This review has been prepared to meet the requirements of section 34A of the National Parks and Wildlife Act 1972.

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FOREWORD

Innamincka Regional Reserve was constituted in 1988 as the first regional reserve in South Australia, and is in many ways a unique protected area in Australia. It protects a vast arid landscape supporting a great variety of habitats with a diverse flora and fauna, including a number of threatened species. The outstanding conservation values of the Cooper Creek and Coongie Lakes Wetlands have earned it recognition as a wetland of international importance under the Ramsar Convention; and it is the traditional lands of the Yandruwandha-Yawarrawarlk People with a wealth of cultural heritage in the reserve. But what makes it truly unique as a protected area is the multiple land use framework that applies to the land, whereby pastoralism and exploitation of some of Australia’s most important oil and gas reserves, and geothermal potential, are recognised land uses alongside with conservation.

This is the second review of Innamincka Regional Reserve to assess the impacts of resource use on the conservation values of the land. Much has changed since the first review in 1988. The Government has implemented a commitment to protect the Coongie Lakes by implementing new management arrangements for exploration and mining in this area, and in recognition of the national significance of the Coongie Lakes, proclaimed 26,669 hectares of the reserve as the Coongie Lakes National Park. There is now much greater engagement with traditional owners and the reserve is recognised as a major geothermal province as a source for generating green power into the future.

This review reinforces the importance of the natural, cultural and economic values of Innamincka Regional Reserve. It discusses the impacts of multiple land use on the natural and cultural features but also highlights the management practices in place which seek to minimise those impacts and strive for sustainability. The review also provides recommendations for the future status and management of Innamincka Regional Reserve.

This report has been tabled in both Houses of Parliament to meet the requirements of section 34A (5) of the National Parks and Wildlife Act 1972.

HON JAY WEATHERILL MP
MINISTER FOR ENVIRONMENT AND CONSERVATION
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The data used in compiling this report has been drawn from existing monitoring programs, audit reports and relevant research. In particular, the Annual Pastoral Inspection Reports prepared by the Land and Biodiversity Services Section of the Department for Water Land and Biodiversity Conservation provided the data for the assessment of impacts of pastoralism. Mr Greg Campbell of S. Kidman & Co. provided additional information and data regarding the pastoral operations at Innamincka. Data on the developments and audits of petroleum activities held by the Petroleum Group of Primary Industries and Resources South Australia was provided for the assessment of impacts of petroleum, geothermal and mining exploration and production activities. Additional data on the developments of petroleum activities was provided by Santos Limited. Impacts of tourism have been discussed and assessed using the knowledge of Department for Environment and Heritage staff.

The Corporate Strategy and Policy Branch of Primary Industry and Resources South Australia prepared the economic assessment of Innamincka Regional Reserve.

The contribution of the review steering committee – Jason Irving, Meredith Brown, Geoff Axford, John Maconochie, Jonathan Woods, Dave Cockshell, Alex McDonald, John McDonald and Liz Ankor – is gratefully acknowledged.
1 INTRODUCTION

1.1 Regional Reserves

Reserves are established under the National Parks and Wildlife Act 1972 and managed by the Director of National Parks and Wildlife subject to any direction by the Minister for Environment and Conservation or the Chief Executive of the Department for Environment and Heritage (DEH). When managing reserves, the Director is required under section 37 of the National Parks and Wildlife Act 1972 to have regard to, and provide actions that are consistent with the following objectives of management stated in the Act:

- preservation and management of wildlife;
- preservation of historic sites, objects and structures of historic or scientific interest within reserves;
- preservation of features of geographical, natural or scenic interest;
- destruction of dangerous weeds and the eradication or control of noxious weeds and exotic plants;
- control of vermin and exotic animals;
- control and eradication of disease of animals and vegetation;
- prevention and suppression of bush fires and other hazards;
- encouragement of public use and enjoyment of reserves and education in, and a proper understanding and recognition of, their purpose and significance;
- generally, the promotion of the public interest;
- in relation to managing a regional reserve, to permit the utilisation of natural resources while conserving wildlife and the natural or historic features of the land; and
- preservation and protection of Aboriginal sites, features, objects and structures of spiritual or cultural significance within reserves.

Section 38 of the Act states that a management plan is required for each reserve. A management plan should set forth proposals in relation to the management and improvement of the reserve and the methods by which it is intended to accomplish the objectives of the Act in relation to that reserve.

The National Parks and Wildlife Act 1972 was amended in 1987 to make provision for multiple-use reserves by creating an additional classification of Regional Reserve. The concept behind regional reserves was to have conservation recognised as a legitimate land use alongside pre-existing and future land uses such as mining and pastoralism. There are seven regional reserves constituted between 1988 and 1993.

Regional reserves meet the requirements of the IUCN (International Union for the Conservation of Nature) Protected Area Management Category VI: Protected area with sustainable use of natural resources. Category VI protected areas ‘conserve ecosystems and habitats, together with associated cultural values and traditional natural resource management systems. They are generally large, with most of the area in a natural condition, where a proportion is under sustainable natural resource management and where low-level non-industrial use of natural resources is compatible with nature conservation is seen as one of the main aims of the area’ (Dudley, 2008).

The key challenge with regional reserves is protecting and maintaining biological diversity and cultural values whilst finding a sustainable balance with the impacts on and utilisation of the reserve’s features.

1.2 Purpose and scope of this review

Pursuant to section 34A (5) of the National Parks and Wildlife Act 1972, the Minister responsible for the administration of the Act must, in relation to regional reserves, at intervals of not more than ten years, prepare a report:

- assessing the impact of the utilisation of natural resources on the conservation of the wildlife and natural and historical features of the reserve;
- assessing the impact or the potential impact of the utilisation of the natural resources of the reserve on the economy of the State; and
- making recommendations as to the future status under this Act of the land constituting the reserve.

The Minister is required to table the report before each House of Parliament.

This is the second ten-year review of Innamincka Regional Reserve since its constitution in 1988 and has been prepared to assess the impacts of utilisation of natural resources on the wildlife, natural and historical features of that reserve and on the State’s economy during the period of 1998-2008. It follows many of the principles adopted for the first review (refer Appendix A).

During the conduct of the review, issues emerged that were outside the scope of this review but will need to be addressed in the ongoing management of the reserve. Some of these issues relate to the scope and quality of baseline data upon which critical analysis of management should rely and which will be essential for the conduct of future reviews under section 34A. Other issues relate directly to the standards and aspects of management that need to be addressed on an ongoing basis.

Recommendations for management, therefore, while not a requirement in the context of the section 34A report, are nonetheless included in this report for the purposes of foreshadowing those issues that will need to be addressed in reviewing the management plan for this reserve.

The report structure is described below.

- **Chapter 2** provides a description of location and the natural, cultural and economic features of the reserve.

- **Chapter 3** summarises the resource use in the last ten years by the current users of the reserve.

- **Chapter 4** identifies the impacts of resource use of the reserve and assesses those impacts on the natural and cultural features of the reserve. This chapter also describes the management strategies that have been implemented.

- **Chapter 5** provides a summary of the impacts of the utilisation of the natural resources of the reserve on the economy of the State.

- **Chapter 6** provides recommendations for the future status and management of the reserve.
2 INNAMINCKA REGIONAL RESERVE

2.1 Location and Size

Innamincka Regional Reserve (1 354 206 ha) is located in the far north-east of South Australia (Figure 1). The reserve was proclaimed under the National Parks and Wildlife Act 1972 on 22 December 1988. It represents 14% of the total area of regional reserves and is the fifth largest reserve in South Australia. Innamincka Township is located within the reserve. Coongie Lakes National Park (26 669 ha) was proclaimed in March 2005 and is completely surrounded by the reserve.

![Figure 1 Innamincka Regional Reserve - Location](image)

2.2 Natural Features

Innamincka Regional Reserve lies within the Channel Country Bioregion and the land is primarily shaped by wind, floods, water flows and rainfall events. The landscape of the reserve is dominated by the Cooper Creek, Coongie Lakes and their associated wetlands and floodplains. The Cooper Creek floodplain, Coongie Lakes and adjacent areas are listed on the Register of the National Estate as a significant intact ecosystem. The Coongie Lakes are Wetlands of International Importance under the Convention on Wetlands of International Importance especially as Waterfowl Habitat (Ramsar, Iran, 1971), and includes one-third of Innamincka Regional Reserve (Figure 2).

The Cooper Creek wetland communities are important sites of high productivity and drought refugia in a predominantly arid environment. Over 60 wetland habitats based on the levels and frequency of inundation, soil types and vegetation species and structure have been described within the Cooper Land System (Mollenmans et al., 1984 in DEHAA, 1998). Annual flows average between a quarter and one-fifth of that of the River Murray, making the Cooper Creek the State’s second largest river (Reid, 2000). Unlike most rivers, the Cooper Creek system has experienced minimal modification to its natural flows, thus highlighting its unique and significant conservation value.

While Innamincka Regional Reserve is located in Australia’s arid zone it contains a diverse range of land systems (Figure 2) including the Cooper Creek wetland communities, Tingana red sand dunes, Marqualpie dunefields, Strzelecki desert, Meminnie gibber plain and Koonchera gibber plains and red dunes (refer Appendix B). The majority of land systems present in the reserve are not represented anywhere else in the South Australian reserve system. The diversity of land systems within the reserve gives rise to a great variety of habitats. There is a diverse flora and fauna
associated with these habitats including a number of threatened species. The Coongie Lakes wetlands and Cooper Creek wetland communities are renowned for providing critical breeding habitat for water bird species (Reid and Gillen, 1988). A variety of dry land bird species including a major assemblage of diurnal raptors have also been recorded in the reserve.

The reserve is also a large important core area at a broad landscape scale and potentially part of increasing connectivity between habitats across South Australia. Innamincka Regional Reserve has considerable wilderness value because of its remoteness, minimal disturbance by modern technological society and self-reliant recreation (Wilderness Advisory Committee, 2004).

2.3 Cultural Features

Indigenous Heritage

The reserve is culturally significant to the Yandruwandha-Yawarrawarrika people. Evidence of long term occupation includes rock art, burial sites, trade and ceremonial sites littered with grinding stones and other artefacts associated with habitation. Areas around the Cullyamurra Waterhole contain numerous significant sights within the reserve. Rock engravings and areas around Cullyamurra Waterhole are on the Register of National Estate. There are also numerous records on the State Central Archive.

Non-Indigenous Heritage

European contact with the region came first with explorers and later with the establishment of the pastoral industry, transport routes and service centre. Significant features include Burke’s grave site, historic buildings and Wills Monument and Blazed Tree. There are a number of State heritage listed areas and places. These include the Former Australian Inland Mission and the Innamincka – Cooper Creek State Heritage Area (Figure 2). Many visitors travel long distances to Innamincka Regional Reserve to experience the harsh outback country associated with early exploration, pioneering and pastoralism.

2.4 Economic Features

Exploration and mining

The underlying Cooper Basin supplies the oil and gas requirements of South Australia, New South Wales, the Australian Capital Territory and the majority of Queensland (PIRSA, 2000). Currently, there is widespread petroleum exploration and extraction occurring throughout the reserve.

In recent years, geothermal research and development has become more prominent in South Australia, with a focus on Innamincka Regional Reserve. The geological formations underlying the Cooper Basin, where naturally occurring ‘hot rocks’ may be present, are the target for geothermal exploration activity. In times of climate change, increasing public awareness, and education about renewable resources, the development of alternative ‘environmentally sensitive’ energy sources has the potential for environmental and economic value.

In the last three years there has been some emerging interest for mineral exploration within Innamincka Regional Reserve. At the present time the majority of mineral extraction is for construction materials associated with petroleum operations within the reserve. However, there is potential for further mineral exploration and mining activity throughout the reserve in the future.

Pastoralism

Innamincka Regional Reserve has a long history of domestic stock grazing since the Innamincka lease was taken up in 1864 (LAB in Reid and Gillen, 1988). The reserve continues to support a substantial cattle production operation today. S. Kidman & Co. is well established in the pastoral folklore of South Australia and continues to be an important contributor to the regional economy (Campbell, 1998 cited in DEHAA, 1998).

Tourism

The isolated and ‘untouched’ appeal of the reserve attracts visitors seeking the bush exploration experience. Increased interest due to the unique natural and cultural features and promotion of the outback region has seen greater numbers of visitors frequenting the reserve over the last ten years. The Innamincka picnic races remain an iconic attraction for employees of local industries.
and visitors alike. The flow-on economic benefits in local sales of fuel, food and accommodation have directly contributed to the regional economy.

2.5 New Management Arrangements for Coongie Lakes

When Innamincka Regional Reserve was proclaimed in 1988, the Coongie Lakes Control Zone was defined by an agreement between the then Ministers of Environment and Planning and Mines and Energy and the Licensees of Petroleum Exploration Licenses (PELs) 5 and 6 (PIRSA, 2000). In reaching this agreement, the companies voluntarily accepted more sensitive modes of exploration and extraction criteria in the Coongie Lakes Control Zone (DELM, 1993).

As part of its pre-election policy commitments, the State Government developed new management arrangements for the Coongie Lakes area of the Innamincka Regional Reserve. The arrangements resulted in four distinctive zones for protecting the area’s conservation values:

1. **Coongie Lakes National Park.** This park, formerly part of Innamincka Regional Reserve, was constituted in 2005 over the core wetlands of Coongie Lakes. Agreement with S. Kidman & Co. Ltd was obtained to excise the fenced-off portion of the Coongie Paddock from the lease area. This park comprises 26,669 hectares and is free of mining and grazing access.

2. **No-mining Zone.** This zone includes all key wetlands and riparian zones with very significant environmental values. No exploration or mining access in this zone is permitted, although pastoral access continues. This zone was proclaimed in 2004 following amendment to the National Parks and Wildlife Act 1972 to introduce section 43AB, which enables the Governor to proclaim a no-mining zone within the Innamincka Regional Reserve.

3. **Walk-in Mining Zone.** This zone excludes exploration and mining activities except for walk-in geophysical surveys and subsurface access in appropriate seasons. It provides a buffer for key wetlands and riparian zones. Its conditions were defined as a “buffer zone” by a Notice published by the Director Petroleum (PIRSA) in the Government Gazette on 14 July 2003. Activities within this zone are covered by Statements of Environmental Objectives under the Petroleum Act 2000 and through the management plan for Innamincka Regional Reserve under the National Parks and Wildlife Act 1972.

4. **Controlled Access Mining Zone.** This zone seeks to protect a major creek/floodplain that requires a different type of restriction; access conditions were defined by a Notice published by the Director Petroleum (PIRSA) in the Government Gazette on 14 July 2003. The Notice has conditions set for access that are over and above normal environmental and management requirements and practices undertaken for the rest of the Cooper Basin (e.g. no earthmoving in periods of flood). Access for all petroleum activities may be possible, provided that they meet a stringent set of conditions, as contained in Statements of Environmental Objectives under the Petroleum Act 2000 and the management plan for Innamincka Regional Reserve under the National Parks and Wildlife Act 1972.

2.6 Native Title

DEH has an active role in Native Title negotiations between the State and the Yandruwandha-Yawarrawarinka people. Negotiations for an Indigenous Land Use Agreement over the Coongie Lakes National Park and Innamincka Regional Reserve are currently progressing. Multiple other Indigenous Land Use Agreements have been negotiated and signed between industry and the Yandruwandha-Yawarrawarinka people.
A Review of Innamincka Regional Reserve 1998 - 2008

Figure 2 Innamincka Regional Reserve - Land Systems and Zoning
3 RESOURCE USE 1, 2

3.1 Petroleum

Gas and oil exploration began in the early 1950s and production in the late 1960s. Prior to 1999, the entire reserve was overlain by Petroleum Exploration Licenses (PELs) 5 and 6, which were held by Santos Limited in conjunction with Delhi Petroleum. In 1999 the term of PELs 5 and 6 expired. Subsequently new PELs were opened for competitive bidding and numerous operators have moved into the region to take up petroleum exploration activities. Petroleum activities are regulated primarily under the Petroleum Act 2000. In the last ten years there has been a general increase in all types of petroleum-related activity within the reserve.

Licenses

There are 14 Petroleum Exploration Licenses (PELs) on the reserve (Figure 3). The total area of PELs cover 63% of the reserve (Figure 3). There are currently no Petroleum Exploration License Applications. Petroleum Production Licenses (PPLs) cover 26% of the reserve (Figure 3). This is a slight decrease to the previous review which documented PPLs covering 29% of the reserve. The total number of PPLs has increased from 52 to 88 in the last ten years. The total PEL and PPL licensed areas cover almost the entire reserve (89%) apart from a small section in the Marqualpie Land System (Figure 3). There is only one Petroleum Retention License (Figure 3).

Seismic survey

In the last ten years 1,694 km of 2D seismic lines exploration have occurred within the reserve (Figure 4). The number of kilometres of 2D seismic line activity has decreased in comparison to the previous ten year review which documented 9,790 km. Since 1957, accumulated 2D seismic activity has resulted in over 29,000 km within the reserve, with most activity occurring in the Cooper, Tingana, Meminie and Marqualpie Land Systems (Figure 4).

The area covered by 3D seismic surveys approximately doubled in the last ten years from 1,034 km² (1988 – 1998) to 2,435 km² (1998 – 2008) (Figure 5). A total of 28% of the reserve has been covered by 3D seismic activity. The total accumulated 3D seismic lines in the reserve is now 17,446 km, an increase of 7,619 km since the last ten year review (see Figure 5). 3D seismic survey activity has predominantly occurred within the Tingana (51%) Cooper (29%) and Meminie (17%) Land Systems. A small proportion of 3D seismic survey activity occurred around the Cooper Creek (25 km²).

Primary Industries and Resources South Australia (PIRSA) carries out regular inspections of seismic lines and, since 1993, the Goal Attainment Scaling (GAS) criteria has been used to assess environmental compliance. Six areas of impact are usually assessed, with visual impact, impact on vegetation and impact on land surface, being the key indicators of whether operators are meeting their environmental obligations in seismic line preparation.

PIRSA’s field assessments carried out from 1993 to 2007 on compliance of seismic line preparation show that over 90% of sites obtained GAS scores of 0, +1, or +2 for the six areas of impacts assessed (PIRSA, 2007) which reflected “acceptable to excellent” environment compliance against the relevant Statement of Environmental Objectives (D. Cockshell, pers. comm.).

Drilling

There are currently 497 wells within the reserve (Figure 6). Ten of the 120 wells drilled since the last review are associated with geothermal exploration activity. Drill pads are generally 100 m by 100 m in size; therefore the total area covered by well sites is about 0.05% of the reserve. The majority of drill sites occur in the Tingana (293 wells), Cooper (134 wells) and Meminie (73 wells) Land Systems. PIRSA’s assessments carried out from 1993 to 2007 on restored well sites and their access tracks show that over 90% of sites obtained GAS scores of 0, +1, or +2 for visual impacts of restored well sites and access tracks. Over 90% of sites assessed also obtained GAS scores of 0, +1 or +2 for short term and long-term revegetation objectives.

1 All data are current as at June 2008.

2 This report is based on the available data, none of which was originally collected specifically for the purpose of indicating trends or changes in natural or cultural features of the Innamincka Regional Reserve.
Figure 3 Innamincka Regional Reserve - Petroleum Licenses

Total Area Current PELs = 8,647 km²
Total Area Current PPLs = 3,476 km²
Figure 4  Innamincka Regional Reserve - 2D Seismic Activity

Legend
- 1998 - 2008 2D Seismic Lines
- Pre 1998 2D Seismic Lines

Coongie Lakes Management Zones
- Coongie Lakes National Park
- No Go Mining Zone
- Walk In Mining Zone
- Controlled Access Mining Zone

2D Seismic Lines (1998 - 2005) = 1,694 km
Total 2D Seismic Lines = 29,137 km

A Review of Innamincka Regional Reserve 1998 - 2008
Figure 5 Innamincka Regional Reserve - 3D Seismic Lines and Survey Areas

Total length of 3D Seismic Lines = 17,446 km
Total area of 3D Survey Area = 2,435 km²

Note: At the scale of this map the majority of 3D seismic lines appear as solid areas.
**Infrastructure**

Most roads, tracks, pipelines and borrow pits are associated with petroleum and geothermal exploration and production activity. A conservative estimate of the amount of roads and tracks constructed within the reserve has been 2,107 km (Figure 7). However, the increase in petroleum and geothermal activity (see section 3.2) suggests a likely increase in the total kilometres of roads and tracks within the reserve over the last ten years. There is greater concentration of roads and tracks within the southern half of Innamincka Regional Reserve (Figure 7), predominantly within the Tingana Land System.

The previous review documented a total of 416 km of pipeline within the reserve. The total kilometres of pipeline increased in the past ten years to 1,365 km (Figure 8). Activity has been concentrated in the Tingana and Cooper Land System (Figure 8).

The number of borrow pits is estimated to be 988 with approximately 79% of borrow pits located within the Cooper and Tingana Land Systems (Figure 9). Borrow pits have the potential to become artificial water sources for feral, native and agricultural animals. A study by Thiessen and Graham (2005) classed 179 borrow pits as ‘having water holding capability’ and up to 535 ‘maybe having water holding capability’ within the reserve (Figure 9).

This study also assessed borrow pits for signs of water erosion and found that more than half (64%) the borrow pits surveyed were graded as having severe to moderate erosion (Thiessen and Graham, 2005).

The petroleum industry regulating body (PIRSA) conducted field inspections within the Cooper Basin (including Innamincka Regional Reserve) which measured borrow pit restoration against GAS criteria and found that 77% of sites inspected scored from -2 to -1 (PIRSA, 2007). This indicates a poor performance against the relevant Statement of Environmental Objective for the Cooper Basin (PIRSA, 2007).

### 3.2 Geothermal

There has been significant development in geothermal exploration and activity in the last ten years in South Australia. Considerable attention has been focused within the reserve because of the geological formations underlying the Cooper Basin. In particular, the Mid-Carboniferous granite which is overlain by up to 3 km of insulating Late Carboniferous-Recent sandstones, siltstones, shales and coals. Anomalous heat is produced in the granite and the presence of overlying sedimentary rocks traps the heat over geologic time. These are the targeted ‘hot rocks’ for geothermal exploration activity. Geothermal energy exploration typically involves searching under sedimentary cover for granitic bodies, then drilling these hot basement rocks and/or drilling the basal sedimentary cover (which is also likely to be hot) and testing temperatures. All geothermal exploration and related activity is regulated by the Petroleum Act 2000.

There are 12 Geothermal Exploration License Applications (GELAs) which cover 41% of the reserve (Figure 10). There are no license applications adjacent to the Coongie Lakes Management Zones (Figure 10). Twelve Geothermal Exploration Licenses (GELs) have been granted within the reserve and cover 26% of the reserve. Almost all the GELs are located within south-central and eastern parts of the reserve. Currently, there are 10 Geothermal Retention Licenses which cover 7% of the reserve (Figure 10). No production licenses have been applied for or granted. Only one water extraction license has been approved.

### 3.3 Minerals

Minerals exploration has only occurred within the last three years within Innamincka Regional Reserve. There are thirteen exploration licences with a further seven exploration licences under application (Figure 11). Exploration Licenses cover 62% and Exploration License Applications cover 29% of the reserve. No on-ground exploration has occurred to date.

There are 30 active mineral tenements within the reserve. These are predominantly borrow pits sourced for aggregates used for petroleum drilling activities (DEHAA, 1999).
A Review of Innamincka Regional Reserve 1998 - 2008

Figure 6 Innamincka Regional Reserve - Wells
Total Wells = 497
Figure 7 Innamincka Regional Reserve - Roads and Tracks

Estimated total length of roads/tracks within Innamincka Regional Reserve = 2107 km
Total Pipelines within Innamincka Regional Reserve = 1 365 km

Figure 8 Innamincka Regional Reserve - Petroleum Gas and Liquids Pipelines

Legend
- Oil pipeline
- Gas pipeline
- Flowlines
- Land Systems

Coongie Lakes Management Zone
- Coongie Lakes National Park
- No Go Mining Zone
- Walk In Mining Zone
- Controlled Access Mining Zone
A Review of Innamincka Regional Reserve 1998-2008
Figure 10 Innamincka Regional Reserve - Geothermal Licenses and License Applications
Total Area GELA = 5 666 km²
Total Area GEL = 3 590 km²
A Review of Innamincka Regional Reserve 1998-2008

Figure 11 Innamincka Regional Reserve - Mineral Licenses and License Applications

Total Area Current ELAs = 3,909 km²
Total Area Current ELs = 8,398 km²
3.4 Pastoralism

Stocking numbers

In the last ten years stock numbers were highest during 2000 and 2001, then decreased until 2008 (Figure 12). The most recent estimate of stock numbers is 12,700 cattle on the reserve (June 2008). This follows the highest annual rainfall event in five years in 2007 (Figure 12). The range in cattle numbers from 1999 to 2008 was 2,500 to 18,227 compared to the previous review which ranged from 5,000 to 19,000. Increases and decreases in stock numbers generally followed rainfall events (Figure 12). Low rainfall and drought conditions on the reserve contribute to the pastoralist’s decisions to decrease stock numbers.

![Figure 12 Annual Rainfall and Cattle Numbers over two decades (1988 - 2008)](image)

Grazing pressure

The distribution of the potential grazing impacts in Figure 13 is based upon simple assumptions and methods as outlined and used in the previous ten year review (refer to DEHAA, 1998). The area of the reserve within each land system, which is potentially subject to three levels of grazing intensity, was estimated by describing grazing zones around each of the permanent or near-permanent water points. These water points include bores, water tanks, troughs, wells and water bodies that are accessed by stock.

This review found the distribution of permanent and near-permanent waters places almost the entire reserve under grazing pressure (Figure 13). Specifically, 32% of the reserve is under low grazing pressure, 46% under medium grazing pressure and 22% under high grazing pressure (Figure 13). The percent of the reserve under medium and high grazing pressure increased by 11% and 7% respectively compared with the previous review. Most at risk of potential high grazing pressure are the Tingana, Strzelecki, Meminie, Marqualpie and Cooper Land Systems (Figure 13). In particular, 89% of the Tingana Land System is at risk from potential medium to high grazing pressure.
Water sources and borrow pits

Cattle water requirements range between 40 and 80 litres per head per day with 100 litres as an exception for a stressed animal (G. Campbell, pers. comm., 2008). An increase in artificial sources of water, such as borrow pits, has occurred within the last ten years (see section 3.1). In a recent study conducted within Innaminka Regional Reserve, all 203 borrow pits surveyed (predominantly located in the Tingana Land Systems) showed signs of cattle presence (Thiessen and Graham, 2005). Fifty percent of borrow pits were rated as having abundant cattle presence, where ‘abundant’ meant ‘widespread and significant’ cattle presence.

Water-holding borrow pits are predominantly located in Jonnothon, Coonatie, Goonaburroo, Tirrawara, Bore Track South, Bore Track North and Mudrange Paddocks (Figure 13). These paddocks are mainly within the Cooper, Tingana and Meminie Land Systems. It has also been recorded that cattle have been using borrow pits as water sources in Coonatie and Bore Track South paddocks (DWLBC, 2004, 2003, 2001). From the period between 2002 and 2006 low rainfall and associated high evaporation suggest that it would be unlikely for borrow pits to have held water for long enough periods to be considered permanent water sources.

However, seasonal rainfall events have the potential for borrow pits to become temporary water sources. Figure 13 highlights borrow pits classed as ‘holding water for long periods’ (characterised by soil type and location in Thiessin and Graham, 2005) and the potential grazing impacts. The majority of borrow pits are located within the Tingana Land System. Figure 13 illustrates the capacity that borrow pits have to open up the entire southern end of the reserve to grazing pressure and thus potentially increase the total grazing pressure throughout the whole reserve.

Vegetation and soil condition

A qualitative methodology for assessing vegetation and soil condition has been adapted for this report as the Annual Pastoral Inspection Reports provided valuable descriptions of paddock conditions over the past seven years (grouping methodology adapted from Jennings, 2001). A qualitative analysis of the reports (DWLBC, 2000, 2001, 2002, 2003, 2004, 2005, 2006 and 2007) found that many words used to describe the vegetation and soil condition of the paddocks were common throughout the reports. Descriptive words were then categorised as either positive or negative descriptors. The percentages per year of positive and negative descriptors were then graphed over time (Figures 14 and 15). Descriptions for vegetation and soil condition were available for 19 and 12 paddocks, respectively.

The pattern of positive and negative descriptors of vegetation condition varied over the seven pastoral reports, but in 2007 clearly showed a substantial increase in percent of positive descriptors in all paddocks (Figure 14). Cattle numbers in 2007 were the lowest since 1988 and rainfall was the highest in five years (Figure 11 and 14).

Positive soil condition descriptors generally followed the same pattern of increases and decreases as rainfall from 2002 to 2007 (Figure 11 and 15). In 2005 and 2006 the percent of negative descriptors increased even though cattle numbers were decreased. However rainfall was low from 2002 to 2007 and this would have been a contributing factor in the increase of negative vegetation descriptors. In 2007 there were no negative descriptions which equated with the highest rainfall in five years and very low cattle numbers. The variability in the pattern of vegetation and soil descriptors is likely to be due to the qualitative method of data collection.

The results from these assessments highlight the need for greater qualitative and quantitative inspection, monitoring, and analysis of the impacts of pastoral activity on the biodiversity of the reserve. Over 100 photo points, including paired sites, and ten exclosures have been established within Innaminka Regional Reserve by both DEH and S. Kidman & Co. A more integrated program would provide greater detail, potentially aiming to separate out impacts of pastoral activity from other impacts such as seasonal fluctuations and rabbit grazing. This would provide a measure of effectiveness of pastoral management in minimising impacts on the vegetation and soil condition of the reserve.
Figure 13 Innamincka Regional Reserve - Potential Grazing Intensity

Note: Medium potential grazing intensity = watered areas 3 - 8km radii
High potential grazing intensity = watered areas 0 - 3km radii
A Review of Innamincka Regional Reserve 1998 - 2008
3.5 Tourism

Available data estimates over 17,500 visitors travelled through Innamincka between July 2007 to January 2008 and annual visitor numbers are estimated at over 34,500 visitors\(^3\). Car manual counters (installed July 2007) are used to estimate numbers within the reserve and as a result it is difficult to distinguish between industry visitors, pastoralists and tourism visitors. However manual counters at Cullyamurra Waterhole and the entrance to Coongie Lakes are beginning to quantify visitor frequency and establish patterns of where visitors go.

The popularity of Innamincka Regional Reserve is supported by the regular sales of Desert Park Passes. Although these passes are a general pass for the outback parks, the majority of visitors who purchase them intend to go to Innamincka Regional Reserve (M. Stephenson, pers. comm., 2008). In the period from 1999 through 2008 over 3,200 passes were bought annually.

Sales of camping permits for Innamincka Regional Reserve have varied over the last ten years (ranging from 326 permits in 2002 to over 1,330 permits in 2007). Generally, the sales of camping permits have risen with a striking increase in 2007. Increased sales are believed to be due to alignment of prices to normal state wide camping permit fees. These numbers are a conservative estimate of visitors to the reserve as an honesty system is in place. Some non-compliance still occurs but has decreased with permanent DEH staff presence on the reserve in the last two years.

Data from the manual counters suggest the pattern of visitors to Innamincka is seasonal with peak periods between April and September. This seasonal pattern suggests that there are periods of intense visitor use for about six months of the year, particularly at popular camping sites such as Policeman’s Point, Cullyamurra Waterhole and Coongie Lakes.

Greater visitor numbers can be attributed to an increase in accessibility to the reserve and available infrastructure, i.e. bituminised roads and public toilets. In the past, the number of visitors to the area, and their associated impacts, increased to a level where it was obvious and unacceptable (DEHAA, 1998). Although data were unavailable to quantify the level of impacts from visitors in the last ten years, visitor numbers have increased since the previous review and it is likely greater numbers have resulted in a continued high level of impact upon the reserve.

3.6 Fishing

There are no figures available for the current or historical levels of recreational fishing but a large percentage of visitors to the area are thought to undertake recreational fishing (DEHAA, 1999). Anecdotal evidence indicates that the recreational fishing effort is concentrated over the school holidays (DEHAA, 1999). Anecdotal evidence also indicates that the main target finfish species is Lake Eyre Callop (undescribed species Maquaria sp B) (DEHAA, 1999). Other species, including catfish (Family Plotosidae) and grunters (Family Tereponidae) are also taken.

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\(^3\) Source: Visitor Management Branch, Department for Environment and Heritage, 2008
4 ASSESSMENT OF IMPACTS

4.1 Impacts on the Natural Features

Impacts occur at landscape or local level and may be ecological, visual or both. The type, duration, frequency and management of the activity can influence the permanency and significance of the impact. This section describes those impacts and the management strategies implemented since the previous review.

4.1.1 Loss of vegetation

Vegetation plays an ecosystem services role in maintaining the quality of soil, water and air (ESA, 2008) and vegetation clearance has an impact on the landscape with local and regional consequences. Removal or disturbance of vegetation can lead to a reduction of habitat, food and shelter (Glanzing, 1995). The frequency of disturbance may influence the intensity of the impact and the regeneration and resilience of vegetation to recover. Activities that result in at least a temporary loss of vegetation include effects from seismic lines, well sites, borrow pits, grazing and firewood collection.

Exploration and production activity

Some removal of vegetation is unavoidable with the construction of seismic lines. Seismic lines are essentially linear tracks four to five metres wide prepared by slashers and dozers to allow the collection of seismic data. The method used for 3D seismic survey is the same as 2D seismic, but 3D seismic lines cross over each other in a grid-like pattern. The impact from 3D seismic surveys is considered to be more intense than 2D seismic because the method requires the same area to be prepared and traversed twice (PIRSA, 2000), although less preparation is used for each set of lines compared to 2D surveying (D. Cockshell, pers. comm., 2008). Seismic activity has increased since the last ten year review, in particular 3D seismic activity (see Figure 5). Seismic activity has predominantly occurred in the Tingana, Cooper, Merninie and Marqualpie Land Systems (see Figures 4 and 5). Vegetation clearance from multiple activities in these land systems may have resulted in reduced habitat for fauna species. However, a study by Watts, et al. (2002), using ants as bioindicators, suggests that seismic lines may actually provide an increase in habitat niches. This study suggests that seeds may collect in windrows and eroded/disturbed areas and potentially result in denser vegetation growth in old seismic lines. Further study is needed to confirm this observation and consider the impacts on other faunal groups.

The impacts and abandonment of seismic lines in the Cooper Basin have been documented in four reports (Moss and Low, 1996; Fatchen and Woodburn, 1997; Fatchen and Woodburn, 1999 and Fatchen and Woodburn, 2000). Following studies by Fatchen and Woodburn (1997; 1999; 2000) there has been considerable effort to minimise ground disturbance from seismic line preparation techniques. This has led to better environmental management of seismic lines, for example techniques such as lifting the blade to preserve rootstock in order to facilitate rehabilitation of the site. PIRSA’s compliance report (2007) documented an increase in environmental compliance against the relevant GAS criteria. This review also found compliance increased slightly (4%) compared to the previous review, suggesting that there is continuing effort to minimise the impact on vegetation caused by seismic activities.

Vegetation removal also results when areas are cleared for drill sites, well sites and borrow pits. Drilling activity and the number of borrow pits has increased in the last ten years by 32% and 100% respectively (see Figures 6 and 9). The impact on the natural features of the reserve by these activities is more likely to be at a local level, and with rehabilitation of drill and well sites, may only have a temporary impact on the landscape. However, PIRSA’s compliance report (2007) reported poor compliance against relevant GAS criteria for the restoration of borrow pits. In particular, 77% of borrow pits assessed scored between -1 and -2 indicating that revegetation was either localised on the base of the borrow pits or no revegetation was evident. Rehabilitation of vegetation around borrow pits with water-holding capacity may have been affected by grazing from feral and domestic herbivores when water is present (see grazing impacts below).

All activities conducted under the Petroleum Act 2000 must have an approved Statement of Environmental Objectives (SEO) in place which identifies the environmental objectives to be achieved pre, post and throughout the activity. The Cooper Basin Geophysical Operations SEO (2006) and Drilling and Well Operations SEO (2003) have been implemented since the previous ten year review. Both the Cooper Basin Geophysical Operations SEO and Drilling and Well Operations SEO have environmental objectives which aim to minimise impact on vegetation. This includes
specific methods minimising vegetation clearance, such as avoiding large trees, retaining root stock and setting up camp sites in previously disturbed areas. In Land Systems such as the Cooper, which contains sensitive wetland environments, clearing is carried out without the use of heavy machinery. Instead ‘lighter techniques’ such as brush cutting or slashing are applied.

As well as preventative measures, rehabilitation is also a requirement under the Petroleum Act 2000. For example, active rehabilitation is required following exploratory drilling activities to facilitate re-establishment of vegetation (PIRSA, 2000). The re-establishment of vegetation is measured in the second key objective of the GAS criteria ‘re-establishment of indigenous vegetation’ (PIRSA, 2006). The GAS criteria continues to provide a means to measure the compliance of petroleum activities on the environment of the reserve. This framework gives a standard against which management of impacts and rehabilitation of vegetation by petroleum activities can be further improved.

Grazing impacts

The level of impact on vegetation from grazing is influenced by numerous factors such as stock numbers, prior grazing regime, type, palatability and resilience of vegetation. The presence of feral herbivores also contributes to the total grazing pressure on the reserve, such as grazing by rabbits and loss of vegetation along the riparian zone as a result of pig rooting. This review found that in the last ten years the area of medium intensity-high intensity potential grazing pressure increased in all land systems. Expansion of total grazing area due to more water sources and possible build-up of feral herbivore populations may have contributed to the increase in area subject to grazing pressure. An increase in grazing pressure from domestic and feral herbivores is likely to result in greater disturbance and removal of vegetation in the reserve.

Following annual inspections, representatives from S. Kidman & Co. and DEH meet to agree on actions concerning the Innamincka Pastoral Lease. Areas of heavy grazing are identified by the Department of Water Land Biodiversity and Conservation, Pastoral Board and recommendations made to the Pastoralist. In particular, some paddocks within the Tingana Land System were identified as heavily grazed, where vegetation cover was severely impacted. As part of managing pastoral impacts, pastoral management reduced stock within both Bore Track North and South from 2005 to 2006 and completely de-stocked in 2007. The inspection in 2007 described improved vegetation and soil condition in these two paddocks. However it is difficult to quantify the impacts by pastoral activity on the vegetation and natural features of the reserve, as illustrated by the assessment of qualitative data. A greater level of biodiversity monitoring and quantitative measurement would better provide the information to assess whether the objectives of land management and biodiversity conservation are being met (for objectives see section 1.1).

As well as developing agreed approaches to managing stock grazing pressure, DEH and S. Kidman & Co. cooperatively reduce feral herbivore grazing pressure. Feral animal control programs in 2002 removed 342 animals and in 2008 a further 529 animals. This has involved active joint management between DEH, S. Kidman & Co. and the South Australian Arid Lands Natural Resource Management Board.

High grazing impact on vegetation can occur in localised areas. Cattle concentrate around water sources (including dams, bores, water holding borrow pits, waterholes and Cooper Creek) and this can result in localised areas of severe overgrazing where ground storey vegetation cover is almost absent with very low leaf litter levels (DWLBC, 2001). S. Kidman & Co. actively manages these impacts through bi-annual stock assessments and annual pastoral inspections. Management strategies to promote vegetation and soil recovery where severe impacts have occurred include destocking paddocks and restricting access to water points. However, there are still some ongoing issues in regards to impact of cattle around water sources. For example, Thiessen and Graham (2005) surveyed 203 borrow pits all of which had evidence of cattle presence. Stock may congregate around borrow pits, when water is present, and potentially have a higher grazing impact within a localised area. Possible directions for management of grazing impacts could include assessing the distribution of borrow pits and the extent of their water-holding capacity, and how this might contribute to an increase in grazing pressure by both feral animals and stock being able to exploit a greater area of the reserve and potentially greater population numbers.

Another impact of grazing on vegetation is selective grazing, which can change vegetation structure. Selective grazing of species can be especially detrimental to plants and animals with
limited geographical distribution as they have a limited ability to disperse and colonise new areas. There are three tree species considered having a limited distribution within the reserve (DEHAA, 1998). These are Native Orange (Capparis mitchellii), Beefwood (Grevillea striata) and Sour Plum (Owenia acidula). Cattle and/or rabbits graze seedlings and suckers of these species and as a result only mature specimens occur (DEHAA, 1998). The three species occur around the Cooper Creek and sand dunes in the Cooper, Tingana, Mernie and Marquialpie Land Systems. This review found that these areas are subjected to a higher level of grazing (see Figure 13) and other types of activity such as seismic, roads and drilling are also concentrated in these areas (see Figures 4, 5, 6 and 7). Further studies of the distribution and persistence of these species may provide information on the impacts of activities such as vegetation clearance and grazing.

Removal of dead trees and woody debris

Dead timber provides cover and habitat for a variety of wildlife species and is important for stabilising banks and reducing erosion (DELM, 1993). Loss of coarse woody debris and standing dead trees is significant because both play a crucial role in the functioning and productivity of ecosystems where they contribute to nutrient cycling, provide habitat for many invertebrates and substrates for plant germination (Cole and Dalle-Molle, 1982; Harmon et al., 1986; Bretz Guby and Dobbertin, 1996; Hecnar and M’Closkey, 1998; Bowman et al, 2000; Farrell and Marion, 2001; Lindenmayer et al, 2002 in Smith 2003). In particular, large dead trees form hollows providing critical nesting habitat for parrots including two distinct populations of the Red-rumped Parrot (Psephotus haematonotus) and Mallee Ringneck Parrot (Barnardius zonarius) which are endemic to the region (Reid and Gillen, 1988).

The majority of large trees are primarily distributed around creek lines, waterholes and on the flood plains. These areas, predominantly within the Cooper Land System, are favoured by both cattle and visitors, and as a result are subjected to more intense use than other land systems of the reserve. River Red Gums are a dominant tree component of the Woodland communities fringing the major river systems within the reserve. Riparian Red Gum Woodland is considered a strong hold for the State rare Barking Owl (Ninox connivens) (Reid and Gillen, 1988). According to Reid and Gillen (1988) distribution of this species appears to be limited by the distribution of River Red Gums. These trees are also important foraging, breeding and nesting habitat for the significant assemblage of raptors which are present on the reserve: one State endangered species (Square Tailed Kite (Lophoictinia isura) and four State rare species, Grey Falcon (Accipiter novaehollandiae), Letter Winged Kite (Elanus Scriptus), Peregrine Falcon (Falco peregrinus) and Black Breasted Bustard (Hamirostra melanostemon). Loss of this important tree species would have a potentially devastating effect on some threatened bird species.

The removal of large dead trees, woody debris and shrubs is mainly attributed to firewood collection. The equivalent of over 230 mature specimens of River Red Gum (Eucalyptus camaldulensis) was felled by visitors to the region in 1987: an estimated average of 3.57 kg of timber per person per day (Gillen, 1988 in White, 2001). Removal of large dead trees and woody debris is a continuing impact primarily caused by visitors to the reserve. DEH is seeking to minimise visitor impacts through the development of the Innamincka Tourism Master Plan (in preparation). The plan will identify infrastructure that is appropriate to visitor needs and locate infrastructure to reduce concentration of visitors and provide the ability to rest high use areas, thereby reducing the environmental impacts from increasing visitation.

Loss of Lignum

Lignum is an important component of arid-zone swamp wetlands (Jaensch and Young, 2006). It is believed that Lignum provides protection to River Red Gum seedlings as well as supporting them during floods. Loss of Lignum along the Cooper Creek is attributed to visitors frequently pushing their vehicles into Lignum clumps to clear areas for camping. Cattle also impact on Lignum vegetation by pushing through clumps to access water sources and consuming new growth (Jaensch and Young, 2006). Exploration and production activity may contribute to the loss of Lignum when activities, such as clearing for seismic lines, occur on large swamps areas (e.g. Tirrawarra Swamp) (see Figure 4).

As well as a protective role, Lignum provides vital habitat for numerous water bird species including the State rare Intermediate Egret (Ardea intermedia), Blue-billed Duck (Oxyura australis) and Glossy Ibis (Plegadis falcinellus) (Jaensch and Young, 2006). Lignum is also the preferred habitat for the State vulnerable Freckled Duck (Stictonetta naevosa), which is listed among the
ten rarest waterfowl in the world (Garnett and Crowley, 2000; Martindale, 1986 in Reid and Gillen, 1988). Lignum provides ideal habitat for breeding water birds, because the shrubs provide a platform (free from predation) on which a nest can be built. Furthermore, the State rare Grey Grasswren (Amytornis barbatus) is confined to Swamp Canegrass and Lignum vegetation (Morton, Short and Barker, 1995; White 2001) and during times of drought Grey Grasswrens may use dense Lignum stands as refuges (Hardy, 2002; DEWHA, 2005).

Dense Lignum beds adjacent to lakes or channels are also critical habitat for the Long-haired Rat (Rattus villosissimus) (Reid and Gillen, 1988; Morton, Short and Barker, 1995; Jaensch and Young, 2006). Increased activity in the Cooper Land System, i.e. increased grazing and visitor pressure, has impacted upon, and potentially decreased, the abundance of Lignum within the reserve. Increased loss of Lignum from the reserve may have serious impacts for the regeneration of River Red Gums and reduce protection, shelter and breeding success of threatened water bird species.

In order to conserve and protect vegetation, special management zones have been set aside to exclude or manage petroleum and pastoral activities. These include Coongie Lakes National Park, Cullyamurra Waterhole Exclosure (131 km²) and the Coongie Lakes Management Zones. The Cullyamurra Waterhole Exclosure excludes grazing only and includes approximately 15 km of Cooper Creek channel and the Cullyamurra Waterhole itself. This has effectively reduced further vegetation loss in these sections of the reserve, in particular protecting sensitive wetland area which contains important habitat i.e. Lignum and River Red Gums. The continuing existence of these areas also provide a unique opportunity for biodiversity and comparison studies for future reviews.

4.1.2 Fragmentation

Fragmentation of natural vegetation disrupts ecosystems and habitats and results in the creation of remnant 'islands' or fragmented patches. There are two primary effects of fragmentation. Firstly, it creates new edges between remnants, and cleared or disturbed land, leading to edge effects. These include changes in the physical environment as well as biogeographical changes (Saunders, Hobbs and Margules, 1991). Biotic changes include invasion by opportunistic species with good dispersal or colonising abilities, such as weeds and feral animals (Glanzing, 1995). Secondly, it isolates and creates barriers between remnants. Studies in arid environments have shown these barrier effects may be less applicable within the Cooper Basin (Moss and Low, 1996; Fatchen and Woodburn, 1997; Fatchen and Woodburn, 1999; Fatchen and Woodburn, 2000). Studies on the impacts of seismic lines in the Cooper Basin suggest that environmental impacts of seismic lines in the Cooper Basin are visual rather than ecological (Moss and Low, 1996; Fatchen and Woodburn, 1997; Fatchen and Woodburn, 1999; Fatchen and Woodburn, 2000). Two studies, using ants as bio-indicators, concluded that seismic line activity had a short (two month) impact but ant activity returned to normal after three years (Watts et al., 2002; McArthur, 2003). Given the temporary effects already identified, further studies on faunal dispersal after seismic lines may provide further information on the effects of seismic line creation in arid landscapes.

The proliferation of roads and tracks throughout the reserve in the last ten years, and accumulation of over 20 years of activity, has resulted in fragmentation of the landscape. Increased roads and tracks results in removal of vegetation and opens up the landscape, potentially increasing accessibility and opportunities for weeds and feral species to invade. Greater accessibility facilitates a higher level of traffic and this may directly result in increased wildlife mortalities. The location of well sites provide a good indication of where most tracks and roads construction occurs because the primary function of roads and tracks within the reserve is access to these sites.

This review found the highest numbers of wells were located in the Tingana, Cooper and Meminie Land Systems (see Figure 6). The impact of wells occurring predominantly in these land systems results in a greater density of roads and tracks and potentially greater impacts on the Cooper Creek, sand dune, and floodplain environments. This review also found that the Tingana Land System receives the highest impacts from combined activities. The nationally vulnerable Dusky Hopping Mouse (Notonmys fuscus) has been recorded close to the reserve and preferentially uses sandy dune habitat (Moseby, Adams and Brandle, 1999) such as the dune country indicative of the Tingana Land System. The higher level of impacts in this system, in particular increased fragmentation from greater numbers roads and tracks and grazing impacts (see section 4.1.1) could potentially contribute to an increased patchiness of habitat and food resources for this vulnerable species.
Unauthorised access and use of roads, access tracks and old seismic lines by vehicles, such as visitor four-wheel drives, can result in further disturbance and clearance of vegetation, and potentially reduce regrowth and rehabilitation. Off-road driving compounds these effects. These impacts by visitors can contribute to further fragmentation of the landscape by decreasing natural rehabilitation of access tracks and increasing patchiness by disturbing and removing vegetation.

Another impact of roads is providing easier access for fauna to water points/sources, resulting in increased grazing (Thiessen and Graham, 2005). They identified that although the Merninie Land System has not been as heavily impacted as Tingana, increasing activity in the area from combined impacts of users of the reserve has the potential to result in a high degree of fragmentation and impact (Thiessen and Graham, 2005). This review found all activities (petroleum, geothermal, pastoral and tourism) have generally increased in the last ten years and mutually contribute to fragmentation of the landscape of the reserve.

Petroleum industry guidelines that have been developed within the last ten years encourage assimilation of drill pad areas and tracks, use of pre-existing roads and facilitating the re-establishment of vegetation to help reduce long term effects of fragmentation. Signage to discourage third party use of tracks and roads is also encouraged. However, there is still need for continual technical improvements and monitoring of impacts to reduce fragmentation of the landscape. In particular, future location and frequency of activities should consider the existing level of impact of roads and tracks, seismic lines and drill pads within land systems that are already considered fragmented, e.g. Tingana and Merninie Land Systems.

4.1.3 Loss of soil condition

Arid zone soils play an important water-holding capacity role and supply nutrients for vegetation and, in return, vegetation plays a fundamental role in the process of soil formation by stabilising and adding organic matter. Loss of vegetation has flow-on effects on the condition of soils within the reserve. Removal and fragmentation of native vegetation has led to changes in nutrient and hydrological regimes (Glanzing, 1995). In particular, vegetation clearance can result in greater instability of soil and increases in wind speed and erosion. Activities on the reserve also directly impact on the soil by disturbing the soil crust, compacting soil and removing topsoil. These impacts may result in a higher susceptibility to erosion and consequently a decrease in soil condition.

Soil crust

Soil crusts are an important characteristic of arid and semi-arid ecosystems. The essential role of these microbiotic crusts in nutrient cycling of arid ecosystems has been increasingly appreciated (Fleischner, 1994). Some of the roles that crusts perform include soil stability, soil infiltration, increasing organic matter and nitrogen fixing (Fleischner, 1994). Given the fragile nature of microbiotic crusts, it follows that they are easily damaged by livestock grazing (Fleischner, 1994) and other activities on the reserve. This is of particular concern around watering points. Concentrated activity around watering points can result in extreme degradation around the water source (up to 0.5 km); where the soil crust is broken, erosion is high and unpalatable plants dominate (James, Landsberg and Morton, 1999). However other activities that occur on the reserve, such as clearing for drill sites, roads, tracks, constructing pipelines and four-wheel driving will also impact on the soil crust. Considering that the value of soil crust is second only in importance to the lack of moisture in the desert (James and Jurinak, 1978 cited in Fleischner, 1994) it could be a useful leading indicator for soil condition in future reviews of the reserve.

Soil compaction

Soil compaction results from numerous activities on the reserve. In particular, soil compaction may be a limiting factor for germination, root growth, plant yield and vigour (Stone, 1989). Soil compaction may also increase water runoff due to the surface layers becoming harder and less porous, thereby decreasing the effectiveness of infiltration. This can lead to water planeing and the likelihood of increased erosion. Activities that may result in soil compaction include operation of heavy vehicles and machinery, camping and walking. The petroleum industry has addressed soil compaction by encouraging techniques such as ripping and using lighter four-wheel drives whilst conducting geophysical operations (Santos, 2006). Livestock trampling has been found to compact soil, significantly reduce water infiltration rate (Abdel-Magid et al., 1987; Fleischner, 1994; Gamougoun et al., 1984; Schlesinger et al., 1990 cited in Castellano and Valone 2007) and accelerate erosion (Reid and Gillen, 1988; Ford, 1995 cited in White, 2001).
inspections (2001 - 2007) reported on soil condition on the reserve, but primarily around erosion and disturbance of soil rather than compaction. Management strategies by the pastoralist, including stock reduction and spelling paddocks, aim to improve the soil condition on the reserve.

**Topsoil**

Topsoil has immense ecological value because it contains the highest organic matter content, seed bank, microorganisms and nutrients for plants. Activities such as sub-surface excavations (borrow pits, sumps and flare-pits) remove topsoil and as a result can remove valuable seed stock from the local area. This can be compounded by the removal of vegetation which results in increased wind and water erosion. Petroleum industry guidelines implemented in the last ten years outline specific environmental objectives to maintain topsoil (Santos, 2006). Operators are encouraged to stockpile topsoil to retain seed bank and respread the top soil on abandonment (Santos, 2003; Santos, 2006).

**Erosion**

Natural erosion and gulling has been amplified by activities within the reserve, such as seismic lines, overgrazing and increased traffic (particularly off-road 4WD driving). Susceptibility to erosion is influenced by the characteristics of the soil. The Meminie Land System is characterised by gibber plains that are less resilient to erosion than other land systems within the reserve (Dobrzinski, 1998). Pre-1960s methods of seismic line survey interfered with water flows, led to erosion on gibber plains and impaired natural water distribution on floodplains (DEHAA, 1998). This review found that an increase in 2D and 3D seismic activity in the last ten years has occurred within the Meminie Land System (see Figures 4 and 5). However, over the last ten years considerable effort has been put into development of industry guidelines and techniques which seek to minimise the impacts on gibber landscapes. This includes new rolling techniques for exploration and production activity in gibber country in order to minimise impacts (Santos, 2006). Since 1998 there has been further reduction in the potential for erosion through no blading and no rolling of seismic lines in gibber country (D. Cockshell, pers. comm., 2008).

The sandy soils of the Tingana Land System are prone to wind-drift when vegetation cover is removed. Increased instability resulting from loss of vegetation (see section 4.1.1) and regrowth delay, due to the arid environment, exposes sand dune soils to higher wind and water erosion. This review identified that the dune country (Tingana Land System) is one of the most heavily impacted land systems. Greater presence in the last ten years of roads, access tracks, increased pipeline access and seismic activity all have the potential to increase erosion and subsequent loss of soil when cut through dunes. Petroleum guidelines aim to decrease impacts in dune systems by minimising dune cuts (Santos, 2006).

Soil drift was identified in a number of paddocks which were subject to heavy utilisation and increased grazing pressure (DWLBC 2002; 2003; 2004; 2006). Following annual inspections the pastoralist actively engaged in management strategies to improve the soil condition on the reserve, including stock reduction and spelling of paddocks. Specifically, de-stocking Meminie paddock from 2005 to 2007 allowed the soil to recover as evidenced by increased percent of positive descriptors in the annual pastoral inspection in regards to soil condition (see Figure 15). However, a possible review of the assessments by the Pastoral Board and DEH may allow for new methods leading to greater understanding and management strategies of pastoral activity on the reserve (e.g. potentially using soil indicators as a means to quantify and identify the level of disturbance.

### 4.1.4 Changes to hydrology

The unique value of the Cooper Creek system is recognised with the majority of the Cooper Land System being listed under The Convention on Wetlands (Ramsar) (see Figure 2). Ramsar wetlands are recognised as a matter of national environmental significance under the Environment Protection and Biodiversity Conservation Act 1999. The ecological importance of the Cooper Creek system is vital to the functioning of the natural environment, the pastoral industry and the Innamincka Township. The Cooper Land System is the most biologically diverse system in the region. Changes in the ecological character, particularly the hydrology of the system, will have a negative impact on the flora and fauna of the Cooper Creek system, in particular aquatic species such as, the endemic Cooper Catfish (Neosiluroides cooperensis), Lake Eyre Callop (Golden Perch (Macquaria sp)), the Cooper Creek Tandan (Neosilurus sp) and the endemic Cooper Creek Turtle (Emydura emoti).
Some impacts, which have occurred in the past ten years, have had a local impact on the hydrology of the Cooper Creek system. These include water extraction for the township, geothermal exploration activity, pastoral use and deterioration of water quality due to human pollution. For the period 1 to 31 January 2007, compared to the same period in 2008, water extraction for residents and visitors increased by 557,710 litres (64%). Osborne (2008) notes that the increase in water extraction is due to greater exploration activity on the reserve and higher accommodation occupancy rates than usual.

Currently there is one licence granted to extract water from the Cooper Creek. This water extraction licence is for geothermal exploration activity. The licence is subject to a number of conditions including a maximum extraction limit of 80 mega litres; water must be flowing through the culverts of the Innamincka causeway and a pumping rate of 16 litres per second (Iliescu, 2003b). However, growth of the operation into production stages may increase demand to extract greater quantities of water from the Cooper Creek. This review found in the last ten years exploration activity, particularly geothermal, and visitor numbers have continued to increase (see sections 3.2 and 3.4 respectively). Both geothermal and tourism activities utilise water from the Cooper Creek system. The documented and likely future increases in reliance and quantity of water extraction by multiple users will impact on the hydrology and ecology of the Cooper Creek system. Future water extraction practices which meet environmental flows requirements will need to be addressed in the management of the reserve in collaboration with the South Australian Arid Lands Natural Resource Management Board, Department for Water, Land, Biodiversity and Conservation and DEH.

At a landscape level there is great concern about water extraction out of the system. Generally, flows reach Cullyamurra Waterhole annually; flows reach the lakes in most years; and around one in fifteen years the lakes dry out (Costelloe, Lewis and Leach, 1998). Altered flood regimes from up-stream, hydrological impacts, long-term climate change and deteriorating quality and quantity of the Cooper Creek system, will ultimately impact on the ecology of the reserve and the adjoining Coongie Lakes National Park. Future reviews should also seek to address the Cooper Creek system as part of the whole Channel Country system to maintain its ecological integrity and functioning. A national/broad-scale approach could be achieved through increasing knowledge via partnerships between the Australian Queensland, South Australian and Northern Territory Governments.

### 4.1.5 Impacts on wildlife

The reserve supports a diverse range of fauna including numerous threatened and endemic species. Some activities may result in a direct impact on certain species e.g. fishing, and other activities such as sub-surface excavations and rubbish disposal may have flow-on impacts on the wildlife of the reserve.

The Cooper Creek system is a well known and popular recreational fishing destination (DEHAA, 1999). Recreational fishing has the potential to decrease fish stock below a sustainable level. Combined with drought conditions, an increase in total visitor numbers and seasonal periods of intense visitor pressure (see section 3.4) may create greater concentrated fishing efforts over smaller areas and result in increased pressure on fish stocks. Fishing pressure has been identified as a potential threat to the endemic Cooper Catfish (Neosiluroides cooperensis) (Unmack, 1996 cited in White, 2001; Hammer, Wedderburn and Van Weenen, 2007). The little available data suggests the species is restricted to permanent waterholes and does not disperse widely to areas inundated during flooding unlike many other species in the Lake Eyre Basin. The potentially highly restricted and fragmented occupied habitat of the Cooper Catfish leaves it susceptible to local losses and range contraction which may have occurred in the past or be occurring, but remains undetected.

The Cooper Creek and Diamantina River Fishing Regulations (Fisheries Management Act 2007), regulate catch size, bag and boat limits and types of fishing gear that can be used. Fishing restrictions and greater on-ground regulation with the presence of two full-time rangers on the reserve has increased preventative measures to decrease exploitation of fish stocks. Other possible impacts on fish stocks such as water diversion, continuing drought, climate change and the continuation of regulation of fishing potentially need to be addressed in the future management of the reserve.

Another impact on wildlife is sub-surface excavations (borrow pits, sumps and flare-pits) which can become sources of water for native wildlife, feral animals and domestic stock. This review found...
there were many borrow pits within the reserve which had water-holding capacity, particularly within the Cooper and Tingana Land Systems. Artificial water sources, such as borrow pits, may contribute to maintaining higher feral animal populations increasing competition and predation pressure on native fauna. Borrow pits and other open water sources may also act as fatal traps for wildlife (Fiori and Zalba, 2003). Although there are guidelines for rehabilitation of sub-surface excavations there is need for greater management to decrease the potential impacts of artificial water sources sustaining feral populations and acting as potential death traps for wildlife (see section 4.1.1).

A further impact on wildlife predominantly caused by visitors to the reserve is improper disposal of litter. Impacts of litter include injury and mortality of wildlife, attraction of wildlife and changes in natural feeding habits. Litter and rubbish can also become a focus for scavenging animals, e.g. dingoes and feral animals, such as foxes and cats, which may result in increased abundance of these animals. A management plan addressing the issue of litter disposal within the reserve is currently being developed (see section 4.1.6).

Continued commitment to areas within the reserve such as Cullyamurra Exclosure, which excludes cattle and protects parts of the Cooper and Memmie Land Systems, are important for conserving and protecting native wildlife species. In particular, Cullyamurra Waterhole, which is the largest and most permanent of the Cooper Creek waterholes found in South Australia, is considered important refugia for aquatic and terrestrial wildlife particularly in dry times (DEHAA, 1998). The proclamation of Coongie Lakes National Park in 2005 also allows for greater protection of wildlife and habitat, particularly waterbirds and aquatic species, within the area of the reserve.

4.1.6 Visual impacts

Visual impacts mainly affect visitor perceptions of the wilderness quality of the reserve, in particular uninformed assumptions about the reserve with regards to the presence of pastoral and petroleum industry. Greater access to information about the reserve and the multi-use concept has been facilitated through the visitor information centre at Innamincka. Within the last ten years the presence of two permanent rangers on the reserve has further assisted in community engagement. This has potentially increased knowledge and promoted visitor understanding of the reserve’s multi-use concept.

Production and exploration industry infrastructure including production wells, flare, borrow pits and seismic lines detract from wilderness quality. The visual impact of above-ground sections of pipeline and the disturbed right-of-way also reduce the wilderness quality of the reserve. There have been significant developments in petroleum operational and planning techniques over the last ten years to minimise visual impacts. These include leaving vegetation and weaving dozers every 75 to 100 metres to reduce visual impacts of seismic lines; and disposing petroleum industry’s refuse by removing rubbish off the reserve to licensed landfill sites (Santos, 2006). Compliance of commercial operators’ visual impacts are monitored by PIRSA. In general there has been good compliance in the last ten years with most well sites and seismic lines scoring between 0 and +2 against GAS criteria key objectives ‘minimisation of visual impact’ and ‘visual impact’ (PIRSA, 2007).

In the previous review a survey of visitor impacts showed that of 21 camping sites, eight had visible rubbish including toilet paper within the reserve (Page, 1992 cited in DEHAA, 1998). In the last ten years litter management has generally improved with the establishment of toilet facilities, which have reduced toilet paper rubbish, and active encouragement of ‘what you bring in, take away with you’ ethos for visitors and commercial operators. The amount of pollution and litter at camping areas has also been greatly reduced by the provision of a rubbish dump at Innamincka (DEHAA, 1998). However, in the last ten years there has been inappropriate use of this dump resulting in a negative visual impact within the reserve. Management of appropriate use of the dump will be addressed in the management plan for the reserve.

4.2 Impacts on the Cultural Features

There is a general view between Aboriginal groups that there has been an increase in negative impacts to cultural features within the reserves (H. Crow, pers. comm., 2008). In particular, it has been expressed that the increased numbers of visitors to the area has seen a decrease in the number of exposed artefacts. Sensitive sites, such as burial sites and grave sites, have been disturbed by visitors unaware of the significance of the sites. It was also noted in the previous ten year review that archaeologists and anthropologists working in the area had indicated concern at
the ad hoc nature of data collection in the region (DEHAA, 1998). There is also a sense of inequity in how different uses of the reserve are regulated, particularly in regards to preventing, reporting and managing impacts on the cultural features of the reserve.

Damage to cultural sites and objects as a consequence of inappropriate commercial activities, wood gathering, souvenir collecting, uncontrolled vehicle access or pedestrian intrusion pose the greatest threats to cultural features of the reserve. While this review was unable to clearly quantify the impacts on the cultural features of this reserve, there were some views expressed that supported the above (DEHAA, 1998; Reid and Gillen, 1988). Over the last ten years the different users of the reserve have employed varying management approaches that seek to minimise impacts and protect the cultural features of the reserve.

The Environmental Impact Report for the Cooper Basin petroleum operators outlines a procedure to provide cultural clearance (Santos, 2006). Cultural heritage clearances include identification and flagging of heritage sites, detouring routes to avoid sites and reporting sites to the relevant authorities (Santos, 2006). Although this review was unable to quantify the impacts of the petroleum industry specifically on the cultural features, the previous ten year review rated the impact by the petroleum industry as ‘minimal’. This could suggest that preventative management by the petroleum industry in relation to protecting cultural heritage has resulted in decreasing the impacts from their activities.

This review was unable to quantify the impacts to Aboriginal heritage by pastoral activities and stock. However, the previous ten year review indicated that stock trampling is the main cause of damage to sites recorded on the register of Aboriginal Sites and Objects (DEHAA, 1998). In particular, conflict arises as many Aboriginal sites occur along the lakeshores and waterholes and cattle activity is focused on natural sources of water. Continued protection for significant sites exists with cattle exclusion areas, such as Cullyamurra Exclosure. However there is need for further work to identify and protect cultural and archaeological sites outside cattle exclusion zones (DEHAA, 1998). The establishment of a consultative and inspection mechanism for works clearances prior to any construction for pastoral development within the reserve has been developed under the pastoral ILUA signed between S. Kidman & Co. and the Yandruwandha-Yawarrawarnda people in 2007.
5 IMPACT OF RESOURCE USE ON THE ECONOMY OF THE STATE

5.1 Petroleum and Geothermal Activity

Over the review period, oil and gas has contributed over $3.2 billion to the State’s Gross State Product (Table 1). This expenditure has created net incomes for South Australians of over $947 million and supported over 16,200 jobs in the period 1998-2007.

Table 1 Estimation of the Economic Impact from Mining Activity in the Innamincka Regional Reserve, 1998 - 2007

<table>
<thead>
<tr>
<th></th>
<th>Value Added ($'000)</th>
<th>Income ($'000)</th>
<th>Employment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Direct Impact</td>
<td>2,354,585</td>
<td>463,660</td>
<td>5,270</td>
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<tr>
<td>Indirect Impact</td>
<td>873,280</td>
<td>483,505</td>
<td>10,970</td>
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<tr>
<td>Total Impact</td>
<td>3,227,865</td>
<td>947,165</td>
<td>16,245</td>
</tr>
</tbody>
</table>

5.2 Pastoral Activity

Despite low rainfall and drought conditions in the later part of the ten year period, stocking rates in the last ten years were only slightly lower than the previous ten years with average annual stocking rates being 11,609 compared with 11,473. Total income (audited EBIT) from the Innamincka pastoral enterprise over the ten years is $9.1 million (Kidman, 2008 cited in PIRSA, 2008). This expenditure has created net incomes for South Australians of approximately $3.8 million and created 170 jobs in the same ten year period.

Table 2 Estimation of the Economic Impact from Pastoral Activity in the Innamincka Regional Reserve, 1998 - 2007

<table>
<thead>
<tr>
<th></th>
<th>Value Added ($'000)</th>
<th>Income ($'000)</th>
<th>Employment</th>
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</thead>
<tbody>
<tr>
<td>Direct Impact</td>
<td>6,375</td>
<td>2,135</td>
<td>130</td>
</tr>
<tr>
<td>Indirect Impact</td>
<td>3,115</td>
<td>1,705</td>
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<tr>
<td>Total Impact</td>
<td>9,490</td>
<td>3,840</td>
<td>170</td>
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5.3 Tourism Activity

Despite evidence of growth in tourism numbers to the region with significant expansion and low vacancy rates at the Innamincka Hotel, estimating the number of visitors to Innamincka Regional Reserve continues to be difficult. This analysis uses the estimate of 34,500 visitors per annum.

International and interstate visitors clearly provide economic benefits to the State but the economic contribution of intrastate tourism is not as clear. That is, intrastate visitors to the region are not an obvious net benefit to the state, unless they are replacing tourism expenditure interstate or overseas, as it would have occurred in the state anyway. Based on the evidence that 50 per cent of visitors visiting the outback region are from South Australia (SATC), the assessment assumes that 17,250 visitors to the reserve provide net benefit to the state. Based on the expenditure profile of overnight visitors to Marree it was assumed that $140 per visitor was spent in South Australia.

Over the last ten years tourism activity has contributed $13.4 million to the State’s Gross State Product. This expenditure has supported net incomes of approximately 7.7 million and underpinned over 205 jobs per annum.

Table 3 Estimation of the Economic Impact from Tourism Activity in the Innamincka Regional Reserve, 1998 - 2007

<table>
<thead>
<tr>
<th></th>
<th>Value Added ($'000)</th>
<th>Income ($'000)</th>
<th>Employment</th>
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<td>Direct Impact</td>
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<td>Indirect Impact</td>
<td>6,340</td>
<td>3,435</td>
<td>80</td>
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<tr>
<td>Total Impact</td>
<td>13,475</td>
<td>7,795</td>
<td>205</td>
</tr>
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</table>

4 Source: Visitor Management Branch, Department for Environment and Heritage, 2008
6 RECOMMENDATIONS

6.1 Reserve Status under the Act

The review recommends that the Innamincka Regional Reserve remains a Regional Reserve as classified under the National Parks and Wildlife Act 1972 at least until the next ten-year review.

6.2 Future Management of Innamincka Regional Reserve

The aim of the recommendations is to strengthen relationships and increase understanding of impacts upon the reserve. It identifies there have also been improvements in the management of activities which have impacted upon the reserve. Greater protection of the Coongie Lakes wetlands has occurred with the proclamation of Coongie Lakes National Park in 2005. There has also been generation of over $3.2 billion to the State economy from the activities on the reserve.

Petroleum and Geothermal Activities

In general there has been an increase in all types of petroleum-related activity on the reserve. To balance increased activity continued regulation by PIRSA has ensured that the impacts on the environment are minimised.

It is recommended that:

- The same level of regulation be applied to any future petroleum and geothermal license holders in the reserve to ensure the current level of protection of wildlife, landscape and Aboriginal heritage features of the reserve is maintained.
- Industry, PIRSA and DEH work together to identify new techniques to achieve sustainable environmental management practices.

Pastoralism

Although the total number of cattle on the reserve did not differ from the previous review, the area available for grazing may have increased, with the increase in the number of borrow pit acting as seasonal water sources. However, it is acknowledged that there are different methods to assess the grazing pressure and pastoral-related impacts on the reserve.

It is recommended that:

- Annual pastoral inspections continue to be undertaken.
- DWLBC, S. Kidman & Co and DEH continue to work together through the Innamincka Pastoral Working Group to explore impact assessment methods and agreed management actions to minimise the impacts of grazing on the reserve.

Borrow Pits

The number of borrow pits has increased in the past ten years. Although there are guidelines for rehabilitation of sub-surface excavations there is need for greater management to decrease the potential impacts of artificial water sources that may increase the ability for herbivores to exploit a greater area of the reserve.

It is recommended that:

- DWLBC and DEH work collaboratively with S. Kidman and Co to increase knowledge and understanding of the general impacts and behavioral ecology of cattle around borrow pits.
- Improve construction, rehabilitation and management practices around borrow pits, to minimise impacts, through working partnerships with PIRSA, S. Kidman & Co and DEH.
**Water Extraction**

The increasing reliance on water from the Cooper Creek system by growing tourism and the geothermal and petroleum industry highlights the need for sustainable catchment management to protect the unique ecological character of this system and address future climate change impacts.

**It is recommended that:**

- Partnerships are strengthened to increase understanding of the Channel Country ecosystem and guide effective catchment management in collaboration with other jurisdictions.
- Develop partnerships with the South Australian Arid Lands Natural Resource Management Board, DWLBC and PIRSA to ensure water extraction from all users is sustainable.

**Visitor Management**

DEH is preparing an Innamincka Tourism Master Plan for the management of visitors and the development of infrastructure within Innamincka Regional Reserve to guide visitor access and ensure impacts on the natural and cultural features of the reserve are minimised.

**It is recommended that:**

- The Innamincka Tourism Master Plan is implemented.

**Cultural Features**

With increased activity by most users within the reserve there is potential for greater impact on the cultural features of the reserve.

**It is recommended that:**

- DEH works closely with the traditional owners and key users of the reserve to improve management of the cultural features of the reserve.

**Biodiversity Monitoring**

In order to accurately measure and provide the level of knowledge needed to assess the impacts of activity on the natural features, it is vital there is a review of existing monitoring programs and the establishment of new programs as needed.

**It is recommended that:**

- DWLBC and DEH work closely together to review the existing rangelands monitoring program for Innamincka Regional Reserve and consider developing new assessment criteria which would provide the knowledge to assess whether the objectives of land management and biodiversity conservation are being met.

**Reserve Management Plan**

The current adopted management plan requires revision and the establishment of clear ecological and wildlife conservation objectives for reserve management.

**It is recommended that:**

- The management plan for Innamincka Regional Reserve be revised as soon as practicable.
REFERENCES AND BIBLIOGRAPHY


Ramsar Convention on Wetlands:

Ramsar Information Paper no. 2. Retrieved on 1 July 2008 from


APPENDIX A: INTERPRETATION OF THE PROVISIONS OF SECTION 34A OF THE ACT

In undertaking this review, it has been necessary to ensure that the requirements of the Act are properly addressed. To facilitate this process, an interpretive analysis of section 34A was conducted as part of the 1988 review. This analysis is still considered relevant and is provided below. This analysis has been used to guide the conduct of the review. It is also useful in guiding the readers of the report.

For the purposes of section 34A (5) (a) (i) and (ii), natural resources are considered to be:

- native vegetation which is utilised by pastoral stock for feed;
- petroleum and any mineralisation that requires the process of recovery to be undertaken by operations that take place within the boundaries of the reserve;
- landscapes and natural features including native vegetation, native animals, birds, invertebrates and other small fauna that are of recreational and educational value to visitors to the reserve and which are accessible to visitors in accordance with the management plan for the reserve; and
- surface and sub-surface water recovered from within the boundaries of the reserve.

For the purposes of section 34A (5) (a) (i) and (ii), utilisation of natural resources is taken to mean:

- recovery (petroleum), mining, grazing (pastoralism), environmental appreciation and recreational activity (tourism) and water recovery and use (general) and includes the infrastructure necessary to facilitate such utilisation;
- the recovery and utilisation of water prior to its inflow to the reserve; and
- where such utilisation is consistent with the specific objective in the Act in relation to the management of regional reserves, that is to say ‘to permit the utilisation of natural resources while conserving wildlife and the natural or historic features of the land’ (section 37(j)).

For the purposes of section 34A (5) (a) (i), i.e. in the context of conservation, impact of utilisation is taken to mean:

- the effects upon the condition of the wildlife and natural features of the reserve and the management strategies that are considered necessary and adequately to sustainable conserve the wildlife and natural features of the reserve and,
- the effect upon the approach taken to managing the wildlife and natural resources of the reserve as a response to a regime that provides for land uses other than those characteristic of other classifications of reserve under the Act.

For the purposes of section 34A (5) (a) (i), conservation of natural and historical features of the reserve is to have such a meaning that is consistent with the relevant objectives for managing reserves as set out in section 37 of the Act, the relevant objectives being:

- the preservation and management of wildlife;
- the preservation of historic sites, objects and structures of historic or scientific interest within reserves;
- the preservation of features geographical, natural or scenic interest.

and where such preservation is undertaken in accordance with other objectives of the Act which address the deleterious impact of weeds and exotic plants, vermin and exotic animals, diseases of animals and vegetation, and bush fires and other hazards.

For the purposes of section 34A (5) (a) (ii), i.e. in the context of the economy of the State, impact of utilisation is taken to mean:

- the contribution of utilisation to the economy of the State in dollar terms; and
- any offsets to benefits that might be occasioned by one form of utilisation as a result of another.
For the purposes of section 34A (5) (a) (iii), the future status under this Act of the land constituting the reserve is taken to mean the classification of the reserve under Part 3, Division 1-4 and 4A of the Act, the classifications available being National Park (Division 1), Conservation Park (Division 2), Game Reserve (Division 3), Recreation Park (Division 4) and Regional Reserve (Division 4A).

Further, for the purposes of section 34A (5) (a) (iii), recommendations as to the future status of the reserve are taken to relate to recommendations made in consideration of:

- the original intent of the reserve classification in providing for the management of the reserve for the purpose of conserving wildlife and natural features and utilising natural resources; and
- any factors that as a result of the review, significantly appear to work against the purpose of the Regional Reserve classification in providing direction for, and facilitating the management of, the reserve.

While the Act, at section 34A, does not provide for the framing of recommendations regarding the ongoing management of the reserve, section 38 of the Act does provide for the preparation and periodic review of reserve management plans.
APPENDIX B: LAND SYSTEMS OF INNAMINCKA REGIONAL RESERVE

Three broad groups of habitat are described within Innamincka Regional Reserve (DEHAA, 1998). These are dune fields (Tingana, Marqualpie and Kertietoonga Land Systems), gibber plains and dissected tablelands (Merninie, Koonchera and Bloodwood Land Systems) and river channels and wetlands (Cooper Land System). The vegetation and soil characteristics of each type of land system are described below.

Cooper Land System

The Lower Cooper floodout and Coongie Lakes are a unique near natural wetland within the Channel Country biogeographic region and play a substantial role in the hydrological and ecological functioning of the Cooper Creek basin. The flows and flooding of the lake system are dependant on the late summer and early autumn rains in the catchment some 800 km upstream. Although flows reach Cullyamurra waterhole nearly every year, not all flows reach Coongie Lakes. However most years the lake system has an inflow of water, which stimulates breeding in the fish populations and fish-eating birds. Flows along the Strzelecki occur on a less frequent basis.

The variability of the flows, rainfall and the vast flat landscape gives rise to a great variety of habitats across the floodplain. Sixty wetland habitats based on the levels and frequency of inundation, soil types and vegetation species and structure have been described within the Cooper Land System (Mollenmans et al., 1984). These habitats do not include the variety of aquatic habitats that are also diverse temporally and spatially. These descriptions provide some insight into the complexity of the diversity of Cooper Creek and its floodplains.

The major waterholes on the main channel of the Cooper support tall woodland consisting of River Red Gum and Coolibah, with Bean Tree, Earah and Broughton Willow, Whitewood and Native Orange. Braided channels and temporary waterholes on both the Cooper and Strzelecki Creeks have similar soils and vegetation. Lignum grows in dense thickets on the banks of the creeks and in large swamps on gray self-mulching, cracking clay soils (eg Tirrawarra Swamp).

The lake margins support Coolibah, and a variety of floodplain vegetation associations. When dry, lake floors support a variety of different ephemeral herblands and grasslands of high biomass which are of great value to the pastoral industry and provide the nutrient input which gives rise to the boom in freshwater fish and insects following flooding.

Cooper Creek in flood also provides a greater diversity of aquatic habitats including braided and single channels, floodplains, waterholes and interdune corridors. The lakes are shallow, intermittent, variable in depth, strongly affected by wind action, variable in temperature, dissolved oxygen concentrations and salinity and subject to day/night thermal stratification. The biotas living in these aquatic habitats are tolerant of extreme environmental conditions, spatially and temporally patchy in community composition and abundance. They exhibit flexible life history strategies, have an opportunistic response to flow variation and are dependent on drought refugia.

Tingana Land System (formally the Della Land System)

The Tingana Land System consists of red longitudinal sand dunes that support Whitewood, Narrow-leafed Hopbush, Sandhill Wattle, Needlewood and Senna species with an understorey of annual grasses and copperburrs. Sandy interdunal swales support colony Wattle, Whitewood, straggly Corkbark, Emubushes and annual grasses and herbs. Interdune flats with cracking clay soils support grasslands consisting of Mitchell Grass, Neverfail and Mulka with poverty bush and copperburr species. Claypan swamps support Lignum, Canegrass and Queensland Bluebush. Occasional small rises support chenopod shrublands of low Bluebush and Cottonbush.

Merninie Land System

The Merninie Land System consists of a pattern of stony tablelands, long silcrete gibber slopes and local ephemeral creeks. The flat-topped mesas support a variety of shrubs and low trees including Eremophils, Saltbush, Gidgee, and Mulga. The stony slopes and alluvial fans emanating from the mesas support Mitchell Grass and copperburrs. The creek-lines that dissect the mesas are lined...
with Red Mulga and Gidgee, and deeper channels contain waterholes lined with arid-form River Red Gums.

**Marqualpie Land System**

The Marqualpie land system is one of four sand dune land systems and consists of a pattern of low, stable, crescent and irregular shaped red dunes, with numerous small interdunal claypans and lakes. Lobed Spinifex Hummock grassland forms the cover on these dunes with Sandhill Wattle, Whitewood and Needlewood being the common emergent species in the sparse overstorey. Areas enclosed in the crescent shaped dunes form swampy soils and vegetation consists of Lignum, Queensland Bluebush and Swamp Canegrass. The more open swales support bloodwood. The Montecleary Creek and tributaries dissect the land system and are lined with riparian woodlands of River Red Gum, Coolibah, River Cooba, Whitewood and Bloodwood, the species mix dependant on inundation frequency.

**Kertietoonga Land System**

The Kertietoonga Land System covers a small area in the north of the reserve. It consists of red dune fields with semi-mobile crests in places and a perennial cover of Sandhill Canegrass and Lobed Spinifex; and interdunal swamps with Starbush, Blackbush and Neverfail. Interdunal drainage and lakes are ephemeral, lakes support Coolibah over Samphire or Lignum shrubland.

**Koonchera Land System**

A small area of the Koonchera land system occurs in the north-west of Innamincka Regional Reserve. This land system comprises gently undulating gibber plains, crossed by major drainage with run-on depressions and swamps and limited occurrences of red dunes. Koonchera is key habitat for the Kowari, Kultarr and Fawn Hopping Mouse.

**Bloodwood Land System**

Several small patches of this land system occur near the northern edge of the reserve. It consists of scattered dunes and sand plains interspersed with gibber gravel flats. Red irregular-shaped sand dunes support an overstorey of Sandhill spider-flower and Sandhill Wattle with a Sandhill Canegrass shrub layer. The Sandplains support Bloodwood and Lobed Spinifex; and the gibber gravel plains support Mitchell Grass, Neverfail and herbs.