gaps at the top and bottom. This will not solve the problem entirely however because there exists an alternative entrance above the gated entrance, which nonetheless requires climbing skills or equipment to negotiate. Despite the placement of a 'barrier' laced with barbed wire in this entrance, this structure is not effective in preventing access via this entrance, and actually facilitates access as the structure can be used as an aid to climb upon to gain entry (Plates K27, 28, 29). It may be possible to reinforce this structure with additional wire.

Access to the Art Passage

To control and monitor visitor numbers in the fragile and vulnerable Art Passage, it is recommended that this section of the cave be managed as a special area, separate to other parts of the cave, and requiring separate approval for entry. Davey and Spate (1990) make a similar recommendation in relation to this site. Entry to this section should not be presumed where permits are issued for other purposes, such as caving or cave diving for example. It may be desirable, and necessary on occasions, that a ranger with knowledge of the cave, accompany visitors to the Art Passage or other sections of Koonalda Cave. Issued permits should include information that indicates restricted areas (Art Passage) and appropriate codes of conduct.

Unauthorized entry into Koonalda Cave and the Art Passage can be monitored relatively simply by installing concealed passive infra-red (PIR) detectors connected to event loggers and battery powered. Any ongoing impacts (including graffiti) can be detected by periodic (eg. annual) photo-monitoring of selected key sites.

Increased ranger patrols and presence on site would greatly assist in maintaining access control, and deterring break-ins. To enable this, it is recommended that a field ranger be permanently stationed in the Nullarbor National Park, based either at Koonalda

homestead, Border Village, or Nullarbor. Then if Koonalda Cave was developed as a public show cave with guided tours, the incidence of forced entries would be reduced.

Management Aims

1. *Prevent unauthorized entry into Koonalda Cave.*
2. *Prevent further damage to engravings in the Art Passage.*
3. *Educate visitors in minimum impact conduct.*

Recommendations

1. Seal the gaps in the existing gate.

2. Investigate the persons responsible for recent graffiti vandalism to Aboriginal engravings in the Art Passage.

3. Provide additional information on-site (including at the homestead, cave entrance, cave gate, Art Passage) that explains the reason for closure of the cave (and Art Passage) with appropriate codes of conduct, the managing authority, and contact details for further information.

4. Install an effective barrier on the upper entrance, which does not interfere with bird and bat movements. Reinforce or remove the existing barrier in the interim.

5. Establish ranger presence on –site; increase ranger patrols.

6. Restrict access to the Art Passage, and manage this section separately to other sections of the cave. Monitor visitor numbers and impacts in this section.

7. Monitor unauthorized entry into the cave and Art Passage using PIR detectors with loggers.

8. Review the restricted access permit system periodically, including visitor numbers and impacts, visitor credentials, and the information provided with permits. Restrict access to bona fide groups only.

3.4.2 Contribution to tourism

The Nullarbor Plain is popularly known (and promoted) for it's many caves, however very few of these are accessible to the general public. Together with the treeless plain, coastal cliffs and whale watching at the Head of the Bight, caves are one of the few scenic attractions for visitors to the Nullarbor Plain. Koonalda Cave is one of the most

accessible and well known cave sites on the Nullarbor Plain, and probably amongst the most frequently visited.

Koonalda Cave is important for local and regional tourism, and it is an identified, actively promoted component within the regional tourism strategy - The Nullarbor brochure and map promotes the cave, but, perhaps ambiguously, the brochure does not promote the Koonalda homestead complex, even though visitors must drive through the homestead complex on their way to the cave!

Value could be added to tourism on the Nullarbor by improving the tourist facilities and information at Koonalda Cave. However, this should not be undertaken until necessary cave conservation actions, and visitor monitoring programs have been developed to cater for increased visitation. It is essential that promotion and marketing of the cave is rigorously controlled and integrated with conservation management objectives. If increased promotion and marketing is not synchronized with site protection and development there is potential for further impacts to occur before protective structures and information have been placed.

If Koonalda Cave were to be properly developed as a guided show cave, as has been previously recommended by various parties, it could potentially become an outstanding scenic attraction on the Nullarbor Plain, and make a significant contribution to future tourism. The present and future visitor management of Koonalda Cave needs to be fully integrated with the homestead complex, as this constitutes a highly important heritage attraction in itself. Together these sites constitute two inseparable ingredients of the tourism experience offered by Koonalda Station.

Management Aim

Ensure Koonalda Cave is appropriately integrated into local and regional tourism strategies, consistent with conservation and management objectives.

Recommendations

1. Liase with regional tourism agencies to ensure appropriate integration of Koonalda Cave and Koonalda homestead complex with regional tourism strategies, consistent with conservation and management objectives.

3.4.3 The Visitor

The number of visitors to Koonalda Cave is not known as few statistics have been collected, however Koonalda is one of the most accessible and well known cave sites on the Nullarbor Plain, and probably amongst the most frequently visited.

A visitor book in the Shearer's Hut at the homestead complex contains visitor statistics and comments recorded from November 2002 to June 2003. This small data set contains

some useful information on general visitor impressions and expectations of the site. Unfortunately other visitor books covering previous years had been removed and could not be relocated for inclusion in this survey.

During the 7 month period there were 77 separate entries and 185 names registered in the visitor book. The book recorded an average 26 names (range 7 – 40) and 11 entries (range 5 – 18) per month. Most visitors were from South Australia and Western Australia, but other Australian states were represented, and there was a notable overseas component, mostly from Europe, but also USA. Visitor groups include: travellers commuting along the Eyre Highway; 'local' residents from the west coast and Eyre Peninsula; adventure travellers engaged in private, 4WD based holiday; cavers and cave divers. Actual visitor numbers to Koonalda Station would be substantially greater than this as not all visitors enter the Shearer's Hut, or sign the book.

General comments made in the visitor book included:

- Koonalda Cave is well known and frequently the primary reason for the visit;
- Many visitors unaware of the existence of the homestead complex, but pleasantly surprised to encounter it whilst on their way to the cave.
- Appreciation and great interest in the homestead complex and it's history;
- Better conservation and management of the homestead site and artifacts is urgently needed;
- Disappointment that the cave can only be viewed from the top, and further access inside the cave is not permitted.
- The cave is still accessible and entered (illegally) by some groups.

3.4.4 Present Visitor Support and Information

Visitor support for Koonalda Cave presently consist of:

- Vehicle access is via 32 km of dirt road from a turn-off on the Eyre Highway. The location of the turn-off, and signage, is not obvious.
- An interpretive sign at Koonalda homestead includes information on the cave, its closed status, and location 7 km to the north.
- Car parking area at the cave entrance, which is situated inside a fenced enclosure (Plate K3).

- Access into the fenced enclosure and cave entrance is provided by a style. There is a cliff hazard warning sign.
- Car parking areas and camping (both undesignated) at the cave entrances;
- Inside the cave there are fixed ladders, and a guide rope.

Koonalda Cave is promoted in the Nullarbor brochure and map. The brochure describes that the cave is "view only from top". Ambiguously, the brochure does not promote the Koonalda homestead complex, even though visitors must drive through the homestead complex on their way to the cave!

There is a perceived need and expectation from visitors, for:

1. Improved conservation and management of the Koonalda homestead complex;
2. Greater access into Koonalda Cave.

Whilst (2) could not be safely achieved without proper development as a guided show cave, it may be possible to address the issue to some extent in the interim, through provision of more information and interpretation on site. It is recommended that this be done.

Access and public appreciation, at least of the entrance to Koonalda Cave, could be improved by construction of a viewing platform, as already proposed by DEH. In addition to improved safety and liability issues, a viewing platform could also be used as a base for interpretative information and explanatory signage. Any structures should be designed with due consideration given to aesthetic values and the natural integrity of the entrance doline, including water channels that drain into the entrance. The design should also consider future possible uses of the site including show cave development, and be compatible with this. All infrastructure should be designed and installed so that it can be replaced or removed whilst leaving behind minimal trace on landscape features.

Koonalda Cave is one of the most well known cave sites on the Nullarbor Plain, and probably amongst the most frequently visited. Visitor numbers are expected to increase in the future as regional tourism strategies continue to promote the Nullarbor (de Bruyn 2003). There is a need for improved visitor support to be provided on the surface, including directional signage, explanatory and interpretive information. In consideration of visitor expectation for improved access into Koonalda Cave, it may be possible to address the issue to some extent in the interim, through provision of more explanatory and interpretative information on the cave, including the reasons for its closure, and appropriate codes of conduct. Providing such information might help to discourage some of the break-ins that are presently occurring.

Whilst maintaining the present situation of disallowing general public access into the cave, for permitted visits inside the cave there is still a need for defined routes to be

marked, particularly in the Gallus Site and Art Passage. This should be done unobtrusively, by adapting one of the standard methods used by caving groups. The fixed ladders and guide rope installed inside the cave are adequate for experienced, permitted groups.

Management Aim

To provide facilities and information to enhance visitor enjoyment and realize the tourist potential of the cave, consistent with protecting cave values.

Recommendations.

1. Undertake a site development and interpretation plan for Koonalda Cave (view from top only), which is integrated with planning for the Koonalda homestead complex.

2. Install route marking through the Gallus Site and Art Passage.

3.4.5 Research and Monitoring

To assist management planning and conservation actions, it is important to have a reliable source of environmental data from which environmental conditions and changes can be monitored, and appropriate responses determined.

There is a need for monitoring visitor numbers, visitor satisfaction, visitor impacts and resource conservation. For planning future visitor support and facilities at Koonalda, rigorous monitoring of visitor numbers over a period of years needs to be undertaken. This data is also essential to enable a proper feasibility study for possible future show cave development. It is therefore recommended that a reliable system for monitoring visitor numbers be installed as soon as possible. The monitoring system could include visitor books installed in prominent locations at the homestead complex, and at the cave entrance. These should be combined with a traffic counter.

Visitor impacts and resource conservation could be evaluated through a systematic monitoring program (eg. photo-monitoring) of key sites that are likely to show signs of change at the earliest possible time, thus allowing remedial action before further damage is suffered. Any ongoing impacts (including graffiti) can be detected by periodic (eg. annual) photo-monitoring of selected key sites. This monitoring system can be used to establish *Limits of Acceptable Change* for specific sites.

Unauthorized entry into Koonalda Cave and the Art Passage can be monitored relatively simply by installing concealed passive infra-red (PIR) detectors connected to event loggers and battery powered. This system has been usefully employed in caves in southwestern Australia.

Management Aim

As a basis for the future research and planning of visitor facilities and conservation actions, establish a program to monitor: (1) traffic circulation, visitor numbers and visitor satisfaction on the surface; (2) illegal entry and visitor impacts inside the cave.

Recommendations

1. Install logbooks for recording visitor numbers and visitor satisfaction at the cave entrance and at the homestead complex.

2. Install a vehicle counter to monitor traffic circulation.

3. Instigate a systematic photo-monitoring program of key sites (including Gallus Site and Art Passage) to evaluate visitor impacts and resource conservation.

4. To monitor illegal entry consider installing concealed passive infra-red (PIR) detectors and loggers.

5. Support bona-fide scientific research, particularly when it assists in management.

3.4.6 Towards Future Show Cave Development

Koonalda Cave has previously been considered suitable, and recommended, for development as a show cave for the public (eg. Angas & Reynolds 1991; Cane 1989; Davey & Spate 1990; SA NPWS 1989). In 1989 the South Australian National Parks & Wildlife Service (Southeast District) prepared an unpublished report titled "Nullarbor National Park, Koonalda Cave: management and development recommendations", however this report could not be found in DEH records at Ceduna or the southeast district. Davey & Spate (1990, pp. 46-49) have already outlined general considerations and some specific recommendations relating to the development of Koonalda as a show cave. We support development of Koonalda Cave as a show cave, but subject to consideration of the issues raised by Cane (1989) and Davey & Spate (1990) in this regard, and, the recommendations made in this report.

The outstanding international significance of the art and other archaeological resources in Koonalda Cave, and its recognized qualities for world heritage listing on this criteria alone (Cane 1992), demands that any development reflect this appropriately, by aiming for best practise standards in show cave development. The importance, sensitivity and vulnerability of the Aboriginal art requires that absolutely no risks could be taken which might further endanger it, and therefore all visits to the cave would have to be closely supervised by a trained guide. Accordingly we do not recommend any form of show cave development that is self-guided, unless adequate security can be assured. Minimal security for this would require roving guides positioned in the cave at all times it was open to the public, and a sophisticated remote sensing and response system.

We do not consider the Art Passage can sustain any increase in visitation due to its fragility and the deleterious effects that would result from dust, lint and lighting (lampenflora), however this does not preclude proper development of other sections of the cave, including the Gallus Site. Cane (1989, pp. 51-53) makes similar recommendations.

Successful show cave development in the future will depend on sustained effort and commitment from the managing authority. To achieve this aim will require a preparatory period, ideally extending over several years, to implement immediate resource conservation requirements, develop heritage conservation plans, monitor visitor numbers and establish baseline conditions. After this preparation then a business and development feasibility study can be undertaken. This study might still indicate that show cave development is not a viable option. In spite of this possible outcome, proper protection of the resource values still needs to be achieved in the meantime.

This requires the provision of adequate funding and resources, some of which might be obtainable from external grants. This avenue could be pursued, initially at least, with the organisations responsible for the state and national heritage listings. In a wider context it is perceived that a useful strategy will be to improve public and political awareness of the outstanding heritage significance, and the urgent conservation issues, affecting both the cave and homestead. Both sites appear to have been largely forgotten and neglected by the archaeologists and heritage conservationists, as well as the wider public.

Interest and support for conservation and rehabilitation work in the Northwest Passage, as well as further research and show cave development, might be more readily obtained if the outstanding heritage values of the site were more widely promoted and recognized. Accordingly it is recommended that a targeted information campaign be directed to improving general understanding of the situation. This could be linked with related objectives such as, for example, resurrection of the Nullarbor World Heritage nomination. The *Asia-Pacific Forum on Karst Ecosystems and World Heritage* (the Mulu Forum) recommended in May 2001, that World Heritage nomination of the Nullarbor Region be considered a priority action (Wong et al. 2001). It is recommended that this nomination be supported and pursued by DEH.

Management Aim

The aim is to prepare for future show cave development by:

1. *Implementing immediate resource conservation requirements;*
2. *Developing heritage conservation plans;*
3. *Monitoring visitor numbers and establishing baseline resource conditions;*
4. *Disseminating information and pursuing wider recognition of issues;*

Recommendations

To prepare for future show cave development, and to meet interim resource conservation requirements, we recommend the following actions be undertaken, listed below in approximate order of importance and priority:

1. Fix the gate problems;
2. Provide interim signage explaining the reasons for cave closure;
3. Increase ranger patrols (establish permanent ranger base in Nullarbor NP);
4. Monitor visitor numbers (surface and illegal cave entry);
5. Seek heritage conservation funding and support;
6. Seek wider recognition and appreciation of site values and conservation issues, through appropriate dissemination of information;
7. Prepare conservation plan for archaeological and cultural heritage (Aboriginal and pastoral era, surface and inside cave);
8. Undertake development and interpretation plan (surface sites only);
9. Relocate the carpark, control erosion and rehabilitate impacted areas;
10. Business and development feasibility study (for show cave development);
11. Development and interpretation plan (for show cave development);

4 PART FOUR

4.1 SCHEDULE OF PRIORITY MANAGEMENT ACTIONS

4.1.1 Murrawijinie Caves

Archaeological survey

1. Survey to include Aboriginal sites in the caves, and pastoral era heritage sites en-route to the caves.

Site development and interpretation plan.

2. Plan to cover the caves and pastoral era heritage sites en-route to the caves.

3. Relocate vehicle access tracks and parking areas outside the surface catchment areas of the dolines and caves.

4. Rehabilitate impacted areas.

5. Develop surface walking trails to cave entrances from relocated parking areas.

6. Cave development to include elevated walkways in all three caves and ladders for entry into caves 1 & 2.

7. Plan to consider protection and interpretation of cultural and natural features, including geology, geomorphology, cave deposits, wildlife.

8. Improve pre-visit information, directional signage, on-site interpretation. Utilise interpretive signage to increase public awareness and appreciation of cave features. Ensure information and signage conveys the appropriate code of conduct in caves.

9. Encourage the local Aboriginal community to support and participate in the development and delivery of interpretation associated with Aboriginal sites in Murrawjinie Caves.

Other actions

10. Initiate a systematic photo-monitoring program to evaluate visitor impacts and resource conservation.

11. Install logbooks in the caves for recording visitor numbers and visitor satisfaction.

12. Install a vehicle counter to monitor traffic circulation.

13. Liaise with local, regional and state tourism agencies and operators to ensure accurate and appropriate promotion and marketing of the caves.

14. Support visitor interpretation programs and/or commercial tour operations, which are consistent with protection of the caves.

15. Undertake safety audits where appropriate.

16. Support scientific research, particularly when it assists in management.

4.1.2 Koonalda Cave

Control Unauthorized Cave Entry

1. Resolve the gate problems and provide interim signage explaining the reasons for cave closure.

2. Investigate the persons responsible for recent graffiti vandalism to Aboriginal engravings in the Art Passage.

3. Restrict permitted access to the Art Passage, and manage this section separately to other sections of the cave.

Ranger Patrols

4. Increase ranger patrols and establish permanent full-time ranger base in the Nullarbor National Park.

Monitoring

5. Monitor visitor numbers with traffic counter and logbooks.

6. Monitor unauthorized cave entry.

7. Initiate photo-monitoring of key sites in the Art Passage and Gallus Site.

Archaeological Survey and Heritage Conservation Plan.

8. Survey and plan to cover Aboriginal and pastoral era heritage inside Koonalda Cave.

Information and Liason

9. Liaise with local, regional and state tourism agencies and operators to ensure accurate and appropriate promotion and marketing of the caves (and homestead complex).

10. Seek wider recognition and appreciation of site values and conservation issues, through appropriate dissemination of information.

11. Pursue heritage conservation funding and support from relevant organisations.

12. Pursue World Heritage nomination for the Nullarbor Region.

Surface Development and Interpretation

13. Relocate vehicle access tracks and parking area outside the catchment basin.

14. Rehabilitate impacted areas.

15. Develop surface walking trails to the cave entrance from the relocated parking area.

16. Improve pre-visit information, directional signage, on-site interpretation. Utilise interpretive signage to increase public awareness and appreciation of cave features. Ensure information and signage conveys the appropriate code of conduct.

Other Actions

17. Support scientific research, particularly when it assists in management.

18. Undertake safety audits as necessary.

Future Actions (for show cave development):

19. Business and development feasibility study

20. Development and interpretation plan (inside cave).

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4.4 APPENDICES

4.4.1 Appendix 1 – Invertebrates Murrawijinie Caves

Invertebrate species recorded from Murrawijinie Caves (N7, N8, N9); extracted from Davey et al. (1992):

Crustacea
- *Buddelundia albormarginata* Wahreberg (N7)

Insecta
- Henicinae Unidentified sp. (N9)
- *Endacusta* sp. (N9)
- *Pallidotettix nullarborensis* Richards (N7, N8, N9)
- Unidenified sp. (N7)
- *Trox amictus* Haaf (N7)
- *Brises acuticornis* Pascoe (N7, N8, N9)

Arachnida
- Protochelifer cavernarum aitkeni Beier (N9)

4.4.2 Appendix 2 - Faunal remains Koonalda Cave

Faunal remains recorded from red unit in Trench III, Koonalda Cave, by Thorne (1971):

Reptiles
- *Trachydosaurus rugosus*

Rodents
- *Leporillus sp.*
- *Pseudomys sp.*
- *Notomys sp,*

Marsupials
- *Dasycerus sp.*
- *Dasyurinus sp.*
- *Sminthopis sp.*
- *Sarcophilus (harrisi?)*
- *Perameles bougainvillea*
- *Bettongia* (*leseuri*?)
- *Macropus* sp.

4.4.3 Appendix 3 – Plants Koonalda Cave

Plants collected from the doline in Koonalda Cave by Symond (1971). Alien species indicated by asterisk.:

Trees

Acacia oswaldii
**Ficus carica,* Domestic Fig

Shrubs

Cassia nemophila var. *coriacea*
Enchylaena tomentosa, Ruby Salt Bush
Lycium australe, Native Boxthorn

Herbs

Agropyron scabrum, Wheat Grass
**Bromus diandrus*
**Chenopodium murale,* Goosefoot
Danthonia caespitosa, Wallaby Grass
**Ehrharta longiflora,* Annual Veldt Grass
Galium gaudichaudii
**Hordeum vulgare,* Cereal Barley
**Hordeum leporinum,* Barley Grass
Lavatera plebeia, Mallow
**Lolium rigidum,* Ryegrass
Oxalis corniculata, Sorrel
Parietaria debilis,
**Schismus barbatus,* Arabian Grass
**Sisymbrium irio,* Mustard
Solanum nigurm, Black Nightshade
**Sonchus oleraceours,* Sow Thistle
Tetragona eremaea, Spinach
**Urtica urens,* Stinging Nettle

4.4.4 Appendix 4 – Invertebrates Koonalda Cave

Invertebrate species recorded from Koonalda Cave, extracted from Davey et al. (1992):

Insecta

Trogloblatella nullarborensis Mackerras
Pallidotettix nullarborensis Richards
Psyllipsocus ramburii Selys-longchamp
Dasypodia selenophora Guenee
Anthela sp.
Monopis spp.
Notospeophonus pallidus Moore

Thenarotes speluncaris Moore
Speotarus lucifugus Moore
Anomaturus crudelis Newman
Quedius luridipennis Macl.
Gnathoncus near *ripicola* Mars.
Corticaria sp.
Brises acuticornis Pascoe

Arachnida

Helaeus sp.
Achaeranea sp.
Physocyclus sp.
Laetesia leo

4.4.5 Appendix 5 – Photographic Inventory (List of Plates)

This report includes a digitized photographic inventory (attached as separate numbered pdf files on CD Rom) of identified natural and cultural resource values, and examples of existing impacts and management issues. A few of the plates are referred to in the text of the report. The numbered plates should be viewed with reference to the plate captions listed below.

Murrawijinie Caves:

Plate M1. Murrawijinie 1 (N7) from the air.

Plate M2. N7 from the air.

Plate M3. N7 entrance and sign from carpark.

Plate M4. N7 entrance – view across to carpark which is directly above the cave passage.

Plate M5. N7 entry climb down log.

Plate M6. N7 main chamber. Note the bone mound in middle foreground.

Plate M7. N7 view out from main chamber.

Plate M8. N7 Location of hand stencils and a stone arrangement.

Plate M9. N7 Stone arrangement.

Plate M10. N7 Stone arrangement.

Plate M11. N7 Anastomosing tubes.

Plate M12. Murrawijinie 2 (N8) and Murrawijinie 3 (N9) from the air. Note size of the de-vegetated car park and camping areas in proximity to the entrances.

Plate M13. N8 entrance and car park directly above underlying cave passage.

Plate M14. N8 entrance and hazard sign.

Plate M15. N8 entrance climb.

Plate M16. N8 – view down entrance slope.

Plate M17. N8 view out of entrance slope.

Plate M18. N8 entrance showing growth of bedstraw (Galium sp.).

Plate M19. N8 view of ceiling showing anastomos ing tubes and daylight hole.

Plate M20. N8 bone deposit.

Plate M21. Murrawijinie 2 (N8) and Murrawijinie 3 (N9) from the air. Note size of the de-vegetated car park and camping areas in proximity to the entrances, and the track to claypan at top.

Plate M22. Car park and camping area at Murrawijinie 3 (N9).

Plate M23. Erosion prone slope leading to entrance of N9.

Plate M24. N9 entrance showing hazard sign.

Plate M25. N9 entrance showing infestation of weeds and figure beside daylight holes.

Plate M26. View across N9 entrance to car park.

Plate M27. Daylight holes.

Plate M28. Daylight holes, view directly up from inside cave.

Plate M29. N9 entrance overhang.

Plate M30. N9 view down boulder slope. The stencil gallery is located to the right.

Plate M31. N9 chamber at base of boulder slope. Note the boulder on flat floor which is a stone arrangement.

Plate M32. N9 stone arrangement. Note concavity and the small boulder propping up the large boulder.

Plate M33. N9 bone deposit below owl roost.

Plate M34. N9 hand stencils.

Plate M35. N9 stencil gallery.

Plate M36. N9 Graffiti.

Plate M37. N9 Graffiti.

Plate M38. Sign near Nullarbor Hotel/Motel, at start of track to Murrawijinie Caves.

Plate M39. Track to Murrawijinie Caves – dry weather access only for 2WD vehicles.

Plate M40. Roberts Well.

Plate M41. Horse Tank.

Plate M42. No. 1 Bore.

Plate M43. Doline near old stock yards.

Koonalda Cave:

Plate K1. Koonald Cave entrance near the end of the pastoral era in 1979. Note de-vegetation caused by grazing, and, the water tanks for stock watering. Photo by Peter Bell.

Plate K2. View south across catchment basin showing cave entrance and car park, 2003. Note recovery of vegetation.

Plate K3. Carpark within catchment basin showing proliferation of tracks close to entrance. Note fence surrounding cave entrance.

Plate K4. Gully erosion on track leading to car park.

Plate K5. Soil erosion on slopes within catchment basin. Note proliferation of vehicle tracks on steep slopes prone to erosion.

Plate K6. Gully erosion on track leading to car park

Plate K7. View from style on fence.

Plate K8. View south across doline towards normal descent point and car park.

Plate K9. View west across doline towards normal descent point.

Plate K10. View south showing large overhang containing daylight holes.

Plate K11. Preparing to abseil from the normal descent point. This point is also an active drainage channel when surface runoff occurs.

Plate K12. Fifteen metre abseil at normal descent point.

Plate K13. Normal descent route can be free-climbed with a handline.

Plate K14. View north showing daylight hole and main entrance.

Plate K15. Alternative 22 metre descent route via daylight hole.

Plate K16. View from bottom of doline, directly up to figure descending daylight hole on rope.

Plate K17. Abseil entry through the daylight hole.

Plate K18. Abseil entry through the daylight hole.

Plate K19. View from bottom of doline, with figure descending daylight hole.

Plate K20. View south towards large overhang and fruit tree grove.

Plate K21. Entrance gate. Note gap between top of gate and the rock at the point above the figure.

Plate K22. Attempted forced entry of gate.

Plate K23. South end of gate showing rocks which can be easily moved to gain entry.

Plate K24. Gate is easily bypassed by shifting two small boulders.

Plate K25. View of upper entrance (height of opening about 6 – 7 metres) situated above the gated entrance, which is just visible in bottom of picture.

Plate K26. View looking out of upper entrance.

Plate K27. Barrier with barbed wire in upper entrance.

Plate K28. Barrier can be used as a platform and aid to entry.

Plate K29. Barrier can be used as a climbing aid to gain entry.

Plate K31. Old bore casing above the West Passage, where previously there was a windmill, tank and trough.

Plate K32. Foundation with signatures at old bore.

Plate K33. Bone deposits below owl roosts in entrance chamber.

Plate K34. View from top of slope in entrance chamber.

Plate K35. Part of winch (?) / windlass (?) structure near top of slope in entrance chamber.

Plate K36. Handline above ladder on slope in entrance chamber.

Plate K37. Fixed ladder on slope in entrance chamber. Note timber steps from pastoral era in foreground.

Plate K38. Stairway constructed from native timber, pastoral era.

Plate K39. View up boulder slope and stairway in entrance chamber. Note collapse of lower parts of stairway.

Plate K40. View from entrance slope towards Northwest Passage and Gallus Site. Trench II (filled-in) is behind the figure. Note extensive areas of compacted floor caused by trampling where there is no defined trail.

Plate K41. View from Gallus Site in Northwest Passage towards entrance slope with natural light. Note extensive areas of compacted floor caused by trampling where there is no defined trail.

Plate K42. Gallus Site in Northwest Passage. Figure is at site of Trench II (filled-in).

Plate K43. Flint mining nucleus (boulder) in front of Trench II (filled-in).

Plate K44. View of Gallus Site from top of the boulder slope in the Art Passage. Trench's I and III are along the right wall, approximately opposite the figure.

Plate K45. Trench I.

Plate K46. Pathway and spoil heaps (right) from archaeological excavations at Gallus Site.

Plate K47. Spoil heap in front of Trench III.

Plate K48. Trench III area. Figure is standing next to stele. Other stone arrangements and flint mining area behind.

Plate K49. No plate 49!

Plate K50. Stele at Trench III.

Plate K51. Stone arrangements at Trench III.

Plate K52. Stone arrangements at Trench III.

Plate K53. Flint mining area. Trench III behind. Rusting wire near figure is remains of archaeologists ladder.

Plate K54. Trench III.

Plate K55. Trench III.

Plate K56. Rusting remains of archaeologists ladder in base of Trench III.

Plate K57. Stratigraphy in Trench III, red layer below white layer.

Plate K58. Sign near Trench III.

Plate K59. Art Passage.

Plate K60. Aboriginal engravings in Art Passage.

Plate K61. Aboriginal engravings in Art Passage. Lines converge towards flint nodule in wall.

Plate K62. Engravings detail.

Plate K63. Graffiti damage "MARK" to Aboriginal engravings.

Plate K64. Recent (year 2000) graffiti damage on top of engravings at The Squeeze.

Plate K65. The Squeeze.

Plate K66. Specimens of flint (labeled and bagged), abandoned by archaeologists at The Squeeze.

Plate K67.Rusting tin at The Squeeze.

Plate K68. Archaeologists survey peg, Art Passage.

Plate K69. Fixed ladder near pump engine.

Plate K70. Pump engine.

Plate K71. Moonmilche (white) beside trail near start of North Passage.

Plate K72. North Passage.

Plate K73. North Passage.

Plate K74. North Passage.

Plate K75. Pump pit, North Passage.

Plate K76. Pump pit and engine, North Passage.

Plate K77. Bore casing, West Passage.

Plate K78. West Passage, lakes and bore casing.

Plate K79. Chamber at junction of West and North Passages.

Plate K80. View across Lake 1 and continuation of North Passage.

Plate K81. View across Lake 1 and continuation of North Passage.

Plate K82. Lake 1, affected by severe sedimentation and organic pollution during the pastoral era.

Plate K83. Graffiti (1939) near Lake 1.

Plate K84. Lookdown Lake, West Passage.

Plate K85. Lookdown Lake, West Passage.

Plate K86. Nullarbor cave cockroach (*Trogloblatella nullarborensis*).

4.5 FIGURES

See pages following.

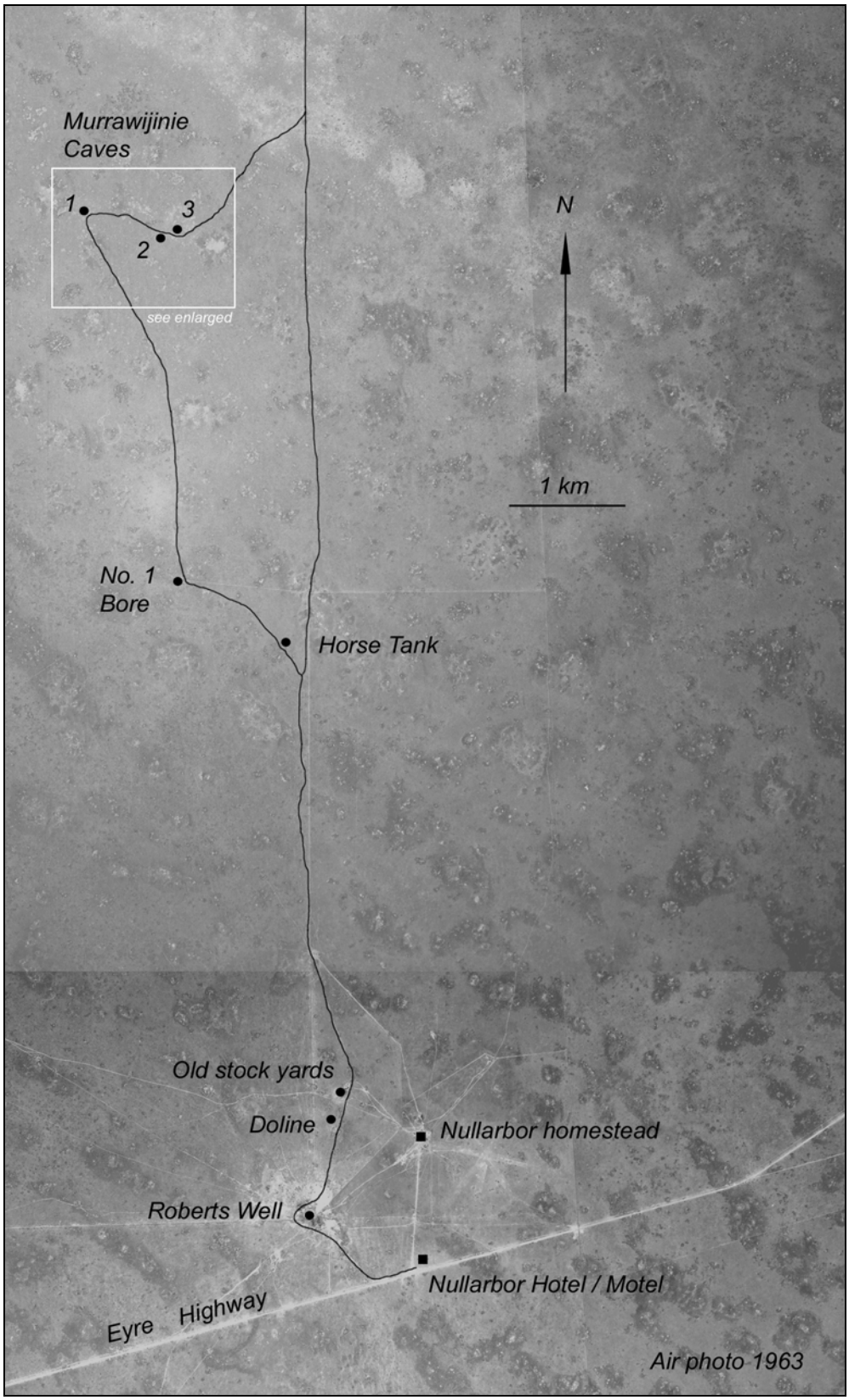

Figure 1. Area map showing location of Murrawijinie Caves and selected features in relation to the Nullarbor Hotel / Motel and Eyre Highway. Air photo 1963.

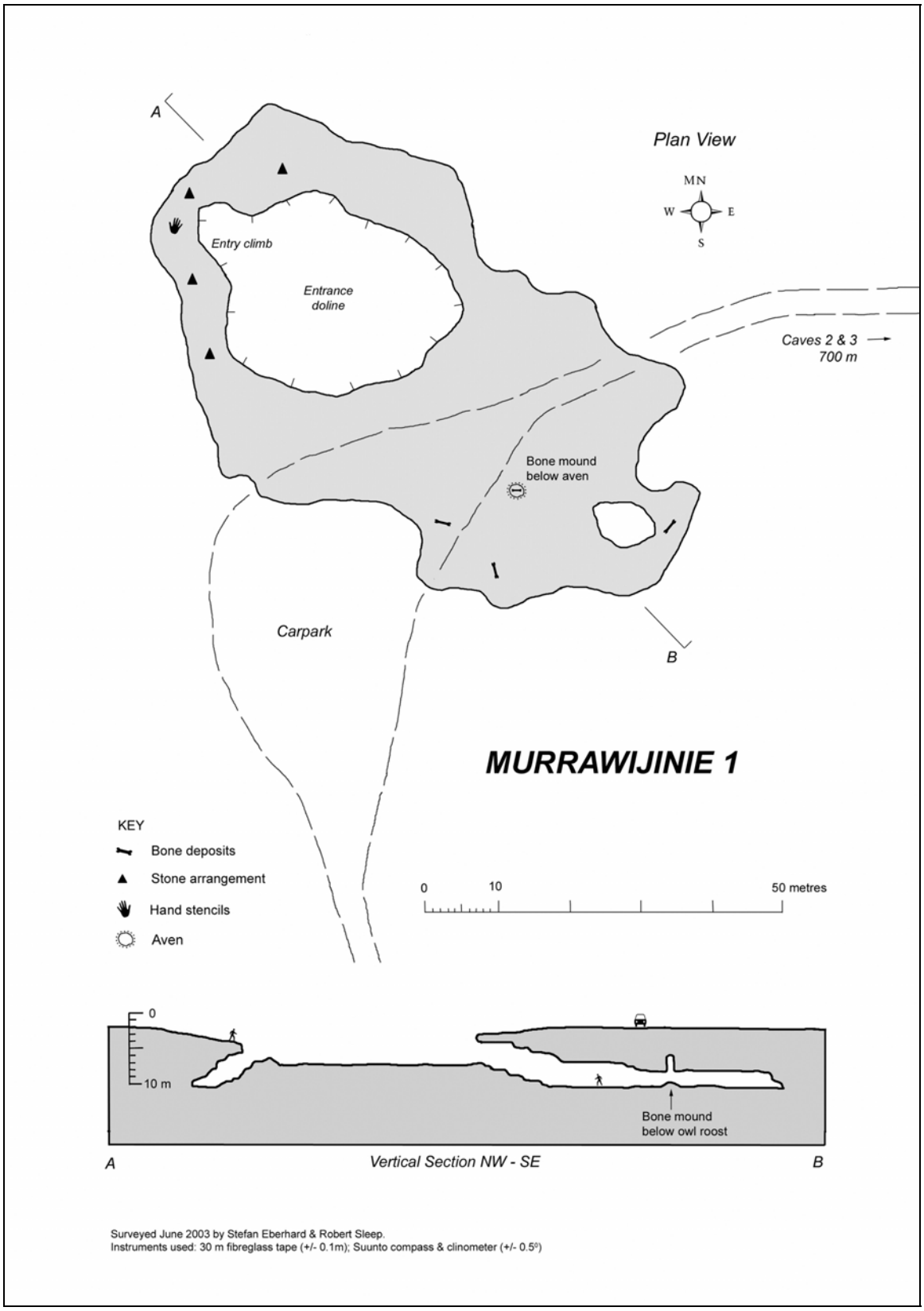

Figure 2. Murrawijinie 1 Cave - plan and profile view showing selected features.

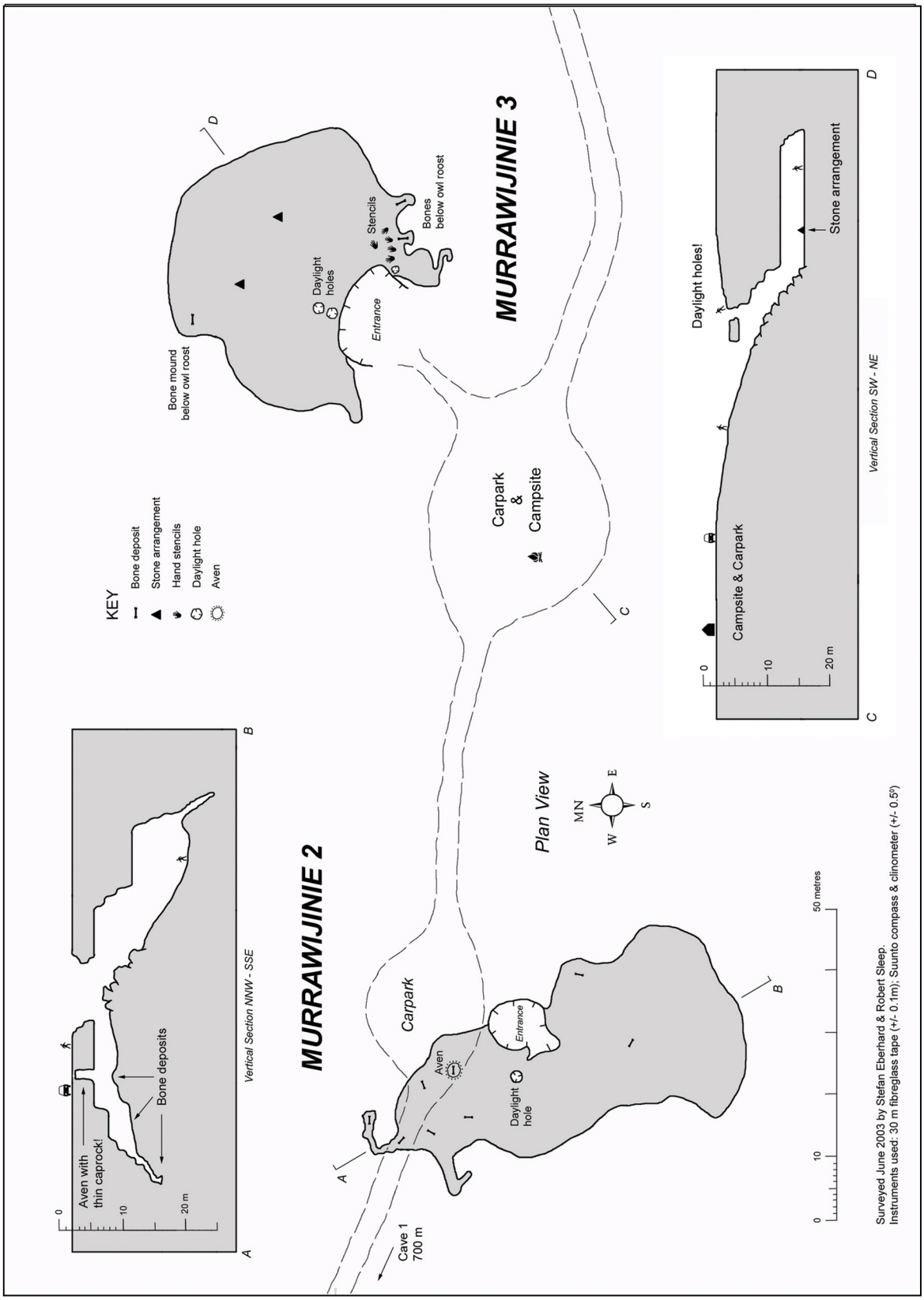

Figure 3. Murrawijinie 2 and 3 - plan and profile views showing selected features.

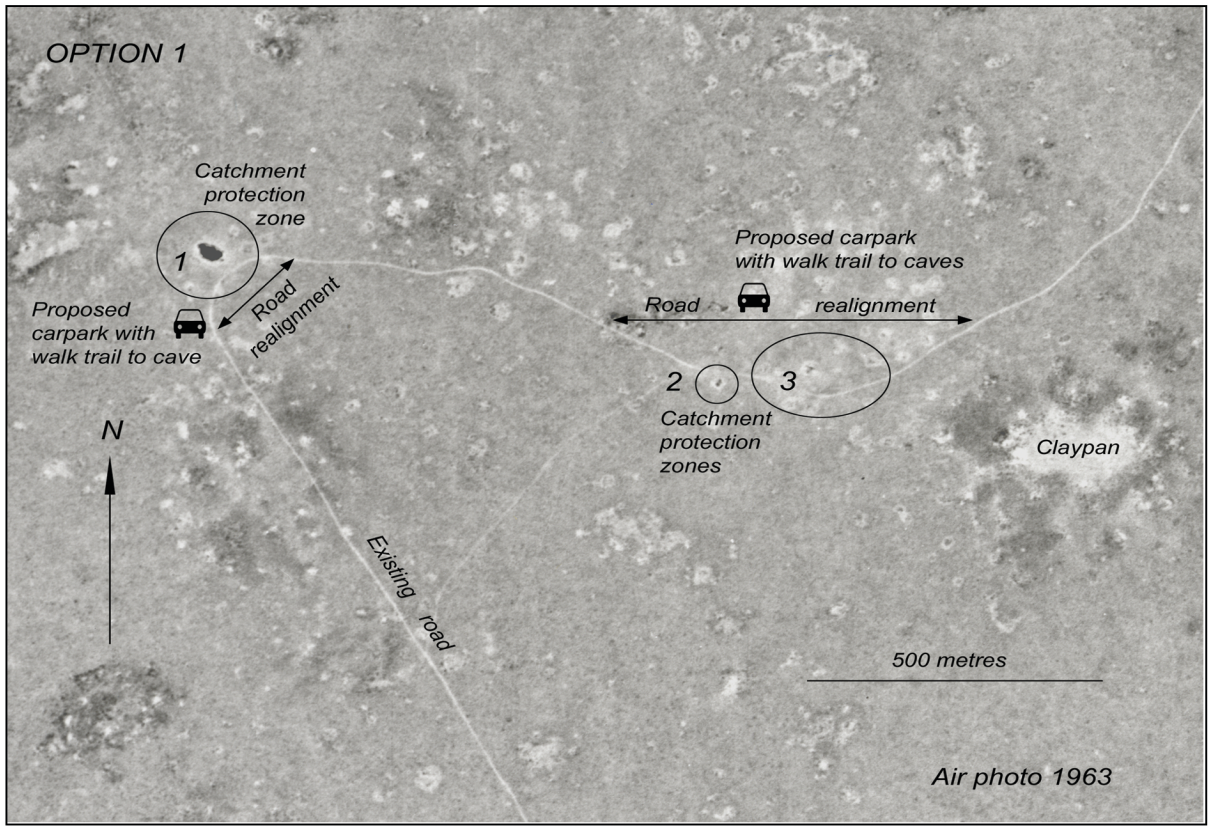

Figure 4. Murrawijinie Caves showing protection zones for doline catchments (approximate only), existing road, and proposed new carparks and road realignments for Option 1. Air photo 1963.

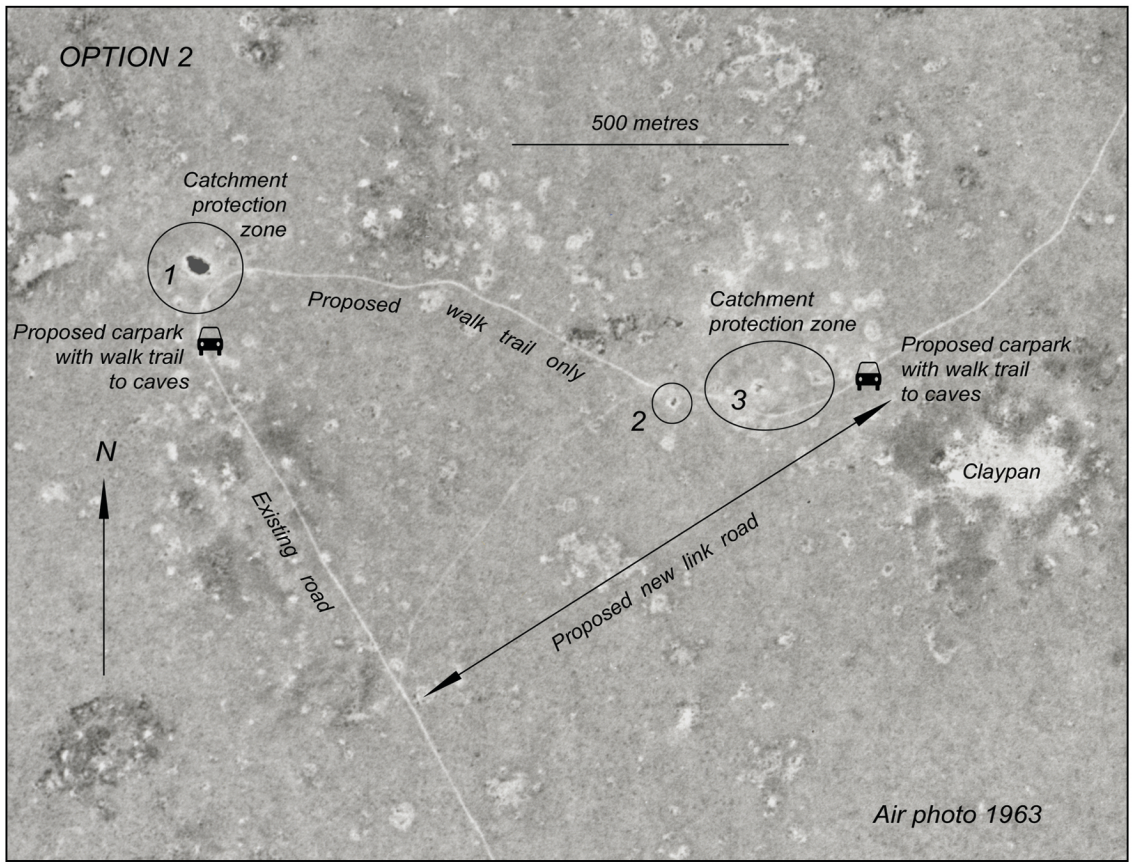

Figure 5. Murrawijinie Caves showing protection zones for doline catchments (approximate only), existing road, and proposed new carparks and road realignments for Option 2. Air photo 1963.

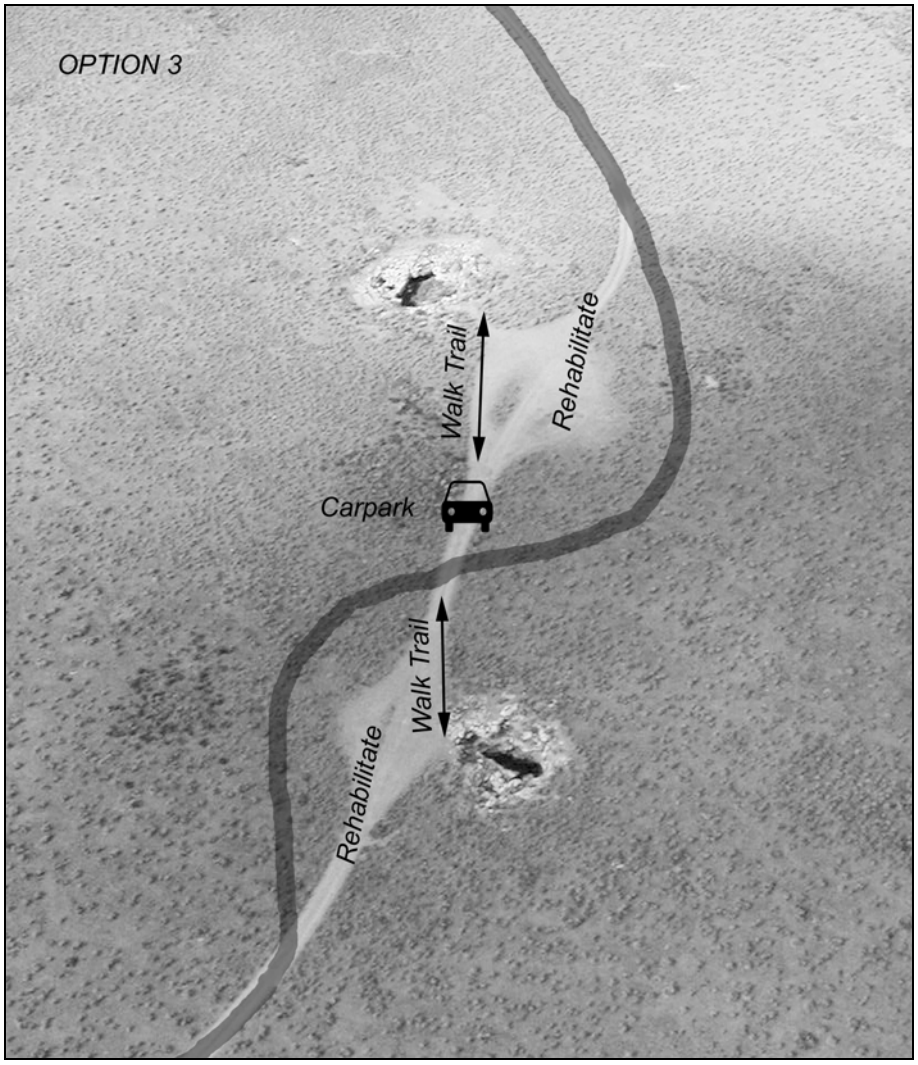

Figure 6. Murrawijinie Caves 2 & 3 showing Option 3 for proposed new carpark and road realignments. Air photo 2003.

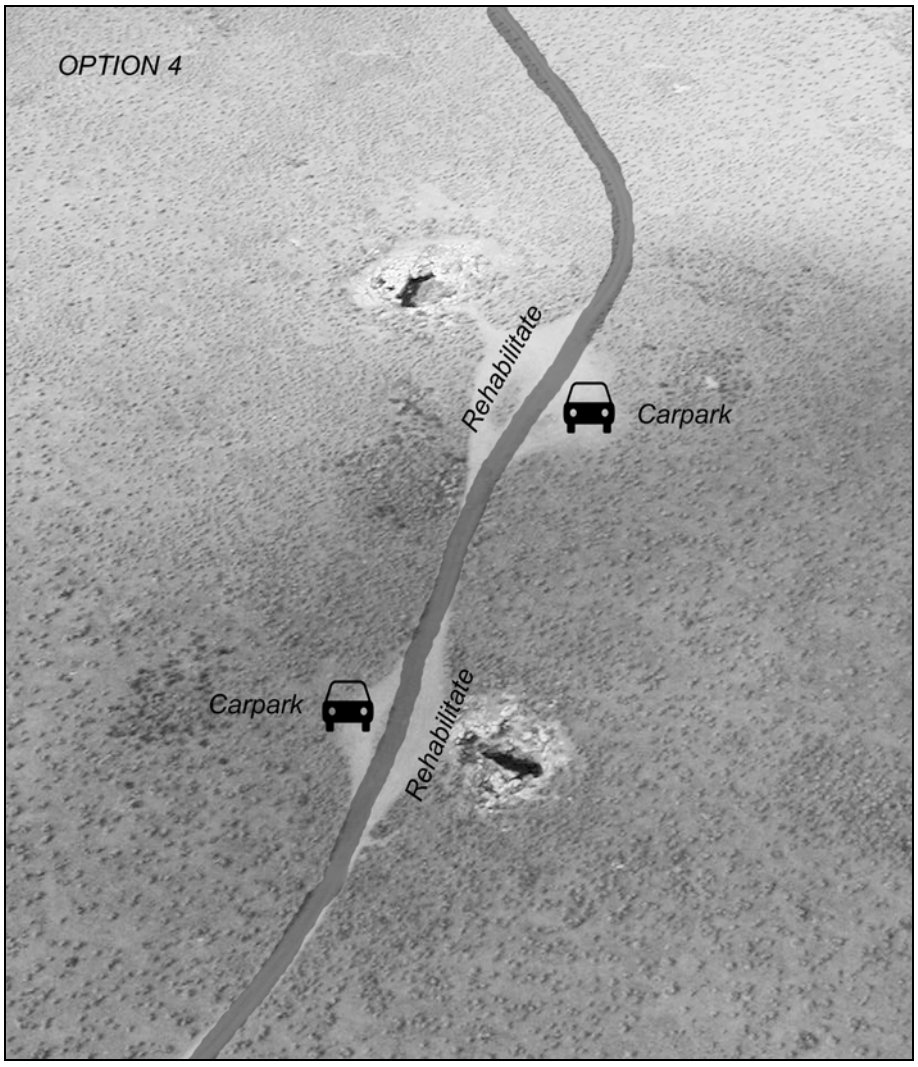

Figure 7. Murrawijinie Caves 2 & 3 showing Option 4 for containment and rehabilitation of existing carparks and roads. Air photo 2003.

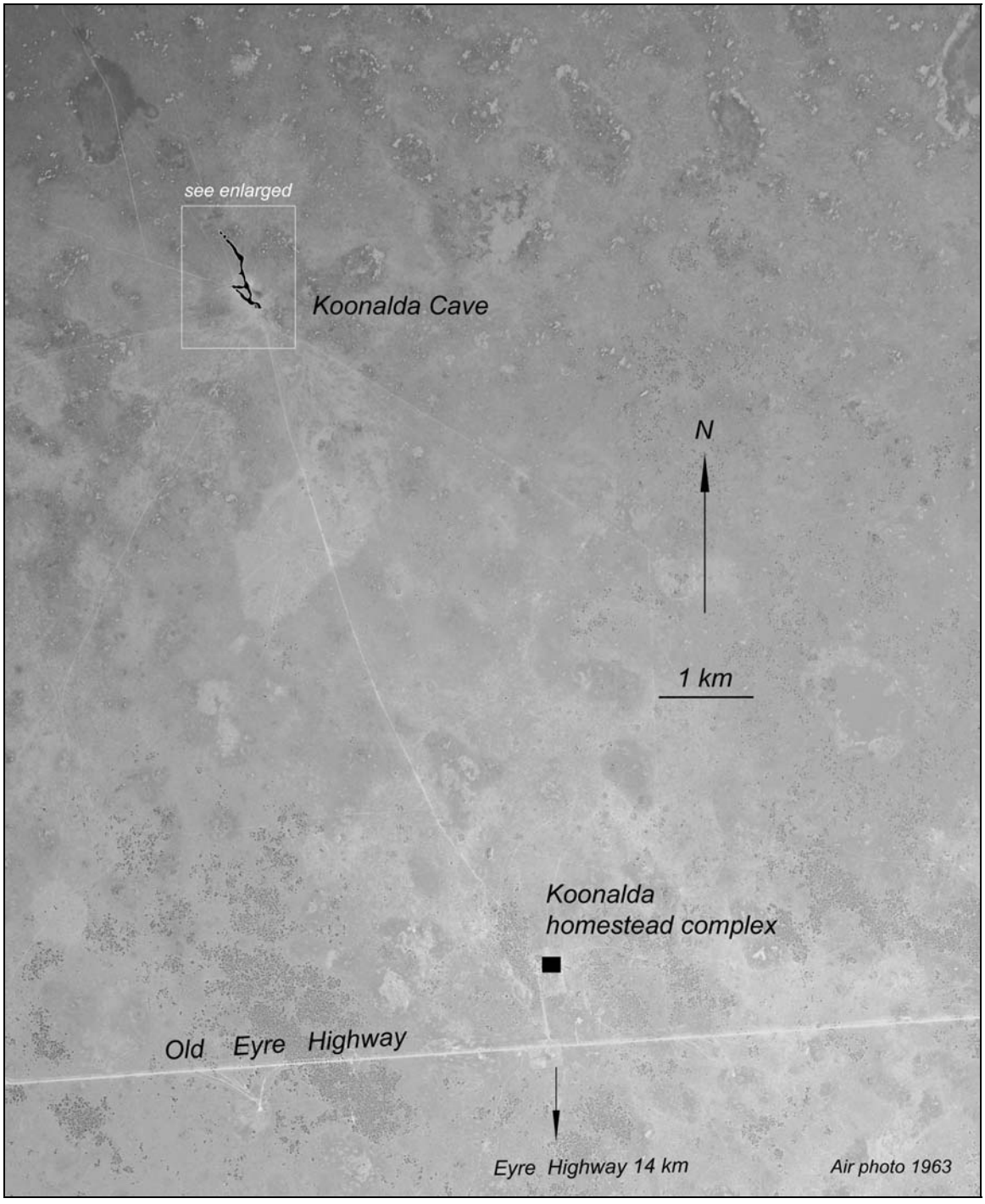

Figure 8. Area map showing location of Koonalda Cave in relation to the Koonalda homestead complex and old Eyre Highway. Air photo 1963.

Figure 9. Koonalda Cave showing extent of surveyed passages in relation to selected surface features, including drainage channels, catchment basin (approximate), vehicle track and carpark. Other vehicle tracks not shown. Air photo 1978.

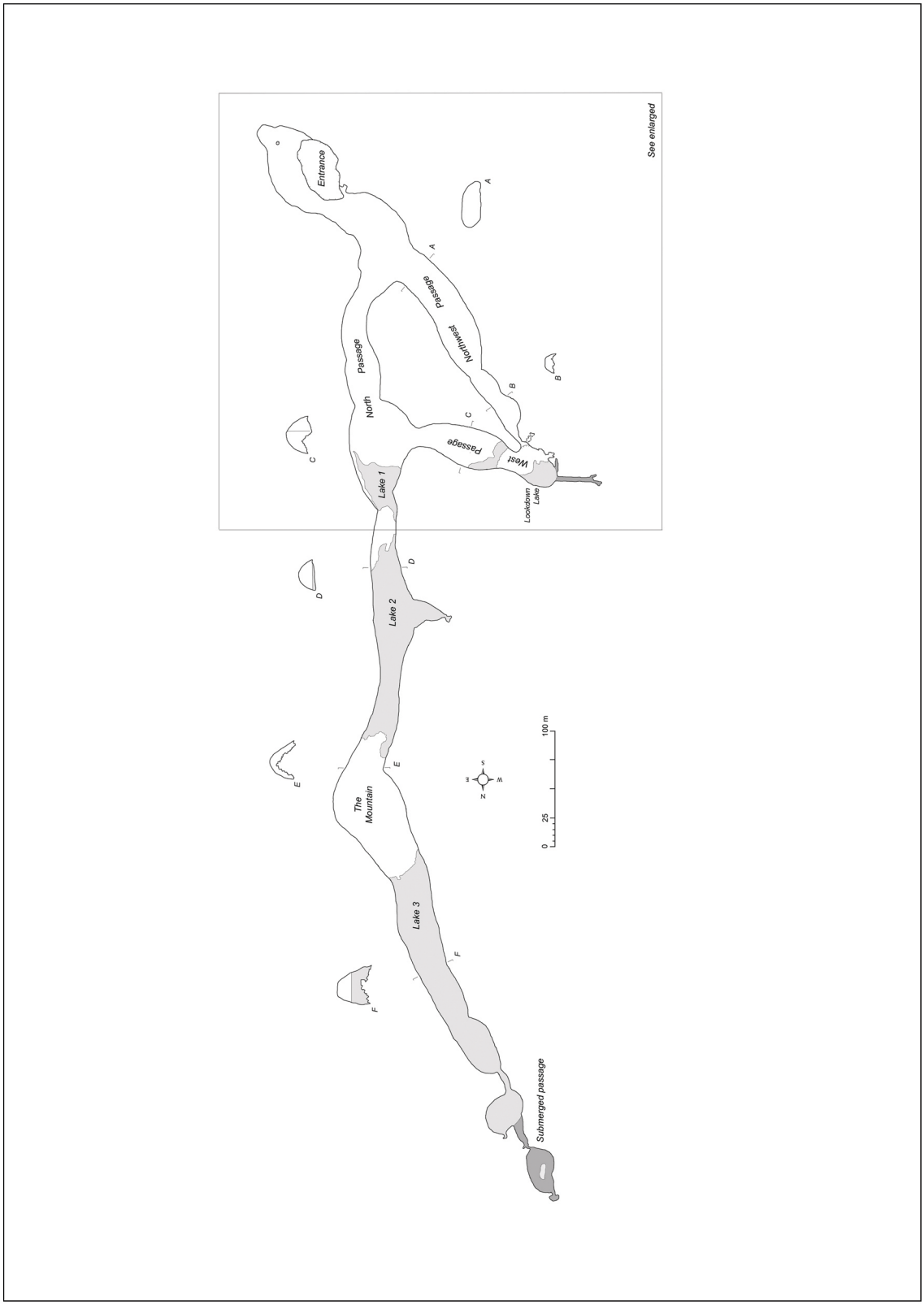

Figure 10. Koonalda Cave - plan view showing selected features. Adapted from map drawn by P. Maynard, surveyed by Sydney University Speleological Society, December 2000.

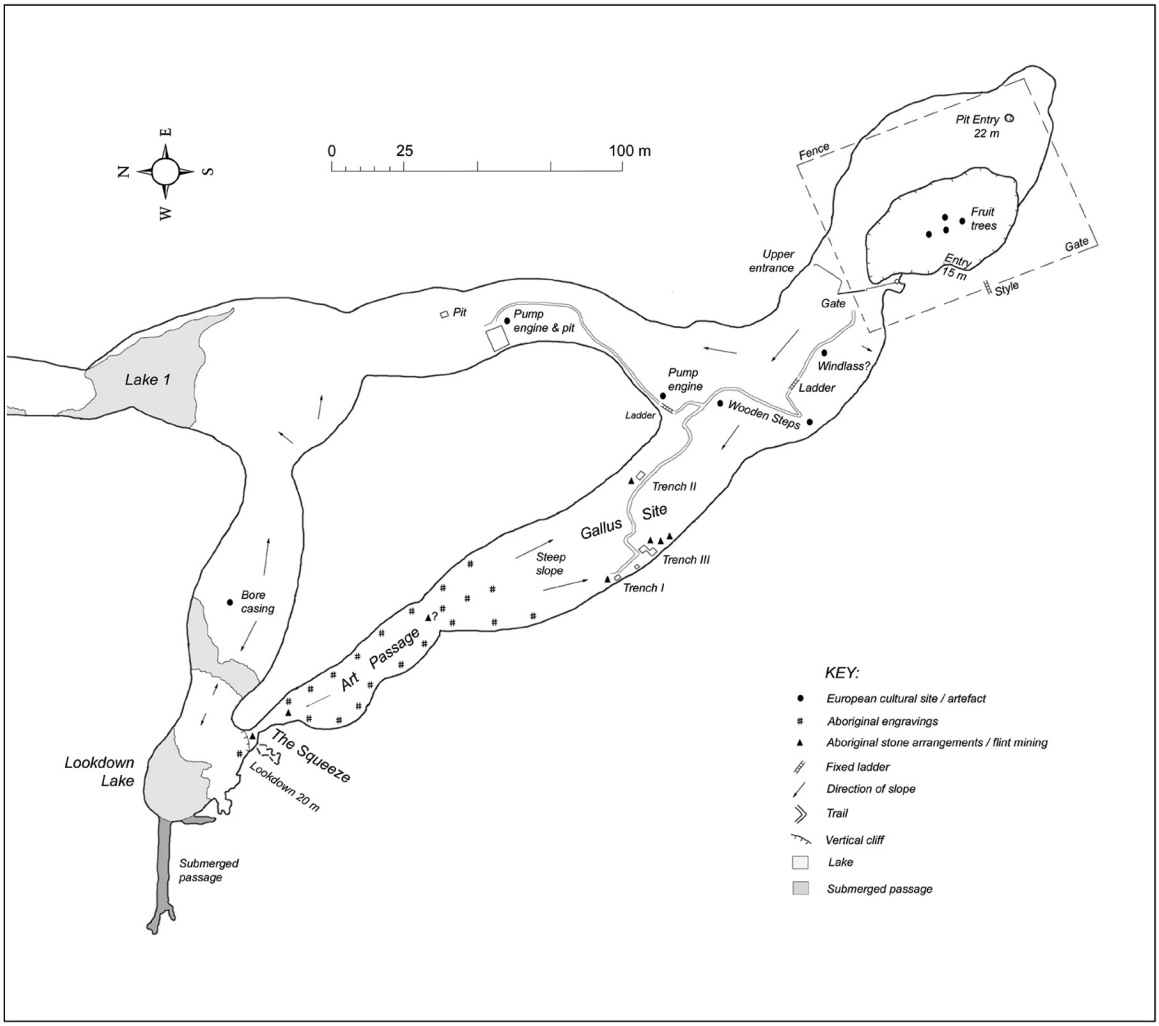

Figure 11. Koonalda Cave – enlarged plan view of entrance and passages showing selected features, including identified heritage sites and artifacts (Aboriginal and European pastoral era). Adapted and modified with additions, from map drawn by P. Maynard, surveyed by Sydney University Speleological Society, December 2000.