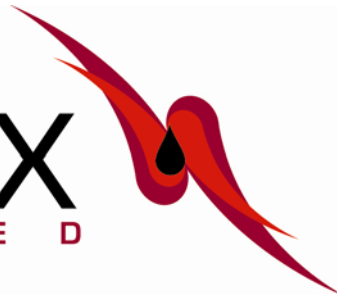


SAPPEX
L I M I T E D



Arckaringa Basin Exploration Drilling Activities

Environmental Impact Report

Final Report
October 2007



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Contents

1	Introduction.....	1
1.1	Location	1
1.2	Project Proponent.....	1
1.3	About this Document	1
2	Legislative Framework.....	3
2.1	Petroleum Act and Regulations.....	3
2.2	Statement of Environmental Objectives	3
2.3	Environmental Impact Report.....	4
2.4	EIR / SEO Assessment and Approval	5
2.5	Approval to Carry Out a Regulated Activity.....	5
2.6	Other Legislation	5
3	Proposed Activities	7
3.1	Overview.....	7
3.2	Drill Site and Access.....	7
3.2.1	Access.....	7
3.2.2	Drill Site.....	8
3.2.3	Borrow Material.....	10
3.2.4	Campsite	10
3.3	Petroleum Drilling and Well Operations	10
3.3.1	Production Testing	11
3.4	CSG Drilling and Well Operations.....	11
3.5	Well Abandonment.....	12
3.5.1	Abandonment Following Drilling	12
3.5.2	Abandonment Following Production	12
3.5.3	Zonal and Well Abandonment During Completions and Workovers 12	
3.6	Site Clean-up and Reinstatement	13
3.6.1	Initial Restoration	13
3.6.2	Partial Restoration.....	13
3.6.3	Final Restoration.....	13
3.7	Associated Activities.....	14
3.7.1	Water Supply.....	14
3.7.2	Waste Management.....	14
3.7.3	Fuel and Chemical Storage	15
3.8	2007/08 Drilling Program.....	15
4	Existing Environment.....	16
4.1	Climate	16
4.2	Biophysical Environment	16
4.2.1	Stony Plains	18
4.2.2	Simpson-Strzelecki Dunefields	23
4.2.3	Great Victoria Desert	25
4.2.4	Gawler.....	26
4.3	Water Resources.....	28
4.3.1	GAB Springs	29

4.4	Hydrogeology	29
4.5	Heritage	30
4.5.1	Indigenous Heritage	31
4.5.2	Historical Heritage	32
4.5.3	Natural Heritage	32
4.6	Land Use	32
4.6.1	Pastoralism	32
4.6.2	Mining	33
4.6.3	Conservation	33
4.6.4	Tourism	34
4.6.5	Defence	34
4.6.6	Native Title	34
4.7	Socio-Economic	34
4.7.1	Population Centres	34
4.7.2	Infrastructure	35
5	Environmental Hazards and Consequences	36
5.1	Hazards	36
5.2	Consequences	36
5.3	Discussion of Key Hazards	40
5.3.1	Earthworks associated with Well Site & Access Track Preparation 40	
5.3.2	Vehicle Movement	42
5.3.3	Vegetation Clearance	42
5.3.4	Down-hole Operations	42
5.3.5	Waste Management	43
5.3.6	Hydrocarbon, Fuel and Chemical Management	43
5.3.7	Disturbance to Livestock and Land Use	44
6	Environmental Risk Management	45
6.1	Access Track Construction	45
6.2	Well Site Selection	45
6.3	Well Site Construction	45
6.4	Management of Drilling Operations	46
6.5	Fuel and Chemical Storage and Handling	47
6.6	Well Site Reinstatement	47
6.7	Pollution and Waste Management	47
6.8	Environmental Management System	48
6.8.1	Environmental Training	48
6.8.2	Emergency Response and Contingency Planning	48
6.8.3	Environmental Monitoring and Audits	48
6.8.4	Incident Management, Recording and Corrective Actions	49
6.8.5	Reporting	49
7	Environmental Risk Assessment	50
7.1	Hazards and Consequences	50
7.1.1	Severity of Consequences	50
7.1.2	Likelihood of occurrence	51
7.2	Risk Assessment	52
8	Consultation	58

8.1	Key Stakeholders	58
8.2	Landholder Consultation	59
8.3	On-going Consultation.....	59
9	References	60
10	Abbreviations.....	62
11	Glossary	63

Appendix 1: Land System Descriptions

Appendix 2: Rare or Threatened Species Recorded in the Region

Appendix 3: Priority Plant Species

Appendix 4: List of Relevant Land Owners

Appendix 5: Consultation Submissions and Responses

Figures

Figure 1: Arckaringa Basin.....	2
Figure 2: Bioregions of the Arckaringa Basin.....	17

Tables

Table 1: Road construction methods for landforms in the Arckaringa Basin.....	8
Table 2: Well lease construction methods for landforms in the Arckaringa Basin	9
Table 3: Typical drilling wastes and disposal methods	14
Table 4: Temperature and Rainfall Records for Coober Pedy.....	16
Table 5: Registered heritage sites in the Arckaringa Basin region	31
Table 6: Hazard and consequence classifications for drilling activities	37
Table 7: Impacts associated with well site/access track preparation in various land systems.....	41
Table 8: Severity of consequences	51
Table 9: Assessment of likelihood.....	51
Table 10: Risk matrix.....	52
Table 11: Summary of impacts and risk levels for drilling operations.....	53
Table 12: Stakeholder consultation.....	58

Plates

Plate 1: Petroleum exploration drilling showing typical layout of well lease	8
Plate 2: Mineral exploration rig, water truck and support vehicles.....	9
Plate 3: Stony Plains (Oodnadatta land system)	20
Plate 4: Moon Plains (Moon Plain land system)	20
Plate 5: Breakaways and Stony Hills (Breakaways land system).....	21
Plate 6: Dunefields and Sand Plains (Wattiwarriganna land system).....	21
Plate 7: Drainage Lines and Flood Plains (in Oodnadatta land system)	21
Plate 8: Great Artesian Basin Springs (in Oodnadatta land system)	22

1 Introduction

SAPEX Limited (SAPEX) holds a number of Petroleum Exploration Licences (PELs) in the Arckaringa Basin in northern South Australia. SAPEX plans to undertake exploration drilling activities in these PELs to identify and delineate potential hydrocarbon prospects. This Environmental Impact Report (EIR) has been prepared as a requirement of the *Petroleum Act 2000* to provide information on the proposed activities, the potential environmental impacts and their management.

1.1 Location

The Arckaringa Basin is located 800 km north-west of Adelaide in South Australia and covers an area of approximately 80,000km² (see Figure 1). SAPEX currently holds PELs 117, 118, 119, 121, 122, 123, and 124, which cover approximately 65,000km² of this region.

A limited amount of petroleum exploration was carried out in the basin between the 1960s and the 1980s, including aeromagnetic and gravity surveys, several seismic surveys, stratigraphic drilling (12 drillholes) and four exploration wells. No commercial discoveries of oil or gas have been made.

The Arckaringa Basin contains early Permian-age sediments that are analogous to the Cooper Basin oil and gas productive areas, but are at shallower depths. The main formations are the Mt Toondina (source, reservoir and seal), the Stuart Range (source and seal) and Boorthanna (source, reservoir and some seal). These are SAPEX's proposed targets for oil exploration using modern seismic techniques (as described in a separate EIR for geophysical operations), modern geological interpretation techniques and drilling (as described in this EIR).

The Arckaringa Basin also contains sub-bituminous coal deposits. These are similar to the mid-Jurassic Walloon Coal Measures in the Surat Basin, which have significant gas reserves. Consequently, SAPEX plans to undertake exploration for coal seam gas (CSG) in the Arckaringa Basin, which is also covered in this EIR. SAPEX also holds two exploration licences (under the *Mining Act 1971*) for coal (EL 3325 and EL 3326) within the Arckaringa Basin.

1.2 Project Proponent

SAPEX was formed in 2000 as a private company and was recently listed on the Australian Stock Exchange.

The corporate goals of SAPEX include conducting exploration for conventional oil and gas deposits in the Arckaringa Basin PEL tenements and conducting a thorough appraisal of the CSG gas potential within the Arckaringa Basin.

1.3 About this Document

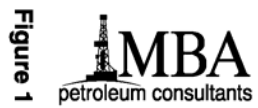
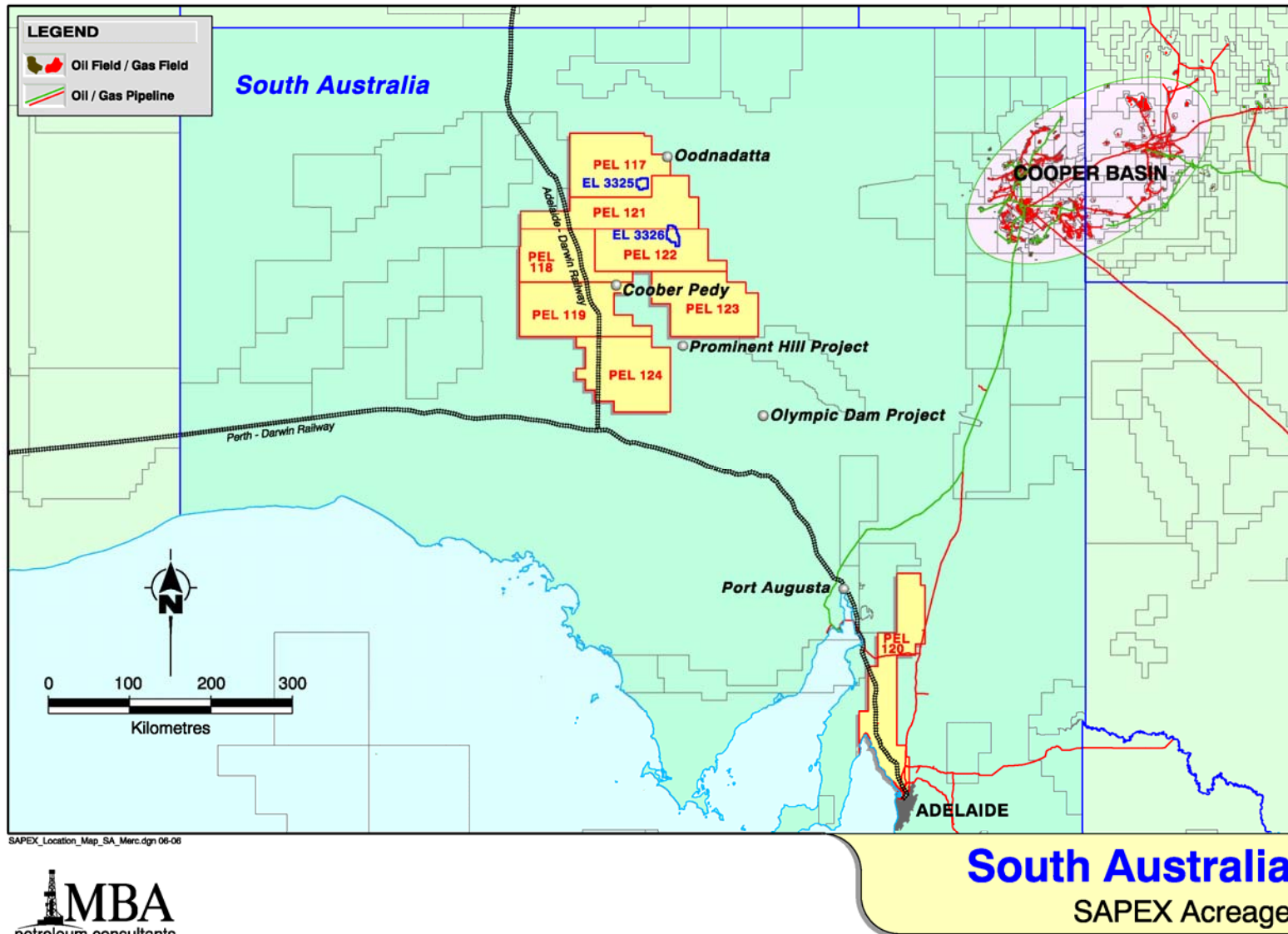
This document has been prepared to fulfil the requirements of an Environmental Impact Report for exploration drilling activities. It has been prepared in accordance with current legislative requirements, in particular Section 97 of the South Australian *Petroleum Act 2000* and Regulation 10 of the *Petroleum Regulations 2000*.

A Statement of Environmental Objectives (SEO) has also been developed in conjunction with this document. The SEO outlines the environmental objectives that SAPEX is required to achieve and the criteria on which the objectives are to be assessed.

This document relates to drilling activities and related well operations carried out in SAPEX's licence areas in the South Australian Arckaringa Basin, which are currently PELs 117, 118, 119, 121, 122, 123, and 124 (see Figure 1).

This document is based on the *South Australia Cooper Basin Operators Environmental Impact Report Drilling and Well Operations* (Santos 2003).

Figure 1: Arckaringa Basin



2 Legislative Framework

This section briefly describes the legislative framework that currently applies to petroleum licensing in South Australia.

2.1 Petroleum Act and Regulations

The legislation governing onshore petroleum exploration and production in South Australia is the *Petroleum Act 2000* and *Petroleum Regulations 2000*. Key objectives of the legislation are:

- to protect the natural, cultural, heritage and social aspects of the environment from risks associated with activities governed by the Act
- to provide for constructive consultation with stakeholders, including effective reporting of industry performance to other stakeholders
- to provide security of title for petroleum, geothermal energy, and other resources governed by the Act and pipeline licences.

The Act and Regulations are objective-based rather than prescriptive (McDonough 1999). An objective-based regulatory approach principally seeks to ensure that industry effectively manages its activities by complying with performance standards that are cooperatively developed by the licensee, the regulatory authority and the community. This contrasts with prescriptive regulation where detailed management strategies for particular risks are stipulated in legislation.

Regulated resources, as defined in Part 1 of the Act, are:

- a naturally occurring underground accumulation of a regulated substance
- a source of geothermal energy, or
- a natural reservoir.

A reference in the Act to petroleum or another regulated substance extends to a mixture of substances of which petroleum or the other relevant substance is a constituent part. Regulated substances as defined in Part 1 of the Act are:

- petroleum
- hydrogen sulphide
- nitrogen
- helium
- carbon dioxide, and
- any substance declared by regulation to be a substance to which the Act applies.

Regulated activities, as defined in section 10 of the Act, are:

- exploration for petroleum or another regulated resource
- operations to establish the nature and extent of a discovery of petroleum or another regulated resource, and to establish the commercial feasibility of production and the appropriate production techniques
- production of petroleum or another regulated substance
- utilisation of a natural reservoir to store petroleum or another regulated substance
- production of geothermal energy
- construction of a transmission pipeline for carrying petroleum or another regulated substance
- operation of a transmission pipeline for carrying petroleum or another regulated substance.

2.2 Statement of Environmental Objectives

As a requirement of Part 12 of the Act, a regulated activity can only be conducted if an approved SEO has been developed. The SEO outlines the environmental objectives that the regulated activity is required to achieve and the criteria upon which the objectives are to be assessed. The SEO is developed on the basis of information provided in an EIR. The EIR is provided by the licensee and contains an assessment of the potential impacts of an activity on the environment.

SAPEX has developed a SEO for drilling activities, based on this EIR. This has been developed as a “generic” SEO – it relates to potential drilling activities anywhere in the Arckaringa Basin, rather than being specific to an individual well.

Generic SEOs have been previously prepared by PIRSA, Ecos and Santos for the following regulated activities:

- *Statement of Environmental Objectives for Seismic Operations in the Otway Basin, South Australia* (Cockshell and Langley, 2001)
- *Statement of Environmental Objectives for Pipeline Preliminary Survey Activities in South Australia* (Ecos Consulting (Aust) Pty Ltd 2001)
- *Statement of Environmental Objectives for seismic operations in the Cooper and Eromanga Basins, South Australia* (Cockshell, 1998)
- South Australian Cooper Basin operators. *Statement of environmental objectives: drilling and well operations* (Santos 2003a).
- *South Australian Cooper Basin Operators. Statement of environmental objectives: geophysical operations* (Santos 2006).

2.3 Environmental Impact Report

In accordance with Section 97 of the *Petroleum Act 2000*, an Environmental Impact Report (EIR) must:

- take into account cultural, amenity and other values of Aboriginal and other Australians insofar as those values are relevant to the assessment
- take into account risks to the health and safety of the public inherent in the regulated activities
- contain sufficient information to make possible an informed assessment of the likely impact of the activities on the environment.

As per Regulation 10 of the *Petroleum Regulations 2000*, the EIR must include:

- a description of the regulated activities to be carried out under the licence (including their location)
- a description of the specific features of the environment that can reasonably be expected to be affected by the activities, with particular reference to the physical and biological aspects of the environment and existing land uses
- an assessment of the cultural values of Aboriginal and other Australians which could reasonably be foreseen to be affected by the activities in the area of the licence, and the public health and safety risks inherent in those activities (insofar as these matters are relevant in the particular circumstances)
- if required by the minister - a prudential assessment of the security of natural gas supply
- a description of the reasonably foreseeable events associated with the activity that could pose a threat to the relevant environment, including information on:
 - events during the construction stage (if any), the operational stage and the abandonment stage
 - events due to atypical circumstances (including human error, equipment failure or emissions, or discharges above normal operating levels)
 - information on the estimated frequency of these events
 - an explanation of the basis on which these events and frequencies have been predicted
- an assessment of the potential consequences of these events on the environment, including;
 - information on
 - the extent to which these consequences can be managed or addressed
 - the action proposed to be taken to manage or address these consequences
 - the anticipated duration of these consequences
 - an explanation of the basis on which these consequences have been predicted
- a list of all owners of the relevant land
- information on any consultation that has occurred with the owner of the relevant land, any Aboriginal groups or representatives, any agency or instrumentality of the Crown, or any other interested person or parties, including specific details about relevant issues that have been raised and any response to those issues, but not including confidential information.

2.4 EIR / SEO Assessment and Approval

Once the EIR and SEO are submitted to the Department for Primary Industries and Resources, South Australia (PIRSA), an assessment is made by PIRSA to determine whether the activities are to be classified as 'low', 'medium' or 'high' impact. This in turn determines the level of consultation PIRSA will be required to undertake prior to final approval of the SEO.

- Low impact activities do not require public consultation and are subjected to a process of internal government consultation on the EIR and SEO prior to approval.
- Medium impact activities require a public consultation process for the EIR and proposed SEO, with comment sought for a period of at least 30 business days.
- High impact activities are required to undergo an environmental impact assessment under the provisions of the *Development Act 1993*.

The level of impact of a particular activity is assessed on the basis of the predictability and manageability of the impacts on the environment. Where the environmental impacts are predictable and readily managed, the impact of the activity is considered low. Where the environmental impacts are less predictable and are difficult to manage, the impact of the activity is potentially high.

Once the approval process is complete, all documentation, including this EIR and its associated SEO, must be entered on an environmental register. This public Environmental Register is accessible to the community from the PIRSA website.

2.5 Approval to Carry Out a Regulated Activity

Prior to commencing a regulated activity (e.g. exploration drilling), Section 74(3) of the Petroleum Act requires that:

- The Minister's prior written approval is required for activities requiring high level supervision (as per Regulation 19), and
- Notice of activities requiring low level supervision is to be given at least 21 days in advance (as per Regulation 18).

New operators (such as SAPEX) are classified as requiring high level supervision for exploration drilling activities. In order to obtain written approval for exploration drilling, an application and activity notification (in accordance with Regulation 20) must be submitted to the Minister at least 35 days prior to the commencement of activities.

The activity notification must provide specific technical and environmental information on the proposed activity and include an assessment to demonstrate that it is covered by an existing SEO.

Consequently, the activity notification process provides an additional opportunity for PIRSA to ensure that the proposed activities and their impacts can be effectively managed and are consistent with the approvals obtained in the EIR and SEO approval process. This is particularly relevant for activities that are conducted under a generic SEO, as it provides site-specific detail that is not usually contained in the generic documents.

The site-specific detail provided would include an assessment of the environment of the proposed location, investigation of specific issues (such as the likelihood of occurrence of threatened species or locations of mound springs or areas of sensitive landscape) and proposed measures to minimise impacts to key issues (e.g. low impact techniques for sensitive areas, sensitive locations to avoid). On-ground environmental investigations would typically be conducted as part of this assessment, particularly where the potential issues are significant or the operation is in a new area.

2.6 Other Legislation

A variety of legislation applies to petroleum exploration activities. Legislation that is particularly relevant to petroleum exploration is listed below (note that this is not a comprehensive list of all applicable legislation).

Commonwealth

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

Native Title Act 1993

Aboriginal and Torres Strait Islander Heritage Protection Act 1984

South Australia

Aboriginal Heritage Act 1988

Crown Lands Act 1929

Environment Protection Act 1993

Fire and Emergency Services Act 2005

Heritage Act 1993

Heritage Places Act 1993

National Parks & Wildlife Act 1972

Native Title (South Australia) Act 1994

Native Vegetation Act 1991

Natural Resources Management Act 2004

National Trust of SA Act 1955

Occupational Health, Safety and Welfare Act 1986

Public and Environmental Health Act 1987.

Approval under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* would be required for activities that impact matters of national environmental significance (e.g. threatened species or communities, Ramsar wetlands, national heritage places). However, the issues that require approval can generally be avoided by appropriate site selection for access tracks and well sites and implementation of field procedures (e.g. flagging and avoiding significant sites).

It is noted that exploration activities that are approved under the Petroleum Act are exempt from requiring approval under the *Native Vegetation Act 1991* for clearance of native vegetation, provided that the activities are in accordance with accepted industry environmental management practices for facilitating the regrowth of native vegetation and there is no practicable alternative involving the clearance of less vegetation or of vegetation that is either less significant or more degraded (see regulation 5(1)(zc) of the *Native Vegetation Regulations 2003*).

3 Proposed Activities

The following section provides an overview of drilling and initial production testing activities. A detailed description of petroleum drilling activities is contained in the Cooper Basin Drilling and Well Operations EIR (Santos 2003)¹.

3.1 Overview

SAPEX plan to carry out exploration drilling for conventional oil and gas and coal seam gas. This will involve several different types of drilling, using different rigs that are suitable for:

- Drilling wells for oil and gas.
- Drilling coreholes (and encapsulating the core to capture gas within it) to evaluate coal seam gas potential
- Drilling wells for coal seam gas.

Oil and gas wells will be drilled using conventional petroleum drilling rigs. CSG coreholes and wells would be drilled using smaller rigs, which would be similar to conventional mineral exploration rigs. Separate rigs for completions or workover may also be used following drilling.

All rigs require a clear and stable drill site with adequate access. However, the larger size of petroleum drilling operations usually requires a larger drill site and more robustly constructed access than typical CSG drilling operations. The potential impact of oil and gas drilling is therefore higher than CSG drilling, and is the main focus of the following sections. CSG drilling can be considered to be a low impact subset of oil and gas drilling operations.

3.2 Drill Site and Access

3.2.1 Access

Drilling operations are accessed using existing station tracks and public roads as much as possible and usually require the construction of a purpose built access track to connect the site to an existing track or road.

The construction method used for access track construction is dependent upon the terrain in which it is being built and the expected level of use or traffic. In most cases the access track is cleared and graded or rolled. Table 1 provides information on the appropriate road construction methods that would be applied to landforms found in the Arckaringa Basin. These landforms are discussed in Section 4.

The number of vehicle movements involved in drilling varies greatly depending on the type of drilling being undertaken.

A conventional oil or gas drill rig typically requires 30-40 semi trailer loads to move the rig and camp to the well site, with a further 10-20 loads of supply, operator equipment and casing. During drilling, a water truck may be required to cart water from a water source to the well site if a water well is not available at the site. Other vehicle movements during drilling typically include daily movements of four-wheel drive vehicles (e.g. contractors or crew changes) and supply runs by a truck (typically 15 t) every 1-2 days).

Drilling for coal cores would require far fewer vehicle movements and would typically involve one truck mounted drilling rig (e.g. 8x4 Volvo with Schramm T660 rig mounted), one support truck with water tank mounted (e.g. MAN 6x6 truck), two 4x4 Toyota Land Cruisers and a caravan for accommodation. Drilling coal seam gas wells would require more vehicle movements, but far less than required for drilling for oil or gas.

¹ Available at http://www.pir.sa.gov.au/petroleum/environment/register/seo_eir_and_esa_reports/drilling

Table 1: Road construction methods for landforms in the Arckaringa Basin

Construction Method	Land System						
	Wetlands (GAB springs)	Drainage Lines & Floodplains	Moon Plains	Breakaways & Stony Hills	Stony Plains	Dunefields & Sand plains	Salt Lakes
Avoid construction	★						★
Utilise naturally cleared areas		★	★	★	★	★	
Avoid steep slopes				★	★		
Weave between trees & large shrubs		★	★	★	★	★	
Clear & grade		★	★			★	
Roll				★	★		
Cap surface		★	★			★	
Culverts or similar installed on drainage crossings		★	★	★	★	★	

3.2.2 Drill Site

Drilling operations require the construction of a stable drill pad for the placement of the drilling rig and areas for associated equipment and facilities (e.g. generators, fuel and chemical storage, casing and pipe storage, offices and accommodation).

A well lease for oil and gas drilling generally requires the following features:

- a compacted and stable drill pad for stabilisation of the rig
- a mud sump for the disposal of drill cuttings and the recirculation of water into the mud system (in the order of 20-30 m by 30-40 m and 2 m deep for petroleum drilling, depending on the particular rig)
- a flare pit for well control and testing operations if required
- a lined 'turkey's nest' for the storage of clean water required for drilling operations (lined with plastic (HDPE) to prevent loss of water through seepage)
- clear entry and exit points for vehicles.



Plate 1: Petroleum exploration drilling showing typical layout of well lease

(Source: Santos 2003)

The size of the well lease depends on the rig being used. Typical oil and gas exploration rigs require a lease with dimensions in the order of 100 m x 120 m. A typical layout of a petroleum exploration well lease is shown in Plate 1.

Rigs used for coal seam gas drilling generally require a much smaller lease, and often require less preparation and compaction of the drill pad. The area required for smaller, mineral exploration style rigs is typically in the order of 20 m x 30 m (see Plate 2). The rigs used for CSG well drilling may require a slightly larger area, which may be in the order of 30 m x 40 m.



Plate 2: Mineral exploration rig, water truck and support vehicles

(Source: Watson Drilling)

Well lease construction methods are dependent upon the terrain in which it is being built. In most locations, with the exception of stony (gibber) plains and dissected tablelands (breakaways), topsoil and vegetation is cleared and stockpiled separately for use in restoration. The selection of non-sloping well sites, especially in the sensitive stony plain and dissected tableland environments is very important in order to avoid the importation of large quantities of borrow material. Well lease construction methods specific to particular landforms are outlined in Table 2.

Table 2: Well lease construction methods for landforms in the Arckaringa Basin

Construction Method	Land System						
	Wetlands (GAB springs)	Drainage Lines & Floodplains	Moon Plains	Breakaways & Stony Hills	Stony Plains	Dunefields & Sand plains	Salt Lakes
Avoid construction	★						★
Utilise naturally cleared areas		★	★	★	★	★	
Avoid steep slopes				★	★		
Avoid trees & large shrubs		★	★	★	★	★	
Clear & grade		★	★			★	
Stockpile topsoil & cleared vegetation		★	★			★	
Roll				★	★		
Cap surface		★	★		★	★	
Build up drill site (only on slopes to provide flat surface)				★	★		
Cut & fill (steep slopes)		★				★	

3.2.3 Borrow Material

Depending upon the nature of the substrates in a particular well location, clay borrow material may be required to stabilise the drill pad or to assist in access track construction. Generally, clay borrow material is sourced from borrow pits located on plains or swales, usually along roadsides and adjacent to well sites. Borrow pits vary considerably in dimension depending upon the quality and quantity of material contained within them.

3.2.4 Campsite

A temporary campsite is usually required to provide accommodation for drilling operations personnel due to the remote location of most drill sites. Campsites for petroleum exploration drilling are usually designed to accommodate approximately 30-40 people. Campsites are usually located near the well site and where possible existing campsites are utilised. Campsite construction methods are similar to these for drill pads with the exception that the location of the campsite is flexible and site clearance or compaction is often not required.

Campsites are usually constructed on naturally clear, flat areas, where disturbance of vegetation and surface drainage and the importation of borrow material can be avoided or minimised. The construction of the campsite may require the excavation of a pit for the disposal of appropriately treated ablutions wastes from accommodation and kitchen facilities. A pit for the burial of putrescible wastes (e.g. food scraps, cardboard) may also be excavated in some circumstances (e.g. at very remote sites, where activities are short term and temporary).

3.3 Petroleum Drilling and Well Operations

Drilling operations will be typical of standard petroleum exploration drilling and are summarised below. Detailed descriptions of drilling operations are provided in Santos (2003). Additional details on the drilling parameters for an individual well site will be provided in activity notification documentation (see Section 2.5).

The following drilling operations will be carried out:

- Drilling to a projected depth (typically 1500 to 2000m). Drilling muds used will be water-based and non-toxic or low toxicity and the sump will not be lined unless the well site is in an area where very shallow aquifers are present.
- Side-wall coring, which may be used to obtain samples to provide information on the formations present.
- Running and cementing surface casing and any intermediate casing required.
- Drill stem testing, which may be used to evaluate pressures and production from any potential hydrocarbon producing formation(s). Drill stem tools would be set to cover the zone of interest, and if the well has potential to flow, it will produce to the surface where it is measured. The production would flow through a separator tank or to a flare pit for flaring. Any small quantities of formation water produced would be disposed of in the drilling sump.
- Openhole logging to evaluate formations of interest.

If the commercial quantities of hydrocarbons are discovered the following will be carried out:

- Running and cementing production casing.
- Installation of well head.
- Completion, which involves cleaning out the casing, perforating the zones of interest, fracturing, acidising or other stimulations, flow back and clean up of the formations, running tubulars, setting packers, running production logging tools and static gradients.
- Artificial lift systems (e.g. jet pump or electronic submersible pumps) may be installed if there is not sufficient pressure in the formation to push oil or gas to the surface. (Note: The operation of these artificial lift systems for production is outside the scope of this EIR).

In the event that a well fails to discover commercial quantities of hydrocarbons it will be plugged and abandoned, as discussed in Section 3.5.1.

The typical duration of drilling for a single well (mobilisation to demobilisation) is in the order of 30 days.

Workover operations may also be carried out on wells. Typically these occur later in a well's life span but may be required soon after drilling. They may include cleaning sand out of the well, replacing liners, plugging the well, repairing casing, drilling deeper, drilling around any obstructions in the well, and re-perforating existing zones in production. Some workovers require only wireline equipment to lower tools into the hole to conduct operations, but others require a workover rig to be moved to the location. Pumps and storage tanks are required for operations that need to circulate workover fluids in the well.

3.3.1 Production Testing

If commercial quantities of hydrocarbons are discovered, production testing may be carried out to evaluate the discovery. Production tests may vary in scope and length, and are typically classed as either initial production testing or extended production testing.

Initial production testing is short term (typically less than 10 days) and relatively small volumes of water and oil are produced. The volume of oil from a typical initial production test is usually between 1,000 and 2,000 barrels (bbl)² and would be unlikely to exceed 4,000 bbl. Production typically flows to a separator tank and then one or more stock tanks (which typically have a capacity of 100 to 300 bbl), and the small volumes of water produced are disposed of to the drilling sump where it evaporates. Installations for initial production testing are normally confined to the drilling pad and tanks are enclosed within a bund.

Produced oil is loaded into tankers and trucked off site. One movement of a single tanker (capacity 200 bbl) would be adequate for transporting oil from tests that produce minimum volumes. For larger test volumes, a two-unit road train (capacity 400 bbl) may be used, resulting in five to ten loads over the duration of a test.

Gas is typically flared during initial production testing of gas wells.

Initial production testing is covered by this EIR.

Extended production testing is longer term (typically up to several months) and larger volumes of formation water may be produced. Extended production testing involves the installation of additional infrastructure and may require the construction of ponds to dispose of water that is produced with the oil and separated in the separator tank.

Extended production testing activities require specific design and planning based on the well site and well flow data.

Extended production testing is not covered by this EIR.

3.4 CSG Drilling and Well Operations

Coal seam gas (CSG) drilling and well operations activities are similar to those undertaken for conventional oil and gas exploration activities, but are generally smaller in scale.

Unlike conventional gas, which is typically found at depths of 1,500 – 2,000 m, CSG is typically found at depths of 300 – 750 m. As a result, the drill rigs used to drill for CSG are usually smaller than those used for conventional drilling. They are often mounted on a truck and can be transported and set up more easily. A sump is likely to be required, although some types of rigs have mud tanks which capture and recycle drilling muds, reducing the size of the sump that is required.

The initial exploration drilling for CSG planned by SAPEX will be similar to mineral exploration drilling and will aim to collect a core sample and measure gas content. These drillholes would typically not be cased, unless they are likely to intersect artesian aquifers, in which case they will be pre-collared by installing and cementing casing to allow well control to be implemented in the case of a water flow. Drilling muds are likely to be used, depending on the nature of the hole. A sump is likely to be required.

² 1 barrel (1 bbl) = 159 litres or 0.159 m³

If early drill holes produce positive results, further drilling will be undertaken to install wells that are capable of producing CSG. In this type of drilling, a well is drilled to a depth of between 300 - 750m to intersect the gas bearing coal seams. Steel casing is cemented to the well bore to prevent water from the water table entering the well bore, and from gas entering the water table.

Hydraulic fracture stimulation may be carried out by pumping a sand and water mixture into the coal seam at high pressure until the coal structurally cracks. Fractures propagate horizontally from the well bore, typically in two directions. This operation can produce new fractures or force the pre-existing fractures in the coal seam to enlarge, extend and network. These fractures, deep in the coal seam, are less than one centimetre wide and have no effect on the ground surface. The sand is used to prevent the fractures from closing, once the water pressure is released. The sand in the coal establishes a porous pathway, enabling gas to flow back to the well bore from a larger drainage area.

At the conclusion of fracture stimulation, a work-over rig installs tubing, a pump (if required) and surface facilities (well head, piping and instrumentation, etc) are then installed and completed. The pump may be required to extract excess water from the coal seam for CSG production. The water generated during CSG production (which is outside the scope of this EIR) is typically stored in evaporation ponds.

3.5 Well Abandonment

3.5.1 Abandonment Following Drilling

Following the drilling of a well and testing and evaluation of its potential, a decision is made on whether to proceed with production of the well (and install production casing) or to abandon it. If a decision is made to abandon the well the following steps are undertaken:

- Plugs are set to isolate all formations that have hydrocarbon shows
- Plugs are set across separate aquifers
- Plugs are set across the surface casing shoe and intermediate casing shoe (if present)
- A plug (typically 15 m) is set at the surface prior to cutting off the surface casing bowl.

The well site is then cleaned up and reinstated as described in Section 3.6 below.

3.5.2 Abandonment Following Production

Once a well has reached the end of its productive life a decision is made on whether to abandon the cased well bore or leave it in a suspended state until it can be abandoned. The well is usually cased to total depth or it may have been cased to just above the producing formation. Either way, the well is evaluated individually to design the abandonment program.

The abandonment program usually involves the following:

- All perforated hydrocarbon zones are isolated from other perforated zones with cement plugs and/or bridge plugs.
- The bond logs are evaluated to ensure that the cement behind the production casing is adequate to avoid crossflow of aquifers with other aquifers or hydrocarbon producing zones.
- A decision may be made to perforate and squeeze off the aquifer to ensure that there is no crossflow.
- An additional cement plug is placed in the surface casing prior to cutting off the well head below ground level.

The well site is then cleaned up and reinstated as described in Section 3.6 below.

3.5.3 Zonal and Well Abandonment During Completions and Workovers

Wells may also be abandoned during or following completion or workover operations. As is the case for abandonment following production, the main objective of well abandonment operations is to seal the well against fluid migration by undertaking the following activities:

- protecting zones from the uncontrolled migration of fluids
- isolating hydrocarbon producing and injection intervals
- protecting people, livestock and wildlife from the uncontrolled migration of fluids.

All wells that are to be abandoned are subject to individual evaluation prior to abandonment to determine the most prudent abandonment procedure as some zones are in natural hydraulic communication.

3.6 Site Clean-up and Reinstatement

The restoration of well sites and associated access tracks is normally undertaken in stages following the completion of drilling operations.

3.6.1 Initial Restoration

Irrespective of the outcome of the drilling operation, initial well lease clean-up involves:

- fencing the drilling mud sump immediately following the completion of drilling to prevent stock access and discourage wildlife access
- backfilling sewage pits (if any) at both the well site and campsite
- pumping any additional water from the turkey's nest into the mud sump and removing the turkey's nest liner.

The drilling mud sump will remain fenced until the contents have dried sufficiently to allow the sump to be backfilled without displacing drilling muds and fluids to the soil surface. The time required for the sump contents to dry is dependent upon the size of the sump and seasonal weather conditions, but for a petroleum well usually takes between 6 and 12 months.

3.6.2 Partial Restoration

When the drilling sump has dried, full or partial restoration of the well site will be undertaken depending upon the outcome of the drilling operations. Partial restoration will be undertaken at well sites that have been successful in discovering commercial quantities of oil or gas as subsequent operations, such as workover and completion activities, require less space than that which was required for drilling operations. Partial restoration involves:

- backfilling the drilling sump to achieve at least 1m cover over mud contents (following drilling operations sufficient freeboard is left to allow for this without creating a raised surface upon restoration)
- partial ripping and respreading of topsoil on excess lease areas to promote revegetation and stabilisation of the lease edges
- backfilling the turkey's nest
- backfilling any additional pits used for loading and offloading earthmoving equipment as well as vent pits (flare pits may be left open for subsequent operations)
- ripping excess loop roads used for road train turnaround
- ripping the campsite and camp access track (unless required for future drilling operations).

3.6.3 Final Restoration

Complete well site, access track and borrow pit restoration will be undertaken if the well fails to discover commercial quantities of oil or gas and is plugged and abandoned, or following completion of production of oil and gas reserves from a particular discovery.

Final surface restoration of well sites will involve:

- backfilling all pits including the drilling mud sump, turkey's nest, flare pits and vent pits
- ripping and recontouring (where appropriate, note ripping will not be undertaken on unsuitable soils – i.e. stony plains) of well sites, campsites and the respreading of stockpiled topsoil and cleared vegetation to promote revegetation
- ripping the access track to relieve compaction and promote revegetation
- removing any windrows to ensure that water flows are not impeded.

Final restoration of borrow pits will involve:

- returning any overburden to the pit
- battering slopes to prevent collapse
- ripping the floor and sides of the pit

- spreading stockpiled topsoil and vegetation
- ripping (where appropriate) haul roads and tracks to relieve compaction.

Restoration and rehabilitation activities will be undertaken in consultation with, and to the satisfaction of the relevant landholder.

3.7 Associated Activities

3.7.1 Water Supply

Water will be required for both domestic and industrial purposes for drilling and well operations. The quality of the water required is dependent upon the intended use.

Domestic Water Supply

Potable water will be required to supply kitchen and ablutions facilities on the drill site and at the camp. The source of potable water will depend on the well location, but may it be sourced from the water supply of a nearby town or station and transported to site in a bulk water tanker.

Drilling Water Supply

The amount of water required for drilling operations depends principally upon the depth of the well that is being drilled. Water use for drilling of an 1800 m deep petroleum exploration well would typically range from 1200 - 1800 barrels (190 to 295 kL) depending on casing diameter.

Water for drilling operations is likely to be sourced from existing artesian and sub-artesian bores located in the region. Supply bores for a drill site will be chosen on the basis of minimising the distance for the water haul and minimising impacts on pastoral activities. However, the water quality (particularly the calcium content) of the water is also considered.

3.7.2 Waste Management

A range of wastes are generated during drilling and well operations. Typical wastes are summarised in Table 3.

Table 3: Typical drilling wastes and disposal methods

Waste	Disposal Method
Domestic Waste	
Sewage and grey water	Onsite treatment with disposal of treated wastewater onto land (well away from watercourses or infrastructure) or collection and disposal off-site at nearby treatment facility. Disposal method for wastewater must comply with the <i>Standard for the Construction, Installation and Operation of Septic Tank Systems in SA</i> , or be to the satisfaction of the Department of Health.
Food waste and paper	Buried on-site or (preferably) collected (may be compacted) for disposal to approved landfill.
Plastic, glass and cans	Collected at the rig site for disposal to approved landfill or recycling where possible.
Workshop waste (rags, filters)	Approved landfill.
Industrial Waste	
Chemical bags and cardboard packaging materials	Compacted and collected at rig site for disposal to licensed facility.
Scrap metals	Collected in designated skip for recycling or to licensed facility.
Used chemical and fuel drums	Collected in designated skip for recycling.
Chemical wastes	Approved landfill or return to supplier

Waste	Disposal Method
Timber pallets (skids)	Recycled or to licensed disposal facility.
Vehicle tyres	Shredded and disposed to approved landfill.

Source: Adapted from Santos (2003)

Campsites require the provision of systems for the management of sewage wastes, which must be managed in accordance with the *Public and Environmental Health (Waste Control) Regulations 1995*. Approved environmental treatment units may be utilised where practical and appropriate. Following treatment via an approved system, waste water may be disposed of on-site (onto land, well away from any place from which it is reasonably likely to enter any waters, and well away from infrastructure) when in remote areas.

Putrescible domestic wastes (e.g. food waste, paper) created at campsites may be buried on-site (in accordance with EPA requirements) if the site is not within reasonable proximity of a licensed waste disposal facility and activities are short term and temporary. Alternatively, they will be stored on site along with other domestic wastes (such as plastics, cans and glass) prior to their transportation to a licensed waste disposal facility. The presence of waste attracts wildlife, most commonly crows, black kites and dingoes. Litter may also be scattered by the wind and scavenging wildlife. Storage methods will take these issues into account to avoid litter scattering and impacts on wildlife (e.g. rubbish bins or skips will be covered; if a pit is dug for disposal of putrescible domestic wastes it will be fenced and waste buried at an adequate depth to prevent it being dug up by scavenging animals).

All industrial solid wastes created during drilling and well operations will be collected in designated skips for eventual recycling or disposal to an appropriately licensed facility. Other wastes associated with drilling and well operations, including drilling fluids and muds, drill cuttings and any other fluids and waste waters are generally disposed to the excavated drilling sump. The contents of the drill sump are allowed to dry before being covered with fill (with at least at least one metre of cover for petroleum exploration drilling sumps).

3.7.3 Fuel and Chemical Storage

A variety of fuels and chemicals are required for drilling and well operations. These include fuel, lubes, oils, solvents and drilling mud additives. The volumes and types of chemicals used will be dependent upon the type of operation.

Diesel storage volumes will also vary depending upon the operation. Diesel storage volumes are usually greatest for drilling operations.

3.8 2007/08 Drilling Program

The proposed 2007/08 drilling program includes coal seam core hole exploration and petroleum exploration.

Coal Core Hole Drilling: Approximately four to six coal core holes are likely to be drilled either late in the third quarter or early in the fourth quarter of 2007. These holes will be drilled on EL 3325 and/or EL 3326 (both held by SAPEX) and/or the area in between these two mineral exploration licences. These holes would be drilled to a maximum depth of approximately 400 metres.

Petroleum Drilling: Two petroleum exploration wells are planned to be drilled in the first quarter of 2008. These holes would be drilled to a depth of approximately 1500 metres. These wells will be drilled in the general vicinity of the coal holes (i.e. in the north-east portion of PELs 117, 121 and 122) but the locations will be determined following a proposed seismic survey.

4 Existing Environment

4.1 Climate

The climate in the Arckaringa Basin is classified as arid and has a typical desert climate of hot to extremely hot, dry summers and mild, dry winters, with low and erratic rainfall. Average annual rainfall at Coober Pedy, in the centre of the region, is 159 mm. Median annual rainfall, which is a more appropriate measure where rainfall is erratic, is 134 mm. Rainfall can occur at any time of year, but rainfall events often occur in summer, when moist tropical air from the north-west monsoon penetrates the region. Record daily falls of between 100 and 200 mm have been recorded across the region (Marla-Oodnadatta SCB 2002). A summary of climate records for Coober Pedy (Station #016007) is provided in Table 4 (Bureau of Meteorology 2007).

The prevailing winds in the summer are from the south or south-east and the winter winds are more variable and come from either the north or the south to south-west quadrants (Bureau of Meteorology 2007).

Climate can be an important consideration when scheduling drilling activities, particularly the likelihood of heavy or prolonged rainfall. However, due to the unpredictable and erratic rainfall (which may or may not occur any time of the year) and the predominantly dry conditions experienced in the region, rainfall is not a significant factor in scheduling drilling in this region.

Table 4: Temperature and Rainfall Records for Coober Pedy

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean Daily Max (°C)	36.2	35.5	32.7	27.6	22.2	18.8	18.7	20.9	24.6	28.8	32.2	34.4	27.5
Mean Daily Min (°C)	20.6	20.7	18.2	14.1	10.1	7.3	6.3	7.4	10.1	13.6	16.6	19.1	13.4
Mean Rainfall (mm)	16.8	23.9	13.5	6.6	13.7	15.0	7.9	9.3	8.6	15.1	11.6	17.0	159.1
Median Rainfall (mm)	5.1	9.4	2.5	1.5	4.6	6.4	3.2	3.5	2.8	6.9	5.1	10.8	133.9

4.2 Biophysical Environment

The area of the SAPEX PELs covers four biogeographical regions (or bioregions), as defined by the Interim Biogeographic Regionalisation for Australia (IBRA). These bioregions, which are broad landscape units based on major geomorphic features, are:

- Stony Plains
- Simpson Strzelecki Dunefields
- Great Victoria Desert
- Gawler.

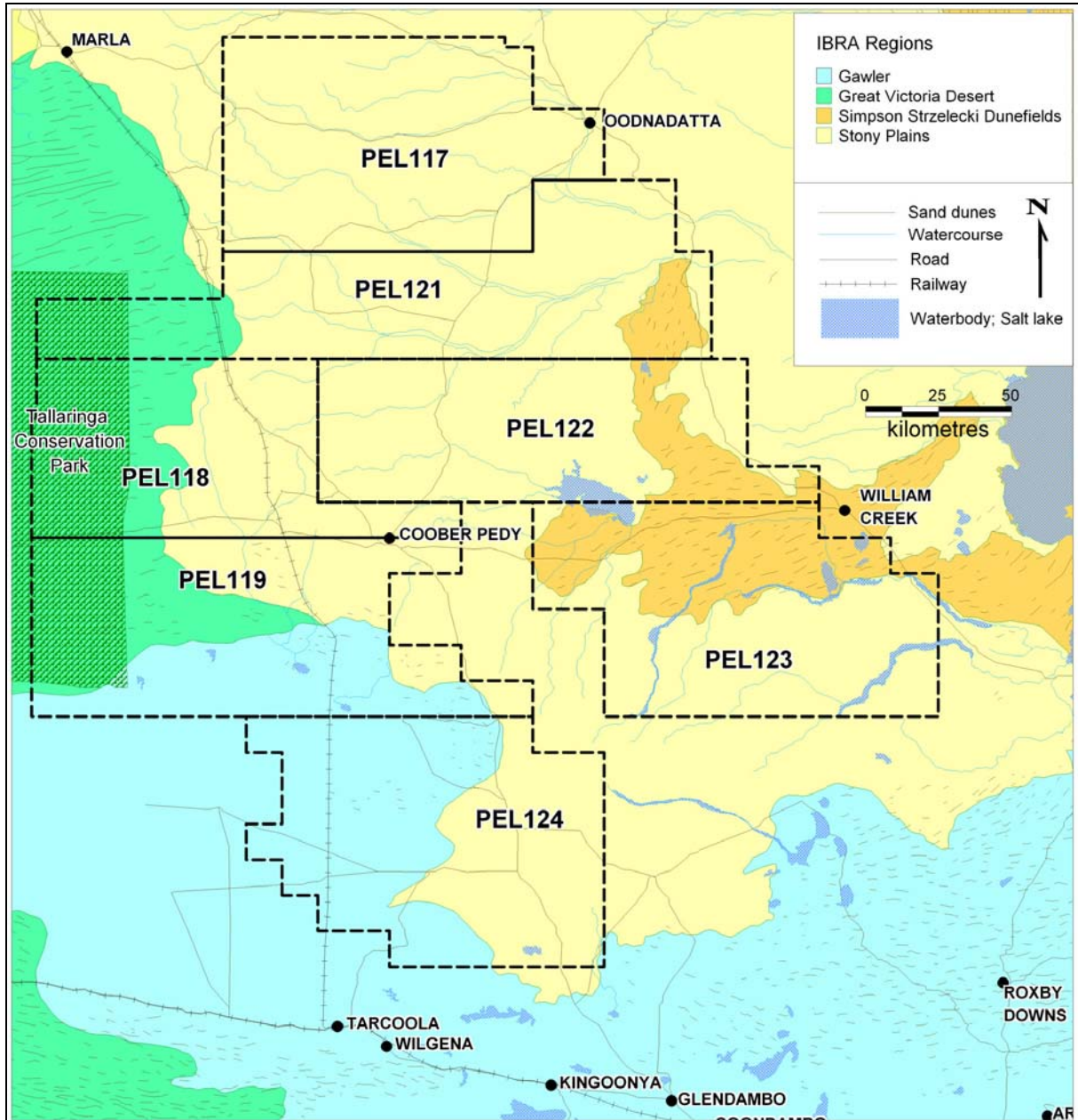
The following sections of this EIR describe the environment within the SAPEX Arckaringa Basin PELs in each of these bioregions. The location of these bioregions is shown in Figure 2.

Each bioregion is divided into subregions under the IBRA classification and can be further divided into land systems, the smallest mapping unit that is used at a national scale (DEH 2005). Land systems are an area, or group of areas, throughout which there is a recurring pattern of geology, topography, soils and vegetation (DEH 2005). The land systems referred to in this document have been used in pastoral management and soil conservation planning and are now being used in regional biodiversity planning (DEH 2005)³.

³ The current IBRA boundaries (shown in Figure 2 of this report) do not match the land system boundaries exactly, but are planned to be realigned when IBRA version 7 is released (DEH 2005). Land systems in this report are grouped into IBRA regions on the basis of the provisional, realigned IBRA boundaries (as per DEH 2005).

To assist in the discussion of potential impacts and environmental management measures in subsequent sections of this EIR, the major land forms encountered within each bioregion are also identified and discussed in the following sections.

Figure 2: Bioregions of the Arckaringa Basin



4.2.1 Stony Plains

The entire Stony Plains bioregion covers an area of 129,240km² and represents 24.8% of the South Australian Arid Lands and 13.2% of the state (DEH 2005). It stretches in an arc from the Northern Territory through to south of Lake Eyre and east to the edges of the Strzelecki Desert and Flinders Ranges.

The Stony Plains bioregion occurs in the central third and the north-east corner of the region covered by the SAPEX Arckaringa Basin PELs and constitutes approximately 60% of the area of the PELs.

The land systems present in the Stony Plains bioregion covered by the SAPEX PELs include: Baltana, Breakaway, Buckshot, Christie, Coongra, Glendambo, Lookout, Moon Plain, Mount Margaret, Oodnadatta, Paisley, Wooldridge and a small area of Wattiwarriganna. A full description of each of these land systems is provided in Appendix 1.

Geology, Soils & Landform

The Stony Plains bioregion is generally described as being a series of 'arid stony silcrete tablelands and gibber and gypsum plains with duplex soils and calcareous earths' (DEWR 2007).

The region has gently undulating gibber and gypsum plains as its dominant feature. These are dotted with occasional lakes, claypans, low hills and ephemeral watercourses and floodplains which typically drain into Lake Eyre (Neagle 2003).

The north-west of the region is interspersed by dissected silcrete-capped tablelands and mesas with extensive gibber covered footslopes on deeply weathered shales (Neagle 2003). These tablelands include the 'Breakaways' landform which occurs in several of the SAPEX PELs.

Some watercourses form major drainage systems featuring deep channels and occasional permanent waterholes (Neagle 2003). Wetlands occur throughout this bioregion with the Great Artesian Basin (GAB) springs being the most significant wetland feature.

The SAPEX PELs are a representative subset of the Stony Plains bioregion. They contain a variety of plains and tablelands interspersed with dunefields, hills and plateaus. Seven major landforms occur within the SAPEX PELs based on the landform groupings in DEH (2005):

- Stony plains
- Moon plains
- Breakaways and stony hills
- Dunefields and sand plains
- Drainage lines and flood plains
- Great Artesian Basin springs
- Salt lakes.

These are discussed further below and photographic examples are provided in Plate 3 to Plate 8.

Stony Plains

This landform is typified by gently sloping plains with a cover of small to large gibber stones. Gilgai are typically present, which are stone-free, often circular depressions with clay soils that receive much of the runoff from the adjacent gibber (Marree SCB 1997). Gibber stones are typically derived from silcrete, but in the Coongra land system the stone cover is comprised of sandstone and shale.

The surface stones generally form a stable pavement that protects the underlying soil from erosion. Grading or removal of the stone cover can result in significant erosion (Marree SCB 1997, Santos 2006).

Stony plains occur in the Oodnadatta, Baltana, Buckshot, Coongra, Lookout and Paisley land systems.

Note: The stony plains landform includes plains formed on elevated plateaus, which are often described as “tablelands” (e.g. in DEH (2005) and soil board plans). However, the term “tableland” has been avoided in the landform description to avoid confusion with the Cooper Basin drilling and well operations EIR and SEO, which use the term in a slightly different sense to describe dissected residuals or breakaways. Such landforms are classified in this EIR as “breakaways and stony hills”, consistent with DEH (2005).

Moon Plains

Plains with clay soils but without significant stone cover occur in the Moon Plain land system. The Moon Plain (located north-east of Coober Pedy) is an undulating plain with soft grey gypseous cracking clay soils and limited drainage.

Breakaways and Stony Hills

This landform includes dissected tablelands and other residual habitats forming mesas or tabletops with a capping of silcrete overlaying various shales (DEH 2005). It is typified by the steep escarpments and mesas of the Breakaway land system, but also includes the stony hills found in a number of land systems and the more rugged ranges such as the Mount Margaret land system.

Breakaways and stony hills occur in the Breakaway, Coongra, Lookout, Paisley (the Stuart Range) and Mount Margaret land systems, with limited occurrences in other land systems including Oodnadatta, Christie and Baltana.

Dunefields and Sand Plains

Dunefields and sand plains occur in limited areas, where they overly the gibber surface or surround rocky outcrops or hills (DEH 2005). Dune soils are typically deep red sands, while soils of plains and interdune swales range from sandy clays to calcareous and siliceous sands.

Land systems with dunefields and sandplains include a small area of Wattiwarriganna (with its extensive dunefields), Woolridge and Paisley (which contain some sand dunes) and Buckshot, Christie and Glendambo.

Drainage Lines and Flood Plains

This land form is typified by ephemeral watercourses, generally draining towards Lake Eyre. In places these form major drainage systems featuring broad flood plains. Large, braided creeks occur throughout the region (e.g. Neales and Arckaringa Creeks).

Drainage lines occur in most land systems; even the less well-drained land systems (such as Moon Plain) tend to be traversed by major drainage lines.

Great Artesian Basin Springs

These high conservation value wetlands are found on the margins of the Great Artesian Basin (GAB). They can take a wide variety of geological forms from large carbonate mounds to sandy seeps (DEH 2005). Typical spring structure includes a vent where it emerges from the ground, a tail which flows from the vent and terminates in the wetland around the base of the spring (if the flow is great enough) and saline spring margins surrounding the spring. GAB springs are discussed further in Section 4.3.1.

GAB Springs in the SAPEX PELs occur predominantly in the Wattiwarriganna and Oodnadatta land systems.

Salt lakes

Salt lakes and salt pans are formed when excess evaporation in interior basins leads to the concentration of soluble salts as a surface crust. Salt lakes occur in limited areas within the SAPEX PELs, including scattered occurrences in the Woolridge land system (in the far north of PEL117) and

in the Moon Plain land system. The largest salt lake in the area is Lake Cadibarrawirracanna (on the boundary of PEL122 & 123). Most other salt lakes in the PELs are relatively small.



Plate 3: Stony Plains (Oodnadatta land system)

(Source: Marla-Oodnadatta SCB 2002)



Plate 4: Moon Plains (Moon Plain land system)

(Source: Marla-Oodnadatta SCB 2002)



Plate 5: Breakaways and Stony Hills (Breakaways land system)

(Source: Marla-Oodnadatta SCB 2002)



Plate 6: Dunefields and Sand Plains (Wattiwarriganna land system)

(Source: Marla-Oodnadatta SCB 2002)



Plate 7: Drainage Lines and Flood Plains (in Oodnadatta land system)

(Source: RPS Ecos)



Plate 8: Great Artesian Basin Springs (in Oodnadatta land system)

(Source: RPS Ecos. Note: This spring, 'The Bubbler', is just outside the SAPEX PELs but is typical of a GAB spring with a tail.)

Flora

The following information has been taken from Brandle (1998), as cited in Neagle (2003).

The stony desert tablelands and gibber plains feature low open shrublands variously dominated by Saltbush (*Atriplex* spp.), Bluebush (*Maireana* spp.) or Samphire (*Sclerostegia medullosa*), short-lived Bindyi (*Sclerolaene* spp.), Thyme Sea-heath (*Frankenia serpyllifolia*) or Bonefruit (*Osteocarpum* spp.) Low Open Shrublands, and Barley Mitchell-grass (*Astrelba pectinata*) or Love-grass (*Eragrostis* spp.) Open Tussock Grasslands.

These plant associations are also present in the breakaways and rocky hills though often with the addition of medium shrubs, such as Wattle (*Acacia* spp.), Emubush (*Eremophila* spp.) and occasionally Silver Needlewood (*Hakea leucoptera* ssp. *leucoptera*). Also present is Mulga (*Acacia aneura* var. *aneura*) Low Woodland, as well as Beaked Red Mallee (*Eucalyptus socialis*).

Drainage channels in the upper catchments tend to have a denser version of the vegetation of the surrounding hills and breakaways with low woodlands of Wattle including Gidgee (*Acacia cambagei*), Coolibah (*Eucalyptus coolabah* ssp. *arida*) and possibly Northern River Red Gum (*E. camaldulensis* var. *obtusa*).

Floodplains and swamps are a mix of low open shrublands variously dominated by Old-man Saltbush (*Atriplex nummularia* var. *nummularia*), Lignum (*Muehlenbeckia florulenta*), Cottonbush (*Maireana aphylla*) or Samphires, as well as Cane-grass (*Eragrostis australasica*) Tussock Grasslands in swamps, and Mitchell-grass, Love-grass or Bindyi Open Tussock Grasslands. Salt pans are usually bare and salt crusted but often have a halo of Cane-grass Tussock Grassland or Grey Samphire (*Halosarcia halocnemoides*), Slender Samphire (*Sclerostegia tenuis*) Low Open Shrubland.

Where dunefields and sand plains overlay gibber surfaces several other plant associations are prominent. Sandhill Cane-grass (*Zygochloa paradoxa*) Open Hummock Grassland dominates deep sands, especially on dunes, but Umbrella Bush (*Acacia ligulata*) Tall Shrublands and Mulga Tall Shrublands are also common. Sand plains support Nitre-bush (*Nitraria billardierei*) Low Open Shrublands or Sturt's Pigface (*Gunniopsis quadrifida*), Bladder Saltbush (*Atriplex vesicaria*) Low Open Shrublands. Small areas of calcareous loams and clays in the western Lake Eyre Basin support Low Bluebush (*Maireana astrotricha*), Bladder Saltbush, Twinleaf (*Zygophyllum* spp.) and/or Balcarra Spear-grass (*Austrostipa nitida*) Low Open Shrublands.

The Moon Plain has very little plant cover in most years, with only a few perennial species present. Mitchell grasses (*Astrelba* spp.) and Neverfail (*Eragrostis setifolia*) are two of the few perennial

grasses found on the Plain, together with Annual Saltbush (*Atriplex muelleri*) and Pop Saltbush (*Atriplex spongiosa/holocarpa*), Mulka Grass (*Eragrostis dielsii* var. *dielsii*), Poverty-bushes (*Sclerolaena* spp.) and Buckbush (*Salsola kali*). Several species of Samphire (*Halosarcia* spp.) are common in the drainage lines, along with Prickly Wattle (*Acacia victoriae* ssp. *victoriae*) Old-man Saltbush (*Atriplex nummularia* ssp. *nummularia*), Lignum (*Muehlenbeckia florulenta*), Swamp Canegrass (*Eragrostis australasica*) and a few stunted Coolibahs (*Eucalyptus coolabah* ssp. *arida*) (Marla-Oodnadatta SCB 2002).

The Stony Plains bioregion supports 13 endemic plant species, including Barkers Mulla Mulla (*Ptilotus barkeri*), Johnston's Slipper Plant (*Embadium johnstonii*), Gypsum Groundsel (*Othonna gypsicola*) and Haegi's Stemodia (*Stemodia haegii*) and provides a habitat for 5 nationally threatened species including Salt Pipewort (*Eriocaulon carsonii*) and Sea-heath (*Frankenia plicata*) (Neagle 2003). Many of these species have been recorded, or may occur, in the SAPEX PELs.

One threatened ecological community listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* is present in the region – "The community of native species dependent on natural discharge of groundwater from the Great Artesian Basin". These communities are associated with the GAB spring wetlands that occur in the region along the margins of the GAB.

Four declared plant species (declared weeds) have been recorded on DEH databases as occurring in the region: African Boxthorn (*Lycium ferocissimum* – PEL121), Caltrop (*Tribulus terrestris* – PEL117, 118, 122, 124), Bathurst Burr (*Xanthium spinosum* – PEL117) and African Rue (*Peganum harmala* – PEL119). Buffel Grass (*Cenchrus ciliaris*) is also prevalent along the Stuart Highway (DTEI, 2007).

Significant Fauna

The diversity of habitats within the Stony Plains bioregion has led to the occurrence of a wide variety and number of species in the region. Over one hundred and fifty bird species and thirty mammal species have been recorded at biological survey sites (Brandle 1998). More than 100 species of reptile have been recorded in the region including 4 endemic species – the Gibber Dragon (*Ctenophorous gibba*), Ochre Dragon (*C. tjantjalka*), Bronze-back Legless-lizard (*Ophidiocephalus taeniatus*) and Woomera Slider (*Lerista elongata*).

The bioregion also supports 8 nationally threatened species and provides primary habitat for the Thick-billed Grasswren (*Amytornis textillis modestus*), Plains Rat (*Pseudomys australis*) and the Bronze-back Legless-lizard (Neagle 2003).

Rare or threatened flora and fauna species that have been recorded in the SAPEX PELs are listed in Appendix 2.

4.2.2 Simpson-Strzelecki Dunefields

The Simpson-Strzelecki Dunefields bioregion covers an area of 277,876km² and extends across South Australia and the Northern Territory with some overlap into Queensland and New South Wales. The SAPEX PELs lie to the west of the bulk of this bioregion and intersect an outlying tongue that constitutes its western-most extent. Approximately 12% of the area of the SAPEX Arckaringa Basin PELs occurs within this bioregion.

The portion of the Simpson-Strzelecki Dunefields bioregion covered by the SAPEX PELs is comprised of the Wattiwarriganna land system. A full description of this land system is provided in Appendix 1.

Geology, Soils & Landform

The Simpson-Strzelecki Dunefields are characterised by the vast aeolian sand dune systems of the Simpson and Strzelecki Deserts. They contain arid dunefields and sandplains with sparse shrubland and spinifex hummock grassland, and cane grass on deep sands along dune crests (DEWR 2007). In places they are interrupted by large clay pans that grade into a large playa complex of salt lakes and gypsum dunes. The main lakes in this system are located outside the Arckaringa Basin to the east and include Lake Eyre and a chain of interconnected lakes in the south-east.

Throughout the bioregion, the dune systems are generally orientated on a north-north-west to south-south-east longitudinal plane. The orientation varies across the SAPEX PELs and the longitudinal orientation of dunes is east-north-east – west-south-west in the southern part of the bioregion and north-north-east – south-south-west in the northern part.

The bioregion also includes the lower reaches of two of Australia's major inland river systems, Warburton and Cooper Creeks and three wetlands of national significance, Lake Eyre, Inland Salt Lakes and the Strzelecki Creek (Neagle 2003). However all of these features are located in the eastern portion of the bioregion, outside the area covered by the Arckaringa Basin.

The Wattiwarriganna land system (which is the only Simpson-Strzelecki Dunefields land system in the SAPEX PELs) is comprised of an extensive dune field of long parallel dunes and broad inter-dunal corridors which include sandy flats and claypans. Numerous large watercourses dissect the land system and there are several mound springs present. Soils in the region range from deep red sandy soils on the dunes to sandy-clay soils in the swales (Marla-Oodnadatta SCB 2002).

The main types of landforms encountered in the bioregion include:

- Dunefields and sand plains
- Salt lakes
- GAB springs.

Flora

Vegetation of the dunes is dominated by a hummock grassland of Sandhill Canegrass (*Zygochloa paradoxa*) or a tall shrubland of Horse Mulga (*Acacia ramulosa*). Umbrella Bush (*A. ligulata*) occurs in isolated stands and Narrow-leaved Hopbush (*Dodonaea viscosa ssp. angustissima*) is also moderately common. Few understorey species grow under or near these two shrubs. Silver Needlebush (*Hakea leucoptera ssp. leucoptera*) also occurs as scattered plants and mulga occurs on some dune footslopes. The understorey includes Tall Kerosene Grass (*Aristida holathera*), Buckbush (*Salsola kali*) and Cattle Bush (*Trichodesma zeylanicum*) (Marla-Oodnadatta SCB 2002).

Interdune corridors include both sandy flats and claypans. Sandy flats support low shrublands of Sturts pigface (*Gunniopsis quadrifida*), Cottonbush (*Maireana aphylla*), Low Bluebush (*Maireana astrotricha*), Bladder Saltbush (*Atriplex vesicaria*), Emubushes (*Eremophila* sp.), Sennas (*Senna* sp.) and Neverfail (*Eragrostis setifolia*), with Mulga grass (*Aristida contorta*) dominant in the understorey. Some claypans support Swamp Canegrass (*Eragrostis australasica*), Old Man Saltbush (*Atriplex nummularia ssp. nummularia*), Cottonbush, Neverfail and Lignum (*Muehlenbeckia florulenta*). Blue rod (*Stemodia florulenta*) is common at claypan margins (Marla-Oodnadatta SCB 2002).

Larger watercourses are usually lined with Coolibah (*Eucalyptus intertexta*), with Sandhill Wattle, Old Man Saltbush, Cottonbush, Sennas, Samphire (*Halosarcia* sp.), Neverfail, Cupgrasses (*Eriochloa* sp.), Silky Browntop (*Eulalia aurea*) and Swamp Canegrass all present in the understorey (Marla-Oodnadatta SCB 2002).

GAB springs support their characteristic vegetation including Common Reed (*Phragmites australis*), Bore-drain Sedge (*Cyperus laevigatus*), Cutting Grass (*Ghania trifida*), Bare Twig Rush (*Baumea juncea*), Sea Rush (*Juncus kraussii*) and Salt Couch (*Sporobolus virginicus*) (Marla-Oodnadatta SCB 2002).

Two proclaimed (weed) plant species have been recorded on DEH databases as occurring in the region: African Boxthorn (*Lycium ferocissimum* – PEL121) and Caltrop (*Tribulus terrestris* – PEL122).

Significant Fauna

Six nationally threatened fauna species have been recorded in the extensive dunefields of this bioregion including Amperta (*Dasycercus cristicaudata hillieri*), Dusky Hopping-mouse (*Notomys fuscus*), Plains Rat (*Pseudomys australis*) and Thick-billed Grasswren (eastern) (*Amytornis textilis modestus*) (Neagle 2003). The latter two species have been recorded within the SAPEX PELs but are usually associated with Stony Plains habitats. The Amperta and Dusky Hopping-mouse occur in the

eastern part of the bioregion and have not been recorded (and are not likely to occur) in the SAPEX PELs.

Rare or threatened flora and fauna species that have been recorded in the SAPEX PELs are listed in Appendix 2.

4.2.3 Great Victoria Desert

The Great Victoria Desert bioregion covers an area of 423,751km² and extends across South Australia and Western Australia. The SAPEX PELs occur at the eastern edge of this bioregion. Approximately 14% of the area of the SAPEX PELs falls within this bioregion.

The Great Victoria Desert is comprised of an old erosional surface on a variety of mostly Archaean rocks, veneered with aeolian sand. It rises from an elevation of about 200 metres above sea level in the south to 700 metres in the north and is characterised by longitudinal dunes that average about 20 m in height and over 100 m in length (CFW 2007).

The land systems present in the area of the Great Victoria Desert bioregion covered by the SAPEX PELs are Mt Willoughby and Tallaringa. A full description of each of these land systems is provided in Appendix 1.

Geology, Soils & Landform

The Great Victoria Desert is characterised by an arid active sand-ridge desert of deep Quaternary aeolian sands overlying Permian and Mesozoic strata of the Officer Basin (DEWR 2007).

The main types of land forms encountered in the region, which occur in both the land systems, are:

- dunefields and sand plains
- drainage lines and floodplains (which are relatively limited in extent).

The Tallaringa land system is comprised of parallel east-west dunes overlying an extensive laterite flat plain with some relief provided by relict ironstone outcrops. The dunes are comprised of red siliceous sands and the plains and silcrete rises are comprised of stony siliceous sands (Kingoonya SCB 1996).

The Mount Willoughby land system is characterised by red pebbly clay plains with occasional low irregular sand dunes. The hard flats contain numerous small swamps or depressions. The drainage systems of the dunes and interdune flats feed into larger swamps such as Wintinna Swamp (Kingoonya SCB 1996).

Flora

The flats and the sandy soils of the dunes and swales are dominated by Mulga (*Acacia aneura* var. *aneura*) Woodland, with Narrow-leaved Hopbush (*Dodonaea viscosa* ssp. *angustissima*) and Emu-bushes (*Eremophila* spp.) and an understorey of Bandicoot Grass (*Monachather paradoxo*) and Kerosene or Mulga grasses (*Aristida* spp.). Neverfail (*Eragrostis setifolia*) and Mulga Grass (*Aristida contorta*) dominant in the understorey of the interdune areas and Woollybutt (*Eragrostis eriopoda*), Woollybutt Wanderrie (*Eriachne helmsii*) and Tall Kerosene Grass (*Aristida holathera*) form the main ground cover on dunes (Marla-Oodnadatta SCB 2002).

The hard flats support sparse to open Mulga, with Rock Emu-bush (*Eremophila freelingii*) also common. The sparser areas support the occasional Tar Bush (*E. neglecta*). These flats contain numerous small swamps or depressions which support dense Mulga Woodland, with Emu-bushes, Sennas (*Senna* spp.), chenopod shrubs and subshrubs. Perennial grasses such as Needle-leaved Threeawn (*Aristida capillifolia*), Cotton Grass (*Digitaria brownie*) and Neverfail and annual grasses such as Mulga Grass and Spear Grass (*Austrostipa* spp.) are also common. After rains the harder flats grow an abundance of Mulga Grass and annuals such as Round-leaf Parakeelya (*Calandrinia remota*) and various everlastings (Marla-Oodnadatta SCB 2002).

Stony siliceous sands of silcrete/calcrete rises and plains are dominated by shrublands of Green Turkey-bush (*Eremophila gilesii*), Crimson Emu-bush (*E. latrobei* ssp. *glabra*) and Green Emu-bush

(*E. serrulata*) with an understorey including Woollybutt Wanderrie, Lovegrasses (*Eragrostis* spp.) and Mulga Grass (Kingoonya SCB 1996).

Drainage systems are predominantly Mulga-lined and support an understorey of Cottonbush (*Maireana aphylla*), Neverfail and Swamp Canegrass (*Eragrostis australasica*) (Marla-Oodnadatta SCB 2002).

Two proclaimed (weed) plant species have been recorded on DEH databases as occurring in the region: African Boxthorn (*Lycium ferocissimum* – PEL121), Caltrop (*Tribulus terrestris* – PEL118). Buffel Grass (*Cenchrus ciliaris*) is also prevalent along the Stuart Highway (DTEI 2007).

Significant Fauna

The South Australian portion of the Great Victoria Desert bioregion supports a number of endemic species including the dragon *Diporiphora lina* which is endemic to the eastern portion of the bioregion (Morton *et al.* 1995). The Malleefowl (*Leipoa ocellata*) is sparsely distributed throughout the South Australian portion of the bioregion and the bioregion is also considered to be the centre of distribution of the Scarlet-chested Parrot (*Neophema splendida*) (Morton *et al.* 1995). None of these species have been recorded within the SAPEX PELs on DEH databases and are more likely to occur further to the south, however it is noted that limited systematic biological survey work has been completed in this area.

The bioregion supports several reptile species with limited distributions, including the skinks *Lerista elongata* and *L. puncticauda* which occur only in the bioregion and Fraser's Snake Lizard *Delma fraseri*, the eastern population of which be considered restricted (Morton *et al.* 1995).

Rare or threatened flora and fauna species that have been recorded in the SAPEX PELs are listed in Appendix 2.

4.2.4 Gawler

The Gawler bioregion covers an area of 60,308km² in South Australia. The SAPEX PELs (PEL119 and 124) intersect this bioregion at its north-western extent and it lies predominantly south of the PELs. Approximately 14% of the area of the SAPEX Arckaringa Basin PELs occurs within this bioregion.

The Gawler bioregion is characterised by several semi-arid to arid landscapes. In the south of the bioregion (to the south of the SAPEX PELs) there are gently undulating calcrete plains with occasional quartzite or granite hills, a zone of saltlakes and gypsum dunes and the Middleback Ranges. These grade into the Gawler Ranges. At their northern margin is an undulating upland plain with shallow loamy soils underlain by quartzite and sandstone that includes the saltlakes of Lake Torrens, Lake Gairder and Everard (Neagle 2003). Undulating calcareous plains extend across the north of the region, becoming sandier with occasional dunes in the north west (Neagle 2003).

The land systems present in the Gawler bioregion covered by the SAPEX PELs include: Carringallana, Christie, Commonwealth, Dingo, Gina, Glendambo, Indooroopilly, Labyrinth, Mailgate and Phillipson. A full description of each of these land systems is provided in Appendix 1.

Geology, Soils & Landform

The Gawler bioregion is generally described as being comprised of flat-topped to broadly rounded hills of the Gawler Range Volcanics and Proterozoic sediments and depositional plains with salt-encrusted lake beds, with shallow loams, calcareous earths and hard red duplex soils (DEWR 2007).

The bioregion covers an area comprised of a wide variety of rocks with different ages and characteristics. The topography is mainly subdued, there being only a limited number of prominent hills and low ranges. This reflects the dominance of relatively young, flat-lying sediments which have not been subjected to major earth movements or uplift (Kingoonya SCB 2002).

The Christie land system is widespread across the region (including the portion within the SAPEX PELs) and offers some relief from the plains. This system is comprised of ancient silcrete rises that have been formed from granitic and gneissic rocks as well as quartz bedrock and silcrete. The silcrete is often present on hilltops (Kingoonya SCB 2002).

The land systems present in the SAPEX PELs occur in a complex mosaic. The main types of land forms encountered in the region include:

- Stony hills
- Dunefields and sand plains
- Drainage lines and flood plains
- Salt lakes.

Stony hills occur in the Christie land system which is an ancient system formed from granitic and gneissic rocks as well as quartz bedrock with silcrete often present on hilltops. Low stony silcrete rises occur in the Mailgate land system.

Dunefields and sand plains are reasonably widespread throughout this part of the bioregion and include the Indooroopilly, Labyrinth, Mailgate, Phillipson dunefield land systems and the Caringallana, Commonwealth, Gina and Glendambo sand plain land systems. Sand plains typically have siliceous sands, sandy red earths or calcareous sandy loams while dune sands are siliceous or calcareous, with gypsiferous dunes bordering salt lakes (e.g. in the Labyrinth and Phillipson land systems).

Drainage lines and floodplains are relatively limited in extent in the areas intersected by the SAPEX PELs, but occur in some land systems such as Caringallana, Commonwealth and Christie. The Dingo land system is a drainage area on alluvial sands and silts around low hills and rises where well-defined watercourses are generally lacking and those that are present do not always go far enough to flow into swamps.

Salt lakes occur predominantly in the Labyrinth and Phillipson land systems. Larger lakes and claypans are either at the end of drainage lines from the Stuart Range, or are a linear series of depressions in ancient river channels that are remnants of a much wetter period than the present.

Flora

The sand plains with occasional dunes in the north-west of this bioregion support Mulga (*Acacia aneura*) Low Open Woodlands and possibly Horse Mulga (*A. ramulosa*) Low Open Woodlands. The swales support a Mulga Low Woodland with Black Oak (*Casuarina pauper*), Bullock Bush (*Alectryon oleifolius*) and Tar Bush (*Eremophila* spp.) and an understorey dominated by grasses with Woollybutt (*Eragrostis eriopoda*), Bandicoot Grass (*Monachather paradoxa*) and Mulga Grass (*Aristida contorta*) being the most common species (Marla-Oodnadatta SCB 2002).

The saline siliceous and gypsiferous sands of dunes or the sand-covered limestone shelves fringing lakes are dominated by Black Oak and Mulga and Horse Mulga woodlands, with Narrow-leaved Hopbush (*Dodonaea viscosa* ssp. *angustissima*) and Boree Tea-tree (*Melaleuca pauperiflora*) are also common. The understorey is often of Bladder Saltbush (*Atriplex vesicaria*) and Kerosene (*Aristida contorta*) or Mulga Grass. Tea-tree (*Melaleuca* spp.), with a common understorey of Neverfail (*Eragrostis setifolia*) often occur on flood-prone swales. Coolibah (*Eucalyptus coolabah* ssp. *coolabah*) woodland occurs in northern parts of the Bioregion on the Ingomar and Mount Penrhyn pastoral leases (Kingoonya SCB 2002).

The calcareous plains north of Lake Gairdner are dominated by Western Myall (*A. papyrocarpa*) Low Open Woodlands and Bluebush (*Maireana sedifolia*), Bladder Saltbush Low Open Shrublands (Kingoonya SCB 2002).

The undulating tablelands west of Lake Eyre support Bladder Saltbush and Low Bluebush (*Maireana astrotricha*) Low Open Shrublands in a mosaic with variable ephemeral communities of Bindyi (*Sclerolaena* spp.) or Love-grass (*Eragrostis* spp.) Low Open Shrublands/Open Tussock Grasslands (Brandle 1998 as cited in Neagle 2003).

Vegetation on low stony rises and slopes is dominated by either Mulga scrub or Bladder Saltbush-Low Bluebush (*Maireana astrotricha*) Low Shrubland, depending on the underlying soils. Shallow stony sandy soils of silcrete rises support Mulga Woodlands with Emu-bushes (*Eremophila* spp) and Cassias (*Senna* spp.), while chenopod shrubs dominate where the sand is deeper or where calcrete or lime are present (Kingoonya SCB 2002).

Chenopod low shrublands dominate the saline alluvial sands and clays at the margins of claypans and salt lakes. These shrublands commonly include Cottonbush (*M. aphylla*), Black Bluebush (*Maireana pyramidata*), Bladder Saltbush, Lignum (*Muehlenbeckia florulenta*), Nitre Goosefoot (*Chenopodium nitriaceum*) and Swamp Canegrass (*Eragrostis australasica*), with an ephemeral herb understorey Kingoonya SCB 2002). Salt tolerant species such as Samphires (*Halosarcia* spp.) and Glassworts (*Sclerostegia* spp.) are also common and often with an understorey of Mulka Grass (*Eragrostis dielsii* var. *dielsii*) (Marla-Oodnadatta SCB 2002).

Drainage areas around low hills and rises are often dominated by chenopod Low Shrublands. Sugarwood (*Myoporum platycarpum*) Open Woodland occurs on the alluvial sands of some watercourses, often in association with Cassias (*Senna* spp.) and Australian boxthorn (*Lycium australe*), with Satiny Bluebush (*Maireana georgei*), Bindyis and Mulga Grass in the understorey. Other watercourses with firmer alluvial sandy soils are dominated by Mulga Woodland, Tall Shrublands of Cassias and Dead Finish (*Acacia tetragonophylla*) and an understorey of Bindyis. The firm alluvial sands of flood plains often support Mulga Woodlands with chenopod Low Shrubland understorey featuring Bladder Saltbush, Cottonbush and Bindyis.

The well-defined watercourses to the west of the Stuart Range on Ingomar Station are generally tree-lined, with Coolibah, Boree Tea-tree, Umbrella bush (*Acacia ligulata*), Dead Finish and Narrow-leaved Hopbush common in the overstorey, and Sturt's Pigface (*Gunniopsis quadrifida*), Cottonbush and Goathead burr (*Sclerolaena bicornis*) dominating the understorey.

One proclaimed (weed) plant species has been recorded on DEH databases as occurring in the region: Caltrop (*Tribulus terrestris* – PEL124). Buffel Grass (*Cenchrus ciliaris*) is also prevalent along the Stuart Highway (DTEI 2007).

Significant Fauna

The Gawler bioregion provides a habitat for two endemic fauna species, the Pernatty Knob-tailed Gecko (*Nephrurus deleani*) (which is restricted to an area that lies outside the SAPEX PELs) and the Thick-billed Grasswren (*Amytornis textillis modestus*). Fourteen nationally threatened fauna species have also been recorded in the bioregion including the Slender-billed Thornbill (*Acanthiza iredalei iredalei*) and Malleefowl (*Leipoa ocellata*) (Neagle 2003).

Rare or threatened flora and fauna species that have been recorded in the SAPEX PELs are listed in Appendix 2.

4.3 Water Resources

Surface water features in the region include rivers, creeks, associated flood plains, salt lakes, internally draining dunefield clay pans and Great Artesian Basin (GAB) springs. The majority of the major rivers in the north of the region drain into Lake Eyre, while rivers and creeks in the southern portion terminate in salt lakes or clay pans.

Surface water in the region is generally ephemeral and is only present following localised rainfall. Several of the rivers and creeks in the region, including the Neales River, Arckaringa Creek, Peake Creek and Margaret Creek, contain semi-permanent and permanent waterholes (DEH 2005). Water in these waterholes may persist for six months or more, some lasting over 12 months (Marla-Oodnadatta SCB 2002).

Permanent surface water can be found at points where artesian water flows to the surface, such as pastoral bores or the GAB springs.

4.3.1 GAB Springs

The most north-easterly portion of the area of the PELs overlies the western edge of the Great Artesian Basin (GAB) and is within the South Australian groundwater provinces of the Lake Eyre Basin and the Eromanga Basin (DWLBC 2006). The GAB aquifer outcrops at the surface to the west of Coober Pedy and deepens in a north-easterly direction to around 250m at Lake Eyre (Marla-Oodnadatta SCB 2002). Vertical leakage from the GAB occurs via a series of springs (known as GAB springs or mound springs) which appear around the southern and south-western margins of the basin (Armstrong 1990).

GAB springs have been described as “oases in the desert” and are foci for plant, animal and human life. They have very high biological and cultural significance (Boyd 1990). They support unique flora and fauna, some of which is endemic to the springs and is considered threatened on a national level. As indicated in Section 4.2.1, the ecological community associated with GAB springs is protected under the *Environment Protection and Biodiversity Conservation Act 1999*. Many of the springs are significant Aboriginal places with abundant archaeological material (Boyd 1990).

GAB spring structure is highly variable, but typically includes a vent where it emerges from the ground, a tail which flows from the vent and terminates in the wetland around the base of the spring (if the flow is great enough) and saline spring margins surrounding the spring (DEH 2005). Mounds can develop at the spring vent by the deposition of carbonate or trapping of windblown material by spring vegetation (Marree SCB 1997).

There are a number of GAB springs present in the eastern portion of PEL121, PEL 123 and PEL124, many of which have been identified as features of high biological and cultural significance.

4.4 Hydrogeology

Priddle (1983) provides a review of the hydrogeology of the Arckaringa Basin, from which the following information has been taken.

The Jurassic and Cretaceous sediments of the Great Artesian Basin, which overlie the Permian rocks of the Arckaringa Basin, form the main aquifers. Limited work has been undertaken on Permian aquifers.

The Upper Jurassic Algebuckina Sandstone forms the main artesian aquifer and has been extensively developed for pastoral usage. It is mainly comprised of a fine to coarse grained sandstone. It thickens from the subcrop, in a northeasterly direction across the Great Artesian basin. This confined aquifer is artesian only in the eastern portion of the Arckaringa basin.

Individual wells in the artesian zone may produce in excess of 4.3 ML/day. Water temperatures up to 99°C have been recorded in wells (Shepherd, 1978).

In some areas the overlying Cretaceous Cadna-owie Formation is of sufficient thickness and areal extent to be hydrologically significant. Since no continuous aquifer is known in the Cretaceous it is likely that sandy horizons in this formation are isolated lenses. The Cadna-owie Formation is hydraulically connected to the Algebuckina Sandstone.

The overlying marine Bulldog Shale provides a confining bed for both the Cadna-owie Formation and Algebuckina Sandstone.

Sands of the Cadna-owie Formation and Algebuckina Sandstone form an unconfined aquifer to the west of the limits of the confined aquifer. It is not known if this aquifer is artesian or non-artesian. In places this unconfined aquifer is overlain by relatively permeable white, siliceous, clay shale enabling direct percolation of fresh water into the sands. Highly saline water occurs in places of ineffective intake where downward percolation of fresh water can not reach the groundwaters contained in either the unconfined or confined aquifers. Examples of the latter situation occur in the Coober Pedy area.

The direction of water movement in the Great Artesian basin is mainly southwesterly from Queensland and New South Wales. Only a small amount of intake occurs along the western margin i.e. the central western Arckaringa Basin area. Intake from this margin would affect recharge in the Arckaringa Basin.

Water Quality of GAB

Although the quality of water in the main GAB aquifer is uniform over wide areas northeast of the Arckaringa Basin, the water quality generally deteriorates in a southwesterly direction across the basin. The salinity increases from 1,500-3,000 mg/L on the eastern margin to 7,000-12,000 mg/L in the central basin area. Farther west the salinities are in excess of 12,000 mg/L, which is too saline for most stock.

Salinities in the southeastern areas north of Kingoonya are less than 12,000 mg/L, reflecting some local intake where the Cretaceous shale is absent and regional isolation from the main pressure basin occurs.

Quality of the water is dependent upon the relative concentrations of ions. A higher bicarbonate content in the eastern part of the basin provides soft water. Higher sulphate contents of western waters makes them highly corrosive.

Water Quality in Permian Aquifers

Quantitative information on Permian aquifers is available for the Lake Phillipson region, in the south-west of the basin. Three interconnecting aquifers have been defined in the coal bearing horizons of the Mount Toondina Formation. The total dissolved solids in these aquifers, in addition to the overlying Jurassic aquifer, range from 100,000 to 150,000 mg/L.

Dissolved solids in this general region range from 7,000-14,000 mg/L. The Lake Phillipson area appears to correspond with an isolated area which has values in excess of 14,000 mg/L (Shepherd, 1978). This may possibly be attributed to an ineffective intake area where "flushing" of the sediments with freshwater is limited.

Quantitative information on water quality and Permian aquifers in the northern and eastern parts of the basin is limited. Total dissolved solids in the Jurassic and Mesozoic sediments generally range from 3,000-7,000 mg/L. An area south of Mt. Willoughby has values of 1,000-3,000 mg/L. Water analyses from Mt Toondina No. 2 stratigraphic bore indicated total dissolved salts of 2,125 mg/L, 1,247 mg/L of which was assumed to be sodium chloride.

Total dissolved salts in the central Boorthanna trough region generally range from 2,000 to 7,000 mg/L values. An area of high salinities (11,000 mg/L) occurs west of Edwards Creek. Low salinity water occurs at shallow depth at Nilpinna Homestead.

Ash analyses of the coal in the Wintinna region (in the north-west of the Arckaringa Basin) reveal lower sodium values than found in the Lake Phillipson area. In this area 'flushing' of the sediments appears to have taken place, possibly due to the proximity of the western intake areas. The presence of massive channel sands in the Permian sequence suggests hydraulic connection to the overlying Algebuckina Sandstone.

4.5 Heritage

A search of the National and State heritage registers has indicated that a number of heritage sites occur within the SAPEX PELs. A summary of these sites is provided in Table 5. Further information on these sites is provided in the sections following the table.

Table 5: Registered heritage sites in the Arckaringa Basin region

Register Source	Site Type	Name	Location
Register of the National Estate (RNE)	Indigenous	The Breakaways Reserve	PEL118, PEL122
RNE	Indigenous	Lake Philipson Area	PEL119
RNE	Indigenous	Ngampayiwahuku	PEL121
RNE	Historic	Stony Creek Rail Bridge	5.5km SSE of Oodnadatta PEL117
RNE, State Heritage Register (SHR)	Historic	Oodnadatta Museum (formerly Railway Station & Station Masters Residence)	Oodnadatta township PEL117
RNE, SHR	Historic	Strangways Springs Site	PEL123
RNE, SHR	Historic	The Peake Ruins	PEL121
RNE, SHR	Historic	Underground Houses & Church (Coober Pedy Catholic Church)	Coober Pedy township PEL118, PEL119
SHR	Historic	Three-roomed dugout (Henryk's Old Dugout)	Coober Pedy township PEL118, PEL119
SHR	Historic	Marree to Alice Springs Railway	Extends from Marree to Oodnadatta PEL117, PEL121, PEL122, PEL123
RNE	Natural	<i>Swainsona minutiflora</i> -Coorikanna Site	PEL117
RNE	Natural	Big Cadna-owie Spring	PEL121
RNE	Natural	Moon Plains	PEL118, PEL122, PEL123
RNE	Natural	<i>Hemichroa mesembryanthena</i> Site	PEL123
RNE	Natural	Billa Kalina Spring	PEL123
RNE SHR	Natural	Arckaringa Hills State Heritage Area	PEL117, EL325
Dept of Transport, Energy and Infrastructure Roadside Significant Site Database (RSSD)	Rare Flora	<i>Embadium johnstonii</i>	Oodnadatta – Coober Pedy Road PEL117
DTEI RSSD	Rare Flora	<i>Embadium johnstonii</i>	Cadney Park – Oodnadatta Road PEL117
DTEI RSSD	Indigenous Heritage	Stone working sites	Coober Pedy – William Creek Road PEL123
DTEI RSSD	Indigenous Heritage	Artefact scatter	Coober Pedy – William Creek Road PEL123

4.5.1 Indigenous Heritage

There are a number of indigenous heritage sites located throughout the Arckaringa Basin. Many of these sites are of cultural significance and reflect Aboriginal occupation of the region. The more prominent sites include The Breakaways formation to the north of Coober Pedy and the Lake

Phillipson area to the south-west of Coober Pedy. Many of the GAB Springs in the region are also an important component of Aboriginal culture. Much of the history of Aboriginal occupation of the land is also evident throughout the landscape in the form of middens, quarries, worksites, campsites and burial sites.

The Mount Willoughby Indigenous Protected Area (discussed in Section 4.6.3), falls within the SAPEX PELs and has a number of identified sites of importance to Aboriginal cultural heritage which are being recorded and preserved. The Pitjantjatjara and Maralinga Tjarutja Aboriginal Lands are located along the western and south-western edges of the region, outside the PELs.

4.5.2 Historical Heritage

Non-indigenous heritage in the region dates back to early exploration of the region in the mid to late 1800's and the expansion of pastoralism. The GAB springs along the south-west margin of the Great Artesian Basin were influential in this expansion, particularly in providing access to permanent water. The overland telegraph line and the Marree to Alice Springs railway line also passed through region of the GAB springs. Other heritage sites in the region are associated with early mineral exploration and the discovery of opal in Coober Pedy in the Stuart Ranges in 1915.

Many of the historical heritage sites in the region are associated with the exploration and development of the region by Europeans in the past 160 years. Prominent historical heritage includes the 'Old Ghan' or Marree to Alice Springs Railway and associated settlements, settlements associated with the Overland Telegraph Line (e.g. Strangways Spring site, The Peake Group), and settlements associated with early pastoral expansion and mining developments (e.g. housing in Coober Pedy, The Peake Group).

4.5.3 Natural Heritage

Natural heritage sites in the region (identified in Table 5) include the geologically significant Arckaringa Hills (130 km north of Coober Pedy), the Moon Plains (10 km north-east of Coober Pedy) which supports a high diversity of rare species, a number of GAB Spring complexes along the western edge of the Great Artesian Basin (e.g. Big Cadna-owie Spring and Billa Kalina Spring) which provide important habitat for a number of indigenous plant and animal species, and sites providing habitat for listed rare flora (e.g. *Swainsona minutiflora*, *Hemichroa mesembryanthena* sites).

4.6 Land Use

The current land uses in the project area include pastoralism, mining, conservation, tourism and defence.

4.6.1 Pastoralism

The main land use in the Arckaringa Basin is pastoralism, with sheep and cattle grazing having been carried out over the past century. Cattle are grazed throughout the north of the region on large pastoral leases, while sheep are restricted to leases south of the Dog Fence, which crosses the SAPEX PELs north and east of Coober Pedy. A limited number of properties are certified for organic production.

Pastoral leases in the PELs include:

- Lambina
- Welbourn Hill
- Todmorden
- Wintinna
- Evelyn Downs
- Arckaringa (including Coorikiana)
- Allandale (including Toondina, Toondina East)
- Mount Willoughby
- Mount Barry
- Nilpinna
- Anna Creek (including The Peak)

- Mabel Creek
- Mount Clarence
- Commonwealth Hill (including Mobella, Pt Commonwealth Hill, Pt McDouall Creek, Pt Mulgathing, Pt Woorong Downs)
- Bulgunnia
- Ingomar (including Lake Wirrida)
- Mount Penrhyn
- McDouall Peak (including Belta Beltana South)
- Billa Kalina
- Millers Creek
- Stuarts Creek
- Mt Eba
- Bon Bon
- Wilgena (including North Well).

4.6.2 Mining

Currently the most significant mining activities in the Arckaringa Basin are opal mining at Coober Pedy and the Prominent Hill mining operation, which has recently been established 130 km south east of Coober Pedy.

Petroleum and mineral exploration also occurs across the region. Of particular note is the Arckaringa Coal Project (operated by Altona Resources) which has commenced an exploration program north of Coober Pedy in the Arckaringa Basin. This project aims to develop Arckaringa Basin coal resources to provide suitable coal feed stock for the gasification and subsequent production of synthetic fuels.

4.6.3 Conservation

The region has two areas formally designated for conservation:

- Tallaringa Conservation Park
- Mount Willoughby Indigenous Protected Area.

Tallaringa Conservation Park is 1,246,000 ha in area. It was proclaimed under the South Australian *National Parks and Wildlife Act 1972* in 1991 and is managed by the Department for Environment and Heritage. It is located 100 km due west of Coober Pedy, on the fringe of the Great Victoria Desert, and contains a vast wilderness of vegetated dunes and gibber rises (DEH 2007). The park supports a variety of important species that have adapted to live in the dry arid area, including a Mulga woodland, found to be different from others already conserved because of the absence of Porcupine Grass (*Triodia*) from the understorey. This was a major consideration when this area was recommended for conservation (SATC 2007). Mining and/or petroleum exploration activities are permitted in this park.

The Mount Willoughby Indigenous Protected Area (IPA) was declared in 2002. It is 386,500 ha in area and is located approximately 30 km north of Coober Pedy (DEWR 2007a). It shares a boundary with Tallaringa Conservation Park to the west. The area was developed for the protection of cultural and biodiversity values. The lease was purchased on behalf of Tjyrlia Aboriginal Corporation by the Indigenous Land Corporation in 1996. Management activities have included fencing off areas of high cultural significance from the rest of the property to limit access and to ensure adequate protection. Since 1991 the number of cattle has been reduced in order to begin restoring land condition. The IPA has been divided into two zones for management purposes:

- Zone A (the East Side Paddock) which is managed under IUCN Category VI: Managed Resource Protected Area i.e. it is managed mainly for the sustainable use of natural ecosystems.
- Zone B (the West Side Paddock) which is managed under IUCN Category II for conservation, tourism and recreation.

The Indigenous Protected Areas (IPA) program is part of Australia's National Reserve System Program which aims to establish a network of protected areas which includes a representative sample of all types of ecosystems across the country. The National Reserve System Program is itself a part of the Australian Government's Natural Heritage Trust. With support from the IPA program, Indigenous

landowners commit themselves to manage their lands for the protection of natural and cultural features in accordance with internationally recognised standards and guidelines.

SAPEX does not have immediate plans to conduct drilling activities in the Tallaringa Conservation Park or Mount Willoughby Indigenous Protected Area, however it is possible that drilling may occur in these areas in the future, dependent on results of other exploration activities in the Arckaringa Basin. Any drilling in these areas would be planned and conducted in consultation with the relevant landowner and would aim to avoid impacts on the areas' conservation or biodiversity values (e.g. by developing specific requirements for the management of access and reinstatement).

4.6.4 Tourism

Significant tourist attractions within the region include Coober Pedy and its opal mining, the Breakaways, the Painted Desert, GAB springs and historical infrastructure associated with the Old Ghan Railway and the Overland Telegraph Line. Nature tourism, bush walking, wildlife, 4WD experiences, camping and indigenous tourism all occur throughout the region across all land tenures.

Tourism visitation in the region is largely restricted to townships, parks and the main network of sealed and unsealed roads connecting them including the Stuart Highway and the Oodnadatta Track.

4.6.5 Defence

The southern part of the area of the SAPEX PELs lies within the Woomera Prohibited Area. There is limited Defence activity across most of this area but entry to the Prohibited Area (except on main road corridors) requires permission from the Commonwealth Department of Defence, in accordance with Regulation 35 of the *Defence Force Regulations 1952*.

The Woomera Prohibited Area intersects PEL118, PEL119, PEL122, PEL123 and PEL124.

4.6.6 Native Title

There are three active native title claims across the PELs:

- SC97/9 – Yankunytjatjara/Antakirinja Native Title Claim
- SC95/7 – Antakirinja Matu-Yankunytjatjara
- SC98/2 – The Arabunna People's Native Title Claim.

The Yankunytjatjara/Antakirinja claim (with the exception of the Marla township) was settled by a consent determination in August 2006 and the Yankunytjatjara/Antakirinja are consequently native title holders in PEL117. The Arabunna People's claim intersects five out of the seven PELs, and the Antakirinja Matu-Yankunytjatjara claim intersects all seven PELs

Native title agreements between SAPEX and these three groups were signed off by the Minister in October 2006. All agreements are conjunctive and cover activities from exploration through to development and production. Under the requirements of these agreements, heritage clearances for any field work will be undertaken prior to the commencement of field activities.

4.7 Socio-Economic

4.7.1 Population Centres

The major town in the region is Coober Pedy, which is located approximately 800 km north-west of Adelaide, and has a population of approximately 3,100 people (ABS 2007).

Regional townships or population centres in the region include:

- Oodnadatta (within PEL117) – population 160
- Marla (50 km west of PEL117) – population 132
- William Creek (10km west of PEL123)
- Glendambo (65 km south of PEL124)
- Cadney Park Roadhouse (10km west of PEL117).

4.7.2 Infrastructure

There is extensive transport infrastructure present in the region including the Stuart Highway (part of the national highway network) and the Adelaide-Darwin Railway, both of which are primary transport routes between South Australia and the Northern Territory. There are also a number of unsealed public roads. Major roads within the SAPEX PELs include:

- Stuart Highway (sealed)
- Oodnadatta Track (Marla-Oodnadatta – unsealed)
- Painted Desert Road (Cadney Park-Oodnadatta - unsealed)
- The Kempe Road (Coober Pedy-Oodnadatta - unsealed)
- William Creek Road (Coober Pedy-William Creek - unsealed)
- Oodnadatta-Marree Track (unsealed).

The major roads in the region are multiple use roads. These roads carry a relatively high traffic volume that is predominantly a mix of heavy vehicles, light industrial/pastoral vehicles and tourist vehicles. Station access roads and internal tracks are generally restricted to pastoral use or occasional tourist traffic and carry a low volume of traffic.

The Dog Fence, constructed to allow sheep grazing in the southern portion of the state, crosses PEL 118, PEL 119, PEL 122 and PEL123.

5 Environmental Hazards and Consequences

This section of the EIR identifies and discusses potential environmental hazards and their consequences resulting from drilling operations in the Arckaringa Basin. The subsequent sections of the EIR then outline the measures that will be implemented to manage the hazards (Section 6) and provide a risk assessment of drilling and well operations (Section 7).

5.1 Hazards

A hazard is defined as “a source of potential harm” (Australian/New Zealand Standard AS/NZS 4360:2004 *Risk management*).

The environmental hazards associated with drilling activities that have potential to result in the most prominent environmental consequences (as previously identified in Santos 2003) are identified as:

- earthworks associated with well site and access track construction and reparation
- vehicle movement
- blowout or kick
- explosion or fire
- equipment or tubular failure
- down hole problems
- casing or cement failure
- loss of radioactive source down hole
- emissions vented from drill stem testing and production testing
- spills or leaks associated with drilling procedures, storage of oil, fuels and chemicals, refuelling operations and high pressure hydraulic systems
- spills from storage and disposal of drilling and completion fluids (e.g. produced formation water (PFW), oil and condensate)
- disposal of domestic and chemical waste and contaminated soil
- extreme weather conditions.

The hazards associated with various drilling activities are summarised in Table 6.

5.2 Consequences

Potential environmental consequences of drilling are summarised in Table 6. The key potential environmental consequences associated with the above hazards are:

- visual impact
- loss of native vegetation and habitat
- introduction and or spread of weeds, pest plants or animals
- soil erosion and disturbance to natural drainage patterns
- contamination of soil, groundwater and/or water courses
- crossflow between aquifers or reduction in pressure in aquifers
- loss of reserves and reservoir pressure
- atmospheric pollution
- disturbance of Aboriginal, cultural or natural heritage sites
- disturbance, injury or death to native fauna
- disturbance, injury or death to livestock
- loss of organic beef certification.

Table 6: Hazard and consequence classifications for drilling activities

Drilling Activity	Hazard	Consequence
Well site and access track construction	Earthworks Vehicle movement Spills and leaks Excavations	Contamination of soil, surface water Loss of vegetation and habitat Soil erosion and disturbance of natural drainage patterns Soil compaction/disruption/deflation, wheel tracks Dust generation Soil inversion Impact and/or damage to cultural/heritage sites Disturbance to native fauna Disturbance to stock Introduction and spread of weeds Visual impact Damage to infrastructure Facilitation of third party access Loss of organic beef certification Noise generation
Drilling Operations, including Well Completion and Workover Operations	Vehicle movement Rig moves	Contamination of soil, surface water Soil compaction/disruption/deflation, wheel tracks Dust generation Disturbance to native fauna Disturbance to stock Introduction and spread of weeds Damage to infrastructure Loss of organic beef certification Noise generation Road hazard / disturbance to local road users
	Blowout or kick Equipment or tubular failure Down hole problems Casing or cement failure	Contamination of soil, surface water or groundwater Crossflow, aquifer contamination or reduction in pressure in aquifers Uncontrolled release of water and hydrocarbon to surface Disturbance to native fauna Disturbance to stock Loss of organic beef certification Atmospheric pollution Loss of reserves and reservoir pressure
	Explosion or fire	Loss of vegetation and habitat Contamination of soil, surface water or groundwater Crossflow, aquifer contamination or reduction in pressure in aquifers Uncontrolled release of water and hydrocarbon to surface Disturbance to native fauna Disturbance to stock Loss of organic beef certification Atmospheric pollution
	Drill pipe failure	Temporary restricted control over well fluids and circulation system
	Loss of containment of gas or oil while testing	Contamination of soil, surface water or groundwater Disturbance to native fauna Disturbance to stock Loss of organic beef certification

Drilling Activity	Hazard	Consequence
		Atmospheric pollution
	Spills or leaks associated with: <ul style="list-style-type: none"> ▪ drilling procedures ▪ storage of oil, fuels and chemicals ▪ refuelling operations and high pressure hydraulic systems ▪ storage and disposal of drilling and completion fluids (e.g. PFW, oil and condensate) ▪ transport of oil and condensate (by road) 	Contamination of soil, surface water or groundwater Loss of vegetation and habitat Disturbance to native fauna Disturbance to stock Loss of organic beef certification Atmospheric pollution Disruption to land use
	Flaring of gas during testing Emissions vented from drill stem testing and production testing	Atmospheric pollution
	Disposal of hydrocarbon and PFW to excavated flare pits during well testing & clean-up	Contamination of soil, surface water or groundwater Loss of vegetation and habitat Disturbance to native fauna Disturbance to stock Loss of organic beef certification
	Loss of radioactive source down hole	Contamination of groundwater (aquifer)
	Flooding of surrounding watercourses/floodplains Extreme weather conditions	Contamination of soil, surface water or groundwater Damage to infrastructure
Waste Handling and Disposal	Disposal of domestic and chemical waste Sewage treatment Disposal of drill cuttings and muds	Contamination of soil, surface water and groundwater Soil inversion Loss of vegetation and habitat Dust generation Soil erosion/ disturbed drainage patterns Visual impact Litter Attraction of scavenging animals (both native and pest species) Loss of organic beef certification
Water supply / Aquifer Use	Depletion of artesian and sub-artesian aquifers Spills and leaks	Depletion of artesian and sub-artesian aquifers Loss of water (wastage)
Fuel & chemical handling & storage	Spills and leaks	Contamination of soil, surface water and groundwater Loss of vegetation and habitat Disturbance to native fauna Disturbance to stock Loss of organic beef certification

Drilling Activity	Hazard	Consequence
Campsites and associated supplies	Vehicle movement Disturbance of vegetation and habitat Spills and leaks Disposal of domestic and chemical waste Fire	Contamination of soil, surface water and groundwater Soil inversion Loss of vegetation and habitat, damage to tree root structures Disturbance to native fauna Disturbance to stock Soil compaction/disruption/deflation, wheel tracks Dust generation Soil erosion/ disturbed drainage patterns Visual impact Litter Fire damage to vegetation and habitat Noise generation Road hazard / disturbance to local road users Loss of organic beef certification
Well site and access track and campsite restoration	Earthworks Vehicle movement Spills and leaks	Contamination of soil, surface water Soil inversion Disturbance to native fauna Disturbance to stock Introduction and spread of weeds Visual impact Damage to infrastructure Impact and/or damage to cultural/heritage sites Loss of organic beef certification Noise generation Dust generation
Monitoring of selected locations	Vehicle movement	Soil compaction/disruption/deflation, wheel tracks Dust generation Introduction and spread of weeds Impact and/or damage to cultural/heritage sites Damage to infrastructure

5.3 Discussion of Key Hazards

5.3.1 Earthworks associated with Well Site & Access Track Preparation

The type and severity of the potential impacts of preparation of access tracks and well sites is dependent to a certain extent on the land system in which the activities are being carried out. Earthworks generally result in the disturbance of soil cover (vegetation, rocks) and structure and expose soils to wind and water erosion.

The potential impacts of specific earthwork activities on different land systems are summarised below and in Table 7.

Wetlands

Wetlands, including the GAB Springs, are highly sensitive environments that can easily be damaged as a result of vegetation clearing, alteration of drainage patterns, spills of oil, fuel or chemicals or fire. Wetlands are avoided under most circumstances as they are generally of high ecological value and sensitivity.

Drainage Lines and Flood Plains

Drainage line and flood plains experience periodic natural disturbance and soil erosion as a result of rainfall and flood events. However the movement of soil, alteration of surface profiles or the removal of vegetation associated with drainage lines and flood areas can lead to the accelerated erosion of soil or the alteration of surface flows.

Moon Plains

The light gypsiferous soils of the Moon Plain are highly prone to rutting as a result of vehicle movement. This in turn can lead to soil erosion as the underlying soils are compacted or exposed to wind and water.

Breakaways and Stony Hills

The steeper slopes and escarpments of these landforms can be unstable and have high erosion potential when disturbed. Heavy vehicle trafficking and ground disturbing activity is avoided on such slopes.

Stony Plains

While gibber plains are generally considered to be a stable environment, disturbance or removal of the surface layer of stones, and the exposure of clay soils, can result in significant erosion by either wind or water. Even in gently sloping areas, water can gather enough force to cause erosion gullies in exposed soils (Santos 1997a). The erosive potential of these soils is clearly evident in areas where grading or removal of gibber has resulted in severe erosion and long-term scarring on the landscape.

Dunefields and Sandy Plains

Dunefields are generally resilient and less likely to suffer long term impacts from soil disturbance. Removal of vegetative cover has the potential lead to blowouts and deflation, however a study of seismic lines in the Cooper Basin concluded that natural rates of erosion on dunes were not accelerated as a result of disturbance to the soil surface (Santos 2003).

Salt Lakes

Salt lakes are often comprised of a thin salty crust overlying a wet clay. As a result trafficking salt lakes is difficult and can result in deep and persistent rutting.

Salt lakes are avoided under almost all circumstances as they are very difficult to rehabilitate once disturbed and are therefore likely to be scarred by any activity on their surface.

Table 7: Impacts associated with well site/access track preparation in various land systems

Land System	Preparation of well site/access tracks	Excavation & Stockpiling
Wetlands (including GAB springs)	Not applicable (wetlands are avoided due to environmental sensitivity)	Not applicable (wetlands are avoided due to environmental sensitivity)
Drainage Lines & Floodplains	<ul style="list-style-type: none"> ▪ Vegetation clearance ▪ Soil erosion (wind and water) ▪ Soil compaction ▪ Disturbance of natural drainage systems ▪ Disturbance to cultural heritage sites (generally low density of sites in floodplains) 	<ul style="list-style-type: none"> ▪ Vegetation clearance ▪ Soil erosion (wind and water) ▪ Disturbance of natural drainage systems ▪ Disturbance to cultural heritage sites (generally low density of sites in floodplains)
Moon Plains	<ul style="list-style-type: none"> ▪ Vegetation clearance ▪ Soil erosion (wind and water) ▪ Soil compaction ▪ Disturbance of natural drainage systems ▪ Disturbance to cultural heritage sites 	<ul style="list-style-type: none"> ▪ Vegetation clearance ▪ Soil erosion (wind and water) ▪ Disturbance of natural drainage systems ▪ Disturbance to cultural heritage sites
Breakaways & Stony Hills	<p>Note: Not applicable for steeper slopes (grading should not occur)</p> <ul style="list-style-type: none"> ▪ Vegetation clearance ▪ Soil erosion (wind and water) ▪ Soil compaction ▪ Disturbance of natural drainage systems ▪ Disturbance to cultural heritage sites 	<p>Note: Not applicable for steeper slopes (excavation should not occur)</p> <ul style="list-style-type: none"> ▪ Vegetation clearance ▪ Soil erosion (wind and water) ▪ Disturbance of natural drainage systems ▪ Disturbance to cultural heritage sites
Stony Plains	<p>Note: Not applicable for steeper slopes or on gibber plains (grading should not occur on these terrain types)</p> <ul style="list-style-type: none"> ▪ Vegetation clearance ▪ Soil erosion (particularly susceptible to water erosion e.g. severe gullyng) ▪ Disturbance of natural drainage systems (e.g. siltation) ▪ Inversion of the soil profile ▪ Disturbance to cultural heritage sites 	<p>Note: Not applicable for steeper slopes (well sites should be avoided on this terrain type)</p> <ul style="list-style-type: none"> ▪ Vegetation clearance ▪ Soil erosion (particularly susceptible to water erosion e.g. severe gullyng) ▪ Disturbance of natural drainage systems (e.g. siltation) ▪ Inversion of the soil profile ▪ Disturbance to cultural heritage sites
Dunefields & Sandy Plains	<ul style="list-style-type: none"> ▪ Vegetation clearance ▪ Soil erosion (wind and water erosion) ▪ Disturbance to cultural heritage sites (dune fields near waterholes are typically of high cultural significance) 	<ul style="list-style-type: none"> ▪ Vegetation clearance ▪ Soil erosion (wind and water erosion) ▪ Disturbance to cultural heritage sites (dunefields near waterholes are typically of high cultural significance) ▪ Inversion of the soil profile
Salt lakes	Not applicable (drilling should not occur on salt lakes)	Not applicable (drilling should not occur on salt lakes)

Borrow pits are generally required for the excavation of material for use on the stabilisation of access tracks, campsites and well sites, depending upon the nature of the substrates at each location. Borrow pits may present a bogging hazard to stock and wildlife. Borrow pits in some locations also provide an alternative water source for stock which results in a redistribution of stock to areas that may not have otherwise been available for grazing.

Borrow material is generally not moved over large distances. However, there is the potential for weed species to be moved along with the construction material.

5.3.2 Vehicle Movement

The movement of heavy vehicles (e.g. trucks, bulldozers, drill rigs, supply trucks, etc) to and from a well site can lead to the damage of vegetation, the generation of dust and/or the compaction of soil, damage to infrastructure (e.g. roads) and collision with wildlife.

Vehicles, especially trucks, also have the potential to cause a hazard to other road users. Rig moves for an oil and gas drilling rig typically involve 30-40 trailer loads for the rig and camp plus additional loads for supplies and equipment, as discussed in Section 3.2.1. However, these moves are infrequent (approximately once per month) and are usually staged over several days. Moves of coal seam gas drilling rigs require far less vehicle movements.

The Stuart Highway (and to a lesser extent the other major roads in the region) carries a relatively high level of heavy traffic. The additional traffic on major roads due to petroleum exploration is not likely to be significant. Use of minor roads and tracks requires careful management (e.g. planning of routes, setting and observance of appropriate speed limits, use of signage where appropriate) in order to minimise the risk and potential disturbance to other road users and landholders.

5.3.3 Vegetation Clearance

The clearance of vegetation during well site and access track preparation cannot be entirely avoided. Vegetation clearance can result in loss of vegetation and fauna habitat, siltation of natural drainage lines and watercourses, destabilisation of creek crossings or watercourses, weed invasion and damage to heritage sites. Vegetation clearance may also impede the movement of fauna, particularly small mammals or reptiles across cleared areas. However, this is considered unlikely to be of significance in most land systems in the region due to the presence of naturally bare or unsheltered locations (Moss and Low 1996).

During the preparation of well sites and access tracks, particular care will be taken to minimise the clearance of vegetation in heavily wooded areas (e.g. River Red-gum or Coolibah woodlands that are found in or near drainage lines). Campsites will be located at the nearest available naturally clear area in which construction does not require significant disturbance to vegetation.

Studies of well site restoration in the Cooper Basin (Fatchen & Woodburn 2000) have found that vegetation is likely to need active assistance (i.e. respreading cleared vegetation and topsoil or spreading seed on prepared surfaces) to recolonise well sites. It is suggested that without this active assistance, it is unlikely that a cover similar to or compatible with the plant cover on surrounds can be achieved in under at least a decade.

5.3.4 Down-hole Operations

The type and severity of potential impacts of down hole activities during drilling, completion and workover is dependent on geological location down hole, whether there is casing cemented in competent formation, down hole conditions, condition of equipment on surface, condition of tubulars, safety awareness, pressures encountered and exposure of reservoirs.

The primary hazard associated with down hole activities is a blowout, which would result in loss of containment of oil, gas, condensate, produced water and drilling fluids, possible crossflow between aquifers, loss of pressure of aquifers and loss of reservoir pressures and possibly an explosion or fire. Blowouts are not common – for example, there has never been a drilling blowout that has reached the surface in the Cooper and Eromanga basins in South Australia. There are considerable safety

measures to avoid a drilling blowout including guidelines, procedures, safety practices, design considerations, well control equipment and certification of trained individuals in drilling.

The chance of a blowout in completion activities is considerably less because the well is cased. Therefore, the well bore is in a stable condition and down hole pressures are fairly well known.

Other hazards associated with down hole operations are a loss of radioactive source down hole. When the wells are open hole logged after drilling, the neutron and gamma ray logging tools emit radiation into the formation and a receiver picks up the signal which is interpreted to relate what the characteristics of the formation are. If the tool is lost down hole, it is retrieved immediately in most cases. However, if it not possible to retrieve the tool it is cemented in the hole to isolate it from adjacent formations.

Drilling fluids in the down hole environment have the potential to invade freshwater aquifers and cause contamination. Constituents of drilling muds are generally non-toxic or have a low effective chronic toxicity at the concentrations present in the drilling mud. Detailed study has shown that although this is an area of concern, drilling fluid impact is not a major component of potential down-hole problems, and that the main consequence of drilling fluid loss is reservoir formation damage rather than an irreversible contamination of the aquifer (Mavroudis 2001, cited in Santos 2003).

5.3.5 Waste Management

The improper storage and disposal of waste products including:

- domestic waste
- chemical waste
- sewage
- produced formation water
- contaminated soil

can result in litter, impacts on fauna and stock, soil contamination, water contamination and risks to human health.

The risk of soil and shallow groundwater contamination associated with the disposal of drilling fluids, cuttings and other fluids associated with completion activities (e.g. frac gels) to the unlined earthen drilling sump is considered low. This is due to the low toxicity associated with additives (Egis 2001) and the presence of fine bentonite clays which form a relatively impervious mud cake in the base of drilling sumps. These techniques are generally accepted industry standard practice for disposal of non-oil based drilling mud systems cuttings.

5.3.6 Hydrocarbon, Fuel and Chemical Management

Key hazards associated with drilling operations and the handling and storage of hazardous substances (including oil, fuel, chemicals, drilling fluids, production water) are associated with spills or leaks.

Spills or leaks may occur as a result of the failure of equipment or human error associated with the following activities:

- drilling operations (including casing or cement failure, equipment or tubular failure)
- storage or transport of oil, fuels and chemicals (including failure of storage tanks)
- storage and disposal of drilling and completion fluids (e.g. produced formation water, oil and condensate)
- refuelling operations
- use of high pressure hydraulic systems.

Unplanned emissions of hydrocarbons, hydrogen sulphide, over-pressured fluids, from the well, including blow out, can cause significant environmental damage by fire and by contamination. Oils recovered by drill stem testing and flaring have the potential to contaminate the local environment if not correctly handled and disposed of.

Spills or leaks can result in the contamination of soil or water (both surface and groundwater) which in turn may lead to impacts on vegetation, fauna, wildlife and people. The loss and subsequent ignition of some hazardous substances may also lead to an explosion or fire.

As indicated in the Sections 6 and 7, appropriate management measures can (and will) be implemented during planning and conduct of operations, to ensure that these hazards do not result in significant environmental risks.

5.3.7 Disturbance to Livestock and Land Use

The presence of a drill rig and drilling personnel and the associated vehicle movements have the potential to disturb livestock, landholders and land use activities. Close liaison is carried out with landholders during the planning and conduct of drilling operations, to ensure that disturbance (e.g. to stock grazing and movement) is minimised. Appropriate access routes to drill sites are chosen in consultation with landholders and any deterioration of station tracks as a result of drilling-related traffic is rectified.

The loss of organic beef certification could occur on those properties that are certified for organic production if stock are allowed access to chemicals or contaminated areas (and if this is detected during tissue tests or inspections by the certifying body). However, the oil and gas industry has been working on organic certified properties in the Cooper Basin for many years without adversely affecting their organic status. Practices have been developed to protect the organic status such as fencing off any areas that may contain hydrocarbons (e.g. spills, drilling sumps), secure storage of hydrocarbons and chemicals and use of appropriate fencing materials (e.g. CCA-free treated pine). Similar practices would be developed in the Arckaringa Basin, in consultation with landholders.

6 Environmental Risk Management

This section summarises the management measures that will be undertaken during drilling and well operations to minimise environmental risks.

6.1 Access Track Construction

To minimise the impact of access track construction the following actions will be taken:

- Existing roads and tracks will be utilised as far as is practicable to avoid the creation of parallel and multiple access tracks.
- Track width will be restricted to the minimum necessary (typically this will be less than 6 m, except on bends where safety considerations will determine width).
- Sites of natural, scientific, Aboriginal or non-Aboriginal heritage significance will be avoided.
- Watercourse or floodplain crossings will be constructed so as to maintain water flows (e.g. culverts may be installed)
- Clearance of vegetation, especially the removal of trees, larger shrubs and other Priority 1, 2 or 3 species (see Appendix 3), will be avoided wherever possible or minimised.
- Earthmoving equipment that is not free of potential weed sources (e.g. soil or plant material) will be cleaned before starting work at the site
- Locations requiring steep cuts or fills will be avoided.
- On some surfaces (e.g. gibber) tracks will be rolled in preference to grading to reduce the risk of erosion.

6.2 Well Site Selection

Well sites will not be constructed on sensitive areas such as salt lakes, steep slopes of breakaways / stony hills and wetlands (including GAB Springs).

To minimise the environmental impact of well sites the following actions will be taken:

- Proposed well locations will be plotted on maps and aerial photographs to allow initial assessment of environmental, access, heritage / native title and landowner issues.
- Proposed well sites will be inspected to make an assessment of potential issues and to determine the best location and orientation of the well site, access tracks, campsite and any borrow pits.
- Work area clearances will be carried out with the relevant native title groups
- Sites identified of known scientific, natural, Aboriginal or non-Aboriginal heritage significance will be completely avoided where possible (however it is noted that some heritage areas are large (e.g. Moon Plains RNE area) and could overlap well site locations).
- In the event that drilling at a non-indigenous or natural heritage site or area is proposed, permission to do so will be obtained from the relevant authority.

6.3 Well Site Construction

To minimise the environmental impact of the construction of well sites, access tracks, camps and borrow pits, the following actions will be taken:

- Well sites will be located and orientated so as to take into account natural drainage patterns (creeks, flood plains and salt lakes) and vegetation and to avoid significant cut and fill.
- Well sites will be constructed to the minimum size required for the safe operation of the drill rig.
- Earthmoving equipment that is not free of potential weed sources (e.g. soil or plant material) will be cleaned before starting work at the site
- Surface levelling and clearance of vegetation, especially the removal of trees and larger shrubs and other Priority 1, 2 or 3 species (see Appendix 3), shall be avoided wherever possible or minimised.
- Cleared topsoil and vegetation will be stockpiled adjacent to the well site/camp site/borrow pit and separately from fill removed from sumps or pits.
- Sumps will be of sufficient size to contain mud discharges and shall be located so as not to impede or pollute surface drainage. Sumps will also be of sufficient depth to have adequate freeboard at the completion of operations to allow for at least 1 m cover of clean fill.
- Where they are required, flare pits will have a suitable fire break around the perimeter.

- Borrow material will be sourced locally, preferably from existing borrow pits
- Borrow pits will preferably be located in areas which are naturally devoid of vegetation or have been previously disturbed. Clearance of vegetation, especially the removal of trees, larger shrubs and other Priority 1, 2 or 3 species (see Appendix 3), will be avoided wherever possible or minimised.
- Campsites will be located adjacent to existing access tracks or roads, utilising areas with sparse vegetation, on well drained land.
- In areas with a stony mantle (e.g. gibber plain) borrow pits will be located in areas which are relatively flat, and low to avoid future erosion. The stony mantle will be stockpiled and respread and rolled when pit is restored.

6.4 Management of Drilling Operations

To minimise the environmental impact of well drilling operations the following actions will be taken:

Drilling Mud Sumps and Flare Pits

- All drill cuttings, muds and drill fluids will be contained within designated mud sumps with adequate freeboard at the completion of operations to allow for a 1m cover of clean fill.

Oil and Gas Systems

- Where appropriate, imperviously lined well cellars shall be installed on oil wells.
- Chemical containment devices shall be installed on gas well skids.
- Well heads shall be shut in and chemicals removed prior to flood events.
- Jet pumps shall be installed within containment device with an adequately sized containment sump.

Well Blowdown/Production Testing

- Blowdowns and testing shall be conducted in accordance with accepted industry standards / good practice.
- Where appropriate the following devices will be used:
 - impermeable flare pit
 - flare tanks
 - separators
 - supervision.

Drilling & Completion Activities

- Drill rig, ancillary and any testing equipment to comply with Regulations, meet relevant industry standards and be "Fit for Purpose".
- Casing design carried out to meet worst case expected loads and environmental conditions determined for the specific geology intercepted by the well. Details of work to be performed are set out in the Drilling Program.
- Casing set in accordance with design parameters and cemented to surface with visible return.
- Blow out prevention precautions / well control equipment in place in accordance with defined procedures and appropriate to the expected downhole conditions.
- Plugs will be installed between aquifers to prevent mixing and uncontrolled flow to the surface.

Well Abandonment

- Isolation barriers will be set in place to ensure that crossflow, contamination or pressure reduction does not occur.
- There will be no provision for cross-flow behind casing between aquifers, and between aquifers and hydrocarbon reservoirs unless approved by DWLBC.

Vehicle Movement

- All vehicles will be required to remain on designated roads and access track or parking areas.
- Where practicable materials will be transported to and from well sites in bulk.
- Where appropriate, temporary signage will be erected on access tracks at intersections with public roads.

Weeds

- Vehicles and equipment involved in drilling operations must be clean when entering the region (i.e. they must not carry potential weed sources such as soil and plant material).
- Vehicles or equipment will be washed down if they pose a significant risk of weed introduction or spread (e.g. they have been in contact with soil in a known area of weed infestation).
- Any weed outbreaks at the well site or access will be controlled, in consultation with appropriate personnel (e.g. landholder, NRM Board officers).

6.5 Fuel and Chemical Storage and Handling

The following actions will be taken:

- All fuel, oil and chemicals will be stored in bunded areas in accordance with appropriate standards, including AS 1940 and EPA guidelines.
- Hazardous materials will be transported and disposed of in accordance with appropriate standards and legislative requirements, including the Australian Dangerous Goods Code and EPA guidelines and licensing requirements.
- Appropriate spill response equipment will be available on site.
- Appropriate MSDS (Material Safety Data Sheets) will be available on site for all fuels and chemicals used on site.

6.6 Well Site Reinstatement

To minimise the environmental impact of the reinstatement of well sites, access tracks, camps and borrow pits, the following actions will be taken:

- All rubbish will be removed from the site.
- Drilling sumps and waste pits will be allowed to dry out before being backfilled with at least 1 m of fill.
- All excess infrastructure will be removed from the site.
- Excess fill materials will be removed and disposed in local borrow pits.
- Sites will be re-contoured to restore pre-existing drainage lines.
- Where appropriate, compacted areas will be ripped.
- Stockpiled topsoil and vegetation will be respread over disturbed areas.
- In gibber plain areas stockpiled gibber mantle will be respread and rolled (i.e. gibber will not be ripped).
- Access roads, borrow pits, well leases and campsites are to be restored and rehabilitated to attain the highest achievable Goal Attainment Scaling (GAS) rating, as defined in the SEO and, where relevant, in PIRSA's *Field Guide for the Environmental Assessment of Abandoned Petroleum Wellsites in the Cooper Basin, South Australia* (PIRSA 2002).

6.7 Pollution and Waste Management

To avoid the pollution of soil or water:

- All operational equipment will be inspected and maintained in accordance with industry-accepted standards and product operational requirements.
- Fuel and oil spills will be reported, chemically treated or bio-remediated and the ground ripped.
- Putrescible domestic wastes (e.g. food waste, paper) created at campsites will be buried on-site in accordance with EPA requirements in some circumstances (e.g. at very remote sites, where activities are short term and temporary) or stored on site prior to transportation to a licensed waste disposal facility.
- Rubbish (including plastics, cans, glass, etc) will be transported to a licensed waste disposal facility and recycled where possible.
- Campsite wastewater will be disposed of in accordance with the *Public and Environmental Health (Waste Control) Regulations 1995*. The waste water disposal system will either comply with the *Standard for the Construction, Installation and Operation of Septic Tank Systems in South Australia* or be operated to the satisfaction of the Department of Health. All waste disposal systems shall be approved by the Department of Health.
- Markers and litter will not be left in the work area after completion.
- Drill cuttings will be returned to the hole or disposed of in the drilling sump.
- Vehicles will travel at slow speed in the vicinity of dwellings.

6.8 Environmental Management System

Drilling operations in the Arckaringa Basin will be undertaken in accordance with the principles of an Environmental Management System (EMS). An EMS is a key tool in the management of the proponent and associated contractors' environmental responsibilities, issues and risks. An EMS also provides a framework for the coordinated and consistent management of environmental issues by ensuring the.

- establishment of environmental policy
- identification of environmental risks and legal and other requirements relevant to drilling operations
- setting of appropriate environmental objectives and targets
- delineation of responsibilities
- establishment of a structure and program to implement environmental policy and achieve objectives and targets, including the development of procedures or guidelines for specific activities and education and induction programs
- facilitation of planning, control monitoring, corrective action, auditing and review of activities to ensure that the requirements and aspirations of the environmental policy are achieved.

SAPEX's and its contractors' operating standards will follow or lead accepted best practice and industry-accepted standards. Ongoing audits of the EMS and associated systems will be conducted on a regular basis to ensure that systems are maintained and being successfully implemented.

Key components of an EMS are discussed in the following sections.

6.8.1 Environmental Training

Prior to the start of field operations all field personnel will be required to undertake an environmental induction to ensure they understand their role in protecting the environment. This induction will be part of a general induction process also including safety procedures. The induction shall include notification of environmental objectives and environmental requirements and include the distribution and explanation of any site specific environmental material.

A record of induction and attendees will be maintained.

6.8.2 Emergency Response and Contingency Planning

In the course of normal operations, there is always the potential for environmental incidents and accidents to occur. To manage these incidents, emergency response plans will be developed to guide actions to be taken to minimise the impacts of accidents and incidents. Emergency response plans will be reviewed and updated on a regular basis to incorporate new information arising from any incidents, near misses and hazards and emergency response simulation training sessions. These plans will also include the facilitation of fire danger season restrictions and requirements.

Emergency response drills will also be undertaken at regular intervals to ensure that personnel are familiar with the plans and the types of emergencies to which it applies, and that there will be a rapid and effective response in the event of a real emergency occurring.

6.8.3 Environmental Monitoring and Audits

Ongoing monitoring and auditing of drilling operations will be undertaken to determine whether significant environmental risks are being managed, minimised and where reasonably possible, eliminated.

Monitoring programs will be designed to assess:

- compliance with regulatory requirements
- visual impact of the operations
- impact upon flora and fauna and general biodiversity
- site contamination
- site revegetation following program completion and any restoration activity
- potential future problems.

6.8.4 Incident Management, Recording and Corrective Actions

SAPEX and its contractors will have a system in place to record environmental incidents, near misses and hazards, track the implementation and close out of corrective actions, and allow analysis of such incidents to identify areas requiring improvement. Such review should be undertaken at least annually. The system will also provide a mechanism for recording 'reportable' incidents, as defined under the *Petroleum Act 2000* and associated regulations.

6.8.5 Reporting

Internal and external reporting procedures will be implemented to ensure that environmental issues and/or incidents are appropriately responded to. A key component of the internal reporting will be contractors' progress and incident reports to SAPEX.

External reporting (e.g. incidents, annual reports) will be carried out in accordance with Petroleum Act requirements and the SEO.

7 Environmental Risk Assessment

Environmental risk is the chance of something happening that will result in impact to an aspect of the environment. Risk is measured in terms of the consequences of an event and their likelihood.

Given appropriate management measures (i.e. those identified in Section 6), most risks can be avoided or reduced to a level that is as low as reasonably practical (ALARP). This is a risk of something happening that is considered to have a minimal impact and which will recover. These parameters are defined within the goal attainment scaling system (defined in the SEO). However, in some cases there may still be 'residual' risks that remain after management measures have been implemented.

An environmental risk assessment of SAPEX's proposed drilling activities has been undertaken to evaluate the level of environmental risk associated with various activities. It provides a framework for assessing risk management priorities and options based on the level of each assessed risk. The risk assessment is described in this section.

The environmental risk assessment was conducted using methodology based on AS/NZ 4360:2004 *Risk Management*.

The first stage of the risk assessment involved identifying the activities that may be a source of risk (hazards) and the possible associated environmental impacts (consequences). The hazards and consequences associated with drilling activities in the Arckaringa Basin have been summarised in Table 6 in Section 5.

Once the consequences were identified, the severity of the consequences (Table 8) and the likelihood of the consequences occurring (Table 9) were allotted. A risk matrix (Table 10) was then used to undertake an environmental risk assessment of each consequence and determine a risk ranking. Results of the risk assessment are presented in Table 11.

Each phase of the risk assessment process is further discussed in the following sections.

7.1 Hazards and Consequences

Primary environmental hazards and the key potential environmental consequences associated with drilling operations in the Arckaringa Basin are identified in Sections 5.1 and 5.2.

To determine the level of risk associated with various hazards and potential consequences, both the likelihood and severity of hazards, and their associated consequences, have to be considered. Categories of likelihood and severity have been determined using subjective estimates of whether or not a particular event or outcome will occur. Drilling operations have been undertaken in the nearby Cooper and Eromanga basins for many years and as a result the environmental hazards and existing management measures are generally well understood. As a consequence the likelihood and severity of consequences of the majority of drilling activities can be confidently predicted based on past experience and professional judgement.

Both the likelihood and severity of consequences have been assessed in the context of the management practices that are currently applied to reduce the level of risk associated with identified hazards and potential consequences.

7.1.1 Severity of Consequences

Environmental consequences can be categorised from negligible to catastrophic (Table 8). These consequences are adapted from the definitions in Santos (2003) (which were based upon definitions in Stoklosa (1999)) and AS/NZS 4360:2004, but have been expanded to incorporate impacts to environmental values such as flora, fauna and biomass and the socio-economic environment.

Table 8: Severity of consequences

Category of Effect	Qualitative Description of Environmental Effects	
	Natural environment	Socio-economic environment
Negligible	Possible incidental impacts to flora & fauna in a locally affected land system but no ecological consequence. Possible incidental impacts to aquifers associated with the oil and gas formation without ecological consequence.	Community is aware of operations and concerns have been addressed
Minor	Changes to the abundance or biomass of biota, and existing soil and/or water quality in the affected land system, but no changes to biodiversity or ecological function. Aquifers have a small amount of exposure from other sources of fluids, negligible volume movement in or out of formations or aquifers. No measurable change to aquifer water quality or pressure in local area.	Temporary disturbance to the community.
Moderate	Changes to the abundance or biomass of biota, and existing soil and/or water quality in the affected land system, with local changes to biodiversity but no loss of ecological function. Detectable change to aquifer water quality and pressure in the local area.	Longer term disturbance able to be managed with communication to affected community
Major	Substantial changes to the abundance or biomass of biota, existing soil and/or water quality in the affected land system with significant change to biodiversity and change of ecological function. Eventual recovery of ecosystem possible, but not necessarily to the same pre-incident conditions. Substantial changes to aquifer water quality and pressure in the local area (i.e. local drawdown adjacent to the oil and gas well or field).	Significant effect which can be mitigated by extensive rehabilitation and negotiation with community
Catastrophic	Irreversible and irrecoverable changes to abundance/biomass or aquifers in the affected area. Loss of biodiversity on a regional scale. Loss of ecological functioning with little prospect of recovery to pre-incident conditions. Widespread effect of reduction in aquifer pressure (i.e. reduced flow from bores in locations remote from operations). Contamination of aquifers remote from operations.	Significant and long lasting negative economic and social effects.

The distinction between temporary and long-term impact depends on many factors, but is ultimately a value judgement based on scientific evaluation and the level of community acceptance. These factors are generally related to climatic events, differing terrain units, vegetation units and timing of activities/operations. Dependent on these factors, a general guideline is that the community should expect recovery from drilling impacts in the north of South Australia after about five to ten years when current techniques are employed. Impacts that are irreversible or are expected to take significantly longer to recover are defined as 'long-term impacts'.

7.1.2 Likelihood of occurrence

The likelihood of potential environmental consequences occurring was qualitatively assessed and categorised according to the criteria outlined in Table 9. This table is based on Table 4(A) of HB 203:2004 (AS/NZS 2004c).

Table 9: Assessment of likelihood

Likelihood	Description
Almost certain	Is expected to occur in most circumstances
Likely	Will probably occur in most circumstances
Possible	Could occur
Unlikely	Could occur but not expected
Rare	Occurs only in exceptional circumstances

7.2 Risk Assessment

The level of risk has been determined by combining the likelihood and the severity of consequences using a risk matrix. Table 10 shows the risk matrix that has been used in this risk assessment. This matrix is based on example matrices provided in AS/NZ 4360:2004 and supporting documentation.

Table 10: Risk matrix

		SEVERITY OF CONSEQUENCE				
		Negligible Effect	Minor Effect	Moderate Effect	Major Effect	Catastrophic Effect
LIKELIHOOD	Almost certain	MEDIUM	HIGH	HIGH	VERY HIGH	VERY HIGH
	Likely	LOW	MEDIUM	HIGH	HIGH	VERY HIGH
	Possible	LOW	MEDIUM	MEDIUM	HIGH	HIGH
	Unlikely	LOW	LOW	MEDIUM	MEDIUM	HIGH
	Rare	LOW	LOW	MEDIUM	MEDIUM	HIGH

The objective of the risk assessment process is to separate the minor acceptable risks from the major risks and to provide data to assist in the evaluation and management of risks.

A summary of the risk levels for drilling activities is provided in Table 11. This risk assessment takes into account the mitigation methods and practices described earlier within this EIR.

The results of the risk assessment indicate that the risk levels for drilling activities are classified as either 'Low' or 'Medium'. No high or very high risks were identified. This indicates that with appropriate planning and management (in accordance with previous sections of this EIR), environmental risks are not at an unacceptable level.

Table 11: Summary of impacts and risk levels for drilling operations⁴

Activity	Hazard	Potential consequence	Severity	Likelihood	Risk
Well site and access track preparation	<i>Earthworks</i> <i>Excavations</i> <i>Vehicle movement</i>	Loss of vegetation and habitat	Minor	Possible	Medium
		Soil erosion and disturbance to natural drainage patterns	Minor	Unlikely	Low
		Soil inversion	Minor	Unlikely	Low
		Soil compaction/disruption/deflation, wheel tracks	Minor	Unlikely	Low
		Dust generation	Negligible	Likely	Low
		Noise generation	Negligible	Likely	Low
		Disturbance to native fauna	Negligible	Likely	Low
		Disturbance to stock	Negligible	Possible	Low
		Introduction and spread of weeds	Major	Unlikely	Medium
		Visual impact	Minor	Possible	Medium
		Damage to infrastructure	Minor	Unlikely	Low
		Impact and/or damage to cultural/heritage sites	Moderate	Unlikely	Medium
		Facilitation of third party access	Minor	Possible	Medium
	<i>Spills and leaks</i>	Contamination of soil, surface water	Minor	Unlikely	Low
Loss of organic beef certification		Moderate	Rare	Medium	
Drilling Operations, including Well Completion and Workover Operations	<i>Vehicle movement</i> <i>Rig moves</i>	Contamination of soil, surface water	Minor	Unlikely	Low
		Soil compaction/disruption/deflation, wheel tracks	Minor	Unlikely	Low
		Dust generation	Negligible	Likely	Low
		Disturbance to native fauna	Negligible	Possible	Low
		Disturbance to stock	Minor	Unlikely	Low
		Introduction and spread of weeds	Major	Unlikely	Medium

⁴ Assumes all activities avoid sensitive areas as described in Section 4 and Section 6 (e.g. GAB Springs).

Activity	Hazard	Potential consequence	Severity	Likelihood	Risk	
		Damage to infrastructure	Minor	Unlikely	Low	
		Loss of organic beef certification	Moderate	Rare	Medium	
		Noise generation	Negligible	Likely	Low	
		Road hazard / disturbance to local road users	Minor	Unlikely	Low	
	<i>Blowout or kick Equipment or tubular failure Down hole problems Casing or cement failure</i>	Contamination of soil, surface water or groundwater	Moderate	Unlikely	Medium	
		Crossflow, aquifer contamination or reduction in pressure in aquifers	Moderate	Unlikely	Medium	
		Uncontrolled release of water and hydrocarbon to surface	Major	Rare	Medium	
		Disturbance to native fauna	Minor	Unlikely	Low	
		Disturbance to stock	Minor	Unlikely	Low	
		Loss of organic beef certification	Moderate	Unlikely	Medium	
		Atmospheric pollution	Negligible	Unlikely	Low	
		Loss of reserves and reservoir pressure	Moderate	Unlikely	Medium	
		<i>Explosion or fire</i>	Loss of vegetation and habitat	Major	Unlikely	Medium
			Contamination of soil, surface water or groundwater	Moderate	Unlikely	Medium
	Crossflow, aquifer contamination or reduction in pressure in aquifers		Minor	Unlikely	Low	
	Uncontrolled release of water and hydrocarbon to surface		Major	Unlikely	Medium	
	Disturbance to native fauna		Major	Unlikely	Medium	
	Disturbance to stock		Moderate	Unlikely	Medium	
	Loss of organic beef certification		Moderate	Unlikely	Medium	
	Atmospheric pollution		Moderate	Unlikely	Medium	
	<i>Drill pipe failure</i>	Temporary restricted control over well fluids and circulation system	Negligible	Possible	Low	
	<i>Loss of containment of gas or oil while testing</i>	Contamination of soil, surface water or groundwater	Moderate	Possible	Medium	
Disturbance to native fauna		Minor	Unlikely	Low		

Activity	Hazard	Potential consequence	Severity	Likelihood	Risk
		Disturbance to stock	Minor	Unlikely	Low
		Loss of organic beef certification	Moderate	Unlikely	Medium
		Atmospheric pollution	Minor	Unlikely	Low
	<i>Spills or leaks associated with:</i> <ul style="list-style-type: none"> ▪ <i>drilling procedures</i> ▪ <i>storage of oil, fuels and chemicals</i> ▪ <i>refuelling operations and high pressure hydraulic systems</i> ▪ <i>storage and disposal of drilling and completion fluids (e.g. PFW, oil and condensate)</i> ▪ <i>transport of oil and condensate (by road)</i> 	Contamination of soil, surface water or groundwater	Moderate	Unlikely	Medium
		Loss of vegetation and habitat	Minor	Unlikely	Low
		Disturbance to native fauna	Minor	Unlikely	Low
		Disturbance to stock	Minor	Unlikely	Low
		Loss of organic beef certification	Moderate	Unlikely	Medium
		Atmospheric pollution	Minor	Unlikely	Low
		Disruption to land use	Minor	Unlikely	Low
	<i>Flaring of gas during testing</i> <i>Emissions vented from drill stem testing and production testing</i>	Atmospheric pollution	Minor	Likely	Medium
	<i>Disposal of hydrocarbon and PFW to excavated flare pits during testing and clean-up</i>	Contamination of soil, surface water or groundwater	Minor	Unlikely	Low
		Loss of vegetation and habitat	Minor	Unlikely	Low
		Disturbance to native fauna	Minor	Unlikely	Low
		Disturbance to stock	Minor	Unlikely	Low
		Loss of organic beef certification	Moderate	Unlikely	Medium
	<i>Loss of radioactive source down hole</i>	Contamination of groundwater (aquifer)	Moderate	Unlikely	Medium
	<i>Flooding of surrounding watercourses/floodplains</i> <i>Extreme weather conditions</i>	Contamination of soil, surface water or groundwater	Minor	Possible	Medium
		Damage to infrastructure	Minor	Unlikely	Low
	Waste Handling and Disposal	<i>Disposal of domestic and chemical waste</i> <i>Sewage treatment</i> <i>Disposal of drill cuttings and muds</i>	Contamination of soil, surface water and groundwater	Moderate	Unlikely
Soil inversion			Negligible	Possible	Low
Loss of vegetation and habitat			Minor	Unlikely	Low

Activity	Hazard	Potential consequence	Severity	Likelihood	Risk
		Dust generation	Negligible	Unlikely	Low
		Soil erosion/ disturbed drainage patterns	Minor	Unlikely	Low
		Visual impact	Minor	Unlikely	Low
		Litter	Minor	Unlikely	Low
		Attraction of scavenging animals (both native and pest species)	Minor	Possible	Medium
		Loss of organic beef certification	Minor	Unlikely	Low
Water supply / Aquifer Use	<i>Depletion of artesian and sub-artesian aquifers</i> <i>Spills and leaks</i>	Depletion of artesian and sub-artesian aquifers	Major	Unlikely	Medium
		Loss of water (wastage)	Moderate	Possible	Medium
Fuel & chemical handling & storage	<i>Spills and leaks</i>	Contamination of soil, surface water and groundwater	Minor	Unlikely	Low
		Loss of vegetation and habitat	Minor	Unlikely	Low
		Disturbance to native fauna	Minor	Unlikely	Low
		Disturbance to stock	Minor	Unlikely	Low
		Loss of organic beef certification	Moderate	Unlikely	Medium
Campsites and associated supplies	<i>Vehicle movements</i>	Soil compaction/disruption/deflation, wheel tracks	Minor	Unlikely	Low
		Dust generation	Negligible	Likely	Low
		Visual Impact	Minor	Unlikely	Low
		Disturbance to native fauna	Negligible	Possible	Low
		Disturbance to stock	Negligible	Possible	Low
		Introduction and spread of weeds	Major	Rare	Medium
		Road hazard / disturbance to local road users	Minor	Unlikely	Low
	<i>Camp site</i> <i>Disturbance of vegetation and habitat</i>	Loss of vegetation and habitat, damage to tree root structures	Minor	Unlikely	Low
		Soil erosion and disturbance to natural drainage patterns	Minor	Unlikely	Low
		Noise generation	Negligible	Likely	Low

Activity	Hazard	Potential consequence	Severity	Likelihood	Risk
	<i>Disposal of domestic and chemical waste Spills and leaks</i>	Visual Impact	Minor	Unlikely	Low
		Soil inversion	Minor	Unlikely	Low
		Contamination of soil, surface water, groundwater	Minor	Unlikely	Low
		Loss of organic beef certification	Moderate	Unlikely	Medium
		Litter	Minor	Possible	Medium
		Visual Impact	Minor	Unlikely	Low
	<i>Fire</i>	Fire damage to vegetation and habitat	Major	Rare	Medium
Well site and access track restoration	<i>Earthworks Vehicle movement</i>	Soil inversion	Minor	Possible	Medium
		Dust generation	Negligible	Likely	Low
		Noise generation	Negligible	Likely	Low
		Disturbance to native fauna	Negligible	Possible	Low
		Disturbance to stock	Negligible	Possible	Low
		Introduction and spread of weeds	Major	Rare	Medium
		Visual Impact	Minor	Possible	Medium
		Damage to infrastructure	Minor	Unlikely	Low
		Impact and/or damage to cultural/heritage sites	Moderate	Unlikely	Medium
	<i>Spills and leaks</i>	Contamination of soil, surface water	Minor	Unlikely	Low
Loss of organic beef certification		Moderate	Rare	Medium	
Monitoring	<i>Vehicle movement</i>	Soil compaction/disruption/deflation, wheel tracks	Minor	Unlikely	Low
		Dust generation	Negligible	Likely	Low
		Introduction and spread of weeds	Major	Rare	Medium
		Damage to infrastructure	Minor	Unlikely	Low
		Impact and/or damage to cultural/heritage sites	Moderate	Unlikely	Medium

8 Consultation

SAPEX will conduct targeted consultation with relevant interested parties, during both the development of this EIR (and accompanying SEO) and during planning for specific exploration programs. This consultation will assist SAPEX in identifying potential impacts and the best form of mitigation or management measures.

SAPEX is committed to maintaining effective communication and good relations with all stakeholders.

8.1 Key Stakeholders

The following stakeholders have been identified as having a direct interest in drilling activities in the Arckaringa Basin:

- State regulatory agencies
- Landholders
- Local government
- Native title / Aboriginal groups

Stakeholder consultation carried out for the development of this EIR is summarised in Table 12. Where future stakeholder consultation is planned but had not been undertaken at the time of writing, the entry has been left blank.

A major part of the consultation is the public consultation process under the Petroleum Act that was coordinated by PIRSA in 2007. The submissions received during the public consultation on the EIR and SEO are contained in Appendix 5, along with SAPEX's responses.

Table 12: Stakeholder consultation

Stakeholder Category	Organisation/Agency	Key Issues
Regulatory Authority	Department of Primary Industries & Resources (PIRSA)	Ongoing liaison regarding approvals, environment, safety, etc.
	Environment Protection Authority (EPA)	See Appendix 5
Government Departments	Department for Environment & Heritage (DEH)	Flora/fauna database records Tallaringa Conservation Park See Appendix 5
	DEH – Heritage Branch	State Heritage Register
	Department of Health	See Appendix 5
	Department of Water, Land & Biodiversity Conservation (DWLBC)	See Appendix 5
	Department of Water, Land & Biodiversity Conservation (DWLBC) – Native Vegetation	See Appendix 5
	Department for Transport, Energy & Infrastructure (DTEI)	RSSD Database, weeds
	South Australian Arid Lands NRM Board	
Commonwealth Government	Department of the Environment & Water Resources (DEWR)	
	Department of Defence	Access to Woomera Prohibited Area
Local Government	District Council of Coober Pedy	

Stakeholder Category	Organisation/Agency	Key Issues
Heritage / Native Title	State Aboriginal Heritage Committee (Aboriginal Affairs & Reconciliation Division, Department of the Premier and Cabinet (AARD))	
	Yankunytjatjara/ Antakirinja Native Title Group	Native title agreements (signed in 2006). (Further consultation will occur prior to Work Area Clearances for exploration programs)
	Antakirinja Matu-Yankunytjatjara Native Title Group	
	The Arabunna People's Native Title Group	
	Tjyrilia Aboriginal Corporation (Mount Willoughby Protected Area)	

8.2 Landholder Consultation

Landholders (land owners or occupiers) within the SAPEX Arckaringa Basin PELs will be informed of the proposed exploration activities and the management of these activities will be discussed. Close liaison will be carried out with landholders directly affected by drilling activities to ensure that activities are planned and carried out to minimise impacts to land use activities. Land occupiers will be formally notified prior to entry for exploration activities in accordance with Petroleum Act requirements and SAPEX will continue to work closely with landholders throughout the duration of its exploration programs.

A list of landholders in the Arckaringa Basin is provided in Appendix 4. These landholders were provided with an information brochure prepared by SAPEX that explained the proposed exploration activities and were also contacted by PIRSA during the public consultation period and provided the opportunity to comment on the EIR and SEO. Closer liaison has commenced with those landholders affected by the initial exploration activities.

8.3 On-going Consultation

SAPEX aims to continue to engage stakeholders for the duration of its exploration activities to ensure that all potential concerns are identified and appropriately addressed. Stakeholder correspondence will be registered and documented to ensure that issues are appropriately addressed.

9 References

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10 Abbreviations

°C	Degrees Centigrade
bbl	Barrels (1 bbl = 159 litres)
BOM	Bureau of Meteorology
CSG	Coal seam gas
DEH	Department for Environment and Heritage (South Australia)
DEWR	Department of the Environment and Water Resources (Commonwealth) (formerly the Department of the Environment and Heritage)
DTEI	Department of Transport Energy and Infrastructure (South Australia)
DWLBC	Department of Water, Land & Biodiversity Conservation (South Australia)
EIR	Environmental Impact Report prepared in accordance with Section 97 of the South Australian <i>Petroleum Act 2000</i> and Regulation 10
EMS	Environmental Management System
EPA	Environment Protection Authority (South Australia)
EPBC Act	<i>Environment Protection and Biodiversity Conservation Act 1999</i> (Commonwealth)
GAB	Great Artesian Basin
h	hours
ha	hectares
kg	kilogram
km	kilometre
L	litre
m	metre
mg	milligram
NPW Act	<i>National Parks and Wildlife Act 1972</i> (South Australia)
PEL	Petroleum Exploration Licence
PIRSA	Primary Industries and Resources, South Australia
PFW	Produced Formation Water
ppm	Parts per million
RNE	Register of the National Estate
s	seconds
SCB	Soil Conservation Board
SEB	Significant Environmental Benefit
SEO	Statement of Environmental Objectives

11 Glossary

Acidising – treatment of oil-bearing limestone or carbonate formations with a solution of hydrochloric acid or other chemicals to increase production. The acid is forced under pressure into the formation where it enlarges the flow channels by dissolving the limestone.

Blow-out or Kickback – when well pressure exceeds the ability of the wellhead valves to control it. Oil or gas flow freely at the surface.

Casing Strings – steel tubing that lines a well after it has been drilled. It is formed from sections of steel tube that have been screwed together.

Drill Pipe – lengths of steel pipe screwed together to form a continuous pipe extending from the drilling rig to the drilling bit at the bottom of the hole. Rotation of the drill pipe and bit causes the bit to bore through the rock.

Drill Stem Tests – conventional method of testing a formation to determine potential productivity before installing production casing in a well. A testing tool is attached to the bottom of the drill pipe and placed opposite the formation to be tested which has been isolated by placing packers above and below the formation. Fluids in the formation are allowed to flow up through the drill pipe by establishing an open connection between the formation and the surface.

Production Casing – steel pipe threaded together and cemented into a well to prevent the wall of the hole from collapsing and to provide a means of extracting oil/gas from the well.

Produced Formation Water (PFW) – water associated with oil and gas reservoirs that is produced along with the oil and gas.

Stuffing Box - is a cylindrical space in a pump casing surrounding the shaft of a pump to prevent leakage.

Well Head – steel equipment installed at the surface of the well containing an assembly of heavy duty hangers and seals. The wellhead is used to support the weight of the casing strings hung from it and to contain the well pressure.

Appendix 1:

Land Systems in the Arckaringa Basin

Land Systems in the Arckaringa Basin

This document provides a detailed description of the land systems in the Arckaringa Basin that are briefly discussed in the EIR. The descriptions are taken from relevant Soil Conservation Board District Plans. The Department of Water, Land and Biodiversity Conservation supplied data used in the map.

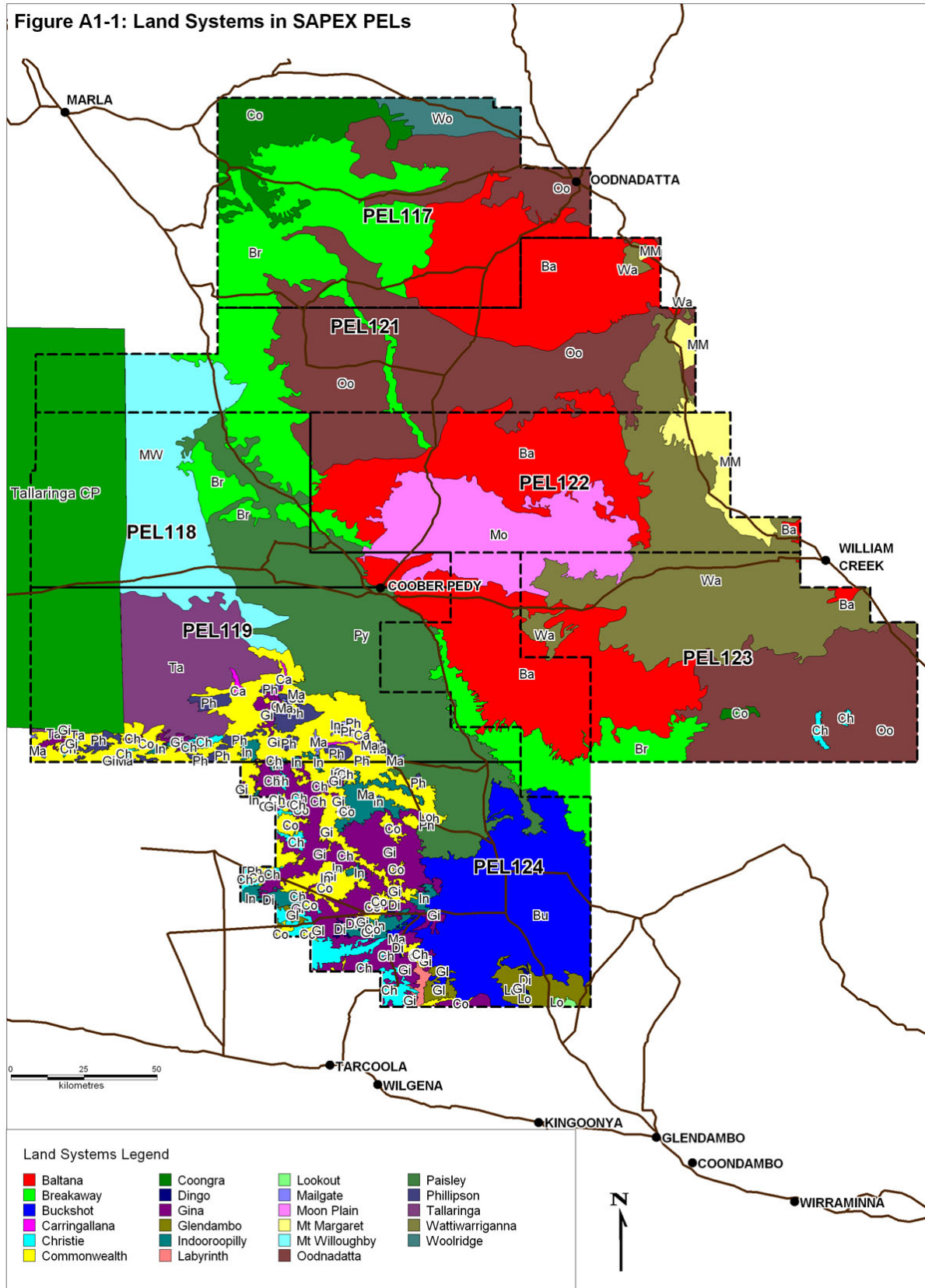


Table A1: Land system summary

Name	Land form	Land features	IBRA Region			
			STP	SSD	GVD	GAW
Baltana	P	Moon plain, Drainage lines/watercourses	X			
Breakaway	U	Tablelands, Drainage lines/watercourses	X			
Buckshot	P	Plains, Drainage lines/watercourses	X			
Carringallana	FP	Drainage lines/watercourses				X
Christie	U	Stony plain	X			X
Commonwealth	SP	Sand plain, Drainage lines/watercourses				X
Coongra	StP / U	Stony plain, Stony Hills, Drainage lines/watercourses	X			
Dingo	FP	Drainage lines/watercourses				X
Gina	P	Plain				X
Glendambo	P	Sand plain	X			X
Indooroopilly	D	Dunes, Swales, Claypans				X
Labyrinth	D	Dunes, Swales, Claypans, Salt lakes				X
Lookout	U	Stony Hills	X			
Mailgate	U	Dunes, Stony Hills				X
Moon Plain	P	Moon plain, Drainage lines/watercourses	X			
Mt Margaret	U	Ranges, Tableland, Stony plain (footslopes)	X			
Mt Willoughby	P	Stony plain, Dunes			X	
Oodnadatta	P	Stony plain, Drainage lines/watercourses, Stony Hills	X			
Paisley	U	Stony Hills, Drainage lines/watercourses	X			
Phillipson	D	Swales, Dunes, Claypans, Salt lakes				X
Tallaringa	StP/D	Dunes, Stony plain			X	
Wattiwarriganna	D	Dunes, Swales, Drainage lines/watercourses, GAB Springs	X	X		
Wooldridge	P, D	Swales, Dunes, Claypans, Salt lakes, Drainage lines/watercourses	X			

Key to Landform

FP = Flood plain including alluvial plains

D = Dunefield (dunes with clay swales, occasional claypans, salt lakes)

StP - Stony Plain

SP = Sand plain (sand over silty clays)

P = Plain

U = uplands including hills, mesas

Key to IBRA Regions

STP = Stony Plains

GVD = Great Victoria Desert

SSD = Simpson Strzelecki Dunefields

GAW = Gawler

General Land System Descriptions from SCB District Plans⁵

Baltana Land System (K, Ma)

The Baltana land system occupies a large area to the east and south of the Stuart Range on McDouall Peak station. It also occurs on Billa Kalina Station.

This land system has formed where erosion of the silcrete capping has exposed the softer Bulldog Shale which has mixed with alluvium from the ranges. This has resulted in the formation of extensive undulating plains with numerous gilgais and some areas of sandsheet. This is known locally as "moon" or "loomy" country. It has distinct similarities with the nearby Oodnadatta land system. Soils, which include silts, sands and grey clays, are covered with a lag of silcrete and quartzite gibbers. The soils comprise brown saline clay which separates it from the softer grey clays of the Moon Plain land system.

No perennial species truly dominate the vegetation on plains and there are often large bare areas, which support ephemeral species following rain, between patches of perennial vegetation. The dominant plant species on the plains are Oodnadatta saltbush, bladder saltbush, neverfail, Mitchell grasses, Flinders grass, button grass, Cooper clover, pale poverty-bush, tangled poverty-bush and samphires (glassworts).

Creeks and watercourses have alluvial sand and cracking clay soils and contain large amounts of shales and gypsum and support very little vegetation. Prickly wattle is the dominant species in the creeks with coolibah, cottonbush and silky browntop also common. Verbine and Cooper clover grow following good rains. Old man saltbush occurs in swamps and some creeks.

Plains, watercourses and run-on flats are all dominated by chenopod low shrublands. Bladder saltbush, woolly bluebush, barley Mitchell grass, neverfail and pale poverty-bush are common on plains with brown clay or silty soils. Watercourses with brown cracking clays and alluvial sands support cottonbush and showy groundsel. Run-on flats have saline grey-brown clays and are characterised by black bluebush, cottonbush, samphire, showy groundsel and swamp canegrass, with barley Mitchell grass and neverfail occurring where gilgais are present.

Sandsheets have formed in some areas from residual yellow sands deposited on the underlying gibber plain. These areas support low open shrublands with Sturt's pigface prominent in the vegetation. Elegant wattle (prickly wattle) and bladder saltbush also occur here.

Breakaway (Ma)

This land system has formed from an eroding basement of Bulldog Shale. Eroding shales and silcretes have resulted in mixtures of silcrete gibber, grey shales and other variously coloured hard and soft shales. The various colours result from the amount of leaching of iron from the shales, with red coloured shales containing more iron and paler ones containing less.

Vegetation of all land units except broad watercourses is dominated by chenopod low shrubland. Tall shrublands of bastard mulga, mulga, northern myall and emubushes are also common. Clay soils over silicified shales of tablelands and low hills are dominated by bladder saltbush, low bluebush and three-winged bluebush, sometimes with mulga and sennas. Vegetation of footslopes also includes bristly sea-heath and samphires, reflecting the more saline nature of the soils, and has fewer trees and tall shrubs.

Solonized red duplex soils of plains support bladder saltbush, low bluebush, samphire and bristly sea-heath, but also have barley Mitchell grass in the gilgais. Alluvial soils of smaller watercourses support bladder saltbush, cottonbush, spiny saltbush, round-leaf emubush, native apricot and showy

⁵ Information taken from the Kingoonya (K), Marla-Oodnadatta (Ma) and Marree (M) Soil Conservation Boards' District Plans.

groundsel. Larger watercourses have mulga or coolibah woodland, with marpoo and bullock bush also present.

Buckshot Land System (K)

The Buckshot land system was formed from erosion of parts of the Stuart Range and is widespread in central parts of the Kingoonya SCB district. Land units comprise very flat plains and broad shallow watercourses.

Between buckshot clad sandy clay plains, red earth and desert loam soils support mulga groves and scrub, with dead finish, crimson turkey bush, round-leaf emubush and low bluebush also present. Gravelly clay plains with desert loam or brown clay soils are dominated by chenopod low shrublands, with cottonbush, bladder saltbush and low bluebush; the understorey is of barley Mitchell grass, neverfail and long-spined poverty-bush. Sandy earth soils of watercourses support mulga woodlands, with dead finish, crimson turkey bush and round-leaf emubush.

Carringallana Land System (K)

The Carringallana land system occupies small areas of sandy country to the west of the Stuart Range on Ingomar Station. Despite the sandy nature of the soil, well-defined watercourses are maintained and these characterise this land system. These watercourses, with their alluvial sandy soils, are similar to the watercourses of the Brumby land system. They are generally tree-lined, with coolibah, boree tea-tree, umbrella bush, dead finish and narrow-leaved hopbush common in the overstorey, and Sturt's pigface, cottonbush and goathead burr dominating the understorey.

Christie Land System (K)

The Christie land system is an ancient system formed from granitic and gneissic rocks as well as quartz bedrock and silcrete, with silcrete often present on hilltops. It is widespread in the western half of the Kingoonya SCB district.

Mulga scrub dominates on shallow stony sandy loams and stony earthy sands on outwash slopes. Tall shrublands of crimson turkey-bush, green turkey-bush, round-leaf emubush, three-wing bluebush and cassias are also present, often with an understorey of perennial grasses including woollybutt and bandicoot grass. Chenopod low shrublands dominate three land units within this land system; silcrete rises with shallow stony sandy loams, silcrete rises with shallow calcareous loams, and valley plains with sandy earth soils. Bladder saltbush and low bluebush are common in all three of these units, with black bluebush joining them on valley plains. Round-leaf emubush and cassias occur in both units featuring silcrete rises, with pearl bluebush present on calcareous soils, and three-wing bluebush and silky bluebush present on non-calcareous soils. Mulga scrub is also found on shallow alluvial sands of watercourses, with dead finish and spiny saltbush.

Commonwealth Land System (K, Ma)

An extensive sand plain, which is quite young in geological terms, occurs in the western part of the Kingoonya SCB district and south-western corner of the Marree-Oodnadatta SCB district, between the Great Victoria Desert in the west and the Stuart Range in the east. It forms the Commonwealth land system.

There are a few well defined watercourses, largely restricted to the eastern margins. Some low sandy rises have formed from the same sediments, but there are no dunes. Numerous claypans collect any runoff, although most rainfall is quickly absorbed into the sandplain. Soils are mostly light and often shallow, and are comprised of siliceous sands, earthy sand or sandy red earths, with bedrock or calcrete close to the surface. Some hardpan soils also occur. Small areas of other land systems are often found surrounded by the sand plains of the Commonwealth land system.

Vegetation of the sand plain is dominated by mulga low open woodland on siliceous sands, earthy sands or sandy red earths, with emubushes, cassias and mulga grass also present. In places where lime and salts are close to the surface, the ground cover is dominated by chenopod species, particularly bladder saltbush and pearl bluebush, with emubushes, cassias and silver tails also

present. Perennial grasses, especially woollybutt and bandicoot grass, dominate the understorey where salts and basement rocks are more than about 60 cm below the surface. Chenopods are more common in the south and east of this land system, reflecting the more saline nature of the soils in these areas.

Salt tolerant species such as samphires, glassworts, black bluebush and cottonbush are common on clay and silty soils at the margins of claypans where salinity is higher than on the sandplain. Mulga grass is often common in the understorey in such places.

Coongra (Ma)

This land system consists of vast sandstone and shale covered slopes, plateaus and plains dominated by bladder saltbush. Undulating stony tablelands with gilgais are dissected by an extensive drainage system although much of the initial drainage is into gilgais. Stones are rounded or angular and range in size from 3 to 30cm in diameter and these form an erosion resistant layer unless they are disturbed.

The slopes are treeless except for the occasional rock emubush tall shrubs. Sparse mulga occurs along shallow creek lines, with this species accompanied or replaced by gidgea on the eastern side of the land system. Coolibahs occur with river red gums along the larger watercourses, often with an understorey of Australian cupgrass.

On the tablelands bladder saltbush grows in association with the perennial grasses like the Mitchell grasses, native millet, katoora, the perennial shrub bristly sea-heath and occasional rock everlastings. Understorey plants include mulga grass, bottlewashers and bogan flea. The majority of perennial plants growing here are the same as those growing on the Oodnadatta land system, with the major difference being that Oodnadatta saltbush is uncommon in the Coongra land system and is a dominant plant in the Oodnadatta land system.

After rain, the Coongra land system is very productive, growing a wide variety of annual, ephemeral and short lived perennials, even in dry times. This system is relatively productive due to its perennial plant component.

Dingo Land System (K)

Drainage areas around low hills and rises in the Mulgathing, Bulgunnia and Wilgena areas, and also to the south of the Stuart Range on Mount Eba Station, comprise the Dingo land system. Well-defined watercourses are generally lacking and those that are present do not always go far enough to flow into swamps.

Vegetation is often dominated by chenopod low shrublands. Sugarwood open woodland occurs on the alluvial sands of some watercourses, often in association with cassias and Australian boxthorn, with satiny bluebush, bindyis and mulga grass in the understorey. Other watercourses with firmer alluvial sandy soils are dominated by mulga woodland, tall shrublands of cassias and dead finish, and an understorey of bindyis. Claypans with saline alluvial sands and silts are often fringed by tea-tree scrub comprising boree tea-tree and broombush, with chenopod low shrublands of black bluebush, cottonbush and nitre goosefoot and grasslands of swamp canegrass. The firm alluvial sands of flood plains often support mulga woodlands with chenopod low shrubland understorey featuring bladder saltbush, cottonbush and bindyis.

Gina Land System (K)

The Gina land system is widespread in the western half of the Kingoonya SCB district. Vegetation of the calcareous sandy loams on plains is dominated by chenopod low shrublands of pearl bluebush and bladder saltbush, with taller shrublands of narrow-leaved hopbush and cassias and an understorey of grasses, particularly bottlewashers. Run-on flats support mulga woodlands with a grass understorey, dominated by neverfail, on sandy earths and sandy red earths. Sand spreads with sandy earth soils also support mulga woodlands with a grassy understorey; also included are cassias and the grasses woollybutt and bandicoot grass.

Glendambo Land System (K)

Glendambo land system is similar to the Gina land system, which occurs further to the west, but differs in having an overstorey of western myall and less perennial grasses on the run-on flats.

Vegetation on the deep earthy sands and shallow siliceous sands of sand spreads is dominated by western myall and mulga woodland, and also includes tall shrublands of bullock bush and cassias. The understorey includes pearl bluebush and Australian boxthorn, with bandicoot grass and woollybutt.

Plains with calcareous earths support western myall woodlands over chenopod low shrublands with an understorey of cassias, bladder saltbush, Australian boxthorn and spiny goosefoot. Plains with red duplex soils support bladder saltbush, low bluebush, cottonbush, black bluebush and Sturt's pigface.

Rises with calcareous sand soils support an open woodland of western myall and chenopod low shrublands of pearl bluebush, bladder saltbush, round-leaf emubush, low bluebush and three-wing bluebush. Run-on flats with sandy red earth soils are dominated by mulga woodlands, with dead finish, crimson turkey bush, spiny saltbush, black bluebush and bladder saltbush also commonly present.

Indooroopilly Land System (K)

The Indooroopilly land system occurs mainly in the far west of the Kingoonya SCB district, with smaller areas having formed on the windward margins of the Stuart Range. Parallel dunes up to 10 m high have formed in the west and are typical of this land system, although parallel ridges and sand spreads less than 5 m high have formed in the east.

Vegetation of the sand dunes is dominated by horse mulga tall shrublands with crimson turkey-bush and narrow-leaved hopbush and an understorey of woollybutt, bandicoot grass and kerosene grass. Mallee occurs in some western parts of this land system. The swales support a mulga low woodland with black oak, bullock bush and tar bush and an understorey dominated by grasses, with woollybutt, bandicoot grass and mulga grass being the most common species.

A few claypans occur in this land system, and these support mulga scrub with swamp chenopods such as cottonbush and black bluebush.

Labyrinth Land System (K)

The Labyrinth land system is widespread in southern central parts of the Kingoonya SCB district, particularly in the Tarcoola and Kingoonya areas. It is made up of a series of small salt lakes and claypans with adjoining sand dunes. It is similar to the Phillipson land system, but also includes a large sand plain supporting bladder saltbush and low bluebush, with native apricot and bullock bush occurring as isolated plants or small thickets.

Vegetation of the dunes is dominated by mulga and horse mulga woodlands, with narrow-leaved hopbush and broom emubush and an understorey of woollybutt and bandicoot grass. Red mallee, twin-leaves and bladder saltbush are also present on gypsiferous sandy dunes bordering the lakes. Low shrublands of bladder saltbush, samphire and Sturts pigface occur in saline sands, silts and clays bordering salt-lakes and claypans. Low chenopod shrublands dominated by bladder saltbush and low bluebush occur on deep siliceous sands of sand plains.

Lookout Land System (K)

The Lookout land system includes areas to the south of the Stuart Range in the central parts of the Kingoonya SCB district. Erosion of underlying bedrock, particularly Bulldog Shale, has created a system of low silcrete-capped hills with adjacent plains.

Calcareous loams and calcareous earths of silicified shales of plains, and calcareous loams of silicified shales on rises, both support chenopod low shrubland with open western myall woodland. Pearl bluebush, three-wing bluebush, bladder saltbush, spiny goosefoot, silver tails and limestone

copperburr occur in both landform units. Vegetation of the plains also includes low bluebush. Mulga is sometimes present in the few small watercourses.

Mailgate Land System (K)

Mailgate land system has formed in hilly country, with sand drift and dunes covering or encroaching on hillsides and rises. The dunes usually lack regular patterns, with their shape and orientation being determined by that of the underlying hills, although on the foot slopes of the Stuart Range they are usually parallel or almost parallel. Sandy country occupies over half the area of this land system. The Mailgate land system occurs in the western half of the Kingoonya SCB district.

Vegetation on low stony rises and slopes is dominated by either mulga scrub or saltbush-low bluebush low shrubland, depending on the underlying soils. Shallow stony sandy soils of silcrete rises support mulga woodlands with emubushes and cassias, while chenopod shrubs dominate where the sand is deeper or where calcrete or lime are present.

Dunes and sand sheets support mulga or horse mulga woodlands and tall shrublands of narrow-leaved hopbush, emubush and cassias. Understorey on dunes and sand sheets is often of bandicoot grass and woollybutt.

Pearl bluebush sometimes occurs on calcareous soils. Bladder saltbush and low bluebush dominate flats between the dunes in areas near the Stuart Range. Mallee species sometimes grow on sandy soils in the south-west of the district.

Moon Plain (Ma)

This land system occurs north-west of Coober Pedy. Its dominant feature is an undulating plain with soft grey cracking gypseous clay soils which generally lack any cover of gibber or other stones. This soil type separates it from the heavier brown clays of the Baltana land system, which it abuts to the west, south and east. The Moon Plain has little drainage and becomes very boggy after rain. However, two major drainage lines run through this system and provide drainage following very heavy rain. They also provide a habitat for the majority of perennial shrubs found in this land system.

The Moon Plain has very little plant cover in most years, with only a few perennial species present. Mitchell grasses and neverfail are two of the few perennial grasses found on the Plain, together with annual and pop saltbushes, mulka grass, pale poverty-bush, tangled poverty-bush, Blacks copperburr and buckbush.

Several species of samphire are common in the drainage lines, along with prickly wattle, old man saltbush, lignum, swamp canegrass and a few stunted coolibahs. Annual saltbush, pop saltbush, limestone bottle-washers, Darling pea, mulka grass, buckbush and various copperburr's also occur. Numerous ephemerals, including Cooper clover, flourish after good soaking rains of more than 50mm.

Mount Margaret (Ma)

This is a small land system located 100 km west of Lake Eyre North. It consists of rugged ranges with deep gorges, a deeply dissected plateau on top of the range, and long-lasting rock holes. The slopes of the range are rough and rocky. These ranges were once part of an inland sea and tidal ripple marks can be seen on rocks at the top of the range. The stripping process of the ancient soils is far more advanced here than in the Breakaway land system, although residual formations of up to 50 m or more above the level of the surrounding Oodnadatta land system are present. Soils may be up to several metres in depth.

The footslopes of this land system can be separated from the adjoining Oodnadatta land system by the presence of ferruginous rather than quartzite gibbers in the Mount Margaret land system.

The upper parts of creeks which begin in the ranges support the northern form of the river red gum, but this tree is replaced by coolibah when the creeks leave the ranges and become wider and the soils are sandier. The creeks also support dead finish and chenopod shrubs and perennial grasses which include lemon-scented grass, cotton grass and swamp wanderrie, often on skeletal rocky soils. The

steep rocky gorges at the head of many of the creeks support mountain wanderrie and spinifex on shallower soils.

An undulating gibber tableland occurs on top of the range, with clay soils and numerous deep drainage lines. This tableland is covered with bladder saltbush, short-winged copperburr, salt copperburr and Mitchell grasses and is similar to the Oodnadatta land system, but lacks the Oodnadatta saltbush.

Steep hill slopes support a tall open shrubland of bastard mulga, mulga, emubushes, sennas, silver tails and perennial sunray, with other daisies, paper daisies and mulga grass. The lower undulating footslopes surrounding the ranges contain gilgais and support numerous chenopods (dominated by Oodnadatta saltbush), mulga grass, Mitchell grasses and other vegetation similar to the Oodnadatta land system.

Mount Willoughby (Ma)

This land system is characterised by red pebbly clay plains with occasional low irregular sand dunes.

The hard flats support sparse to open mulga, with rock emubush also common. The sparser areas support the occasional tar bush. These flats contain numerous small swamps or depressions which support dense mulga woodland, with emubushes, sennas, chenopod shrubs and subshrubs. Perennial grasses such as needle-leaved threeawn, cotton grass and neverfail and annual grasses such as mulga grass and spear grass are also common. After rains the harder flats grow an abundance of mulga grass and annuals such as round-leaf parakeelya and various everlastings.

Mulga woodland occurs on both the dunes and interdune flats, with neverfail and mulga grass dominant in the understorey of the interdune areas and woollybutt, woollybutt wanderrie and tall kerosene grass being the main ground cover on dunes.

There are several predominantly mulga-lined drainage systems which feed into larger swamps, such as Wintinna Swamp, and these support cottonbush, neverfail and swamp canegrass.

Oodnadatta (Ma, M)

The Oodnadatta land system is the largest and most extensive land system found in the Marla - Oodnadatta Soil Conservation District. This extremely extensive land system extends from Dalhousie southward along the western side of Lake Eyre and into the south-west of the Marree SCD.

This land system is comprised of extensive undulating plains with a lag of silcrete and quartzite gibbers with numerous gilgais and occasional plateaus. It has an extensive drainage system with large braided creeks such as the Neales and Arckaringa Creek.

As for similar tableland land systems, the major soils are the duplex loams over clays of the gibber "shelf" areas, and the self-mulching clays of the gibber-free gilgais. Gibber soils are saline and dispersive, being either deep red clays or clay loams. Much of the soil salinity is now thought to have arisen through vertical leakage at the margins of the Great Artesian Basin, which this land system follows. Gilgais have much lower salinity. Gibber cover may be derived from silcrete or gypcrete, and there are areas with a very high gypsum content south of Lake Eyre South

Gilgais are the most productive component of this land system due to the combination of water run-on from shelves, cracking clays which do not seal until much of the profile has been wetted and the lower salinity. They are able to trap water run-off from the impervious stony flats which surround them. This water is then retained for extended periods by the clayey soil. Gilgais vary in size from only a few metres to approximately 10 metres in diameter and may be irregular in shape. The densest vegetation occurs in gilgais and on gilgai fringes or along watercourses. The stony shelves between the gilgais are often bare or covered only with a few bindyis or sparsely distributed samphire.

Gilgais support perennial low shrubs, Oodnadatta saltbush and / or samphire depending on salinity, and perennial grasses particularly native millet, barley Mitchell grass and katoora. Other common species include fairy grass, neverfail, plains lantern-bush, five-minute grass, bladder saltbush and

occasionally cottonbush. The irrigation from adjoining shelves results in dense growth of ephemerals after rain, particularly windmill grasses, Australian cup-grass, Flinders grasses and bottlewasher. The edges of gilgais support perennial shrubs such as bladder saltbush and bristly seaheath. Trees and tall shrubs are usually absent, whether because of limited water storage, salinity or excessive gypsum at depth.

Predominantly perennial plants such as bladder saltbush, katoora, neverfail, bristly sea-heath and rock everlasting grow on the less productive gilgai fringes. A sparse scattering of ephemeral herbs and forbs occur after winter rainfall.

Gibber areas between gilgais are by comparison almost unvegetated. Ephemerals appear after major rains which are sufficiently heavy to leach salts out of the upper soil profile. Such rains have to be major and prolonged, since the gibber soil surface seals rapidly when wet, and most water runs off into gilgais.

Low hills and escarpments, (jump-ups) have gypseous clay loam soils, without gilgai formation. Bladder saltbush, low bluebush, black bluebush, harlequin fuchsia-bush typically occur. Annual species include Tate's bindyi, spear grass, kerosene / mulga grass, and common and jointed bottlewasher.

Gidgee is common along creek lines in northern parts of the land system and mulga grows along creek lines throughout the land system. Coolibah grows along the larger watercourses, sometimes in association with river red gums.

Alluvial soils of watercourses support coolibah, river red gum, Broughton willow, prickly wattle and gidgea, and mineritchie in the north of the District. The shrub layer is dominated by old man saltbush, cottonbush and lignum with an understorey of grasses which may include swamp canegrass, neverfail, Mitchell grasses, silky brown tops, and perennial cupgrass. Cooper clover and verbine are common in wet seasons. The sandy floodouts adjacent to the creek support gidgea, coolibah and Mitchell grasses. Claypans with heavy brown clays are generally bare other than at their margins.

Numerous mound springs occur in this land system. Springs vary from active with visible flows to extinct and include the whole range between the two extremes. Mound springs often support dense grasslands of common reed when they are not subject to persistent grazing. Prolonged grazing removes the common reed and the more resilient but much smaller bore-drain sedge replaces it.

Paisley Land System (K, Ma)

The Paisley land system describes the Stuart Range which extends north-west from Coober Pedy. Bulldog Shale commonly underlies the heavy clay soils, with infrequent silcrete outcrops. Silicified bands in the Bulldog Shale are the source of opals in the Coober Pedy area. Soils include texture contrast soils and brown clays, alluvial sands and loams. Chenopod low shrubland dominates on all units except watercourses.

Vegetation on silcrete rises is characterised by a low shrubland of bladder saltbush, low bluebush, three-wing bluebush, silky copperburr and round-leaf emubush on stony sandy-loam soils. Bladder saltbush, low bluebush, barley Mitchell grass, neverfail, long-spined poverty-bush, silky copperburr and native apricot are found on stony red duplex and brown clay soils of low hills and rises and on the heavier soils of gilgais.

Outwash slopes, with stony red duplex soils, are characterised by bladder saltbush, low bluebush, round-leaf emubush, three-wing bluebush, limestone cassia and pale poverty-bush. Mulga scrub occurs on alluvial sands and skeletal loams of watercourses, with dead finish, bladder saltbush, black bluebush, cottonbush, Sturt's pigface and spiny saltbush all being common in this unit.

On Mabel Creek, a specific unit exists which describes the floodout areas from Mabel and Woorong Creeks, with the floodout flats having silty clay soils and being overlain in places by longitudinal dunes which run parallel to the direction of water flows creating flood channels between the dunes. A few fresh waterholes occur in the main channels of the creek.

Vegetation is dominated by coolibah, with weeping emubush and an extensive understorey of neverfail, umbrella grass, native millet and nardoo, with ephemeral herbs and grasses also present following flooding. There are many claypans around which grow tea-tree and lignum and the occasional nitre goosefoot.

Phillipson Land System (K)

Phillipson land system is quite variable in its composition. It is widespread throughout the Kingoonya SCB district, although most common in the north and west, particularly on Commonwealth Hill Station, where it occupies the lowest areas of the regional landscape. It is absent from the south-east corner of the district. It is characterised by salt-lakes and claypans with associated lunettes and sand dunes. Low limestone and gypsum cliffs border many of the lakes, especially in the west of the district. This limestone often forms a shelf around some of the larger lakes and this has allowed sand to accumulate and form dunes at the lake's edge. Larger lakes and claypans are either at the end of drainage lines from the Stuart Range, or are a linear series of depressions in ancient river channels that are remnants of a much wetter period than the present. Vegetation includes both salt tolerant species and those which can stand periods of inundation.

Vegetation on siliceous sands of dunes is dominated by mulga and horse mulga woodlands, with a grass understorey of mainly bandicoot grass and woollybutt. Narrow-leaved hopbush and turpentine bush are also common. Saline siliceous and gypsiferous sands of dunes fringing lakes are dominated by mulga and horse mulga woodlands, with narrow-leaved hopbush and boree tea-tree are also common. The understorey is often of bladder saltbush and kerosene or mulga grass.

Chenopod low shrublands dominate the saline alluvial sands and clays at the margins of claypans and salt lakes. These shrublands commonly include cottonbush, black bluebush, bladder saltbush, lignum, nitre goosefoot and swamp canegrass, with an ephemeral herb understorey. Black oak - mulga woodland occurs on the gypsiferous sands of dunes and on sand-covered limestone shelves bordering claypans and salt-lakes.

Tea-tree often occurs on flood-prone swales, with mulga woodland dominating on swales with deeper sandy soils. Some calcareous swales are dominated by bladder saltbush and black bluebush. Neverfail is common in the understorey of flood-prone swales. Coolabah woodland occurs in northern parts of the district on Ingomar and Mount Penrhyn leases, but is not found in the south of the district.

Tallaringa Land System (K)

The Tallaringa land system occurs where parallel east-west dunes of red siliceous sands overlie an extensive laterite plain. Relict ironstone outcrops provide some relief to this almost flat plain. This land system occurs on Mobella and Commonwealth Hill stations, but is more extensive to the north-west of Mabel Creek and north of the Kingoonya Soil Conservation District.

This land system is dominated by mulga woodland, with narrow-leaved hopbush and emubushes on the sandy soils of dunes and swales, or by shrublands of green turkey-bush, crimson emubush and green fuchsia-bush on stony siliceous sands of silcrete rises and plains. Understorey on sandy soils is commonly bandicoot grass and kerosene or mulga grasses, while on calcrete rises and plains it often includes woollybutt wanderrie, lovegrasses and mulga grass.

Wattiwarriganna (Ma)

The Wattiwarriganna land system is formed from a series of large parallel sand ridges overlying an older gibber plain, with swales usually containing a gibber pavement. Dunes are generally from 100 m to 500 m apart and up to 10 m in height.

The quartzite and silcrete gibbers are gravel rather than scree size because they have been sorted as they travelled further from their source. Numerous large watercourses dissect the land system. Dunes usually have deep red sandy soils, although dunes in this land system on Billa Kalina Station are generally paler. Sandy or clay-loam soils occur in the swales, which are generally flat, but may contain low sandy or calcareous clay rises.

The swamps have brown clay, or cracking grey or brown clay, or yellow or red sandyloam soils. Numerous large watercourses dissect the land system.

Vegetation of the dunes is dominated by a hummock grassland of sandhill canegrass or a tall shrubland of horse mulga. Marpoo occurs in isolated stands and narrow-leaved hopbush is also moderately common. Few understorey species grow under or near these two shrubs. Silver needlebush also occurs as scattered plants and mulga occurs on some dune footslopes. The understorey includes tall kerosene grass, buckbush and cattle bush.

Interdune corridors include both sandy flats and claypans. Sandy flats support low shrublands of Sturts pigface, cottonbush, low bluebush, bladder saltbush, emubushes, sennas and neverfail, with mulga grass dominant in the understorey. Some claypans support swamp canegrass, old man saltbush, cottonbush, neverfail and lignum. Blue rod is common at claypan margins.

Larger watercourses are usually lined with coolibah, with marpoo, old man saltbush, cottonbush, sennas, samphire, neverfail, cupgrasses, silky browntop and swamp canegrass all present in the understorey. Cane-grass (swamp cane-grass) is common at some swamps and claypans. Swamps have similar understorey vegetation to watercourses but usually lack the associated riparian woodlands.

Several mound springs occur within this land system and support their characteristic vegetation including common reed, bore-drain sedge, cutting grass, bare twig rush, sea rush and salt couch.

Wooldridge (Ma)

This land system forms a transition between the gibber plains and plateaus of the Oodnadatta land system and the mulga woodlands of the Pedirka land system. It contains a combination of highly calcareous open flats, wide braided watercourses fringed by sand dunes and clay pans. There are also some coolibah swamps and salt pans. Dune soils are typically deep red sands, with alluvial silts and clays in flooded areas and hard red clay on the flats.

The calcareous flats grow open communities of sparse mulga and dead finish, with low bluebush and/or bladder saltbush. Individuals of both species are separated by areas of bare ground which grow predominantly annual grasses and herbs after rain. These annual grasses are usually dominated by mulga grass and bottlewashers. Cannonballs, poverty-bush, buckbush and various emubushes and sennas also occur.

The dunes between the open flats support a greater variety of perennial plants, most of which are palatable to livestock. The overstorey vegetation is dominated by mulga, with marpoo sometimes more frequent than the mulga, especially on sand dunes. Dead finish is also present, as are emubushes. The understorey is dominated by grasses, especially mulga grass, limestone bottlewashers and tall kerosene grass. A wide variety of annual and ephemeral plants which are considered valuable for fattening livestock also occur after rain.

Watercourses contain gidgea, mulga, dead finish, river red gum and coolibah, with understorey shrubs including cottonbush, lignum and Queensland bluebush. Mitchell grasses, swamp canegrass, silky browntop and native millet are the most common perennial grass species. After flooding, watercourses and low lying areas grow an abundance of annuals which include button grass, verbine, Cooper clover and munyeroo.

Western myall occurs in greyish loam over limestone on the hard plateau near Mount Alice, although this area is dominated by a low shrubland of bladder saltbush and low bluebush. Mitchell grasses, spear grass and bottlewashers occur in the understorey.

Appendix 2:

Rare or Threatened Species Recorded in the Region

Rare or Threatened Species in the Arckaringa Basin

A search of the Commonwealth Environment Protection and Biodiversity Conservation (EPBC) database and the South Australian Department for Environment and Heritage (DEH) databases has identified the following rare or threatened flora and fauna species as being present or likely to occur within the SAPEX PEL's.

Where an entry in the table is based on a predicted occurrence in the EPBC database rather than an actual record, it has been marked with an asterisk (*).

Species Name ⁶	Common Name	Conservation Status	
		C'wlth (EPBC)	SA (NPW Act)
Mammals			
<i>Dasycercus cristicauda</i> *	Mulgara	Vulnerable	Endangered
<i>Notoryctes typhlops</i> *	Southern Marsupial Mole, Yitjarritjarri	Endangered	Endangered
<i>Petrogale lateralis</i> *	Black-footed Rock-wallaby (MacDonnell Ranges race), Warru	Vulnerable	Endangered
<i>Pseudomys australis</i>	Plains Rat	Vulnerable	Vulnerable
Reptiles			
<i>Ophidiocephalus taeniatus</i>	Bronzeback Snake-lizard	Vulnerable	Vulnerable
Birds			
<i>Acanthiza iredalei iredalei</i>	Slender-billed Thornbill (western)	Vulnerable	Vulnerable
<i>Acanthiza robustirostris</i>	Slaty-backed Thornbill		Rare
<i>Amytornis textilis modestus</i>	Thick-billed Grasswren (eastern)	Vulnerable	Vulnerable
<i>Anas rhynchotis</i>	Australasian Shoveler		Rare
<i>Aphelocephala pectoralis</i>	Chestnut-breasted Whiteface		Rare
<i>Ardeotis australis</i>	Australian Bustard		Vulnerable
<i>Biziura lobata</i>	Musk Duck		Rare
<i>Cacatua leadbeateri</i>	Major Mitchell's Cockatoo		Vulnerable
<i>Cinlosoma castanotus</i>	Chestnut Quail-thrush		Rare
<i>Climacteris affinis</i>	White-browed Treecreeper		Rare
<i>Coturnix ypsilophora</i>	Brown Quail		Vulnerable
<i>Emblema pictum</i>	Painted Finch		Rare
<i>Falco hypoleucos</i>	Grey Falcon		Rare
<i>Gerygone fusca</i>	Western Gerygone		Rare
<i>Grus rubicunda</i>	Brolga		Vulnerable
<i>Hamirostra melanosternon</i>	Black-breasted Buzzard		Rare
<i>Leipoa ocellata</i> *	Malleefowl	Vulnerable	Vulnerable
<i>Neophema chrysostoma</i>	Blue-winged Parrot		Vulnerable
<i>Pachycephala rufogularis</i>	Red-lored Whistler	Vulnerable	Vulnerable
<i>Phaps histrionica</i>	Flock Bronzewing		Vulnerable

⁶ A * indicates that a species has been predicted as likely to occur in the Arckaringa Basin but has not actually been recorded in PELs.

Species Name ⁶	Common Name	Conservation Status	
		C'wth (EPBC)	SA (NPW Act)
<i>Pomatostomus temporalis</i>	Grey-crowned Babbler		Rare
<i>Pyrrholaemus brunneus</i>	Redthroat		Rare
<i>Stictonetta naevosa</i>	Freckled Duck		Vulnerable
Flora			
<i>Acacia rhodophloia</i>	Minni Ritchi		Rare
<i>Aristida arida</i>			Rare
<i>Atriplex humifusa</i>			Vulnerable
<i>Atriplex kochiana</i>	Koch's Saltbush		Vulnerable
<i>Bergia occultipetala</i>			Vulnerable
<i>Blechnum nudum</i>	Fishbone Water-fern		Rare
<i>Brachyscome eriogona</i>			Rare
<i>Bulbostylis turbinata</i>			Rare
<i>Callitriche sonderi</i>	Matted Water Starwort		Rare
<i>Ceratogyne obionoides</i>	Wingwort		Rare
<i>Cyperus bifax</i>	Downs Flat-sedge		Rare
<i>Embadium johnstonii</i>	Johnston's Slipper-plant		Vulnerable
<i>Eragrostis lacunaria</i>	Purple Love-grass		Rare
<i>Eremophila pentaptera</i>			Rare
<i>Frankenia cupularis</i>			Rare
<i>Frankenia plicata</i>		Endangered	-
<i>Goodenia anfracta</i>			Rare
<i>Goodenia chambersii</i>			Rare
<i>Goodenia lobata</i>			Rare
<i>Goodenia saccata</i>	Flinders Ranges Goodenia		Rare
<i>Gunniopsis kochii</i>	Koch's Pigface		Rare
<i>Halosarcia cupuliformis</i>			Vulnerable
<i>Hemichroa mesembryanthema</i>	Pigface Hemichroa		Vulnerable
<i>Maireana melanocarpa</i>	Black-fruit Bluebush	Vulnerable	Rare
<i>Nicotiana truncata</i>			Rare
<i>Nymphoides crenata</i>	Wavy Marshwort		Rare
<i>Ophioglossum polyphyllum</i>	Large Adder's-tongue		Rare
<i>Osteocarpum acropterum var. deminutum</i>	Wingless Bonefruit		Rare
<i>Poa fax</i>	Scaly Poa		Rare
<i>Ptilotus aristatus var. eichlerianus</i>			Vulnerable
<i>Ptilotus barkeri</i>	Barker's Mulla Mulla		Rare
<i>Pycnosorus chrysanthes</i>			Endangered
<i>Pycnosorus globosus</i>	Drumsticks		Vulnerable
<i>Santalum spicatum</i>	Sandalwood		Vulnerable

Species Name ⁶	Common Name	Conservation Status	
		C'wth (EPBC)	SA (NPW Act)
<i>Sclerolaena blackiana</i>	Black's Bindyi		Rare
<i>Senecio gypsicola</i>	Gypsum Groundsel		Rare
<i>Stemodia sp. Haegii</i> (J.Z.Weber 9055)	Haegi's Stemodia	Endangered	Rare
<i>Austrostipa nullanulla</i> *	Club Spear-grass	Vulnerable	-
<i>Swainsona vestita</i>			Vulnerable
<i>Swainsona minutiflora</i>	Small-flower Swainson-pea		Vulnerable
<i>Swainsona oligophylla</i>			Rare
<i>Typhonium alismifolium</i>			Rare
<i>Wurmbea stellata</i>	Star Nancy		Rare
<i>Zygophyllum crassissimum</i>	Thick Twinleaf		Rare
<i>Zygophyllum humillimum</i>	Small-fruit Twinleaf		Rare
<i>Zygophyllum hybridum</i>			Rare

Appendix 3: Priority Plant Species

Priority Plant Species

Exploration activities often require the clearance of vegetation to facilitate access to areas of interest. Where possible the clearance of vegetation is avoided, however when clearance is required it is important that steps be taken to minimise the clearing of important species.

To assist with determining which plant species should be avoided or minimally cleared, four categories of conservation priority have been defined for the Arckaringa Basin. These conservation priorities take into account characteristics such as longevity, growth rate, regeneration rate and abundance, and any State or Commonwealth listing.

These priorities provide a general guide, however the significance of some species will depend to some extent on the species' location and the characteristics of the land form in which it is located. Site specific assessments will be used to refine the priorities for a given activity or location.

The conservation priorities are as follows:

Table A3-1: Conservation Priorities

Priority	Typical Plant Type/Characteristics ⁷	Clearance
Priority 1	Long time to reach maturity Slow growth rate Poor regeneration from seed or rootstock May be uncommon State or Commonwealth listed species	Avoid clearance of mature trees Very high conservation priority
Priority 2	Long time to reach maturity Slow growth rate May be relatively uncommon May regenerate from seed &/or rootstock	Avoid clearance wherever possible High conservation priority
Priority 3	Short to moderate time to maturity Moderate growth rate Regenerates from seed &/or rootstock Relatively abundant	Clear only the minimum necessary Moderate conservation priority
Priority 4	Short time to maturity Fast growth rate Good regeneration from seed &/or rootstock Abundant Short-lived annuals and ephemerals generally fall in this category	May be cleared if necessary Low conservation priority

⁷ A specific plant species may not necessarily exhibit all of these characteristics

The following table provides some examples of plant species in each category of priority.

Prior to the commencement of activities, relevant personnel will be provided with information sheets (including photographs) to assist in the identification and management of the priority plant species present at the location.

Table A3-2: Examples of plant species for each conservation priority

Priority	Common Name	Scientific Name
Priority 1	Western Myall River Red Gum Coolibah Black Oak	<i>Acacia papyrocarpa</i> <i>Eucalyptus camaldulensis</i> <i>Eucalyptus coolabah</i> <i>Casuarina pauper</i>
Priority 2	Mulga Dead Finish Old Man Saltbush Bluebush Bullock Bush White Cypress-pine	<i>Acacia aneura</i> <i>Acacia tetragonophylla</i> <i>Atriplex nummularia</i> <i>Maireana sedifolia</i> <i>Alectryon oleifolius ssp. canescens</i> <i>Callitris glaucophylla</i>
Priority 3	Tar Bush Samphire	<i>Eremophila glabra</i> <i>Halosarcia sp.</i>
Priority 4	Sandhill Canegrass Most grasses	<i>Zygochloa paradoxa</i> Graminae sp.

Appendix 4:

List of Relevant Land Owners

Relevant Land Owners in the Arckaringa Basin

Pastoral Leases

Property Name	Contact Details
Welbourn Hill	<i>Details removed from public version</i>
Todmorden	
Wintinna West (Wintinna)	
Evelyn Downs	
Arckaringa (including Coorikiana)	
Allandale (including Toondina, Toondina East)	
Mt Barry	
Nilpinna	
Anna Creek (including The Peak)	
Mabel Creek	
Mount Clarence	
Commonwealth Hill (including Mobella, Pt Commonwealth Hill, Pt McDouall Creek, Pt Mulgathing, Pt Woorong Downs)	
Bulgunnia	
Ingomar (including Lake Wirrida)	
Mount Penrhyn	
McDouall Peak (including Belta Beltana South)	
Billa Kalina	
Stuarts Creek	
Mt Eba	
Bon Bon	
Wilgena (including North Well)	
Mount Willoughby	
Lambina	
Millers Creek	

Conservation Reserves

Property Name	Contact Details
Tallaringa Conservation Park	<i>Details removed from public version</i>

Native Title Groups

Name	Contact Details
Arabunna People	<i>Details removed from public version</i>
Antakirinja Matu-Yankunytjatjara	
Yankunytjatjara/Antakirinja	
Aboriginal Legal Rights Movement	

Appendix 5: Consultation Submissions and Responses

No.	Agency or Individual	Issues Raised or Comments Made	Response
1.	Dept of Health	<p>Comment 1</p> <p><u>EIR 3.7.2 – Waste Management</u> – table 3 p.14, the disposal method for sewage & grey water states that “Following treatment via an approved system, waste water may be disposed of on-site (well away from watercourses or infrastructure) when in remote areas.” It is preferable to state that: “The method of disposal for wastewater must comply with the <i>Standard for the Construction, Installation and Operation of Septic Tank Systems in SA</i>, or be to the satisfaction of the Department of Health”. This would then reflect what is contained in section 6.7 of the EIR.</p>	Table 3 has been modified accordingly.
2.	Dept of Health	<p>Comment 2</p> <p><u>EIR 6.7 Pollution & Waste Management</u> – Dot point 3 could also reflect the requirements of Food Safety Standard 3.2.3.6 to have a facility for the storage of garbage & recyclable matter that adequately contains & encloses all matter & can be easily & effectively cleaned. Therefore it is recommended that the following be added; “<i>There will be facilities for the storage of garbage and recyclable matter that adequately contains and encloses all matter and can be easily and effectively cleaned prior to approved disposal onsite or transportation offsite.</i>”</p>	SAPEX acknowledge that it and its contractors have a responsibility to comply with all relevant legislation and standards, including the Food Act and Food Safety Standard. However, the EIR and SEO are not considered by SAPEX or PIRSA to be the appropriate place to reflect this detail, as it is more of an occupational health and safety matter.
3.	Dept of Health	<p>Comment 3</p> <p><u>SEO Objective 10</u> – It would be preferred if an additional objective or an addition to objective 10 could reflect: “<i>Minimise the risks to public health & maximise the benefits to public health</i>”. This could also include compliance with the <i>Food Act 2001</i> to ensure safe food & water is provided to all employees.</p> <p>To tie in with Comment 2, an additional objective could also include the removal of all waste & ensuring safe food & water (reflecting comments regarding 6.7 above).</p>	See response for Comment 2.

No.	Agency or Individual	Issues Raised or Comments Made	Response
4.	EPA	<p><u>EIR</u> – Turkey’s Nest - More detail is required regarding the proposed construction & use of the turkey’s nest including:</p> <ul style="list-style-type: none"> ▪ the amount of freeboard allowance; ▪ type & thickness of lining; ▪ how removal of hydrocarbons will be undertaken if necessary. 	<p>Turkey’s nests are primarily utilised for the storage of a ‘clean’, fresh water supply for drilling. They are lined with a plastic (HDPE) liner to prevent the loss of water through seepage. The freeboard in a turkey’s nest is typically in the order of 0.3 to 0.5 m at the commencement of drilling.</p> <p>The turkey’s nest is sometimes used for produced water disposal during extended production testing, however extended production testing is outside the scope of this EIR and SEO. It is not standard practice to use the turkey’s nest for water disposal during initial production testing (which is within the scope of this EIR and SEO) and section 3.3.1 of the EIR has been corrected to remove the reference to this. Section 3.2.2 of the EIR has been modified to clarify the role of the turkey’s nest and its lining.</p> <p>The turkey’s nest would not contain hydrocarbons during drilling and initial production testing, and their removal would not be necessary.</p>
5.	EPA	<p><u>EIR</u> - Drilling mud_– The use of a mud tank to capture & recycle drilling mud, to minimise the size of the mud sump is preferred by the Authority.</p>	<p>The re-circulation of drilling muds through a mud tank is standard practice as drilling muds are an expensive resource. However once muds become contaminated with drill cuttings or are no longer meeting operation criteria they are disposed of to the drill sump.</p> <p>The drill sump is of sufficient size/volume to accommodate all waste drilling mud and 1m of fill/cover. Sump sizes vary depending on the type of drilling rig, but for conventional petroleum rigs can be in the order of 20-30 m by 30-40 m and 2 m deep. (This typical sizing has been added into Section 3.2.2 of the EIR).</p>
6.	EPA	<p><u>EIR 3.2.4 – Campsite waste management</u> – waste generation at well sites & associated camps is considered by the EPA to be higher in quantities than during geophysical operations, due to the consolidation of staff & operational activities in one location for a period of time. As a result, all materials at these sites, including putrescible wastes, must be collected, segregated & disposed of at an approved Waste Transfer Facility, rather than buried.</p>	<p>SAPEX’s preference is also to remove all waste, including putrescible waste, to an approved facility. However, there may be circumstances where the drill site is very remote and the activities are to be of a temporary nature. In these circumstances the burial of putrescible wastes is considered to be a suitable option.</p> <p>Section 3.2.4 and 3.7.2 and 6.7 of the EIR have been modified to indicate that this may occur at very remote sites, where activities are short term and temporary.</p>

No.	Agency or Individual	Issues Raised or Comments Made	Response
7.	EPA	<p><u>EIR 3.6.1 – Initial restoration</u> – if water from the turkey’s nest is likely to be contaminated with hydrocarbon or other listed pollutants (see Part B Schedule 1 of the <i>Environment Protection Act</i>), it should not be transferred into the mud sump; rather this material should be removed by a licensed waste contractor. Alternatively it may be allowed to evaporate & the remaining residue removed by a licensed waste contractor prior to recovery of the liner (assuming the liner is HDPE or similar).</p>	<p>As discussed above, the turkey’s nest is used for the storage of clean drilling water and would not contain hydrocarbons.</p> <p>All drilling fluids including muds and water are disposed of to the drilling sump, in accordance with standard industry practice. It is acknowledged that drilling muds may contain low levels of hydrocarbons (if they are encountered during drilling). Drill stem tests or initial production tests may also produce low volumes of formation water, which are typically disposed of to the drilling sump after passing through a separator tank. Some hydrocarbons may remain in this water after separation.</p> <p>At the conclusion of drilling operations the sump is permitted to dry out and is then backfilled with at least 1m of fill and the site reinstated. The residue in the sump is not removed as it is both impracticable and costly to remove.</p> <p>As indicated in section 5.3.5 of the EIR, the risk of soil or shallow groundwater contamination associated with the accepted industry practice of disposal of these fluids to the unlined earthen drilling sumps has been previously evaluated and is considered to be low. The presence of fine bentonite clays (which allow the formation of a relatively impervious mud cake in the base of drilling sumps) and the low effective toxicity associated with drilling additives are the basis for the utilisation of bury and cover techniques.</p>
8.	EPA	<p><u>EIR 3.7.2 – Waste water management</u> – following treatment via an approved sewage management system, waste water must be removed from the site by a licensed waste transporter in order to comply with clause 11 of the <i>Environment Protection (Water Quality) Policy 2003</i>.</p> <p>11 – General obligation to avoid discharge etc into waters</p> <p>(1) A person who is undertaking an activity, or is an occupier of land, must take all reasonable and practicable measures (not being measures that themselves cause environmental harm) to avoid the discharge or deposit of waste from that activity or land—</p> <p>(a) into any waters; or</p> <p>(b) onto land in a place from which it is reasonably likely to enter any waters (including by processes such as seepage or infiltration or carriage by wind, rain, sea spray, or stormwater or by the rising of the water table),</p> <p>and, in taking those measures, must apply the waste management hierarchy.</p>	<p>SAPEX will comply with Clause 11 by ensuring that waste water is discharged onto land, well away from any place from which it is reasonably likely to enter any waters. Section 3.7.2 of the EIR and the “Guide to how...” for Objective 10 in the SEO has been modified to mirror this wording.</p> <p>It is also noted that drilling operations will be occurring in very remote areas and the removal of treated waste water from campsites’ sewage management system is not practical.</p>

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9.	EPA	These amendments should be made in the EIR, the EIR reviewed thoroughly accordingly & the amendments subsequently addressed in the SEO.	Acknowledged
10.	DEH	<u>EIR 3.2.3</u> – the proponent should address the issue of borrow pits becoming small dams in the event of rainfall, & being subjected to erosion & potential water traps for fauna.	<p>Section 5.3.1 of the EIR indicates that borrow pits can be a bogging hazard for stock and wildlife and can provide alternative water sources for stock and changes in stock distribution and the erosion potential is mentioned in several locations (e.g. Table 6, Section 6.3).</p> <p>Added in the SEO under Objective 2 (Guide to how..): “Facilities (e.g. borrow pits, well cellars) are designed and constructed as far as practicable to minimise fauna entrapment”, “Sumps and mud pits are fenced as appropriate to minimise wildlife access” and “Borrow pits are restored to minimise water holding capacity where agreements are not in place with stakeholders”</p> <p>Other relevant management measures are located in:</p> <ul style="list-style-type: none"> ▪ Section 3.6.3 (restoring pits by battering slopes, ripping the floor and sides and respreading topsoil and cleared vegetation) ▪ Section 6.2 and 6.3 (assessment to select best orientation and location, avoiding significant vegetation, using existing pits where practicable, locating in flat areas to avoid erosion, stockpiling topsoil and vegetation) ▪ Section 6.6 (restoration in accordance with GAS criteria in SEO) and PIRSA Field Guide. ▪ The SEO (Appendix 2) where criteria are specified for construction and restoration.
11.	DEH	<u>EIR 3.6</u> – Rehabilitation should be undertaken in consultation with, & to the satisfaction of the landowner.	Document edited to reflect this.
12.	DEH	<u>EIR 3.6.1</u> – The proponent should address the issue of sumps being potential fauna traps whilst they contain water. Escape routes should be established for trapped fauna and periodic checks for trapped fauna should be carried out.	<p>Drilling sumps are generally constructed with one ramped edge. Following drilling operations the sumps are fenced to prevent access by stock and larger animals while the sump is drying out, prior to backfill. The reference to fencing sumps to prevent stock access in Section 3.6.1 has been modified by adding “and discourage wildlife access”. As the sumps are located in the cleared drill lease, the numbers of smaller fauna present and at risk of being trapped in the sump is likely to be low.</p> <p>The SEO has also been modified as discussed in the comment on Section 3.2.3 above.</p> <p>Due to the remote location and duration of drying time (in the order of 6 months) it is not practical to regularly inspect sumps for trapped fauna.</p>

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13.	DEH	<u>EIR 3.8</u> – Remove the reference to PEL120 in the para on coal core hole drilling.	Removed. PEL120 (a SAPEX PEL located outside the Arckaringa Basin) was inadvertently included here.
14.	DEH	<u>EIR 4.3.1</u> – The proponent should note that the ecological community associated with GAB mound springs is protected under the <i>Environment Protection and Biodiversity Conservation Act 1999</i> .	Noted. This is already stated in Section 4.2.1 but has been added to section 4.3.1.
15.	DEH	<u>EIR 6.4 - Vehicle movement</u> – the proponent should be aware that a 40km/hr speed limit applies within the Tallaringa Conservation Park.	Noted. In the event that exploration activities are undertaken in the Tallaringa CP this information will be included in the Environmental Assessment report (which includes site specific environmental assessments and management objectives and strategies) for that specific survey program. These documents are a component of the activity notification documentation required by PIRSA.
16.	DEH	<u>EIR Table 9 – Campsites & associated supply logistics: Camp site</u> – question that “loss of vegetation and habitat, damage to tree structures” is “negligible”. This is in light of the rehabilitation method of ripping being likely to damage root structures. Suggest re-evaluation of the severity classification or more closely address the issue of ripping and its effect on tree roots in the rehabilitation section.	The severity classification in this table (Table 11) is “Minor” and this is considered appropriate in relation to the possibility of damage to root structures. However, it is noted that this damage is considered unlikely to occur, due to the following factors: <ul style="list-style-type: none"> ▪ Campsites are preferentially located in areas devoid of vegetation ▪ Positioning campsite facilities in close proximity to trees is generally avoided The use of ripping for reinstatement of campsites is only undertaken if compaction has occurred and if the soil is suitable for ripping. Ripping is not undertaken in close proximity to trees.
17.	DEH	<u>EIR</u> - DEH would appreciate receiving any copies of audits and monitoring reports that are provided from Arckaringa Basin.	Noted.
18.	DEH	<u>SEO 1.2 Scope</u> – PEL124 should be included in the first paragraph.	This section has been amended.
19.	DEH	<u>SEO Objective 1</u> – include within Guide to how Objectives can be Achieved – “Prior to activity approval, the Heritage Branch, DEH, is to be consulted and provided with the locations of proposed activity in order that it may provide advice on protecting non-indigenous heritage sites”.	Added “Consult with Heritage Branch, DEH regarding location of non-indigenous heritage sites” to “Guide to how...”.

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20.	DEH	<p><u>SEO Objective 2</u> – Under a new sub-category “<i>Operations in the Tallaringa Conservation Park</i>”, include under Assessment Criteria:</p> <ul style="list-style-type: none"> ▪ “The impact on the environmental values of Tallaringa Conservation Park will be minimised”. ▪ “The licensee and contractors are aware of the regulatory requirements regarding correct conduct in the park, strictly adhering to the <i>National Parks and Wildlife Act 1972</i> and associated Regulations”. ▪ “The District Ranger is notified of the commencement date of activities at least ten days prior to work commencing and communication with the District Ranger is maintained whilst activities are being carried out”. <p>“Firewood collection is not permitted within Tallaringa Conservation Park”.</p>	<p>First dot point has been included under Assessment Criteria.</p> <p>Second, third and fourth dot points have been included under “Guide to how...” and a new Assessment Criteria added: “DEH requirements for notification and operation in Tallaringa CP are met” in order to keep the Assessment Criteria high level.</p>
21.		<p><u>SEO Assessment Criteria: campsite and survey line preparation</u> – include the following: “Exploration activity should not be carried out within Vegetation Heritage Agreement areas unless there is consultation with PIRSA, the Native Vegetation Council and DEH prior to the activity approval.”</p>	<p>Included as a “Guide to how...”. It is noted that there is only one such area within the PELs and it is not likely that activity will occur in this area.</p>
22.	DEH	<p><u>SEO Objectives 2 & 3</u> – include “No domestic camp pets are allowed at campsites or work sites” within Assessment Criteria.</p>	<p>Included as a “Guide to how...” for Objective 2. The Assessment Criteria are relatively high-level compliance measures and this is considered more appropriate at the “Guide to how...” level.</p>
23.	DEH	<p><u>SEO Objective 4</u> – include “<i>No contamination of topsoil from groundwater</i>” within Assessment Criteria and address this issue in Guide to how Objectives can be Achieved.</p>	<p>Considered that the existing assessment criteria: “No soil contamination as a result of drilling and production testing activities” covers this.</p> <p>Uncontrolled groundwater flows would not be expected to occur during drilling or initial production testing as casing / well control aim to prevent this. Uncontrolled flows to the surface are a non-compliance with the SEO (see Objective 5).</p>
24.	DEH	<p><u>Objective 6</u> – include “The speed limit within Tallaringa Conservation Park of 40 km/hr will be observed” within Guide to how Objectives can be Achieved.</p>	<p>Included as a “Guide to how...” for Objectives 2 and 7 (“Objective 6” is understood to refer to the Geophysical SEO which matches Objective 7 in this SEO).</p>
25.	DEH	<p><u>Objective 8</u> – include “<i>Entrances to access tracks will be disguised to discourage third party users</i>” in Guide to How Objectives can be Achieved.</p>	<p>This is not a general practice for drilling operations as there are some issues with drilling personnel finding access tracks, safety of vehicles and trucks entering or leaving the tracks and the turning circles of large trucks transporting drill rigs.</p>

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			Objective 7 refers to use of signage to discourage third party access and the GAS criteria refer to ripping access tracks and blending colours and contours with the surroundings on restoration. ("Objective 8" is understood to refer to the Geophysical SEO which matches Objective 9 in this SEO).
26.	DWLBC	<u>EIR - Weeds</u> – The Animal & Plant Control Group regard the section on weed control as comprehensive & commend SAPEX on their engagement with regional NRM boards and landowners.	Acknowledged
27.	DWLBC	<u>EIR & SEO - Vertebrates</u> – management of vertebrates, particularly dingos, is not covered in the plan. Dingos can become a significant hazard and an OHS&W and animal welfare problem in remote camps outside the Dog Fence. The plan should include consideration of operating procedures to avoid attracting dingos to camps by managing waste appropriately; staff should also be warned not to feed dingos.	Acknowledged. The waste management objective 10 includes a reference to the coverage of bins to prevent access by fauna and the EIRs refer to waste attracting scavenging animals such as dingoes. The SEOs have been modified to include "No domestic pets will be allowed on site" and "Feeding of wildlife (e.g. dingoes) will not be permitted" in the "Guide to how ..."
28.	DWLBC	<u>EIR & SEO</u> - It is recommended that the company adopt clear policies on dingos and dogs in camps.	Acknowledged. See comment above.
29.	Native Vegetation Council	<u>EIR & SEO</u> - No issues to raise.	Acknowledged