Environmental Impact Report

Drilling Activities in PELs 81 and 253, Officer Basin

September 2010

Prepared for:
Rodinia Oil Corp.
(operating in Australia as Officer Basin Energy Pty Ltd, a wholly owned subsidiary)

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1 Introduction

Officer Basin Energy Pty Ltd (OBEPL), a wholly owned subsidiary of Rodinia Oil Corp., holds petroleum exploration licences (PELs) 81 and 253 in the Officer Basin, an area comprising part of the Great Victoria Desert in the far west of South Australia. PELs 81 and 253 are situated entirely within the Maralinga Tjarutja Lands. OBEPL 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 and Geothermal Energy Act 2000* to provide information on the proposed activities, the potential environmental impacts and their management.

1.1 Location

The Officer Basin spans 525 000 km^2 of central southern Australia from the Yilgarn Block in Western Australia east to the Gawler Craton in South Australia (PIRSA 2010). OBEPL holds petroleum exploration licences within the South Australian sector of the Officer Basin. This report details PELs 81 and 253 which extend from west of Coober Pedy and south of Marla in the north of the state, to the border of the Mamungari Conservation Park (formerly Unnamed Conservation Park) in the west. These licences lie entirely within the Maralinga Tjarutja Lands and partially within the Woomera Prohibited Area (see Figure 1).

1.2 Project Proponent

Rodinia Oil Corp., operating in Australia as Officer Basin Energy Pty Ltd (a wholly owned subsidiary), is a public company incorporated in Canada. Rodinia's primary assets include interests in petroleum exploration licences and permits in central Australia. The company has interests in the Officer Basin in both South Australia and Western Australia, and the Georgina Basin in the Northern Territory.

OBEPL is the principal licensee and operator of petroleum exploration licences and licence application areas in the Officer Basin including PELs 81 and 253 on the Maralinga Tjarutja Lands and PELAs 303, 351 and 445 on the Anangu Pitjantjatjara Yankunytjatjara Lands. OBEPL holds an 80% interest in PELs 81 and 253.

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 and Geothermal Energy Act 2000* and Regulation 10 of the *Petroleum and Geothermal Energy Regulations 2000*.

A Statement of Environmental Objectives (SEO) has also been developed in conjunction with this document. The SEO outlines the environmental objectives that OBEPL 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 OBEPL's licence areas in the Maralinga Tjarutja Lands in the Officer Basin (see Figure 1).

This document has been developed based on a number of existing Environmental Impact Reports, principally the *South Australia Cooper Basin Operators Environmental Impact Report Drilling and Well Operations* (Santos 2003) and the *Arckaringa Basin Exploration Drilling Activities Environmental Impact Report* (RPS Ecos 2007a). This EIR has also used information on the existing environment from the Officer Basin geophysical operations EIR (OBEPL 2007) where appropriate.

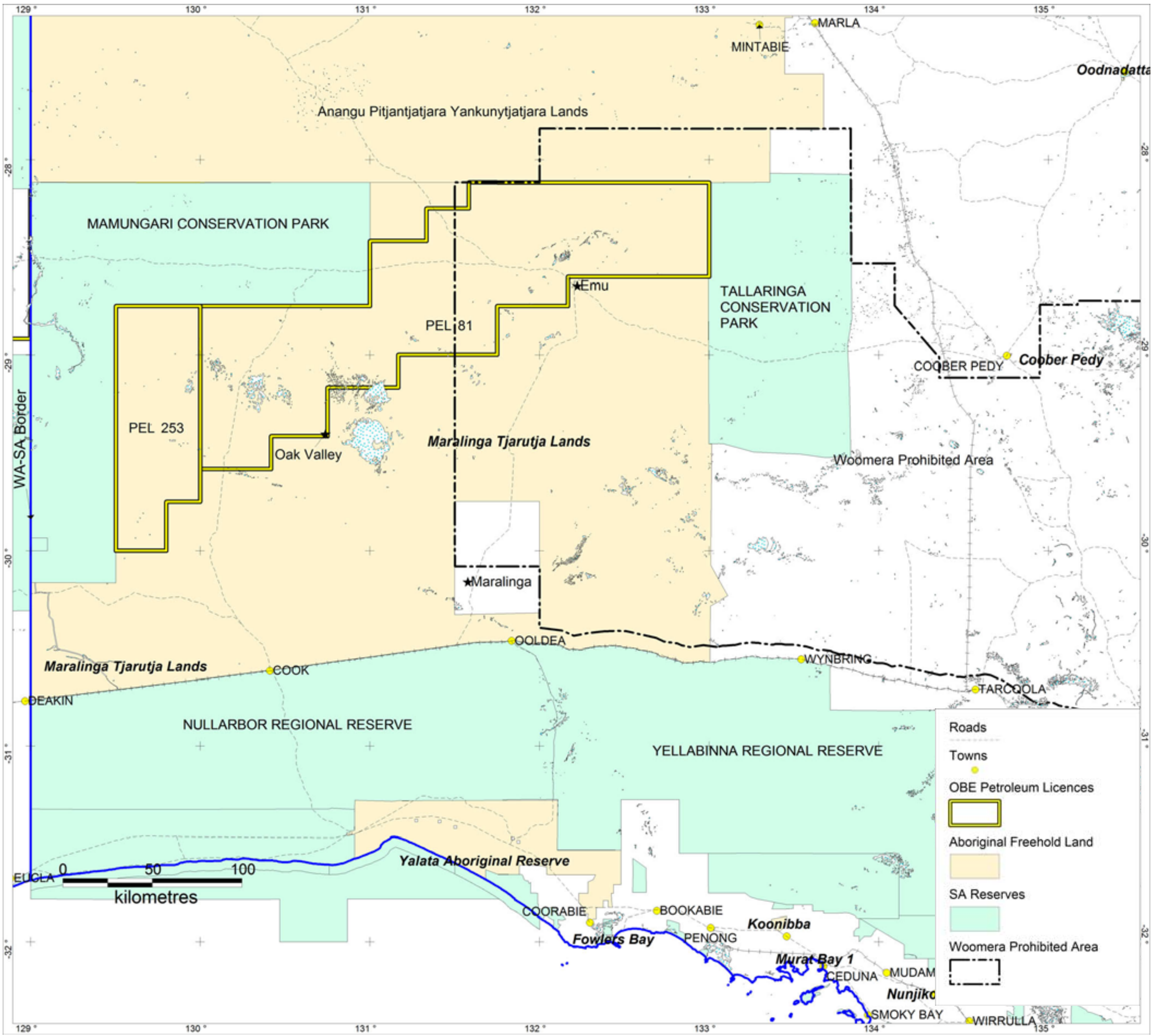

Figure 1: PELs 81 and 253, Officer Basin, western South Australia.

2 Legislative Framework

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

2.1 Petroleum and Geothermal Energy Act and Regulations

The legislation governing onshore petroleum exploration and production in South Australia is the *Petroleum and Geothermal Energy Act 2000* and *Petroleum and Geothermal Energy 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 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
- any other substance that naturally occurs in association with petroleum; or
- 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 Statement of Environmental Objectives (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.

OBEPL 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 Officer Basin, rather than being specific to an individual well. This "generic" approach has been followed for geophysical and drilling activities in most regions of the state that are being actively explored for petroleum, including the Cooper Basin (Santos 2006, Santos 2009), Arckaringa Basin (RPS Ecos 2007b & c), St Vincent and Walloway Basins (RPS Ecos 2008), Otway Basin (Kane 2007) and the Officer Basin (OBEPL 2009, Coffey 2009).

2.3 Environmental Impact Report

In accordance with Section 97 of the *Petroleum and Geothermal Energy 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 and Geothermal Energy 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
    - the size and scope of these consequences and
    - the cumulative effects (if any) of these consequences when considered in conjunction with the consequences of other events that may occur on the relevant land (insofar as this is reasonably practicable); and
  - 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 and Geothermal Energy 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 OBEPL) 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 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 are often 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 Torrens 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 Places Act 1993
Maralinga Tjarutja Land Rights Act 1991
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 and Geothermal Energy 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 petroleum 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 Drill Site and Access

3.1.1 Access

Drilling operations are accessed using existing tracks and public roads as much as possible. They 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 road construction methods that would be applied to landforms found in the Officer Basin. These landforms are discussed in Section 4.

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).

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

Construction Method	Land System				
	Drainage Lines	Stony Rises	Gibber Pavement	Dunefields & Plains	Salt Lakes
Avoid construction					★
Utilise naturally cleared areas	★	★	★	★	
Avoid steep slopes		★	★		
Weave between trees & large shrubs where possible	★	★	★	★	
Clear & grade	★	★		★	
Roll			★		
Cap surface	★			★	
Culverts or similar installed on drainage crossings	★	★	★	★	

Where possible, access tracks may be constructed along previously used seismic lines, in order to minimise additional disturbance. For example, seismic lines (which were originally prepared in 1993 by state and Commonwealth government agencies) and also utilised for access in OBEPL's 2008 and 2009 seismic surveys) are present near the eastern, western and northern boundaries of PEL 253 and are likely to be used as access routes, with shorter access tracks to drill sites coming off these.

[1] Available at http://www.pir.sa.gov.au/petroleum/environment/register/seo,_eir_and_esa_reports/drilling

It is planned that road construction (and well lease preparation) would be carried out by Maralinga Tjarutja, who also undertook the line preparation work for OBEPL's seismic surveys.

3.1.2 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, depending on the particular rig and the depth of the well)
- 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 and a turnaround area for semi-trailers.

Plate 1: Petroleum drilling rig 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.

Well lease construction methods are dependent upon the terrain in which it is being built. In most locations, with the exception of areas with gibber pavement, topsoil and vegetation are cleared and stockpiled separately for use in restoration. The selection of well sites without steep slopes (especially in the more sensitive environments such as gibber areas) 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 Officer Basin

Construction Method	Land System				
	Drainage Lines	Stony Rises	Gibber Pavement*	Dunefields & Plains	Salt Lakes
Avoid construction					★
Utilise naturally cleared areas	★	★	★	★	
Avoid steep slopes		★	★		

Construction Method	Land System				
	Drainage Lines	Stony Rises	Gibber Pavement*	Dunefields & Plains	Salt Lakes
Avoid trees & large shrubs where possible	★	★	★	★	
Clear & grade	★	★		★	
Stockpile topsoil & cleared vegetation	★			★	
Roll			★		
Cap surface	★		★	★	
Build up drill site (only on slopes to provide flat surface)		★	★		
Cut & fill (steep slopes)	★			★	

*As discussed in Section 4.2, gibber pavement is not widespread or extensive in the PELs.

3.1.3 Borrow Material

Depending upon the nature of the substrates in a particular well location, borrow material such as clay or limestone may be required to stabilise the drill pad or to assist in access track construction (for example on dune crossings). Generally, 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.

3.1.4 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, previously used 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. As discussed in Section 3.5.2, wastewater handling and treatment must be in accordance with the *Public and Environmental Health (Waste Control) Regulations 1995*.

3.1.5 Airstrip

An airstrip in reasonably close proximity to the drilling operations (e.g. within approximately two hours' travel time) is required, in order to fly drilling personnel to and from the site during crew changeover, as well as providing aircraft access in an emergency.

OBEPL anticipates that either the landing facility at Oak Valley would be used or, alternatively, that there may be a previously constructed airstrip within reasonable proximity that can be repaired or upgraded. However, if such options are not available within a suitable distance, it may be necessary to construct a temporary airstrip to support drilling operations.

An airstrip for drilling operations would be in the order of 1.5km long by 20m wide, with 50m at each end approximately 35m wide to allow the aircraft to turn. In addition, an area 20 metres each side of the landing strip would need to be cleared of objects on a transitional slope of 2.5 degrees. The approach and take off area would need to be cleared of objects for 900 m above a transitional slope of 5 degrees.

If a temporary airstrip is required, it would not be designed as an all weather strip, so it is not anticipated that any capping material would be required (i.e. the airstrip surface would only be graded). The landing strip would need to be prepared to meet CASA and RFDS guidelines of "driving a vehicle along the runway at a speed of 75 km/h without discomfort to the occupants".

If a new airstrip is required, a location would be selected where earthworks and vegetation clearance requirements are limited. It would preferably be in an open area with few trees. However, it is possible that clearance of some woodland vegetation may be required.

The details of the airstrip location, clearance and construction requirements would be provided in an activity notification to PIRSA (as discussed in Section 2.5).

3.2 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 2500 to 3000m). 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 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 3.3.1.

The typical duration of drilling for a single well (mobilisation to demobilisation) is in the order of 30 to 35 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.

Well completions and workovers are usually carried out by smaller rigs than those used in the initial drilling of the well.

3.2.1 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.

3.3 Well Abandonment

3.3.1 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 3.4 below.

3.3.2 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.

[2] 1 barrel (1 bbl) = 159 litres or 0.159 m^3

- 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 3.4 below.

3.3.3 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 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.

3.4 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.

3.4.1 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 or discourage feral animal and wildlife access
- backfilling treated wastewater 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.

3.4.2 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 that 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).

3.4.3 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 such as gibber pavement) 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 (unless otherwise agreed with Maralinga Tjarutja)
- 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 Maralinga Tjarutja.

3.5 Associated Activities

3.5.1 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.

<u>Domestic Water Supply</u>

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 settlement and transported to site in a bulk water tanker.

<u>Drilling Water Supply</u>

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 3000 m deep petroleum exploration well would typically range from 1800 - 2400 barrels (290 to 385 kL) depending on casing diameter.

Water for drilling operations may be sourced from existing artesian and sub-artesian bores. Alternatively, it may be obtained from a new bore drilled under the *Natural Resources Management Act 2004.* Supply bores for a drill site will be chosen on the basis of minimising the distance for the water haul and minimising impacts on other users of the bores. However, the water quality (particularly the calcium content) of the water is also considered.

3.5.2 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 or a pit (well away from watercourses). Disposal method for wastewater must comply with the *Standard for the Construction, Installation and Operation of Septic Tank Systems in SA*, or be to the satisfaction of the Department of Health.
Food waste and paper	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
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 would be disposed of on-site (onto land, well away from any place from which it is reasonably likely to enter any waters).

Waste management practices will be guided by the principles of the waste hierarchy (i.e. avoid, reduce, reuse, recycle, recover, treat, dispose).

Domestic wastes (e.g. food waste, paper, plastics, cans and glass) will be stored on site in secure bins or skips. Recyclable materials will be segregated for transport to a recycling facility where practicable. Other materials will be transported to a licensed waste disposal facility.

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).

The presence of waste attracts wildlife, for example 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).

3.5.3 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.

4 Existing Environment

4.1 Climate

The climate in the region is arid, with warm to extremely hot summers and mild to warm winters. Rainfall is not seasonal (i.e. the probability of rain falling is almost equal for each month) and is unpredictable, varying significantly from year to year (Greenslade *et al.* 1986). Winter rainfall is associated with frontal activity across southern Australia, while summer rains may occur from either isolated thunderstorms or rain bearing depressions. The latter rains tend to be heavy. Thunderstorms are relatively common with an average of 15 - 20 thunderstorms per annum although the events are isolated and unpredictable. At Maralinga, in the south of the region, median annual rainfall is 235.6 mm.

Mean annual evaporation rates are high and vary from 2.5 to 3 metres in the southern part of the region to near 4 metres on the region's northern edge. Frost is not uncommon during winter. A summary of climate records for Maralinga (Station #018114) is provided in Table 4 (BoM 2010).

Table 4: Temperature and Rainfall Records for Maralinga

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean Daily Max (^{o}C)	33.2	32.8	30.1	25.6	20.9	18.4	16.9	18.8	22.4	26.3	29.5	29.5	25.4
Mean Daily Min (^{o}C)	16.5	17.0	15.7	13.2	9.8	8.1	6.5	7.0	9.2	11.3	13.4	13.6	11.8
Mean Rainfall (mm)	12.7	19.3	20.4	15.7	19.1	19.5	18.8	15.1	19.2	17.8	19.3	26.6	223.3
Median Rainfall (mm)	7.1	8.0	7.3	8.6	17.8	12.6	14.9	11.5	10.6	11.8	14.8	15.4	235.6

Note: The Maralinga weather site has operated since 1955. The Cook site, 120km to the south-west (with data from 1918-2009) has similar temperature averages but mean and median annual rainfall are lower (181.4mm and 169.6mm respectively). This reflects a known increase in annual rainfall to the north, but may also be biased by the differing lengths of record.

4.2 Biophysical Environment

The OBEPL PELs are located almost entirely within the Great Victoria Desert biogeographical region (or bioregion) as defined by the Interim Biogeographic Regionalisation for Australia (IBRA). The only exception is the southern extremity of PEL 253, which lies within the Nullarbor bioregion. These bioregions extend from the southern rangelands of Western Australia into the western half of South Australia.

The Great Victoria Desert bioregion is characterised by dunefields located between the Musgrave Ranges in the north and the Nullarbor Plain in the south. It consists of active sand-ridge desert of deep Quaternary aeolian sands, which overly the Permian and Mesozoic units of the Officer Basin. It extends from near Laverton in Western Australia eastwards to Marla in South Australia, with approximately 50% of the bioregion in South Australia (ANRA 2010a).

The majority (70%) of the Nullarbor bioregion lies within Western Australia and within the flat treeless Nullarbor Plain. It forms the onshore part of the Eucla Basin, one of the world's largest karst regions. The south-eastern margin of the bioregion forms part of the Great Australian Bight coastline (ANRA 2010b).

4.2.1 Environmental Associations

The Great Victoria Desert and Nullarbor bioregions are divided into subregions under the IBRA classification and can be further divided into environmental associations, following the classification of Laut *et al.* (1977). Environmental associations are classified on the basis of landforms, surface water, soils, vegetation and land use.

Seven environmental associations occur in PELs 81 and 253, with the majority of the area of the PELs being within the Victoria Desert, Purndu and Nurrari environmental associations. The far eastern portion of PEL81 is within the Dingo environmental association, and the south-western portions of the PELs intersect the Maralinga, Yellabinna and Muckera environmental associations.

The environmental associations found within PELs 81 and 253 are shown in Figure 2 and the descriptions of these environmental associations from Laut *et al.* (1977) are summarised in Table 5. Further detail on these environmental associations is provided in Appendix 1.

Table 5: Environmental Associations in PELs 81 and 253

IBRA Bioregion	**Environmental Association***	**Description**
Great Victoria Desert	Victoria Desert (8.2.1)	An extensive dunefield with occasional silcrete rises and shallow depressions. Vegetation is a mixed cover of low open woodland, tall shrubland, low shrubland, and a hummock grassland or hard spinifex.
	Purndu (8.2.8)	A gently undulating dune-covered plain. The vegetation cover is low open woodland with an understorey of grasses and low shrubland with a hummock grass understorey.
	Nurrari (8.2.2)	A plain with dunes and a chain of dry lakes. Vegetation is a mixed cover of tall open shrubland, low open woodland, low shrubland and a hummock grassland of hard spinifex.
	Maralinga (8.2.3)	A low calcrete rise forming a distinctive break between the Nullarbor Plain and the Great Victoria Desert. The vegetation cover is low open woodland with a low shrub understorey, or hummock grassland.
	Dingo (8.2.7)	An undulating plain with dunes, low gibber-covered rises and shallow sandy depressions associated with a relict drainage system. Vegetation is a mixed cover of low open woodland with an understorey of grasses and ephemeral forbs, low shrubland with an understorey of hummock grasses and chenopod shrubland.
	Yellabina (7.5.2)	Plains with closely spaced easterly-trending dunes and occasional rock outcrops. The vegetation cover is open mallee scrub with a chenopod shrub or grass understorey.
Nullarbor	Muckera (7.6.6)	A gently undulating limestone plain with sinkholes and inactive drainage lines. Vegetation is a cover of hummock grassland, low open woodland with a hummock grass understorey and low chenopod shrubland.

*Numbering of environmental associations as per Laut *et al.* (1977) is shown in brackets.

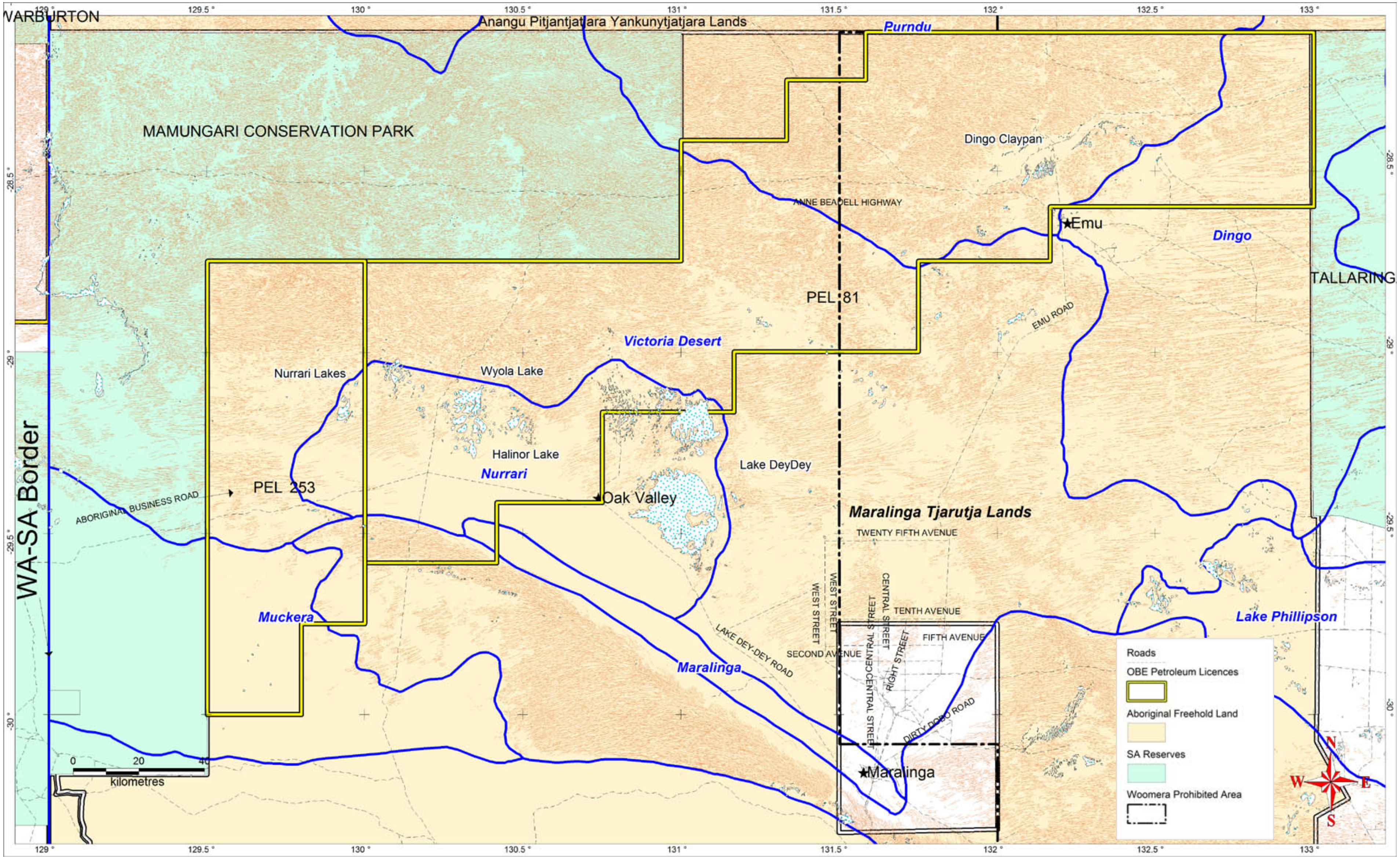

Figure 2: Location of environmental associations within PELs 81 and 253

4.2.2 Land Forms

The land forms encountered within PELs 81 and 253 are summarised in this section, to assist in the discussion of potential impacts and environmental management measures in subsequent sections of this EIR.

The dominant landscape features of the region are the Great Victoria Desert and the Nullarbor Plain. The Great Victoria Desert forms the southern part of the anti-clockwise whorl of dunefields of Australia. The dominant landforms are dunes and swales with local occurrences of playa lakes, associated lee-sided mounds (lunettes) and rocky prominences. Drainage is a very minor feature with creeks forming within swales and mostly draining lakewards (ANRA 2010a).

The northern margin of the Nullarbor Plain overlies the southern region of the Officer Basin and is characterised by extensive treeless plains and shallow calcareous loamy soils. The surface is gently undulating, and any change in surface relief is due to karst development. The landscape is occasionally interrupted with 'dongas', shallow circular depressions with sufficient soil and localised drainage to support scattered small trees or large shrubs (ANRA 2010b).

The major types of land forms that occur in PELs 81 and 253 are:

- Dune fields
- Stony plains
- Limestone plains
- Playa (salt) lakes
- Drainage lines and localised low lying areas (which are rare and atypical of the region)
- Minor rocky outcrops.

Dune Fields

The dune system of the Great Victoria Desert is one of the largest in Australia. Dunes comprise longitudinal ridges, often elongated for many kilometres in the general direction of the influential wind. In some areas (such as the Maralinga Rise) alignment can vary due to the underlying topography. Although dunes are generally in a parallel alignment, they can also frequently be joined in Y-junctions with the V part facing upwind. Interdune corridors are generally 300-500m with taller dunes having wider corridors, and range from 2-20m in height. Dunes are predominantly red in colour due to hematite staining of the sand grains; very occasionally dunes composed of white sands can be encountered (Greenslade *et al*. 1986).

Extensive surface exposures of calcrete and silcrete materials are frequently seen exposed within interdune corridors. These stony areas discussed further below.

Stony Plains

As indicated above, the Great Victoria Desert Bioregion has some extensive surface exposures of calcrete and silcrete materials. Typically these are found exposed within the interdune corridors rather than as a discrete landscape component, however they can form extensive undulating dune-free surfaces extending for several kilometres in places. Ferritic nodule spreads appear to be less widely distributed. Silcrete generally occurs as stony gibber spreads. Stones are in most cases angular and varnished, 2-8 cm in diameter. An intact silcrete layer has been reported near Observatory Hill, located east of PEL 81. Two forms of calcrete occur in the survey area, banded and pisolitic, with banded calcrete being the most common. Calcrete pisolites have been observed. Calcrete is widespread and bluebush indicates that calcrete is present (Greenslade *et al*. 1986).

True gibber soils (which have a pavement of silcrete stones embedded in a thin loamy surface layer which overlies easily dispersable clay subsoils) are notable because of their susceptibility to erosion when the surface pavement of gibber stones is removed. Severe erosion in these soils can occur even on relatively gentle slopes (e.g. 2 to 3 degrees) when the protective crust and gibbers are removed. Laut *et al.* (1977) report the occurrence of these soils in the Dingo environmental association in the far east of PEL 81, however they are not extensive or widespread within the PELs.

Limestone Plains

Large areas of limestone plains with shallow calcareous loamy soils dominate the southern region of the Officer Basin and are almost totally featureless apart from gentle undulations which interrupt an otherwise level surface. Sinkholes and inactive drainage lines are also scattered across the plain (Greenslade *et al*. 1986).

Playa Lakes

Playa lake systems in the Great Victoria Desert include the Nurrari and Wyola Lakes and Lakes Dey-Dey and Maurice. The exposed surface of these lakes generally consists of dry clay, silt or sand, veneered with a salty or gypsiferous crust (Greenslade *et al.* 1986). Many playa lakes have lee-side dunes (lunettes) on their eastern margin. Small claypans and salinas may also form in interdune corridors as a result of ephemeral runoff from dunes.

Many of the lakes in the region (e.g. Lake Maurice and the Serpentine Lakes of the Mamungari Conservation Park) are outside the PELs and the area of OBEPL operations. The Serpentine Lakes system is a remnant of a defunct and sediment-choked palaeo-river valley which flowed south. Similar palaeo-river systems also occur further to the east (Douglas 1979).

Drainage lines and localised low lying areas

Paleao-drainage lines are ubiquitous, long and drain from the Musgrave Ranges to the north through to the Proto Eucla basin to the south. These drainage systems rarely carry water. There are also minor localised drainage artefacts from hardpan and rare rocky outcrops.

Water also accumulates in localised longitudinal low lying areas, in dune corridors. These are small, commonly less than 200m by 200m, and uncommon. Where found, the vegetation is characterised by shrubby halophytes.

Minor rocky outcrops

A sedimentary rock sequence (Observatory Hill) is exposed throughout the Great Victoria Desert bioregion. This comprises ‘white fine to medium micaceous sandstone, clayey or feldspathic, occasionally silty’ (Noorina geological map, cited in Greenslade *et al*. 1986). Outcrops are low and rounded consisting of gently rising main slope which terminates in debris slopes formed from intact and disintegrated rock floaters (Greenslade *et al*. 1986). Rocky prominences in the OBEPL areas are sporadic. Plate 2 shows a typical rocky prominence.

Plate 2: Rocky prominence (Source: OBEPL library)

4.3 Flora and Fauna

The sand plains and dune fields of the Great Victoria Desert are rich in flora and fauna, and form the biologically richest and least disturbed sandy desert in South Australia (Foulkes and Thompson 2008). Because of its remoteness and the lack of reliable water, the region escaped the severe impacts associated with European settlement and livestock grazing, and is in relatively natural condition (Foulkes and Thompson 2008).

4.3.1 Vegetation

The vegetation in PELs 81 and 253 is dominated by woodlands of mallee (*Eucalyptus* spp.) and Mulga (*Acacia aneura* complex) with an understorey of short-lived tussock grasses and herbs, spinifex hummock grasses (*Triodia* spp.) or shrubs. The region appears to be in relatively natural condition, with very little exotic flora having been introduced. Since European settlement, changes to Aboriginal burning practices and grazing by rabbits and camels have influenced the status, structure and distribution of individual plant species and communities (Foulkes and Thompson 2008).

Typical arid-adapted species dominate most of the region, including *Acacia*, *Casuarina* and *Eucalyptus* spp. and hummock grasses of the genus *Triodia* (Spinifex)). Samphires (*Tecticornia* spp.) and other chenopods are more common in the saline areas and areas high in gypsum. Within the dunefields, Eucalypts generally dominate the upper reaches of the sand-dunes, whilst Mulga and Black Oak (*Casuarina pauper*) communities are prominent in the swales. Tall shrubland *Acacia* species (e.g. Horse Mulga (*Acacia ramulosa*) and Umbrella Bush / Sandhill Wattle (*Acacia ligulata*)) generally occupy the dune crests. Parts of the region within the Nullarbor bioregion are characterised by chenopod shrublands (*Atriplex*, *Maireana* and *Sclerolaena* species) and mulga woodlands (Foulkes and Thompson 2008).

Fire has had a significant influence on vegetation structure and composition, as a result of both traditional Aboriginal burning practices and more recent wildfires. Regeneration in areas such as mulga woodlands following more recent fires has been prevented or greatly reduced by rabbits, resulting in grasslands with sparse emergent mulga, such as found to the south-east of Oak Valley (Foulkes and Thompson 2008).

Vegetation mapping (DEH 2010b) has identified 21 vegetation communities within the area of the PELs. These are listed in Table 6. Photographs of common vegetation communities are shown in Plate 3 to Plate 10.

There are no vegetation communities listed as having national or state conservation significance recorded within the Maralinga Tjarutja Lands (Foulkes and Thompson 2008).

Table 6: Vegetation Communities Mapped in PELs 81 and 253

SA VEG ID	Vegetation Community	Landform / environment description
GC0002	Mulga *Acacia aneura** low open woodland	Sandy plain to plain; sand to clayed sand; sandy plain to plain
GV0001	Mulga *Acacia aneura* low open woodland	Plain; sand; dunefield
GV0003	Horse Mulga *Acacia ramulosa* var., Mulga *Acacia aneura* low open woodland	Dune / consolidated dune; sand; dunefield
GV0004	Bullock Bush *Alectryon oleifolius* ssp. *canescens*, False Sandalwood *Myoporum platycarpum* ssp. *platycarpum*, Black Oak *Casuarina pauper* +/- Victoria Desert Mallee *Eucalyptus concinna* +/- Red Mallee *Eucalyptus oleosa* ssp. +/- Summer Red Mallee *Eucalyptus socialis* ssp. mid open woodland	Interdune corridor; sand to sandy loam
GV0005	Black Oak *Casuarina pauper* +/- Western Myall *Acacia papyrocarpa* low woodland	Plain; sandy loam; plain to dunefield
GV0006	Black Oak *Casuarina pauper*, Bullock Bush *Alectryon oleifolius* ssp. *canescens* +/- Mulga *Acacia aneura* low woodland	Sandy plain; sandy loam; dunefield
GV0007	Marble Gum *Eucalyptus gongylocarpa*, Ooldea Mallee *Eucalyptus youngiana* +/- Victoria Desert Mallee *Eucalyptus concinna* +/- Jinjulu *Eucalyptus glomerosa* low open woodland	Plain; sandy loam to loamy sand; dunefield
GV0009	Victoria Desert Mallee *Eucalyptus concinna* +/-Ooldea Range Mallee *Eucalyptus canescens* ssp. *canescens* +/- Summer Red Mallee *Eucalyptus socialis* ssp. +/- Vokes Hill Mallee *Eucalyptus eremicola* +/- Mulga *Acacia aneura* mid mallee woodland	Plain; sand; sandy plain
GV0010	Victoria Desert Mallee *Eucalyptus concinna* +/- Summer Red Mallee *Eucalyptus socialis* ssp. +/- False Sandalwood *Myoporum platycarpum* ssp. *platycarpum* mid mallee woodland	Sandy plain; sand; sand plain
GV0014	Mulga *Acacia aneura* tall sparse shrubland	Interdune corridor; sandy loam; dunefield; found on buchshot
GV0015	Umbrella Bush *Acacia ligulata* +/- Narrow-leaf Hop-bush *Dodonaea viscosa* ssp. *angustissima* +/ -Horse Mulga *Acacia ramulosa* var. tall open shrubland	Plain; skeletal soil; dunefield
GV0016	Bladder Saltbush *Atriplex vesicaria* ssp. +/- Mallee Hemichroa *Hemichroa diandra* +/- Samphire *Tecticornia* sp. low open shrubland	dry waterbodies, playa / pan and associated gypsiferous lunettes
GV0017	Narrow-leaf Hop-bush *Dodonaea viscosa* ssp. *angustissima* +/- Umbrella Wattle *Acacia oswaldii* tall sparse shrubland	Closed depression; sandy loam; flood plain
GV0018	Samphire *Tecticornia* sp., Bladder Saltbush *Atriplex vesicaria* ssp. low open shrubland	Plain; sand; dunefield
GV0019	Buckbush *Salsola tragus* +/- Woolly–fruit Bluebush *Eriochiton sclerolaenoides* +/- Oblique-spined Bindyi *Sclerolaena obliquicuspis* +/- Grey Bindyi *Sclerolaena diacantha* +/- Balcarra Spear-grass *Austrostipa nitida* +/- Common Bottle-washers *Enneapogon avenaceus* low open shrubland	Playa / pan;consolidated dunefield
GV0021	Desert Senna *Senna artemisioides* ssp. *petiolaris* +/- Broad-leaf Desert Senna *Senna artemisioides* ssp. *X coriacea* mid open shrubland	Plain; sand; sand plain
NB0003	Black Oak *Casuarina pauper*, Mulga *Acacia aneura* low open woodland	Plain; sand; plain; lichen crust
NB0011	Bladder Saltbush *Atriplex vesicaria* ssp. low shrubland	Plain; medium clay; plain; lichen crust

SA VEG ID	Vegetation Community	Landform / environment description
NB0013	Woolly-fruit Bluebush *Eriochiton sclerolaenoides* +/- Oblique-spined Bindyi *Sclerolaena obliquicuspis* +/- Spear-fruit Bindyi *Sclerolaena patenticuspis* +/- Jointed Bottle-washers *Enneapogon cylindricus* low shrubland	Plain; sandy clay loam; plain; lichen crust
NU0003	Dead Finish *Acacia tetragonophylla*, Native Apricot *Pittosporum angustifolium* low open woodland	Occurs on sandy clay loam soils of shallow depressions (dongas) in limestone plain
NU0012	Balcarra Spear-grass *Austrostipa nitida*, Wallaby Grass *Austrodanthonia caespitosa* +/- Desert Spear-grass *Austrostipa eremophila* low tussock grassland	Plain; sandy clay loam; plain

*Note: Mulga (*Acacia aneura* complex) has been shortened to *Acacia aneura* to avoid confusion in this table.

Plate 3: Dunefield vegetation in the west of PEL81, showing Horse Mulga (*Acacia ramulosa*) on the dune crest (foreground), Mulga (*Acacia aneura* complex) woodland in the swale and Mallee (*Eucalyptus* spp.) woodland on the far dune slope

Plate 4: Black Oak (*Casuarina pauper*) woodland

Plate 5: Mallee (*Eucalyptus* spp.) woodland over Spinifex (*Triodia* spp.)

Plate 6: Mulga (*Acacia aneura* complex) woodland

Plate 7: Very open Mulga (*Acacia aneura* complex) woodland over grasses

Plate 8: Marble Gum (*Eucalyptus gongylocarpa*) woodland

Plate 9: Fire-affected Mallee (*Eucalyptus* spp.) woodland (possible drilling site)

Plate 10: Mulga (*Acacia aneura* complex) woodland on stony soil

4.3.2 Significant Flora

A number of rare or threatened plant species are known to occur in the PELs. A search of the Commonwealth Environment Protection and Biodiversity Conservation (EPBC) Act database (DEWHA 2010b) and the Biological Databases of South Australia (BDBSA) (DEH 2010a) has identified nine rare or threatened plant species as having been recorded in PELs 253 and 81, with a further 12 rare or threatened species recorded in the adjacent Mamungari Conservation Park (Table 7).

Although not all the species recorded in Mamungari Conservation Park would be expected to occur in the PELs, these species' records have been included in Table 7 as there has been significant amount of data collected in the park, and these data provide a useful supplement to the historical records and recent biological survey work (Foulkes and Thompson 2008) undertaken within the PELs and other areas of the Maralinga Tjarutja Lands.

Table 7: Rare or threatened plant species recorded in PELs 81 and 253 or Mamungari Conservation Park

Species Name	Common Name	Conservation Status		Record in PELs	Record in Mamungari CP
		Cwth	SA		
Acacia helmsiana	Helm's Wattle		R		✓
Alyogyne pinoniana var. *microandra*			V	✓	
Austrostipa nullanulla	Club Spear-grass	V	V		✓
Brachyscome ciliaris var. *subintegrifolia*			R		✓
Choretrum glomeratum var. *chrysanthum*	Yellow-flower Sour-bush		R		✓
Corynotheca licrota	Sand Lily		R	✓	
Eucalyptus canescens ssp. *beadellii*	Beadell's Mallee		R	✓	✓
Eucalyptus kingsmillii ssp. *alatissima*	Kingsmill's Mallee		R		✓
Eucalyptus wyolensis	Wyola Mallee		R	✓	
Frankenia cinerea			R		✓
Goodenia glandulosa			R		✓
Lobelia heterophylla			R		✓
Maireana melanocarpa	Black-fruit Bluebush		R	✓	
Melaleuca nanophylla	Dwarf-leaf Honey-myrtle		R	✓	✓
Olearia arida	Desert Daisy-bush		V		
Santalum spicatum	Sandalwood		V	✓	✓
Sclerolaena blackiana	Black's Bindyi		R		✓
Sclerolaena fusiformis			V	✓	
Sclerolaena symoniana	Symon's Bindyi		V	✓	✓
Swainsona dictyocarpa			V		✓
Swainsona kingii			V		✓

*Conservation status under the SA *National Parks and Wildlife Act 1972* & Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*: R – Rare, V – Vulnerable, E – Endangered.

One species of national conservation significance, Club Spear-grass (*Austrostipa nullanulla*) has been recorded in the vicinity of the PELs: in Mamungari Conservation Park to the west of PEL 253 and several locations to the south of PEL 81. This species is listed as vulnerable under both the South Australian *National Parks and Wildlife Act 1972* and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*. In South Australia it occurs on gypseous soils on the outskirts of salt lakes (Pobke 2007, DECCW 2005). It is considered quite possible that Club Spear-grass occurs within the PELs in this habitat.

4.3.3 Weeds

The Maralinga Tjarutja Lands and the PELs have very low levels of weeds, with only eight species recorded in the Maralinga Tjarutja Lands biological survey (Foulkes and Thompson 2008). Weeds recorded within the PELs in the Biological Databases of South Australia (BDBSA) (DEH 2010a) are listed in Table 8.

A number of other weeds have been recorded in the adjacent Mamungari Conservation Park (DEH 2010a) including Wild Oat (*Avena* spp.), Wild Turnip (*Brassica tournefortii*), Ward's Weed (*Carrichtera annua*) and the declared weed species Salvation Jane (*Echium plantagineum*) and Horehound (*Marrubium vulgare*). At this stage the weed species present in the park are restricted in range (Mamungari Conservation Park Board of Management 2007).

Buffel Grass (*Cenchrus ciliaris*) is known in the broader region from a small number of records but is not recorded within the PELs in the BDBSA (DEH 2010a). This exotic species, although not declared under the *Natural Resources Management Act 2004*, has been identified as a concern in regard to long term risks to biodiversity if it is left to spread from the small number of known outbreaks (AW NRM Board 2010).

Table 8: Weeds recorded within PELs 81 and 253 in the BDBSA

Species	Common Name	Status under *Natural Resources Management Act 2004*
Erodium aureum		-
Setaria parviflora	Slender Pigeon-grass	-
Setaria sp.	Pigeon-grass	-
Sonchus oleraceus	Common Sow-thistle	-
Tribulus terrestris	Caltrop	Declared

4.3.4 Fauna

The Great Victoria Desert bioregion supports a high diversity of native fauna. A number of species are endemic to the region, such as the Linga Dragon (*Diporiphora linga*).

Common fauna of the region are discussed in the following paragraphs. The following section (4.3.5) provides information on fauna of conservation significance.

<u>Birds</u>

The Biological Survey of the Maralinga Tjarutja Lands and previous observations have recorded 133 species of birds across the Maralinga Tjarutja Lands, and most of these would be expected to occur in the PELs. Common bird species in the Maralinga Tjarutja Lands include Yellow-throated Miner (*Manorina flavigula*), Budgerigar (*Melopsittacus undulatus*), Grey-fronted Honeyeater (*Lichenostomus plumulus*), White-fronted Honeyeater (*Phylidonyris albifrons*), Chestnut-rumped Thornbill (*Acanthiza uropygialis*), Masked Woodswallow (*Artamus personatus*), Spiny-cheeked Honeyeater (*Acanthagenys rufogularis*), Black-faced Woodswallow (*Artamus cinereus*), White-browed Babbler (*Pomatostomus superciliosus*) and Mulga Parrot (*Psephotus varius*). Galahs (*Cacatua roseicapilla*), Willie Wagtails (*Rhipidura leucophrys*) and Crested Pigeons (*Ocyphaps lophotes*) are also common (Foulkes and Thompson 2008).

<u>Mammals</u>

Up to 43 native species of mammals and nine introduced species have existed within the Maralinga Tjaturja Lands within the past two hundred years (Foulkes and Thompson 2008). There are at least 27 native mammal species currently occurring on the Maralinga Tjaturja Lands and at least 17 native species are presumed extinct in the region (Foulkes and Thompson 2008). Many of the medium sized mammals recorded up to the early 1900’s have been lost from the region (and are completely extinct in many cases), possibly due to a combination of the extreme drought in the 1930s, predation from cats, foxes and dingoes and competition from rabbits (Foulkes and Thompson 2008).

The most commonly recorded mammal species in the Biological Survey of the Maralinga Tjarutja Lands included the Sandy Inland Mouse (*Pseudomys hermannsburgensis*), the introduced House Mouse (*Mus musculus*), the Ooldea Dunnart (*Sminthopsis ooldea*), Wongai Ningaui (*Ningaui ridei*) and Gould's Wattled Bat (*Chalinilobus gouldii*).

Common and widespread introduced species include the One-humped Camel (*Camelus dromedarius*), Rabbit (*Oryctolagus cuniculus*), Feral Cat (*Felis catus*) and Red Fox (*Vulpes vulpes*). Camels can occur in very high numbers depending on seasonal conditions (AW NRM Board 2010).

Reptiles and Amphibians

The Maralinga Tjarutja Lands support a high diversity of reptiles. There have been 94 species of reptiles and a single species of frog (Trilling Frog *Neobatrachus centralis*) recorded from the Maralinga Tjarutja Lands, making it one of the most reptile rich regions in Australia (Foulkes and Thompson 2008).

The most commonly recorded reptile species in the Biological Survey of the Maralinga Tjarutja Lands included Sandplain Ctenotus (*Ctenotus schomburgkii*), Military Dragon (*Ctenophorus isolepis*), Pale Knob-tailed Gecko (*Nephrurus laevissimus*), Eastern Desert Ctenotus (*Ctenotus regius*), Beaked Gecko (*Rhynchoedura ornata*) and Thorny Devil (*Moloch horridus*). Medium-sized reptiles such as Dwarf Bearded Dragon (*Pogona minor*) and Sand Goanna (*Varanus gouldii*) are also relatively common. Snake species present include banded snakes (*Simoselaps* spp.), Mulga Snake (*Pseudechis australis*) and brown snakes (*Pseudonaja* spp.).

4.3.5 Significant Fauna

A search of the Commonwealth Environment Protection and Biodiversity Conservation (EPBC) Act database (DEWHA 2010b) and the Biological Databases of South Australia (DEH 2010a) has identified eight rare or threatened fauna species as having been recorded in PELs 253 and 81, with a further 13 rare or threatened species recorded in the adjacent Mamungari Conservation Park or predicted to occur in the area (Table 9). Species predicted to occur in the area by the EPBC Act database but not actually recorded are marked with an asterisk (*) in Table 9.

As discussed above for flora, although not all the species recorded in Mamungari Conservation Park would be expected to occur in the PELs, these species' records have been included in Table 9 as there has been significant amount of data collected in the park. Because biological survey work in the PELs has not been exhaustive, these data provide a useful supplement to the historical records and recent biological survey work (Foulkes and Thompson 2008) undertaken within the PELs and other areas of the Maralinga Tjarutja Lands.

Table 9: Rare or threatened fauna species recorded in PELs 81 and 253 or Mamungari Conservation Park

Species Name	Common Name	Conservation Status[1]		Record in PELs	Record in Mamungari CP
		Cwth	SA		
Birds					
Acanthiza iredalei iredalei	Slender-billed Thornbill (western)	V	R		✓
Amytornis striatus	Striated Grasswren		R	✓	
Ardeotis australis	Australian Bustard		V	✓	✓
Climacteris affinis	White-browed Treecreeper		R	✓	✓
Falco peregrinus	Peregrine Falcon		R		✓
Leipoa ocellata	Malleefowl	V	V	✓	
Lophocroa leadbeateri	Major Mitchell's Cockatoo		R	✓	✓
Neophema splendida	Scarlet-chested Parrot		R	✓	✓
Northiella haematogaster narethae[2]	Blue Bonnet (Naretha)		R	✓	✓
Pachycephala inornata	Gilbert's Whistler		R	✓	✓
Polytelis alexandrae	Princess Parrot	V	V		✓
Mammals					
Bettongia penicillata penicillata	Brush-tailed Bettong (south-east mainland)	EX	E	✓	
Dasycercus cristicauda	Mulgara	V	E	*	
Leporillus conditor	Greater Stick-nest Rat	V	V		✓
Notoryctes typhlops	Southern Marsupial Mole, Yitjarritjarri	E	V		✓
Nyctophilus gouldi	Gould's Long-eared Bat		E		✓
Sminthopsis psammophila	Sandhill Dunnart	E	V	*	
Reptiles					
Ctenophorus salinarum	Claypan Dragon		R		✓
Diplodactylus pulcher	Patchwork Gecko		R		✓
Liopholis kintorei	Great Desert Skink, Tjakura, Warrarna, Mulyamiji	V	E	*	
Varanus brevicauda	Short-tailed Pygmy Goanna		R		✓

[1]Conservation status under the SA *National Parks and Wildlife Act 1972* & Commonwealth *Environment Protection and Biodiversity Conservation Act 1999*: R – Rare, V – Vulnerable, E – Endangered, EX – Extinct

[2]Subspecies information is not contained in BDBSA records, however as the range of this subspecies is in the vicinity of the PELs, BDBSA records of *Northiella haematogaster* may be this subspecies and have been included.

* Indicates the species has been predicted to occur by the protected matters search tool (DEWHA 2010b) but has not been recorded in the BDBSA (DEH 2010a).

Two other species listed under the Commonwealth EPBC Act were predicted by the protected matters search tool (DEWHA 2010b) to occur in the vicinity of the PELs: Thick-billed Grasswren (eastern) *Amytornis textilis modestus* and Plains Rat *Pseudomys australis* (both listed as vulnerable under the EPBC Act). These species occur in the Stony Plains bioregion, well to the east of the PELs. They have not been recorded in the BDBSA within 150 km of the eastern boundary of the PELs and are not considered likely to occur.

The following paragraphs provide further information on the EPBC Act listed fauna species that are known to occur or may occur in the region of the PELs.

Slender-billed Thornbill (western) (*Acanthiza iredalei iredalei*)

Listed under the EPBC Act as vulnerable, this species has been recorded infrequently in areas adjacent to the PELs (Mamungari CP and south of Oak Valley). It usually occurs in chenopod shrublands that are dominated by samphires or *Maireana* and *Atriplex* associations, and is occasionally recorded in acacia woodlands adjacent to more preferred habitat. It is distributed across in arid and semi-arid regions of southern Western Australia and south-western South Australia (DEWHA 2010a). It is noted as a rarely recorded species in the Maralinga Tjaturja Lands (Foulkes and Thompson 2008).

Malleefowl (*Leipoa ocellata*)

Listed under the EPBC Act as vulnerable, this species is thought to be sparsely distributed throughout the Maralinga Tjarutja Lands (Foulkes and Thompson 2008). There have been a number of recent observations in the region during targeted searches, which were predominantly in the southern part of the Maralinga Tjarutja Lands (Foulkes and Thompson 2008). Malleefowl inhabit shrublands and low woodlands that are usually dominated by mallee vegetation, and are found in arid and semi-arid regions across southern Australia (DEWHA 2010c). The species has declined significantly over the past three generations in both extent of occurrence and area of occupancy, due to the effects of predation and wildfire and habitat and population fragmentation (Foulkes and Thompson 2008).

Princess Parrot (*Polytelis alexandrae*)

Listed under the EPBC Act as vulnerable, this species has been recorded on a number of occasions in Mamungari Conservation Park. Most observations have been in Marble Gum woodlands west of Vokes Hill corner and this appears to be the preferred breeding habitat of this species in South Australia (Foulkes and Thompson 2008). Princess Parrots are said to be highly nomadic and are sparsely distributed in arid regions of Western Australia, the Northern Territory and South Australia, mainly in the Great Sandy, Gibson, Tanami and Great Victoria Deserts (DEWHA 2010e). The species is an irregular visitor to most sites in its range.

Brush-tailed Bettong (south-east mainland) (*Bettongia penicillata penicillata*)

The Brush-tailed Bettong (south-east mainland) is considered to be extinct and is listed under the EPBC Act as such. The single record in the PELs dates back to 1897. Colonies of the closely related Woylie (*Bettongia penicillata ogilbyi*) have been introduced to offshore islands and several mainland sites in South Australia, but this subspecies is not present in the region.

Mulgara (*Dasycercus cristicauda*)

The Mulgara is listed as vulnerable under the EPBC Act and is presumed extinct from the Maralinga Tjarutja Lands, although it is a possibility that it may still be located in the region in appropriate areas of Spinifex – sand plain habitats (Foulkes and Thompson 2008). The records in the region are generally to the south of the PELs and date from pre-1950. Despite extensive and relatively intensive search efforts, the last confirmed specimen from the Maralinga Tjarutja Lands was collected in 1933. (Note: there has been considerable taxonomic confusion and re-sorting of the Mulgaras; Foulkes and Thompson (2008) use the name *Daycercus blythi* for this species).

Greater Stick-nest Rat (*Leporillus conditor*)

Listed under the EPBC Act as vulnerable, this species is extinct in the region, and was last recorded on mainland Australia in 1933 (Foulkes and Thompson 2008). It was considered to be extinct on the mainland prior to its reintroduction from offshore islands to several other islands and Roxby Downs on the mainland.

Southern Marsupial Mole (*Notoryctes typhlops*)

The Marsupial Mole is listed under the EPBC Act as endangered (and is listed as vulnerable in South Australia). It has been recorded at several locations in Mamungari Coonservation Park, as well as to the south of the PELs. It is widely distributed across the sandy deserts of Australia, but is difficult to detect. Evidence of Marsupial Moles was found at four locations during the Biological Survey of the

Maralinga Tjarutja Lands, and at a further 15 of the twenty locations searched in the Maralinga Tjarutja Lands by trenching during targeted investigations (Foulkes and Thompson 2008). It is possibly still widespread, but rarely seen (Foulkes and Thompson 2008).

Sandhill Dunnart (*Sminthopsis psammophila*)

Listed under the EPBC Act as endangered, this species was not recorded by the Biological Survey of the Maralinga Tjarutja Lands (Foulkes and Thompson 2008). Database records of this species are all from the Yellabinna area south-east of the PELs (the closest record is 120 km away). It is found in South Australia, Western Australia and the south-west of the Northern Territory and occurs on sandy substrates with *Triodia* hummock grass and sand dunes with mallee, Marble Gum or *Callitris* overstorey (Foulkes and Thompson 2008).

Great Desert Skink (*Liopholis kintorei*)

This species, which is listed under the EPBC Act as vulnerable, has not been recorded in the PELs and was not recorded by the Biological Survey of the Maralinga Tjarutja Lands. There is one record of the species from targeted surveys in 2005 located approximately 7 km north of PEL 81, just inside the northern boundary of the Maralinga Tjarutja Lands. All other records of this species in South Australia are further north. It is a large burrowing lizard that occurs in sand plains and sand ridges, often with hummock grassland of *Triodia* spp. but in South Australia has been found in Mulga woodland with tussock grasses (DEWHA 2010d). The Great Desert Skink is currently known from a small number of isolated populations (DEWHA 2010d).

4.4 Water Resources

The Officer Basin occurs in an area of low rainfall and high evaporation. Surface water (ephemeral and permanent) is virtually non-existent, and groundwater, where present, is usually highly saline (Morton and Drexel 1997). Although data on groundwater are very sparse, it is considered unlikely that more extensive searching in this environment will yield any major resources of low salinity groundwater (Morton and Drexel 1997).

4.4.1 Surface water

There is little evidence of surface water in the Officer Basin region. The ephemeral streams of the Musgrave Block to the north and Eromanga Basin to the east vanish abruptly in the environment of higher permeability and porosity of the Palaeozoic sandstones in the Officer Basin, which result in faster penetration of water into the subsurface and a lower watertable (Morton and Drexel 1997). The ephemeral Officer Creek, which flows into the area from the north, extends into the basin approximately 50 km (approximately 100km north of PEL 81) before being absorbed, but it is by far the most persistent of such features. Other indications of the gathering of surface waters for recharge are very few and uncertain (Morton and Drexel 1997).

There are a small number of isolated rockholes and soaks in the region, such as the Ooldea Soak to the south of the PELs, which is known as Youldeh by Aboriginal people and was previously a reliable source of water and a principal refuge during severe droughts (Foulkes and Thompson 2008). Several soaks (marked as “Native Wells” on 1:250,000 mapping) occur in PEL 81 north of Wyola Lake, near the Vokes Hill road.

The only other evidence of surface water of any kind comprises the salt lakes around the southern edge of the basin outcrop such as those at Serpentine Lakes in Mamungari Conservation Park, Lake Dey Dey and Lake Maurice (which lies south of PEL 81), Wyola and Nurrari Lakes, and north of Emu Junction. These highly saline environments, which occur along the southern boundary of the north-dipping Palaeozoic sediments of the basin, are interpreted as discharge zones (Morton and Drexel 1997).

4.4.2 Groundwater

The following information is taken from Morton and Drexel (1997).

On the basis of the very sparse information that exists, Lau *et al*. (1995a, 1995b) referred to all known groundwater as being interlinked in one unconfined system, with the Precambrian surface regarded as hydrogeological basement. While this may be a simplification, there is insufficient evidence to justify subdivision. The system extends from surface in the discharge zones south of the Officer Basin to considerable depth in Birksgate 1, and spans a host time range from Tertiary palaeochannel sediments to Cambrian Observatory Hill Formation. These sediments are highly variable in composition and are impossible to divide into aquifers and aquitards on the available information.

Shale of the Observatory Hill Formation contains sand sequences, while the Trainor Hill Sandstone may be impermeable in parts. A major increase in the density of geological information is needed before there is any hope of mapping individual aquifers, if such exist. Lau *et al*. (1995a, 1995b) also noted that there may well be perched aquifers in the palaeodrainage channels, hosted by Tertiary Hampton Sandstone or Pidinga Formation. A confined or semi-confined aquifer may be present in the Murnaroo Formation, which is intersected in several holes in the southeastern part of the basin. This aquifer yielded saline water in the Tallaringa Trough and near Maralinga, and is probably recharged in the area of the Nawa Ridge where the formation is closest to surface and subcrops under Tertiary sediments.

<u>Recharge</u>

Subsurface water flow may occur through the Tertiary palaeochannels which extend southwards from the Musgrave Block over the full surface extent of the Officer Basin. While there is no firm evidence of such water movement, it must be expected on the basis of the proven water content in these features to the north, the permeability of the sediments, and the potentiometric gradient. Such waters would be expected to be saline. Below the base of the Tertiary sediments, any southward flow of groundwater into the basin is expected to be blocked by the steep, fault-controlled northern edge of the basin and the steeply dipping Adelaidean sediments. Movement of water from Western Australia eastwards into the South Australian portion of the Officer Basin is possible, but the potentiometric surface indicates that the major flow direction is to the south. Thus, apart from surface flow, most recharge into the groundwater system of the Officer Basin is expected to come from local recharge.

<u>Discharge</u>

The only evidence of surface discharge from Officer Basin aquifers is the salt lakes along the southern margin. Subsurface discharge may occur into the overlying Eucla Basin to the south of the Ooldea Range, but this is speculative. Since the Officer Basin sediments dip gently northwards, and the base of the Cambrian is not deep below the Ooldea Range, the presence of impermeable ‘Wirrildar beds’ in seismic shotholes in this area may be a barrier to southward groundwater movement and may be partly responsible for the surface discharge in this area. Thus, there may be little or no movement of water between the Officer and Eucla Basins. It is presently thought that virtually all discharge from the Officer Basin sediments is through the salt lakes near the Ooldea Range.

4.5 Heritage

The Great Victoria Desert region of the Officer Basin has broad indigenous cultural and historical significance. Current land uses throughout the area include both cultural and natural environment conservation.

4.5.1 Indigenous Heritage

Aboriginal people have inhabited the Great Victoria Desert for at least 20,000 to 24,000 years (Shephard 1995) and association with the area has been established to 39,000 years ago on the Nullarbor Plain immediately to the south (Mamungari Conservation Park Board of Management 2007). The traditional Maralinga Lands were the homelands of people linked to the Kokatha, Wirngu and Pitjantjatjara (O'Connor 1997). Aboriginal groups followed well-established routes and special Dreaming tracks marked with rock holes, soaks and dams to permanent or semi-permanent water sources in the Great Victoria Desert. A water source at Ooldea Soak, known as Youldeh by Aboriginal people was important throughout the desert, as it was a principal refuge during severe droughts. Ooldea was a meeting place, ceremonial and trade centre. Ceremonies continued to be held up to the 1940s. Aboriginal people as far away as Mann, Musgrave, Everard and MacDonnell Ranges would visit Ooldea for this purpose (ANRA 2010a). As discussed in Section 4.7, the Aboriginal community at Oak Valley is located on the south-eastern edge of PEL 81.

The Maralinga Tjarutja Lands are rich in sites of both archaeological and spiritual significance. All personnel working in the area must be made aware of the requirements of the *Aboriginal Heritage Act 1988* as well as the obligations required of OBEPL and its contractors under the land access and production agreement for petroleum exploration and production between OBEPL and Maralinga Tjarutja. This agreement contains specific requirements for the protection of cultural heritage, including the undertaking of clearance surveys by Maralinga Tjarutja before any ground disturbing activity occurs.

4.5.2 Historical Heritage

A search of National and State heritage registers has indicated that a number of heritage sites occur in the region of the PELs. A summary of these sites is provided in Table 10. Further information on these sites is provided in the sections following the table.

Table 10: Non-indigenous heritage sites in the Officer Basin region

Register Source	Site Type	Name	Location
Register of the National Estate (RNE)	Historic	Maralinga Village and Forward Area	Maralinga Defence land (prohibited area), south of PEL 81
RNE	Historic	Emu Field Village Site and Range	235km west of Coober Pedy on Emu - Coober Pedy Road (Anne Beadell Highway), 4km east of PEL 81
RNE	Natural	Un-named Conservation Park (now Mamungari Conservation Park)*	150km west of Maralinga in the Great Victoria Desert, adjacent to PELs 81 and 253

*See Section 4.6.2 for discussion

<u>Maralinga</u>

The Maralinga sites were used for British nuclear tests during the 1950s and are of particular social significance to the Aboriginal people of the region and ex-service personnel. As a consequence of the testing program the Aboriginal people were denied access to sites of traditional significance, discouraged from a traditional lifestyle and movement across the area, and were dispossessed by the use of the range for defence purposes. They may also have suffered adverse health effects from exposure to radioactive contamination. There are also ex-service personnel and others employed at the range at the time of the tests, who believe that adverse health effects have resulted from their service during the test program. The sites also have some social significance to the general Australian community as a consequence of their place in history, which is reflected in the numerous books, films and press reports, both at the time of the tests and subsequently (AHPI 2010).

The Maralinga Village site has generally been cleared of buildings although numerous foundations and the road system remain. Only about five buildings and three water tanks remain and a few modern structures have been introduced. The airfield remains and was a major collection point for rainwater for the village; one building remains at the airfield. The Forward Area contains an extensive track network; minor relics from the period of use; other earthworks associated with the tests; firing pads from the minor trials; and plinths marking the major explosion sites (AHPI 2010).

<u>Emu Field Village</u>

The Emu atomic weapons test sites and facilities are historically significant as the site for the second series of tests by the United Kingdom which included two of the twelve major fission explosions in Australia. The range is also significant as the site for the first series of minor trials (the kitten trials) which were to become a major component of the overall program in later years (AHPI 2010).

For reasons similar to those at Maralinga, the Emu sites have social significance for Aboriginal people of the region and ex-service personnel. In particular, the black mist incident at Wallatinna, where Aboriginal people were exposed to fallout from the totem 1 explosion, and the closure of the Ooldea Aboriginal Reserve before the tests began, are examples of events significant in shaping the views of Aboriginal people to the program of tests (AHPI 2010).

4.6 Land Use

Most of the Officer Basin region is Aboriginal lands, and PELs 81 and 253 lie entirely within the Maralinga Tjarutja Lands. Pastoral development in the region is confined to a few peripheral areas in the south and east, outside PELs 81 and 253, where water and feed are available in some years. Most of the region is unsuited to grazing as water is very limited and fodder plants are very sparsely distributed (ANRA 2010a).

The *Maralinga Tjarutja Land Rights Act 1984* granted freehold title to an area of about 81,373 km^2 (or about 7.7 percent of South Australia) to Maralinga Tjarutja, a corporate body established under that Act and of which all traditional owners are members. The land is held in fee simple by the Maralinga Tjarutja and cannot be sold, compulsorily acquired, resumed or forfeited (ATNS 2010). The Maraliga Tjarutja people use the land exclusively and apart from the Maralinga Tjarutja community at Oak Valley there are no other permanent residents in the Maralinga Lands.

4.6.1 Resource Exploration

At the present time OBEPL are licensed for petroleum exploration in the areas covered by the PELs. In addition, there are several applications by other parties for petroleum exploration in areas adjacent to the OBEPL licences.

To date, there has been little exploration of the Officer Basin with only 30 wells deeper than 500m drilled in the entire region. Only 12 of the approximately 70 drill holes are petroleum exploration wells of sufficient depth to enable the stratigraphy to be pieced together (Morton and Drexel 1997).

Petroleum exploration in the Officer Basin began in the 1960s, initially by Exoil, Conoco and Outback Oil. Comalco carried out mineral and petroleum exploration from 1980-89, and significantly improved understanding of the geology and petroleum potential of the northeast Officer Basin. Amoco briefly explored an adjacent area in the mid-1980s, and in 1993, the Australian Geological Survey Organisation (AGSO) recorded a 550 km seismic transect across the Murnaroo Platform and Birksgate Sub-basin. In the same year, the South Australian Department of Mines and Energy (now PIRSA) recorded 378 km of seismic data in the Marla area (Morton and Drexel 1997).

A number of Mineral Exploration Licences are held for areas in the region of the PELs by Lost Sands and Iluka. In addition several other mineral companies have current applications in the region. At the time of this report there were no applications for geothermal licences.

4.6.2 Conservation

The Great Victoria Desert region has two areas formally designated for conservation, both of which are adjacent to (but outside) PELs 81 and 253:

- Tallaringa Conservation Park
- Mamungari Conservation Park (formerly the Unnamed Conservation Park).

Tallaringa Conservation Park is 1,246,000ha in area 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 immediately to the east of PEL 81. The park contains a vast wilderness of vegetated dunes and gibber rises (DEH 2010c) and 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 Mamungari Conservation Park is located immediately to the west of PEL 81 and north and west of PEL 253. Title to the Conservation Park, an area of about 21,000km^2, was transferred to Maralinga Tjarutja in 1985 on behalf of the Southern Pitjantjajarra people under the *Maralinga Tjarutja Land Rights Act 1984* (ATNS 2010). Mining and petroleum access is not permitted in this park.

The park consists of a vast plain of longitudinal sand ridges and an area of playa lakes, and preserves a huge tract of virtually trackless wilderness adjacent to Western Australia. Several rare or vulnerable plant species occur in the park, as do a number of interesting plant and bird species (AHPI 2010). The park is managed jointly by the Maralinga Tjarutja traditional owners and the Department for Environment and Heritage (DEH). It is one of the largest parks in the world and one of only two biosphere reserves registered by UNESCO in South Australia. It is also listed on the Register of the National Estate (AHPI 2010). Visitors are required to obtain a permit for travelling through the Maralinga Tjarutja Lands (DEH 2010c).

The Nullarbor National Park, and the Nullarbor and Yellabinna Regional Reserves are also in the broader region but are located more than 75km south of PELs 81 and 253.

4.6.3 Tourism

There is limited tourism in the area of the PELs due to the extreme remoteness of the area. Permits are required for visiting the conservation parks and for travelling through the Maralinga Tjarutja Lands and the Woomera Prohibited Area. Tourists with permits can travel along the Anne Beadell Highway or the Vokes Hill Corner to Cook Road, but must be self sufficient as there are no services available (Shephard 1995).

4.6.4 Defence (Woomera Prohibited Area)

The eastern portion of PEL 81 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*.

4.7 Socio-Economic

The Great Victoria Desert is one of the most sparsely populated areas in Australia.

Oak Valley is the only population centre in the vicinity of the PELs. Oak Valley is a remote aboriginal community, located on the south-eastern edge of PEL 81 on the southern fringe of the Great Victoria Desert, approximately 516 km northwest of Ceduna on Maralinga Tjarutja Lands. Oak Valley was established in 1985 as a community out station for Anangu people displaced from the Maralinga Lands for the British atomic tests (Maralinga Tjarutja 2010). It now acts the population centre of the Maralinga Tjarutja Lands with a local population of about 100 people in 20 families. At times during special cultural activities the population has risen to 1,500 people, with visitors from neighbouring communities (Maralinga Tjarutja 2010). There is regular movement of people between Ceduna, Yalata, Oak Valley, and other communities in the region (AW NRMB 2010).

There are no other population centres within the PELs. Ceduna, which lies over 400 km south-east of the PELs, is the largest centre in the broader region and has a population of approximately 3,574. It has the highest percentage of Aboriginal people of all local government areas in South Australia, currently standing at 24.1% (860) of the local population (ABS 2010). Ceduna is the major service centre for the Aboriginal communities in adjacent unincorporated areas as well as for the region's wheat and sheep farmers, mining interests and travellers on the trans-national Eyre Highway.

4.7.1 Infrastructure

There is no major transport infrastructure in the region of the PELs. The major national east-west highway (Eyre Highway) follows the Nullarbor coast and is located approximately 178km south of PEL 253. The Trans Australian Railway also travels east-west and is located approximately 77km south of the boundary of PEL 253. The Central Australia Railway is similarly located approximately 115km east of PEL 81.

There are a number of unsealed tracks and roads utilised predominantly by the Aboriginal communities (e.g. Lake Dey-Dey Road, Aboriginal Business Road). A number of roads in the region were originally constructed to support the nuclear testing program (in the vicinity of Maralinga), or the Woomera Rocket Range (e.g. the east-west Anne Beadell Highway which bisects PEL 81), or as part of resource exploration. A small number of 4WD tourists also travel through the region, however permits must be obtained to travel through Maralinga Tjarutja Lands, and these are generally restricted to use of the Anne Beadell Highway.

Airstrips suitable for small aircraft are available at several locations including Oak Valley.

Water catchment shelters have been constructed by Maralinga Tjarutja along several tracks in the area, including the road to Oak Valley. These sites on the road are used in times of extreme temperatures in the summer months for accessing fresh rain water (Maralinga Tjarutja 2010).

Plate 11: Water catchment shelter on the Oak Valley road

5 Environmental Hazards and Consequences

This section of the EIR identifies and discusses potential environmental hazards and their consequences resulting from drilling operations in PELs 81 and 253 in the Officer 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 11.

5.2 Consequences

Potential environmental consequences of drilling are summarised in Table 11. 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.

Table 11: Hazard and consequence classifications for drilling activities

Drilling Activity	Hazard	Potential Consequence
Well site and access track construction Temporary airstrip construction (if required)	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 Introduction and spread of weeds Increased access by feral animals Visual impact Damage to infrastructure Facilitation of third party access Noise generation
Drilling Operations, including Well Completion and Workover Operations	Vehicle movement Airstrip use Rig moves Routine drilling	Contamination of soil, surface water Soil compaction/disruption/deflation, wheel tracks Dust generation Disturbance to native fauna Introduction and spread of weeds Damage to infrastructure 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 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 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 Loss of vegetation and habitat Disturbance to native fauna Atmospheric pollution
	Spills or leaks associated with: ▪ 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 Atmospheric pollution Disruption to land use

Drilling Activity	Hazard	Potential Consequence
	Flaring of gas during testing Emissions vented from drill stem testing and production testing	Atmospheric pollution Disturbance to native fauna
	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
	Loss of radioactive source down hole	Contamination of groundwater (aquifer)
	Flooding of surrounding area Extreme weather conditions	Contamination of soil, surface water or groundwater Damage to infrastructure
Waste Handling and Disposal	Handling and disposal of domestic and chemical waste Sewage treatment and effluent disposal 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)
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
Campsites and associated supplies	Vehicle movement Disturbance of vegetation and habitat Spills and leaks Handling and 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 Increased abundance of feral animals 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
Well site, access track, campsite and airstrip restoration	Earthworks Vehicle movement Spills and leaks	Contamination of soil, surface water Soil inversion Disturbance to native fauna Introduction and spread of weeds Visual impact Damage to infrastructure Impact and/or damage to cultural/heritage sites 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 and 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 landform 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 landforms are summarised below.

Dunefields and 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, studies of seismic lines in the Cooper Basin have concluded that natural rates of erosion on dunes were not accelerated as a result of disturbance to the soil surface (Santos 2003). The soils in these areas can be susceptible to localised erosion where runoff is increased (e.g. if water running off minor rocky outcrops is channelled along roads).

Gibber Pavement

While gibber pavement is 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.

Minor Rocky Outcrops

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

Drainage Lines

Drainage lines 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.

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.

5.3.2 Borrow Pits

Borrow pits are generally required for the excavation of material for use in 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 wildlife. Borrow pits in some locations also provide an alternative water source which may result in a redistribution or increase in abundance of feral animals such as camels.

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.

5.3.3 Vehicle Movement

The movement of heavy vehicles (e.g. trucks, bulldozers, drill rigs, supply trucks) to and from a well site can lead to damage of vegetation, generation of dust and/or compaction of soil, damage to infrastructure (e.g. roads) and collision with (or disturbance to) 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 3.1.1. However, these moves are infrequent (approximately once per month) and are usually staged over several days.

The Eyre Highway carries a relatively high level of heavy vehicle 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 landowners.

5.3.4 Vegetation Clearance

The clearance of vegetation during well site and access track preparation (and airstrip preparation if it is required) cannot be 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 spread and damage to heritage sites. Vegetation clearance may also impede the movement of fauna, particularly small mammals or reptiles across cleared areas. The clearance of narrow corridors for access tracks may also increase access to feral animals, including predators such as cats and foxes.

During the preparation of well sites and access tracks, particular care will be taken to minimise the clearance of vegetation in heavily wooded areas. Campsites will be located as far as possible in naturally sparse or clear areas in which campsite establishment does not require significant disturbance to vegetation. The airstrip (if required) would be located in an area where earthworks and clearance of vegetation are limited (e.g. not in densely wooded areas).

The impacts on threatened fauna species in the area from vegetation clearance are not likely to be significant, due to the avoidance / mitigation measures that will be in place (see Section 6) and because the area impacted will represent a very small fraction of the total habitat available.

5.3.5 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 density-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).

5.3.6 Waste Management

The improper storage and disposal of waste products including domestic waste, chemical waste, sewage, produced formation water and 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.

5.3.7 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 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.

5.3.8 Disturbance to Landowners

The presence of a drill rig and drilling personnel and the associated vehicle movements have the potential to disturb Traditional Landowners and land use activities. Close liaison will be carried out with Maralinga Tjarutja during the planning and conduct of drilling operations, to ensure that disturbance is minimised. Appropriate access routes to drill sites will be chosen in consultation with Maralinga Tjarutja and any deterioration of roads and tracks as a result of drilling-related traffic is rectified.

As discussed in Section 3.1, it is planned that road construction (and well lease preparation) would be carried out by Maralinga Tjarutja, who also undertook the line preparation work for OBEPL's seismic surveys.

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 Well Site Selection

Well sites will not be constructed on sensitive areas such as salt lakes or steep stony slopes.

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 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.
- Where initial assessment of environmental issues indicates the potential for occurrence of significant species (e.g. Malleefowl, Great Desert Skink), site inspections will include specific assessment for their presence
- Heritage clearance surveys will be carried out with Maralinga Tjarutja
- Sites identified of known scientific, natural, Aboriginal or non-Aboriginal heritage significance will be avoided.

6.2 Access Track and Airstrip 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.
- Road and track establishment will be rationalised with other users (e.g. mineral explorers) where possible.
- 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.
- Any watercourse crossings will be constructed so as to maintain water flows (e.g. culverts may be installed)
- Clearance of vegetation will be restricted to the minimum necessary and the removal of more significant vegetation (e.g. large trees) will be avoided wherever possible.
- 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 pavement) tracks will be rolled in preference to grading to reduce the risk of erosion.

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 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
- 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 Clearance of vegetation, especially the removal of trees and larger shrubs, 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 gibber pavement, 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.

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 in accordance with the Drilling Program.
- Blow out prevention precautions / well control equipment in place in accordance with defined procedures and appropriate to the expected downhole conditions.

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.
- Vehicles will travel at slow speed in the vicinity of residences or settlements
- 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 will be inspected and assessed for the risk of spreading weed material and, if required, cleaned prior to entering the licence areas.

- Vehicles or equipment will be washed down if they pose is 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 and handled in accordance with relevant standards, including AS 1940 and EPA guideline *080/07 Bunding and Spill Management*.
- 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 pavement 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.

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.
- Domestic wastes (e.g. food waste, paper, plastics, cans and glass) will be stored on site in secure bins or skips.
- Recyclable materials will be segregated for transport to a recycling facility where practicable. Other materials will be transported to a licensed waste disposal facility.
- 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 disposed of in the drilling sump.

6.8 Environmental Management System

Drilling operations in the Officer 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.

OBEPL and its contractors' operating standards will follow industry-accepted standards.

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, environmental requirements and obligations under the land access and production agreement between OBEPL and Maralinga Tjarutja, and shall 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

OBEPL 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. The system will also provide a mechanism for recording 'reportable' incidents, as defined under the *Petroleum and Geothermal Energy 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 OBEPL.

External reporting (e.g. incidents, annual reports) will be carried out in accordance with Petroleum and Geothermal Energy 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. However, in some cases there may still be 'residual' risks that remain after management measures have been implemented.

An environmental risk assessment of OBEPL'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 Officer Basin have been summarised in Table 11 in Section 5.

Once the consequences were identified, the severity of the consequences (Table 12) and the likelihood of the consequences occurring (Table 13) were allotted. A risk matrix (Table 14) 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 15.

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 PELs 81 and 253 in the Officer 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 the 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 result, 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 (i.e. the mitigation methods and practices described earlier within this EIR).

7.1.1 Severity of Consequences

Environmental consequences can be categorised from negligible to catastrophic (Table 12). 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 12: 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 13. This table is based on Table 4(A) of HB 203:2004 (AS/NZS 2004c).

Table 13: 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 14 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 14: 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 15. 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 majority of the risk levels for drilling activities are classified as either ‘Low’ or ‘Medium’. No very high risks were identified and the only high risk identified was for the airstrip construction, if it was to be established in a densely wooded area. 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 15: Summary of impacts and risk levels for drilling operations[3]

Activity	Hazard	Potential consequence	Severity	Likelihood	Risk
Well site and access track preparation Temporary airstrip construction (if required)	*Earthworks* *Excavations* *Vehicle movement*	Loss of vegetation and habitat	Minor	Possible	Medium
		Loss of vegetation and habitat for airstrip **if** in densely wooded area	Moderate	Likely	High
		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	Minor	Possible	Medium
		Introduction and spread of weeds	Major	Unlikely	Medium
		Increased access by feral animals	Minor	Possible	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
	Spills and leaks	Contamination of soil, surface water	Minor	Unlikely	Low
Drilling Operations, including Well Completion and Workover Operations	*Vehicle movement* *Airstrip use* *Rig moves* *Routine drilling*	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	Minor	Unlikely	Low
		Introduction and spread of weeds	Major	Unlikely	Medium

[3] Assumes all activities avoid sensitive areas and implement management measures as described in Section 3 and Section 6.

Activity	Hazard	Potential consequence	Severity	Likelihood	Risk
		Damage to infrastructure	Minor	Unlikely	Low
		Noise generation	Negligible	Likely	Low
		Road hazard / disturbance to local road users	Minor	Unlikely	Low
	Blowout or kick *Equipment or tubular failure* *Down hole problems* *Casing or cement failure*	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
		Atmospheric pollution	Negligible	Unlikely	Low
		Loss of reserves and reservoir pressure	Moderate	Unlikely	Medium
	Explosion or fire	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
		Atmospheric pollution	Moderate	Unlikely	Medium
	Drill pipe failure	Temporary restricted control over well fluids and circulation system	Negligible	Possible	Low
	Loss of containment of gas or oil while testing	Contamination of soil, surface water or groundwater	Moderate	Possible	Medium
		Loss of vegetation and habitat	Minor	Unlikely	Low
		Disturbance to native fauna	Minor	Unlikely	Low
		Atmospheric pollution	Minor	Unlikely	Low
	Spills or leaks associated with: ▪ *drilling procedures* ▪ *storage of oil, fuels and chemicals*	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

Activity	Hazard	Potential consequence	Severity	Likelihood	Risk
	▪ *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)*	Atmospheric pollution	Minor	Unlikely	Low
		Disruption to land use	Minor	Unlikely	Low
	Flaring of gas during testing *Emissions vented from drill stem testing and production testing*	Atmospheric pollution	Minor	Likely	Medium
		Disturbance to native fauna	Minor	Unlikely	Low
	Disposal of hydrocarbon and PFW to excavated flare pits during testing and clean-up	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
	Loss of radioactive source down hole	Contamination of groundwater (aquifer)	Moderate	Unlikely	Medium
	Flooding of surrounding area *Extreme weather conditions*	Contamination of soil, surface water or groundwater	Minor	Unlikely	Low
		Damage to infrastructure	Minor	Unlikely	Low
Waste Handling and Disposal	*Handling and disposal of domestic and chemical waste* *Sewage treatment and effluent disposal* *Disposal of drill cuttings and muds*	Contamination of soil, surface water and groundwater	Minor	Unlikely	Low
		Soil inversion	Negligible	Possible	Low
		Loss of vegetation and habitat	Minor	Unlikely	Low
		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
Water supply / Aquifer Use	*Depletion of artesian and sub-artesian aquifers* *Spills and leaks*	Depletion of artesian and sub-artesian aquifers	Major	Unlikely	Medium
		Loss of water (wastage)	Moderate	Possible	Medium
Fuel & chemical handling & storage	*Spills and leaks*	Contamination of soil, surface water and groundwater	Minor	Unlikely	Low

Activity	Hazard	Potential consequence	Severity	Likelihood	Risk
		Loss of vegetation and habitat	Minor	Unlikely	Low
		Disturbance to native fauna	Minor	Unlikely	Low
Campsites and associated supplies	*Vehicle movements*	Soil compaction/disruption/deflation, wheel tracks	Minor	Unlikely	Low
		Dust generation	Negligible	Likely	Low
		Visual Impact	Minor	Unlikely	Low
		Disturbance to native fauna	Minor	Unlikely	Low
		Introduction and spread of weeds	Major	Rare	Medium
		Road hazard / disturbance to local road users	Minor	Unlikely	Low
	Camp site *Disturbance of vegetation and habitat*	Loss of vegetation and habitat, damage to tree root structures	Minor	Possible	Medium
		Soil erosion and disturbance to natural drainage patterns	Minor	Unlikely	Low
		Disturbance to native fauna	Minor	Unlikely	Low
		Increased abundance of feral animals	Minor	Possible	Medium
		Noise generation	Negligible	Likely	Low
		Visual Impact	Minor	Unlikely	Low
	Handling and disposal of domestic and chemical waste *Spills and leaks*	Soil inversion	Minor	Unlikely	Low
		Contamination of soil, surface water, groundwater	Minor	Unlikely	Low
		Litter	Minor	Possible	Medium
		Visual Impact	Minor	Unlikely	Low
	Fire	Fire damage to vegetation and habitat	Major	Unlikely	Medium
Well site, access track, campsite and airstrip restoration	*Earthworks* *Vehicle movement*	Soil inversion	Minor	Possible	Medium
		Dust generation	Negligible	Likely	Low
		Noise generation	Negligible	Likely	Low
		Disturbance to native fauna	Minor	Unlikely	Low
		Introduction and spread of weeds	Major	Unlikely	Medium

Activity	Hazard	Potential consequence	Severity	Likelihood	Risk
		Visual Impact	Minor	Possible	Medium
		Damage to infrastructure	Minor	Unlikely	Low
		Impact and/or damage to cultural/heritage sites	Moderate	Unlikely	Medium
	Spills and leaks	Contamination of soil, surface water	Minor	Unlikely	Low
Monitoring	*Vehicle movement*	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

OBEPL has undertaken and will continue to undertake targeted stakeholder consultation regarding its petroleum exploration operations in the Officer Basin. This has included consultation undertaken during the development of the land access and production agreement with Maralinga Tjarutja, during the development of the EIR and SEO for geophysical operations, during the planning and implementation of geophysical programs and in the development of this EIR and SEO.

8.1 Key Stakeholders

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

- Maralinga Tjarutja
- State government regulatory agencies
- Other state and Commonwealth agencies.

Key stakeholders are listed in Table 16 and consultation undertaken is summarised in the following sections.

Table 16: Key Stakeholders

Stakeholder Category	Organisation/Agency
Landowners	Maralinga Tjarutja
Regulatory Authority	Department of Primary Industries & Resources (PIRSA)
Government Agencies	Department for Environment & Heritage (DEH)
	Department of Water, Land & Biodiversity Conservation (DWLBC)
	Department of Health
	Environment Protection Authority (EPA)
	Planning SA
	Alinytjara Wilurara NRM Board
	Department of Defence (Commonwealth)
	Department of the Environment, Water, Heritage and the Arts (Commonwealth)

8.2 Landowner Consultation

OBEPL has been actively consulting Maralinga Tjarutja for more than three years and has maintained and enjoys a good relationship with Maralinga Tjarutja. Consultation has included formal and informal presentations and discussions at meetings and workshops, negotiations during the development of the land access and production agreement and liaison during the planning, cultural heritage clearance and implementation phases of the recent seismic surveys.

During the field trip undertaken while preparing this EIR, OBEPL's representative (Jim Allender) addressed a council meeting at Oak Valley and outlined the planned program to drill for oil and gas and possible location, the drilling process and associated activities such as road construction.

OBEPL will maintain close liaison with Maralinga Tjarutja as detailed planning for the drilling program progresses, and will provide formal notification of entry for exploration activities in accordance with Petroleum and Geothermal Energy Act requirements. As discussed previously, Maralinga Tjarutja will also undertake heritage clearance surveys and it is planned that road construction (and well lease preparation) would be carried out by Maralinga Tjarutja.

Prior to the finalisation of this SEO, OBEPL will seek comments from Maralinga Tjarutja in relation to any specific issues they would like included in the SEO that are not otherwise dealt with.

8.3 Government Agencies

Consultation with state government agencies will be coordinated by PIRSA through the SEO approval process, as occurred during the development of the geophysical SEO. During this process, relevant government agencies are invited to comment on the EIR and draft SEO prior to its finalisation. OBEPL will respond to comments and action them where required and as advised by PIRSA.

Consultation with Commonwealth agencies will be undertaken if or when required for specific drilling programs (e.g. if access to the Woomera Prohibited Area is required or if a referral under the Commonwealth Environment Protection and Biodiversity Conservation Act is necessary).

8.4 Ongoing Consultation

OBEPL aims to continue to engage stakeholders for the duration of its exploration activities, predominantly through the channels discussed in Sections 8.2 and 8.3, to ensure that all potential concerns are identified and appropriately addressed. Stakeholder questions, comments and concerns will be addressed by OBEPL during the consultation process and in an ongoing manner.

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10 Abbreviations

bbl	Barrels (1 bbl = 159 litres)
BOM	Bureau of Meteorology
CASA	Civil Aviation Safety Authority
DEH	Department for Environment and Heritage (South Australia)
DEWHA	Department of the Environment, Water, Heritage and the Arts (Commonwealth)
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 *Petroleum Act 2000* and Regulation 10
EMS	Environmental Management System
EPA	Environment Protection Authority (South Australia)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
NPW Act	*National Parks and Wildlife Act* 1972 (South Australia)
PEL	Petroleum Exploration Licence
PIRSA	Primary Industries and Resources, South Australia
PFW	Produced Formation Water
ppm	Parts per million
RFDS	Royal Flying Doctor Service
RNE	Register of the National Estate
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.

Fracturing – the process of pumping proppant (such as larger grained sand) into the formation with powerful hydraulic pumps to create enough downhole pressure to cause fractures to open in the reservoir. The proppant remains in place once the hydraulic pressure is removed and therefore props open the fracture and enhances flow into the wellbore.

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: Environmental Association Descriptions

Environmental Association Descriptions

The following table summarises the descriptions of the environmental associations found within PELs 81 and 253. Information is taken from Laut *et al.* (1977). Environmental associations are numbered as per Laut *et al.* (1977).

Table A1-1: Environmental Association Descriptions

Environmental Association	Landforms	Soil	Vegetation	Land limitation*
Victoria Desert (8.2.1) An extensive dunefield with occasional silcrete rises and shallow depressions. There is a mixed cover of low open woodland, tall shrubland, low shrubland, and a hummock grassland or hard spinifex.	Long low sandy interdunes. Frequent and co-dominant. Max slope 3%.	Uc5.21: red earthy sands with no surface roughness. Gravel soils deep well drained and neutral.	Low open marble gum (*E.gongylocarpa*) and mulga (*Acacia aneura*) woodland co-dominant with tall Red-budded mallee (*E. kingsmillii ssp.alatissima*), Ooldea mallee (*E. youngiana*) and Victoria Desert mallee (*Eucalyptus concinna*) shrubland and hard Spinifex (*Triodia basedowii*) ground storey.	Slight drift
	Long sandy dunes. Frequent and co-dominant. Max slope 10%	Uc1.23: red siliceous sands with no surface roughness. Soils deep well drained and neutral.	Hummock grassland dominant with sub-dominant low shrubland of Needlebush (*Hakea* spp.), *Grevillea* spp. and native fuschia (*Eremophila* spp.). Ground storey of hard spinifex.	Moderate drift
	Medium sandy depressions. Rare and minor. Max slope 2%.	Dr1.33 Crusty red duplex soils. Gilgai, deep poorly drained and alkaline.	Tall shrubland of Ooldea mallee, Victoria Desert mallee and Red-budded mallee. Ground storey of short grasses.	Salinity
	Medium silcrete rises. Rare and minor in relative area. Max slope 3%	Um5.41: reddish dense loams with rock outcrops. Soils well-drained and neutral	Low open shrubland of native fuschia, mulga, and birdseye (*Senna* spp.) dominant with ground storey of short grasses and forbs	Slight drift
Purndu (8.2.8) A gently undulating dune-covered plain. The cover is low open woodland with an understorey of grasses and low shrubland with a hummock grass understorey.	Very large sandy plains. Dominant. Max slope 3%.	Uc5.21: red earthy sands with no surface roughness. Soils deep, well drained and neutral.	Low open woodland of mulga and marble gum dominant with sub dominant tall shrubland of mallee eucalypts, grevillea and needlebush. Ground cover of woollybutt, blackheads and feathertop spinifex (*Triodia schinzii)*.	Slight drift
	Long sand dunes. Frequent and sub-dominant. Max slope 10%	Uc1.23: red siliceous sands with no surface roughness. Soils deep, well drained and neutral.	Tall shrubland of needlebush, sandhill wattle (*Acacia ligulata*), grevillea, native fuschia. Ground storey of hard spinifex, kerosene grass and forbs.	Moderate drift
	Small sandy depressions. Rare and minor. Max slope 2%	DR1.33: crusty red duplex soils with no surface roughness. Soils deep, poorly drained and alkaline	Canegrass (*Eragrostis australasica*) grassland dominant with sub dominant low shrubland of saltbush (*Atriplex* spp.), nitrebush and samphire.	Salinity
Nurrari (8.2.2) A plain with dunes and a chain of dry lakes. There is a mixed cover of tall open shrubland, low open woodland, low shrubland and a hummock grassland of hard spinifex.	Very large sandstone / limestone plains. Dominant. Max slope 5%.	Uc5.21: red earthy sands co-dominant with Gc1.21: red calcareous earths with rock outcrops. Soils shallow, well drained and alkaline.	Tall open shrubland of Ooldea mallee, Red-budded mallee with hard spinifex, woollybutt (*Eragrostis eriopoda*) and kerosene grass (*Aristida contorta*) ground cover dominant. Low open woodland of marble gum, mulga, black oak (*Casuarina pauper*) and myall (*A. papyrocarpa*) with hard spinifex ground storey sub-dominant.	Slight drift
	Medium alluvium lakes.	Dr1.33: crusty red duplex soils with	Low shrubland sub-dominant. Samphire (*Tecticornia spp.*) ground	Salinity

Environmental Association	Landforms	Soil	Vegetation	Land limitation*
	Common and sub-dominant.	no surface roughness. Soils deep, poorly drained and alkaline.	storey.	
	Long clay lunettes. Common and sub-dominant, max slope 8%.	Um1.23: reddish siliceous loams with no surface roughness. Soils deep well drained and alkaline.	Low shrubland of nitrebush (*Nitraria billardierei*).	Sheet erosion
	Long sandy dunes. Common and sub-dominant. Max slope 17%.	Uc1.23: red siliceous sands with no surface roughness. Soils deep well drained and alkaline.	Hummock grassland dominant with sub-dominant low shrubland of Needelbush, grevillea, and native fuschia. Ground storey of hard spinifex and kerosene grass.	Moderate drift
	Small calcarenite rises. Rare and minor. Max slope 5%.	Um5.11: reddish powdery calcareous earths with rock outcrops. Soils shallow and well drained and alkaline.	Low open woodland of black oak, myall, and mulga dominant with ground storey of native fuschia, hard spinifex and birdseye.	Slight drift
Maralinga (8.2.3) A low calcrete rise forming a distinctive break between the Nullarbor Plain and the Great Victoria Desert. The cover is low open woodland with a low shrub understorey, or hummock grassland.	Long calcrete rises. Rare and dominant. Max slope 5%.	Gc1.12: brown calcareous earths with rock outcrops. Soils shallow, well drained and alkaline.	Hummock grassland of hard spinifex, kerosene grass and blackheads co-dominant with low open woodland of myall, mulga, and black oak and ground storey of hard spinifex native fuschia and birdseye.	Slight drift
Dingo (8.2.7) An undulating plain with dunes, low gibber-covered rises and shallow sandy depressions associated with a relict drainage system. There is a mixed cover of low open woodland with an understorey of grasses and ephemeral forbs, low shrubland with an understorey of hummock grasses and chenopod shrubland.	Long sand plains. Frequent and dominant. Max slope 3%.	Gn2.12: red massive earths co-dominant with Uc5.21: red earthy sands. No surface roughness, soils deep, well drained and neutral.	Tall open mulga shrubland with ground cover of blackheads (*Enneapogon* spp.), kerosene grass and forbs dominant. Minor areas of low shrubland of bladder saltbush (*Atriplex vesicaria*) and ground storey of woollybutt, bandicoot grass (*Monachather paradoxus*) and forbs including *Sclerolaena* spp.	Sheet erosion
	Long sandy dunes. Frequent and sub-dominant. Max slope 10%.	Uc1.23: red siliceous sands with no surface roughness, soils deep, well drained and neutral.	Low shrubland of native fuschia, birdseye, grevillea and mulga. Ground storey of kerosene grass.	Moderate drift
	Medium gibber rises. Common and sub-dominant. Max slope 3%	Dr1.33: crusty red duplex soils with stones. Soils deep, well drained and alkaline.	Low open shrubland of birdseye, native fuschia, dead finish (*Acacia tetragonophylla*) and bullockbush (*Alectryon oleifolius*). Ground storey of bluebush (*Maireana* spp.), blackheads and herbs.	Gullying locally
	Small depressions. Rare and minor. Max slope 2%	DR1.33: crusty red duplex soils with no surface roughness. Soils deep, poorly drained and alkaline	Low shrubland of bluebush, samphire, sea heath (*Frankenia* spp.) and cane grass.	Salinity
Yellabina (7.5.2) Plains with closely spaced easterly-trending dunes and occasional rock outcrops. The cover is open mallee	Very large low sandy interdunes. Co-dominant. Max slope 1%.	Gc1.22: red calcareous earths with no surface roughness. Lime gravel soils, deep, well drained and alkaline.	Mallee of Yorrell (*E.socialis*), mallee, teatree (*Melaleuca golmerata*) and false sandalwood (*Myoporum platycarpum*) with ground storey of saltbush and daisy bluebush (*Cratystylis conocephala*).	Slight drift

Environmental Association	Landforms	Soil	Vegetation	Land limitation*
scrub with a chenopod shrub or grass understorey.	Long sand dunes. Frequent and co-dominant. Max slope 17%	Uc1.23: reddish siliceous sands with no surface roughness, soils deep, well drained and alkaline.	Mallee of black oak, mallee and teatree with ground storey of porcupine grass (*Triodia irritans*).	Moderate drift
	Medium alluvium pans. Rare and minor.	DR1.33: crusty red duplex soils with no surface roughness. Soils deep, well drained and alkaline	-	None
	Small granite, silcrete rock outcrops. Rare and minor. Max slope 17%	None	-	None
Muckera (7.6.6) A gently undulating limestone plain with sinkholes and inactive drainage lines. There is a cover of hummock grassland, low open woodland with a hummock grass understorey and low chenopod shrubland.	Very large limestone plains. Dominant. Max slope 1%	Gc1.12: reddish calcareous earths dominant. No surface roughness, gravel, soils shallow well-drained and alkaline. Uc1.43 reddish firm siliceous soils sub-dominant. Rock outcrops, gravel, soils shallow, well-drained and alkaline.	Hummock grassland dominant with sub-dominant low open woodland of myall, black oak and mulga. Hard spinifex ground storey.	Slight drift
	Small limestone dolines. Rare and minor. Max slope 56%	Uc5.21; reddish earthy sands with no surface roughness. Soils shallow, well-drained and alkaline.	Low shrubland of bluebush (*Maireana sedifolia*) and samphire with ground storey of tussock grass and forbs.	Slight drift
	Small sand/limestone channels. Rare and minor. Max slope1%.	Uc5.21: reddish earthy sands with no surface roughness. Soils shallow well drained and alkaline	Low woodland mulga. Ground storey of cottonbush (*Maireana aphylla*).	Slight drift
	Long sandy dunes. Rare and minor.	Uc1.23: reddish siliceous sands with no surface roughness. Soils deep well drained and alkaline	Open mallee of red mallee (*E.oleosa*), Victoria Desert mallee with ground storey of bluebush and saltbush.	Moderate drift

*Laut *et al.* (1977) comment on “land limitation” in the context of land use.