2020

Environmental Impact Report

Geophysical Operations in the Otway Basin, South Australia

beach

August 2020

Revision	Date	Reason for issue	Reviewer/s	Consolidator	Approver
C	25/03/2020	Updated for downhole survey	SM / BW / J Conti / J Cocker / WM/ CK / ZB	BW / AC	SM
D	23/04/2020	Updated following Beach review	ZB / J Cocker/J Conti / WM / TH	AC / BW	SM
E	14/7/2020	Internal review	RM/CB	CK	
F	5/8/20	Updates and internal and JV review	WM/J Cocker/CT/JV	CK	
0	18/8/2020	Issued for Public Consultation	CK	CK	TF

Environmental Impact Report

Table of contents

Table of figures

List of tables

List of appendices

Summary

Beach Energy Limited and its group subsidiaries (Beach) hold a number of petroleum exploration, production and retention licences in the onshore Otway Basin in the South East of South Australia. This Environmental Impact Report (EIR) has been prepared by Beach under the *Petroleum and Geothermal Energy Act 2000* to cover Beach's ongoing geophysical operations in the region. Previous EIRs (and associated Statements of Environmental Objectives (SEO)) covering geophysical operations in the Otway Basin region were developed by the Department of Energy and Mining (DEM) (see Roberts, 2001; Annear, 2013). This EIR (and associated SEO) updates and supersedes previous EIRs and SEOs developed to cover geophysical activities in the region.

Background

Exploration for hydrocarbons in the South East first commenced in the 1890s and the first deep exploration well, Robe-1, was drilled in 1915. The Katnook Gas Processing Facility near Penola was established in 1991 following the first commercial gas discovery at Katnook in 1987 and the subsequent discovery of further commercial gas fields. Since this time, companies such as Beach, Origin Energy and Adelaide Energy have continued to explore for hydrocarbons, with a number of successful wells discovering new gas fields.

This EIR relates to Beach's ongoing geophysical operations located within Beach's licence areas in the onshore Otway Basin in the South East of South Australia. It does not cover other petroleum activities such as drilling, well operations, fracture stimulation, production or processing operations.

Land Use and Environment

The fertile land of the South East supports a diverse range of industries including wool, meat, dairy, forestry, wine grapes, cereal cropping, horticulture crops and seed production, which are heavily dependent upon water resources in the region. Groundwater is the primary source of water, with the irrigation industry being the most significant user.

The region has low topographical relief and a general absence of surface watercourses. A network of constructed drains is present, which has allowed formerly inundated land to be developed, minimising seasonal waterlogging and removing salt from the region. The alteration of wetland flooding and drying regimes has resulted in a decline in biodiversity in some areas. Native vegetation clearance across the South East is extensive, with an average of 10% of native vegetation remaining. A number of threatened ecological communities and threatened flora and fauna species occur in the region, and are generally confined to or reliant on areas of remnant vegetation.

The region hosts an extensive network of limestone sinkholes and caves, including the World Heritage-listed Naracoorte Caves which are located predominantly north of the Beach licence area. Eleven National Parks and Wildlife Act reserves are present within the Beach licence areas, however this EIR does not cover activities in National Parks and Wildlife Act reserves.

Penola is the largest town centre within the Beach licence area. Other nearby population centres include Naracoorte and Lucindale (to the north of the licence area), Millicent (to the south) and Robe and Beachport (to the west).

Environmental Impact Assessment

This EIR assesses the potential impacts posed by hazards that may result from geophysical operations. Potential hazards addressed include:

- seismic line and drilling site preparation

- infrastructure construction (access track, camp site, laydown and magazine) and rehabilitation / restoration activities
- drilling activities
- drilling through shallow freshwater aquifers
- physical presence of geophysical survey machinery, equipment, camp and personnel
- emissions from geophysical survey activities (air, noise, light and vibration)
- use of roads and movement of vehicles and heavy machinery
- spills or leaks
- storage of fuel, oil and chemicals
- unauthorised access by third parties
- fire
- spread of weeds and pathogens
- storage, handling and disposal of waste; and
- storage, handling and use of explosives.

The risk assessment contained in this EIR indicates that the level of risk posed by geophysical operations is generally very low and can be adequately managed to prevent unacceptable environmental impacts. In particular:

- Potential impacts to land use and property management are mitigated through consultation with landholders regarding the location, management and timing of proposed activities, with the aim of minimising disturbance. Ongoing liaison with landholders will be carried out following geophysical activities. Disturbance will be rehabilitated to the satisfaction of landholders following the conclusion of activities, with pasture or vegetation re-established, unless landholders request specific infrastructure (e.g. access tracks) is left in place.

- Significant impacts to flora and fauna are avoided through the environmental assessment and planning process undertaken for specific geophysical survey programs. This will include locating activities in previously disturbed or cleared areas, fencing to prevent fauna (or stock) access, weed and fire prevention measures and transport procedures. Disturbance to areas of native vegetation and wetland areas will be avoided.

- Spills or leaks of fuels, oils or chemicals are mitigated by restricting the storage and handling of fuel and chemicals to designated areas with use of appropriate secondary containment, and immediate clean-up and remediation of any spills.

- Shallow unconfined aquifers will be protected by ensuring drilling, backfilling and rehabilitation practices comply with relevant industry standards and guidelines.

- Traffic management and noise limitation procedures will be implemented, and adequate buffers will be maintained between proposed activities and residences, infrastructure and stock. Impacts to landholders and communities will be mitigated through ongoing consultation regarding the proposed activities, with the aim of identifying potential issues and minimising disturbance.

A range of management measures will be implemented and are listed in this EIR and they will be incorporated into the accompanying Statement of Environmental Objectives (Beach Energy, 2020).

Stakeholder Consultation

[Note: This section will be updated with further detail on community engagement following public consultation process]

Beach is committed to maintaining open and effective communication and good relations with all stakeholders and has been undertaking a program of consultation with directly affected parties, the broader community and other stakeholders.

Ongoing liaison will be undertaken with landholders whose properties are likely to be sites for future exploration activities, and Beach will continue to consult with stakeholders as geophysical operations progress, to ensure that all potential concerns are identified and appropriately addressed.

Beach is confident that with the implementation of the management measures outlined in this EIR, the proposed activities do not present a significant level of environmental risk.

1 Introduction

Beach Energy Limited and its group of subsidiaries (Beach) hold several petroleum exploration, production and retention licences in the onshore Otway Basin in the South East of South Australia. Beach's petroleum licences include Petroleum Exploration Licence (PEL) 494, Petroleum Retention Licences (PRLs) 1, 2, 13, 32 and Petroleum Production Licences (PPLs) 62, 168 and 202. Beach's petroleum licences (henceforth referred to as the licence area) cover a continuous area of approximately 1360 km^2 (Figure 1-1).

Beach plans to undertake geophysical operations in the licence area to identify and delineate potential hydrocarbon prospects. This Environmental Impact Report (EIR) has been prepared as a requirement of the South Australian *Petroleum and Geothermal Energy Act 2000* to provide information on the proposed activities, the potential environmental impacts and their management.

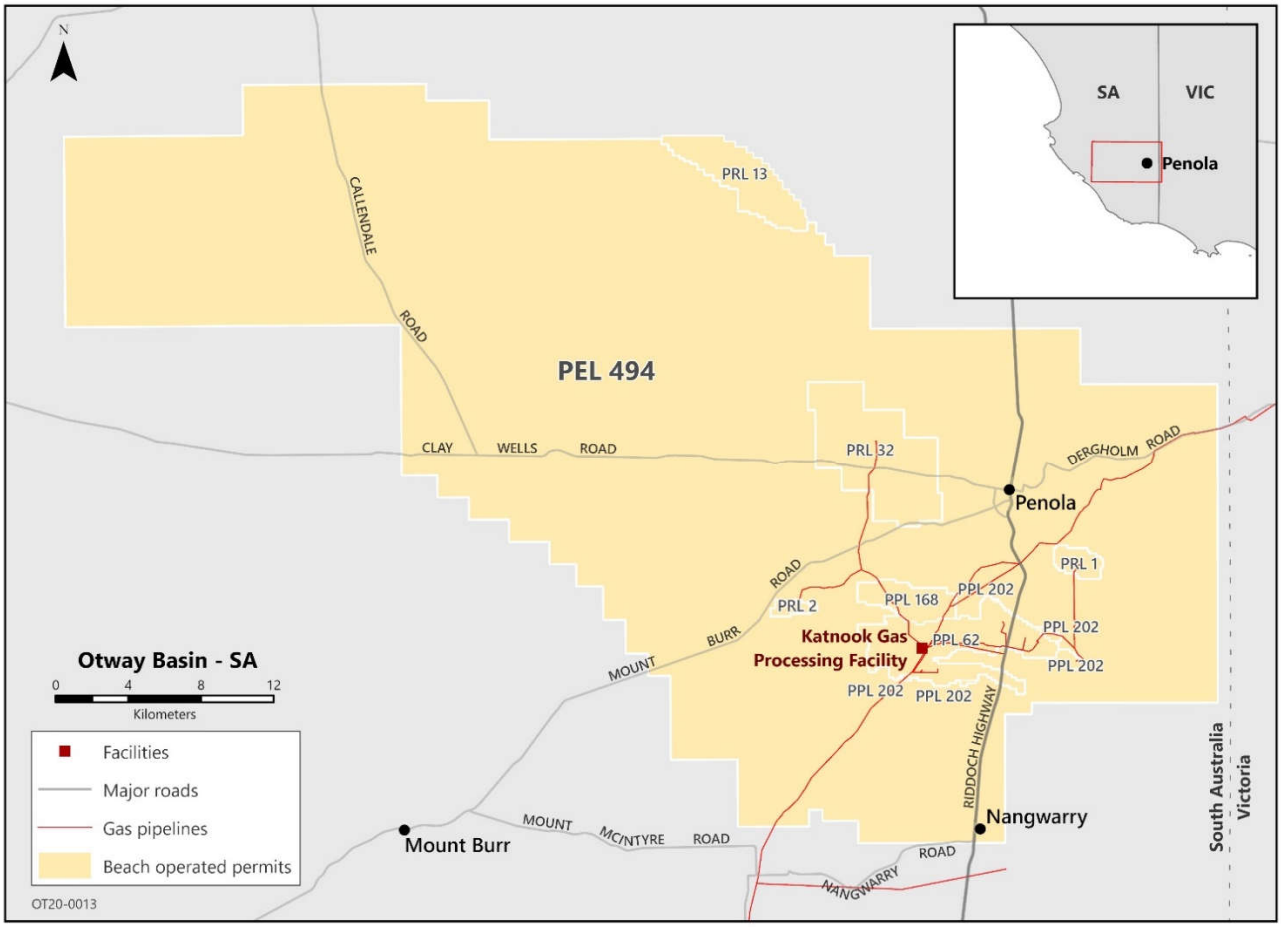


Figure 1-1: Location of Beach Energy's onshore South Australian Otway Basin licence area

1.1 Background

The Otway Basin is located along the south-east margin of the Australian mainland and is second only to the Cooper and Eromanga Basins as the most explored oil and gas province in South Australia. The Basin extends west-northwest for approximately 500 km along the southern Australian Coast from South Australia to Victoria. Approximately 70% of the basin is located offshore, commencing in South Australian waters south-east of Kangaroo Island and extending south-

east to Port Phillip Bay in Victoria (Figure 1-2). The South Australian onshore sector of the Otway Basin is located in the South East region and covers approximately 9,650 km^2 (Boult and Hibburt, 2002).

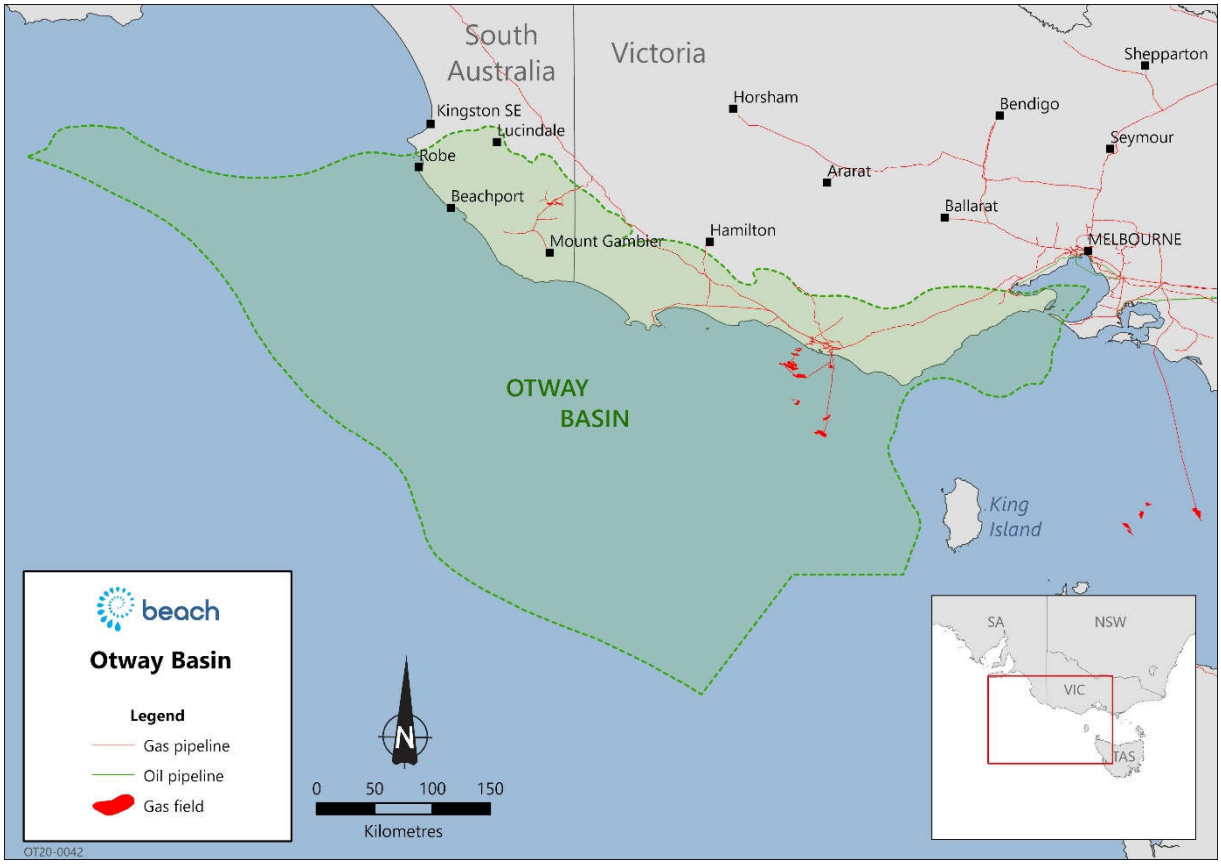


Figure 1-2 Location of the Otway Basin

1.2 Beach Energy Company Profile

Beach is an ASX listed, oil and gas exploration and production company headquartered in Adelaide, South Australia. It has operated and non-operated, onshore and offshore, oil and gas production from five producing basins across Australia and New Zealand, and is a key supplier to the Australian east coast gas market.

Beach's asset portfolio includes ownership interests in strategic oil and gas infrastructure, such as Moomba processing facility, as well as a suite of high potential exploration prospects.

Beach currently holds one petroleum exploration licence (PEL), three petroleum production licences (PPL) and four production retention licences (PRL) in the South Australian section of the onshore Otway Basin, both in its own right and with co-ventures. The locations of Beach's operations are shown in Figure 1-1.

1.3 Exploration History of the onshore Otway Basin

Exploration for hydrocarbons in the South East commenced in the 1860s. The earliest hydrocarbon exploration well drilled in the region, Salt Creek-1, was drilled in 1866 near the Coorong. Salt Creek-1 was located north of the edge of the Otway Basin, and did it not discover any hydrocarbons, but did mark the first serious attempt to find oil in Australia (Boult & Hibburt, 2002).

The drilling of numerous exploration wells in the broader region followed, and in 1915 the first deep exploration well in the Otway Basin, Robe-1, was drilled. The well reportedly intercepted flammable gas, but no commercial hydrocarbons were discovered. These early exploration wells are now considered to have been too shallow, and not to the depths required to intercept commercial hydrocarbons in the region (Beach Energy, 2015).

The lack of early drilling success led to the need for survey methods to identify subsurface geological conditions prior to choosing drilling locations. Early geophysical surveys in the region included magnetic surveys (a means of detecting subsurface magnetic anomalies) in the 1930s, and then aeromagnetic and gravity surveys (a means of calculating the density of subsurface geology) in the late 1940s to 1960s. These surveys improved the geological understanding of the region, but they did not lead to any material discoveries. As a result, limited exploration drilling occurred from 1940 to 1960.

Drilling recommenced in the early 1960s following the development of improved geophysical survey and structural drilling techniques. The new surveys were termed 'seismic surveys' because they utilised reflection seismology methods (refer to Section 3.2 for further information). Seismic surveys and structural drilling techniques provided more information about deeper geological structures, which allowed deeper wells to be drilled targeting specific structures. During this period, the General Exploration Company and Beach undertook the first 2D seismic surveys in the South East. Beach drilled Geltwood Beach-1 in 1963, south west of Millicent, in search of oil, but the well was unsuccessful. Minor discoveries were made over the following two decades, but they were limited to a few small gas fields.

The prospectively of the Basin was subsequently downgraded in the early 1980s (Felton & Jackson, 1987). Further improvements to seismic survey technology in the 1980s provided higher resolution imaging of geological structures, which led to a better understanding of the stratigraphic relationships in the Basin (DEM, 2019). This improved understanding contributed to the first commercial gas discovery at Katnook-1 (located ~12 km north-west of Nangwarry) in 1987. This was quickly followed by discovery of the Ladbroke Grove Field (~1.5 km south of Katnook-1) in 1989. Further commercial gas fields were discovered in the area surrounding Katnook, and in 1991 the Katnook Gas Processing Facility was established to process and distribute gas. Pipelines were constructed to take the gas to the Katnook facility and the adjacent Ladbroke Grove Power Station (Beach Energy, 2015).

Further technological improvements in the early 1990's, including use of 3D seismic survey technology (refer to Section 3.2) led to improved drilling success rates, and companies such as Origin Energy, Adelaide Energy and Beach have continued to explore for hydrocarbons in the region (Boult & Hibburt, 2002). To date, 115 wells have been drilled across the South East, and approximately 10,500 km of 2D seismic lines, and 780 km^2 of 3D seismic survey area have been acquired across the region. Several new gas fields have since been discovered including Wynn-2 in 2005 and Jacaranda Ridge-2 in 2007. The Katnook Gas Processing Facility produced gas until 2011, and the Ladbroke Grove power station also used local gas. The SEA gas pipeline, stretching from the Victorian Otway Basin to Adelaide, became operational in 2004. An offshoot to this pipeline now provides gas to the local markets in the South East and the Ladbroke Grove power station (Beach Energy, 2015).

As discussed above, Beach has a long history of exploration in the onshore Otway Basin. To date, Beach has drilled 22 wells in the Otway Basin. Most recently, Beach drilled the Haselgrove-3, Haselgrove-4 and the Dombey-1 wells near Penola in 2017 and 2019, respectively. Beach considers the Otway Basin to have substantial exploration potential because of its existing conventional gas, condensate and oil discoveries. Beach plans to continue exploration for hydrocarbons in

the Otway Basin and has prepared this EIR to cover ongoing geophysical operations in its licensed area in the South East of South Australia.

1.4 About this document

This document has been prepared to satisfy the requirements of an Environmental Impact Report (EIR) under the *Petroleum and Geothermal Energy Act 2000*. It has been prepared in accordance with current legislative requirements, in particular Section 97 of the Act and Regulation 10 of the *Petroleum and Geothermal Energy Regulations 2013*.

1.4.1 Scope

This EIR has been written to address geophysical operations undertaken in Beach's licence area[1] in the onshore Otway Basin in the South East of South Australia (Figure 1-1), rather than relating to a specific site or sites, or to specific projects. This approach has been applied in many other EIRs and SEOs that have been developed under the Petroleum and Geothermal Energy Act including previous EIRs and SEOs developed by Origin Energy, Adelaide Energy and Beach Energy for exploration in the onshore Otway Basin. Activities covered by this EIR include:

- planning
- cultural heritage survey
- access track and seismic survey preparation activities
- surveying operations
- recording operations
- camp sites and associated activities
- rehabilitation / restoration; and
- monitoring and auditing.

As discussed in Section 2.1.4, prior to commencement of geophysical operations, additional site-specific and technical detail for operations at individual survey locations must be provided to DEM under the activity notification / approval requirements of the Act, including a demonstration that the activities are covered by (and are compliant with) an applicable SEO.

[1] Geophysical surveys may, from time to time, ingress upon adjacent contiguous land located outside Beach's licence area (Figure 1-1). These activities are required to ensure adequate geophysical data acquisition of the licence area. In such circumstances, Beach would apply for an Associated Activities Licence (AAL) to conduct associated activities on land located outside the area of the primary licence. An associated activity is anything that is reasonably necessary for, or incidental to, carrying out regulated activities in the area of, or the vicinity of, the primary licence area.

2 Legislative Framework

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

2.1 Petroleum and Geothermal Energy Act

Petroleum activities in South Australia are governed by the *Petroleum and Geothermal Energy Act 2000* (the Act) and the *Petroleum and Geothermal Energy Regulations 2013* (the Regulations). This legislation is administered by the Department for Energy and Mining (DEM). The Act and Regulations are objective-based rather than prescriptive. 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.

Key objectives of the legislation include:

- to create an effective, efficient and flexible regulatory system for exploration and recovery or commercial utilisation of petroleum and other regulated resources
- to minimise environmental damage from the activities involved in exploration and recovery or commercial utilisation of petroleum and other regulated resources
- to establish appropriate consultative processes involving people directly affected by regulated activities and the public generally
- to protect the public from risks inherent in regulated activities.

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.

2.1.1 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.

Under Regulation 14 of the Petroleum and Geothermal Energy Regulations, an approved SEO must be reviewed at least once in every five years.

2.1.2 Environmental Impact Report

In accordance with Section 97 of the Act, an 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 Regulations, for the purposes of an EIR, a licensee must provide:

- 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.

2.1.3 Environmental Significance Assessment and SEO Consultation Requirements

The EIR is submitted to DEM and an Environmental Significance Assessment is undertaken in accordance with criteria established under Section 98 of the Act[2], to determine whether the activities described in the EIR are to be classified as 'low', 'medium' or 'high' impact. A corresponding SEO is prepared, reflecting the impacts and measures identified in the EIR or other assessments that may be required as determined by the classification.

The classification also determines the level of consultation DEM will be required to undertake prior to approval decisions being made on the SEO as follows:

- **Low impact activities** do not require public consultation and are subjected to a process of internal government consultation and comment 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 DEM website.

2.1.4 Activity Notification / Approval Process

Prior to commencing a regulated activity, 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).

[2] Criteria for classifying the level of environmental impact of regulated activities are published on the DEM website: http://energymining.sa.gov.au/petroleum/legislation_and_compliance/environmental_register#criteria

In order to obtain written approval for activities requiring high level supervision, an application and notification of activities (in accordance with Regulation 20) must be submitted to the Minister at least 35 days prior to the commencement of activities.

The notification of activities 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 DEM 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 an SEO that applies to a broad geographical area, 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 sensitivity) and proposed measures to minimise impacts to key issues (e.g. modified techniques for more sensitive areas, sensitive locations to avoid).

2.2 Other Legislation

A range of Commonwealth and South Australian legislation may apply to petroleum activities. Legislation that is particularly relevant to petroleum exploration is listed below (note that this is not a comprehensive list of all applicable legislation) and additional detail on key legislation is provided in the following list.

Commonwealth

Aboriginal and Torrens Strait Islander Heritage Protection Act 1984

Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act)

Native Title Act 1993

South Australia

Aboriginal Heritage Act 1988

Crown Lands Act 1929

Explosives Act 1936

Environment Protection Act 1993

Fire and Emergency Services Act 2005

Forestry Act 1950

Heritage Places Act 1993

National Parks and Wildlife Act 1972

Native Title (South Australia) Act 1994

Native Vegetation Act 1991

Natural Resources Management Act 2004 (will be superseded by the Landscape South Australia Act 2019 on 1st July 2020)

South Australian Public Health Act 2011

Work Health and Safety Act 2012

Commonwealth Environment Protection and Biodiversity Conservation Act

Approval under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is required for activities that will or may have a significant impact on Matters of National Environmental Significance (MNES) including World Heritage properties, National Heritage places, Ramsar wetlands of international importance, listed threatened species and ecological communities, migratory species, Commonwealth marine areas, the Great Barrier Reef Marine Park, nuclear actions and a water resource in relation to coal seam gas development and large coal mining development.

With regard to operations in the onshore Otway Basin, issues that may trigger assessment under the EPBC Act can generally be avoided by site selection. Based on current expectations, Beach believes the requirement for assessment of proposed activities under the Act is unlikely to be required.

Native Vegetation Act

Exploration activities that are approved under the Petroleum and Geothermal Energy Act do not require approval under the *Native Vegetation Act 1991* for clearance of native vegetation, provided that the activities are undertaken in accordance with approved industry standards that are directed towards minimising impact and encouraging regrowth of any native vegetation that is cleared (see Regulation 15 of the *Native Vegetation Regulations 2017*).

As discussed in Section 5.3, Beach plans to avoid activities in areas of remnant vegetation as far as practicable.

Environment Protection Act

The *Environment Protection Act 1993* imposes a general duty of care not to undertake an activity that pollutes, or might pollute, the environment unless all reasonable and practicable measures have been taken to prevent or minimise any resulting environmental harm.

Environmental authorisations are required to undertake activities prescribed under the Act. The Environment Protection Act also imposes an obligation to report incidents causing or threatening serious or material harm to the EPA, where applicable, in accordance with Sections 83 and 83A of the Act.

The Environment Protection Act does not apply to petroleum exploration activity undertaken under the Petroleum and Geothermal Energy Act or to wastes produced in the course of an activity (not being a prescribed activity of environmental significance) authorised by a lease or licence under the Petroleum and Geothermal Energy Act when produced and disposed of to land and contained within the area of the lease or licence.

Landscape South Australia Act

The *Landscape South Australia Act 2019* (the Act) superseded the *Natural Resources Management Act 2004* on 1 July 2020. Under transitional arrangements the existing South East Regional NRM Plan has automatically transferred to the Limestone Coast Landscape Board as a transitional Regional Landscape Plan (Plan) which will be subject to review and development to meet the requirements of the Landscape South Australia Act over the next 12 months. The current Plan sets out a number of water affecting activities that must not be undertaken without a permit. These are usually avoidable by careful planning and siting of infrastructure to avoid watercourses and surface water features and maintain water flows. The Act also governs the control of declared pest plants and animals.

Aboriginal Heritage Act

The *South Australian Aboriginal Heritage Act 1988* (Act) provides protection for all Aboriginal sites, objects and remains across the state. The Act applies to all land and bodies of water, including Beach Energy's Otway Basin operations. The Act vests the powers to protect and preserve Aboriginal heritage to the Minister for Aboriginal Affairs and Reconciliation, who is required to take such measures as are practicable for protecting and preserving Aboriginal sites, objects and remains. Authorisation is required for any damage, disturbance or interference to Aboriginal sites, objects or remains. Penalties apply for failure to comply.

Where Aboriginal sites, objects and remains are encountered on private land, the *Aboriginal Heritage Act 1988* (Act) requires Beach Energy to report these discoveries to the Minister for Aboriginal Affairs and Reconciliation as soon as practicable. Once reported, AAR will notify the relevant Aboriginal group of the discovery.

Further, where Aboriginal sites, objects and remains are discovered, mitigation measures should be implemented to ensure the heritage is avoided. If the works cannot be relocated to avoid the Aboriginal site, object or remains, an authorisation is required pursuant to section 23 of the Act.

Under section 28(1) of the *Coroners Act 2003*, SA Police (SAPOL) must be notified if skeletal remains are discovered. SAPOL will determine whether the remains are Aboriginal ancestral remains. If the remains are determined to be Aboriginal remains, Beach Energy must contact AAR. AAR will then liaise with Beach Energy and the relevant Traditional Owners regarding the management and protection of the Aboriginal remains.

In the event of any heritage discovery, Beach Energy must ensure that the heritage is not damaged, disturbed with or interfered. To achieve this, works should halt in the vicinity of the discovery and advice should be sought from the Traditional Owners, a qualified heritage consultant or from AAR.

3 Description of Activities

The following section provides an overview of geophysical operations. The descriptions focus on 2D and 3D seismic survey operations using a range of surface and underground source and receiver types. These surveys are the predominant geophysical survey methods proposed to be implemented by Beach in the South-East Otway Basin. Descriptions of other geophysical operations (such as uphole surveys) are also provided.

3.1 Grouping of Operations

Operations considered in this EIR include seismic line and access track preparation, shot hole / uphole drilling, surveying and recording, campsites and associated activities, monitoring and auditing, and rehabilitation / restoration where required.

To clearly outline the processes involved, and assess the impacts of geophysical operations on the environment, the activities have been grouped and considered as follows:

- Overview of Geophysical Data Acquisition Methods (Section 3.2)
- Seismic Survey Energy Sources and Receivers (Section 3.3)
    - Energy Source Point Types (Section 3.3.1); and
    - Receiver Point Types (Section 3.3.2).
- Types of Seismic Survey (Section 3.4)
    - 2D and 3D Seismic Surveys (Section 3.4.1); and
    - Uphole Surveys (Section 3.4.2).
- History of Seismic Surveys in the Licence Area (Section 3.5)
- Description of Seismic Survey Planning and Operations (Section 3.6)
    - Planning (Section 3.6.1)
    - Cultural Heritage Surveys (Section 3.6.2)
    - Access Track and Seismic Survey Preparation Activities (Section 3.6.3)
    - Surveying Operations (Section 3.6.4)
    - Recording Operations (Section 3.6.5)
    - Camp Sites and Associated Activities (Section 3.6.6)
    - Rehabilitation / Restoration (Section 3.6.7); and
    - Monitoring and Auditing (Section 3.6.8).

3.2 Overview of Geophysical Data Acquisition Methods

Geophysical data acquisition allows resource explorers to gather information about the location and characteristics of geological structures located beneath the earth's surface. This information is used to assist in identifying areas where hydrocarbons (and other natural resources) may be present.

Onshore geophysical surveys (seismic surveys) for petroleum hydrocarbon exploration predominantly utilise the principles of reflection seismology to collect geophysical data. The methods are largely based around how acoustic / sound waves change their speed (velocity) and direction (reflection and refraction[3]) as they pass through different types of soil and rock. Interpretation of changes in velocity and direction of sound waves as they pass through soil and rock enables geophysicists to determine geological conditions and structures in a given survey area.

Seismic surveys require an energy source to create a sound wave on or near the earth's surface, and receivers to record the reflected waves (refer Figure 3-1). Prior to the 1970s, seismic surveys in Australia used small explosive charges placed in or on the surface or buried in shallow holes as the energy source to generate sound waves. Other systems to create a controlled seismic 'source point' have been developed over the years including 'vibroseis', which uses a vibrator on the surface to generate sound waves, and weight drop (or thumper) which uses a heavy weight dropped from a height as the energy source. Source point types are discussed further in Section 3.3.1.

The generated sound waves travel into the earth where they reflect off subsurface geological formations back to the surface. The returning sound waves are recorded by a series of sensors commonly referred to as 'receiver points'. These sensors include receivers such as geophones, accelerometers and fibre optic cables. Receiver point types are discussed in Section 3.3.2.

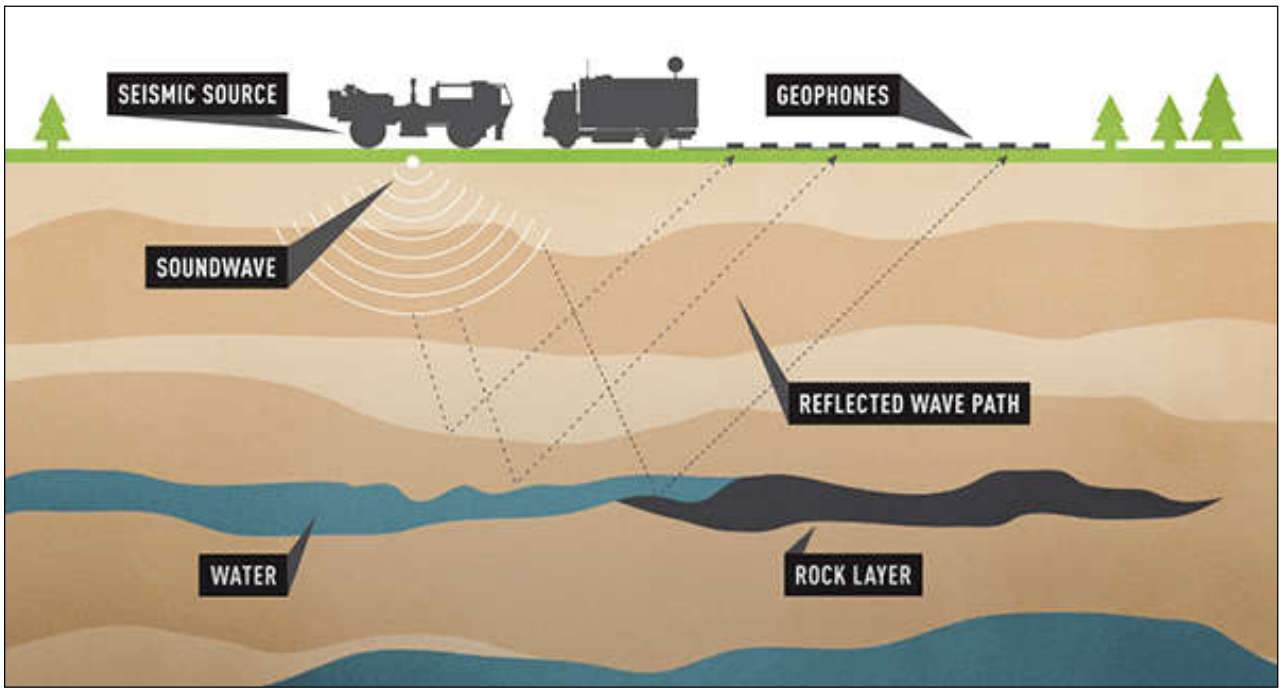


Figure 3-1: Typical onshore seismic survey outline (Source: APPEA, 2019)

Source and receiver points are typically laid out in relatively straight lines or multi-line grids (commonly referred to as 'seismic lines'), however survey designs will vary with survey requirements. Source and receiver points may be located on the surface, buried in trenches or placed in drilled holes, or used in combination depending on survey requirements, the

[3] Seismic refraction is the change in direction of a sound wave as it passes from one medium to another

surface environment and the nature of the geology in the survey area. All source and receiver points are numbered, and the position of each point is accurately mapped. The number of source points and their positions are carefully designed to improve the downward-going sound energy, minimise the energy going in other directions, and minimise impacts to surface and subsurface environments. The different types and methods of seismic survey are described further in Section 3.4.

3.3 Seismic Survey Energy Sources and Receivers

3.3.1 Energy Source Point Types

Seismic surveys can utilise a range of energy sources to generate sound waves. Modern onshore seismic surveys typically utilise either a 'vibroseis' system, weight drop system or small buried explosive charges (buried source).

Vibroseis

Vibroseis is the most common energy source used for modern 2D and 3D seismic surveys. The vibroseis system is a truck-mounted system that uses a large oscillating mass (vibrator) to generate acoustic waves of varying frequencies. The vibrator is typically in the form of a large retractable plate (mounted to the underside of a truck) that can be lowered to the ground with pressure applied (see Figure 3-2). The plate is applied to the ground for each vibration (source point), and then raised up as the truck moves to the next source point. Small vibrator pad marks (i.e. shallow indentations on the soil surface) may be left on soil where the vibrator pad was pressed against the ground surface. These indentions are temporary, and they typically naturally rehabilitate within a short period of time.

Vibroseis produces a low energy density, which allows it to be used in sensitive environments, cities and other built-up areas (e.g. the centre of Paris) without damaging buildings or the environment in close proximity to the energy source (APPEA, 2019). Vibroseis trucks typically use large balloon type tyres (or tracks less typically), to lower their surface pressure and footprint (see Figure 3-2).

The process of undertaking a seismic survey utilising vibroseis is described further in Section 3.6.5.

Figure 3-2: Vibroseis trucks (Source: Sercel, 2020)

Weight Drop (or Thumper)

The weight drop system is a simple method used to generate a sound wave. A heavy weight is dropped from a height of several metres onto a base plate located on the ground. When the weight makes contact with the base plate it generates a 'thump', which imparts a sound energy source into the ground. Weight drops are a common source used for uphole surveys (as described in Section 3.4.2). Weight drop units are commonly mounted to a small truck or tractor type vehicle (Figure 3-3). As with vibroseis, this method can result in shallow indentations on the ground surface, which are temporary, and typically naturally rehabilitate within a short period of time.

Figure 3-3. Weight drop ('thumper') unit mounted to a tractor

Buried Source

The buried source method involves the drilling of shallow holes, commonly referred to as 'shot holes' into which small explosive charges are placed to generate a 'buried source' of energy. Shot holes typically range between 5 to 80 m in depth and no more than 20 cm in diameter.

Buried sources are commonly used to generate higher quality acoustic source energy, and at the same time reduce disturbance to land and vegetation in sensitive environments (e.g. areas where large vehicle access is limited). This method also improves data quality in areas where near surface geology interferes with acoustic source energy transmission. Areas with karst structures (such as those present in the South-East Otway Basin) or areas with significant laterites[4] can cause down-going acoustic waves to scatter and weaken at the near surface (see Figure 3-4) (Grimes, 1994; Crook et al, 2015). Placing energy sources (and / or receiver points) below these shallow structures can significantly improve data quality, and in some cases, it is the only way to acquire useable seismic survey data.

[4] Laterites are soil and rock rich in iron and aluminium, that may form chunks and boulders.

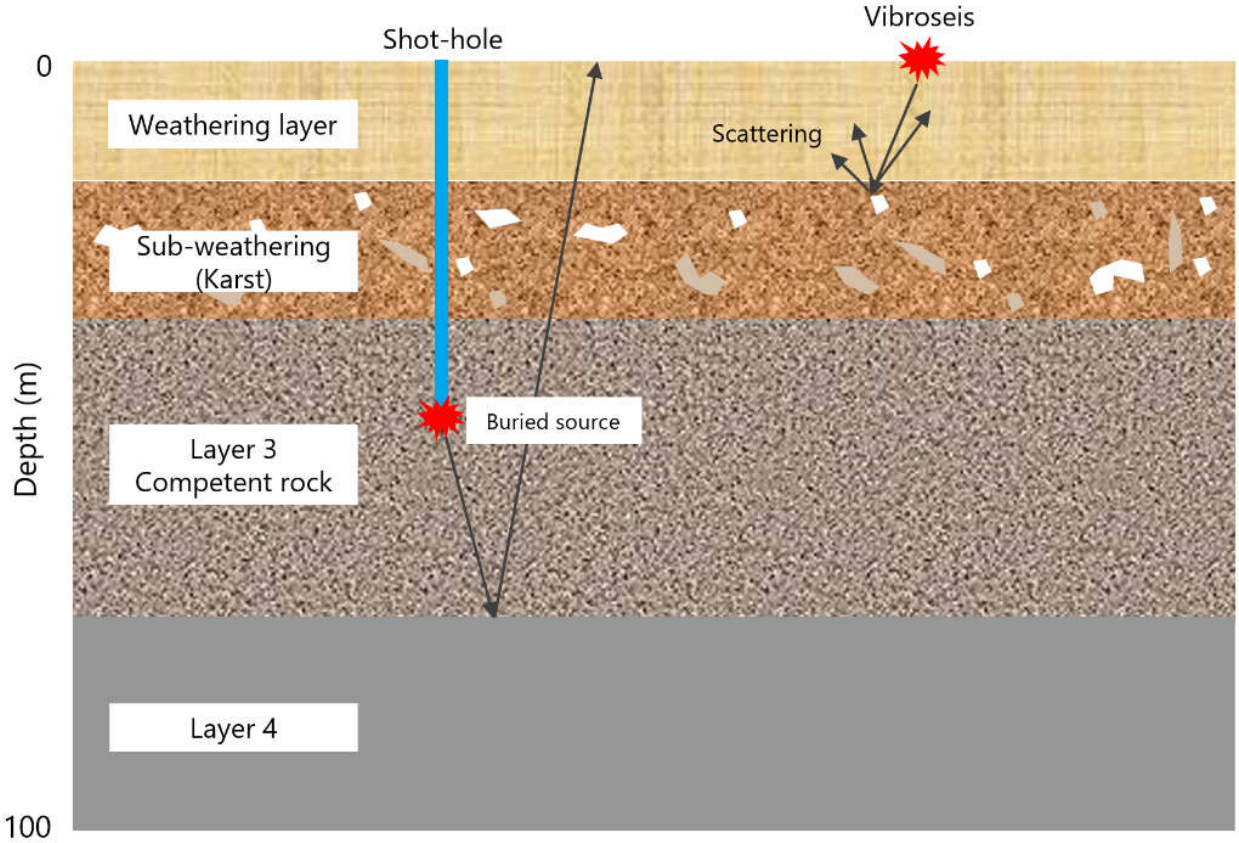


Figure 3-4: Schematic of buried source vs. vibroseis source type behaviour in an area with a Karst Layer

Shot holes can be drilled using hand-held motorised augers, small vehicle mounted drill rigs (e.g. bob cat or light vehicle), standard water bore truck-mounted mud / rotary rigs or heli-portable rigs, depending on terrain, access and depth requirements. Minimal to no site preparation is typically required to locate a drilling rig, and hand portable drilling rigs can be walked into sensitive areas with no vegetation clearing required.

A small charge (0.5 to 4 kg) is placed in each shot hole following drilling and a detonation wire is run to the surface. The hole is then immediately backfilled with drill cuttings, bentonite clay and / or gravel and capped to the surface with native soil . The backfilling process ensures the charge is secured in the bottom of the hole and limits energy loss up the hole. Shot hole depth and charge size requirements are dependent on near surface geological characteristics (typical shot hole depths and charge sizes are detailed in

Table 3-1). Seismic charges are solid (i.e. not a liquid or emulsion) and are typically encased in sealed hard-plastic shells (see Figure 3-5). Seismic charges typically contain several common types of explosives, including TNT (Trinitrotoluene), RDX (Cyclonite) and PETN (Pentaerythritol tetranitrate) (Orica, 2017). At least two detonators are typically placed with each charge to ensure that the charge is detonated.

During recording operations (as described in Section 3.6.5) each charge is individually detonated using specialised equipment, resulting in a minor sound at the surface (i.e. small thud). Following detonation, wiring is cut off a few centimetres below the surface level, and any subsidence in the hole is remediated using native soil. Localised disturbance associated with shot hole drilling activities is temporary, and sites typically naturally rehabilitate within a short period of time. Further detail on rehabilitation / restoration is provided in Section 3.6.7.

Table 3-1: Shot hole depths and maximum charge sizes

Shot Hole Depth		Charge Size
5 to 10 m		0.5 kg
10 to 20 m		1 kg
20 to 30 m		2 kg
>30 m		4 kg

Figure 3-5: Orica Pento-Seis and Pentex charges (Source: Orica, 2020)

3.3.2 Receiver Point Types

There are many types of seismic sensors (receivers), such as geophones, accelerometers and fibre optic cables. These sensors convert the extremely small returning sound waves into data that can interpreted by geophysicists. Many thousands of sensor locations are required to record the returning acoustic waves and sensors are typically installed temporarily on the surface or downhole. Sensors are typically arranged in linear patterns along seismic lines, but arrangements vary with survey requirements (refer to Section 3.4.1). Sensors can also be installed permanently for long-term monitoring purposes (see Figure 3-8).

Geophones

Geophones located on the surface are typically pushed into the soil surface using small metal spikes to ensure a firm connection with the ground. A range of geophone types are shown in Figure 3-6 and Figure 3-7. Geophones may also be partially buried in small shallow holes for improved sensitivity (Figure 3-7).

Buried geophones (commonly referred to as 'downhole geophones') can be installed into drill holes of varying depths (typically ranging from 10 m to 300 m). Downhole geophones are typically deployed temporarily (1-2 hours) during 'uphole' surveys (refer to Section 3.4.2), semi-permanently (i.e. weeks to several months) to monitor ongoing data during a 2D or 3D seismic survey program (refer to Section 3.4.1), or permanently for passive monitoring or time-lapse applications. Downhole geophones can consist of a single geophone (typically used for uphole surveys) or for semi-permanent installations, a string of multiple geophones (i.e. up to 20 individual geophones) may be installed (see Figure 3-8). Permanent installation of downhole geophones typically requires cementing the geophones in place in cased drill holes (up to 300 m deep).

Fibre Optic Cables / Sensors

Fibre optic cable and sensors can be deployed into drill holes in a similar way to geophones, either temporarily or cemented in place as described above (refer Figure 3-8). Fibre optic cables can also be deployed in a shallow trench (<50 cm deep) to either replace geophones and / or provide supplemental information, or installed into trenches over several kilometres (see Figure 3-8). The trenches are typically installed adjacent to 3D / 2D seismic lines. Upon completion of the

survey, the cable and sensors are typically removed, and the trench is backfilled. Distributed Acoustic Sensing (DAS) technology is used to interrogate the cable and extract the required seismic information.

Figure 3-6: Geophone types (Source: Dean & Sweeney, 2019)

Figure 3-7: Wireless geophone ('node') with sensor installed in shallow hole

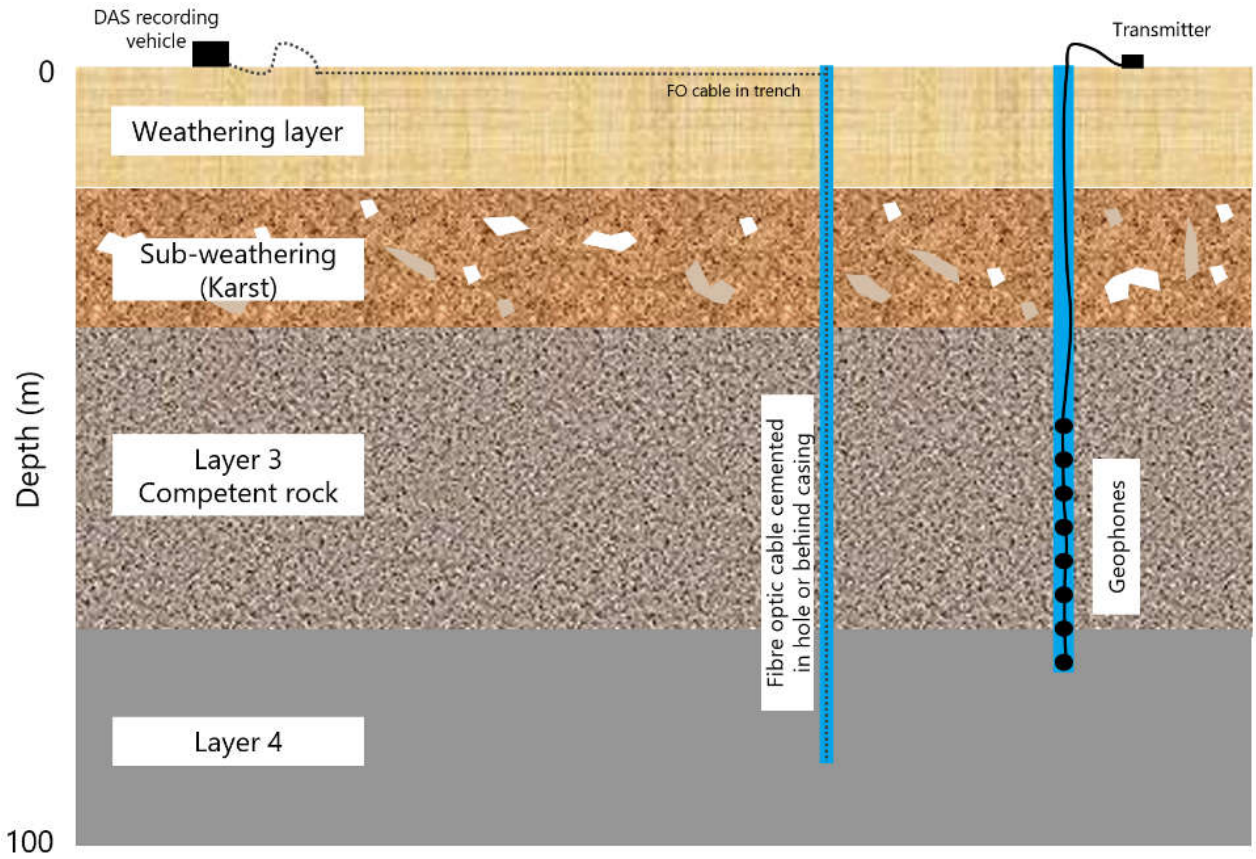


Figure 3-8: Schematic of downhole geophone and fibre optic cable (DAS technology) installation

3.4 Types of Seismic Survey

3.4.1 2D and 3D Seismic Surveys

Until the early 1980s, onshore seismic surveys were typically conducted along single seismic survey lines with source and receiver points located along the same line. The resulting data creates a simplistic two-dimensional (2D) image representative of a slice through the subsurface structures beneath a particular seismic line (see Figure 3-10). 2D seismic surveys typically involve a series of seismic lines in the order of 10 km to 50 km in length, with spacing between lines of approximately 0.25 km to 5 km (see Figure 3-9). Spacing between shot and receiver points along the seismic lines for 2D surveys is typically in the range of 5 m to 50 m. The seismic line itself is usually 3 m – 5 m wide.

While 2D seismic is still undertaken, the majority of modern seismic surveying uses the three-dimensional (3D) survey method. The 3D methodology is similar to 2D, but instead of a single line of source and receiver points, the source and receiver points are located on dedicated source lines and receiver lines laid out in a grid pattern across a survey area (see Figure 3-9). Receiver points are laid down in parallel 'receiver lines', and the source points are laid out in perpendicular parallel 'source lines' to form a cross-hatched grid.

3D seismic surveys can range in size from several km^2 to several thousand km^2, and spacing between seismic lines is typically in the order of 100 m to 400 m. Spacing between source and receiver points typically ranges from 5 m to 50 m. The grid arrangement means that source and receiver points are spread across the entire survey area, which allows each receiver point to collect seismic reflections from multiple directions across the survey area (see Figure 3-9). This data can

then be analysed to create a 3D image of the survey area subsurface (see Figure 3-10). Section 3.6 provides further detail on seismic survey planning, seismic line preparation, and 2D and 3D seismic survey operations.

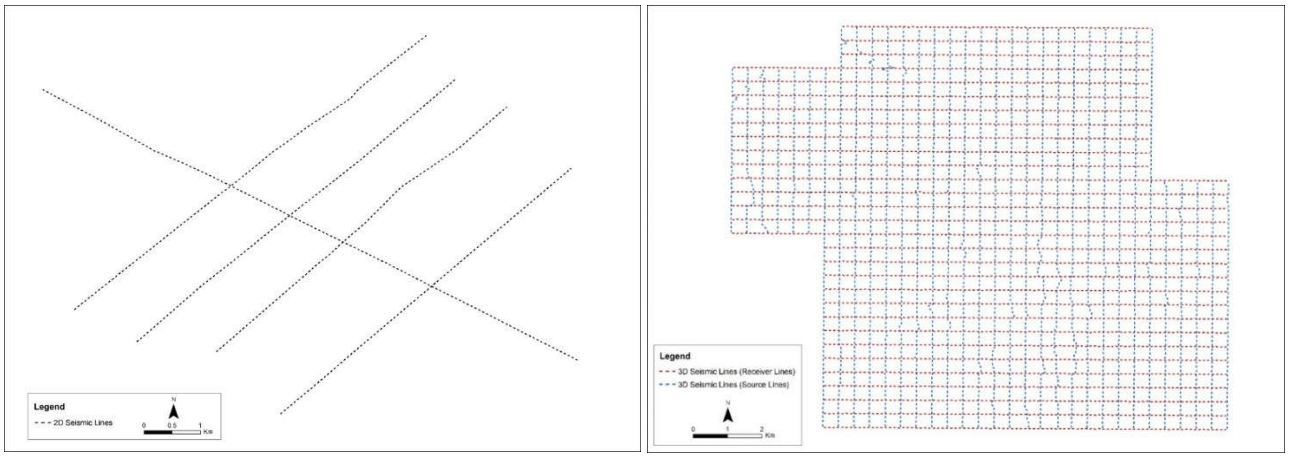


Figure 3-9: Comparison of 2D and 3D seismic survey design

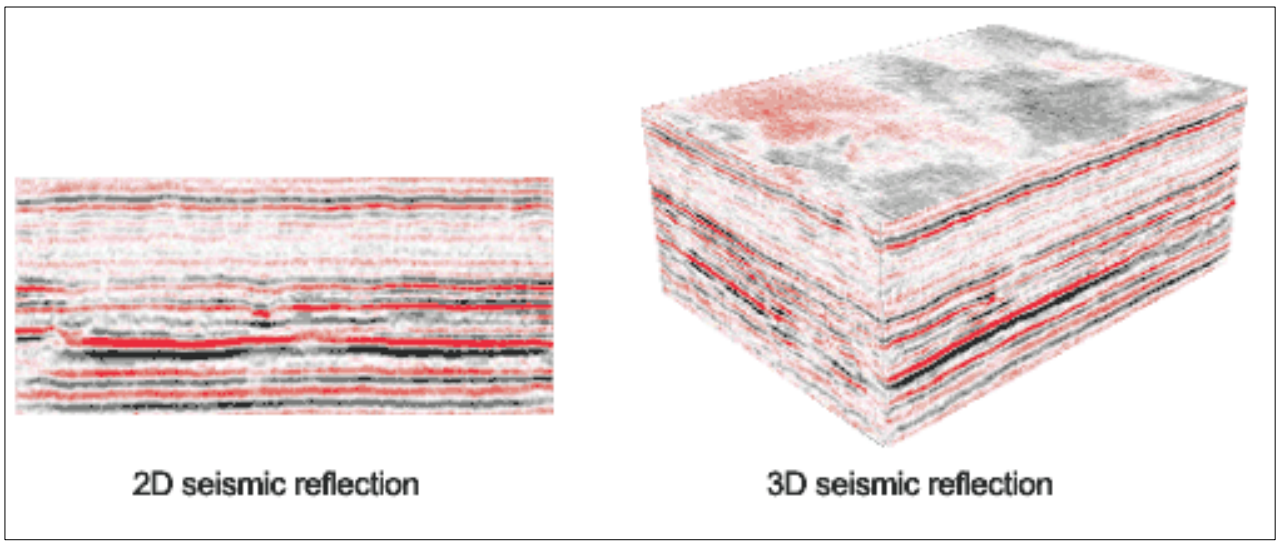


Figure 3-10: Comparison of 2D and 3D seismic survey images. (Mari and Chapellier, 1999)

3.4.2 Uphole Surveys

Uphole surveys are another geophysical method that utilises drill holes to record and calibrate 2D / 3D seismic survey data. Uphole methods involve drilling holes usually within the range of 30 m to 90 m deep but up to 300m deep in some instances, and located 1 km to 5 km apart along 2D / 3D seismic lines. A downhole geophone is placed in the hole at varying depths , and the source energy (typically a weight drop as described in Section 3.3.1) is located at the surface.

Uphole drilling involves a very similar process to that required for shot hole drilling (refer Section 3.3.1), with key differences being that upholes may require a larger bore diameter, and potentially use of a larger drilling rig and additional equipment (Figure 3-11). Minimal site preparation is required for uphole surveys as the drilling rig uses existing seismic lines, roads and tracks to access drilling locations. Following the completion of drilling each uphole, the drill rig will mobilise to the next drilling location and a data logging vehicle (typically a 4WD light vehicle) will move in to record geophysical data.

On completion of data logging (usually 1-2 hours per uphole), drill cuttings are returned to the hole, and the hole is capped to the surface with native soil . Localised disturbance at uphole sites will typically naturally rehabilitate within a short period of time. A significant amount of uphole drilling / logging has been undertaken across South Australia to date, particularly in the Cooper and Otway Basins. This data has been captured in an open file database by DEM, which now minimises the need for new upholes in areas previously explored.

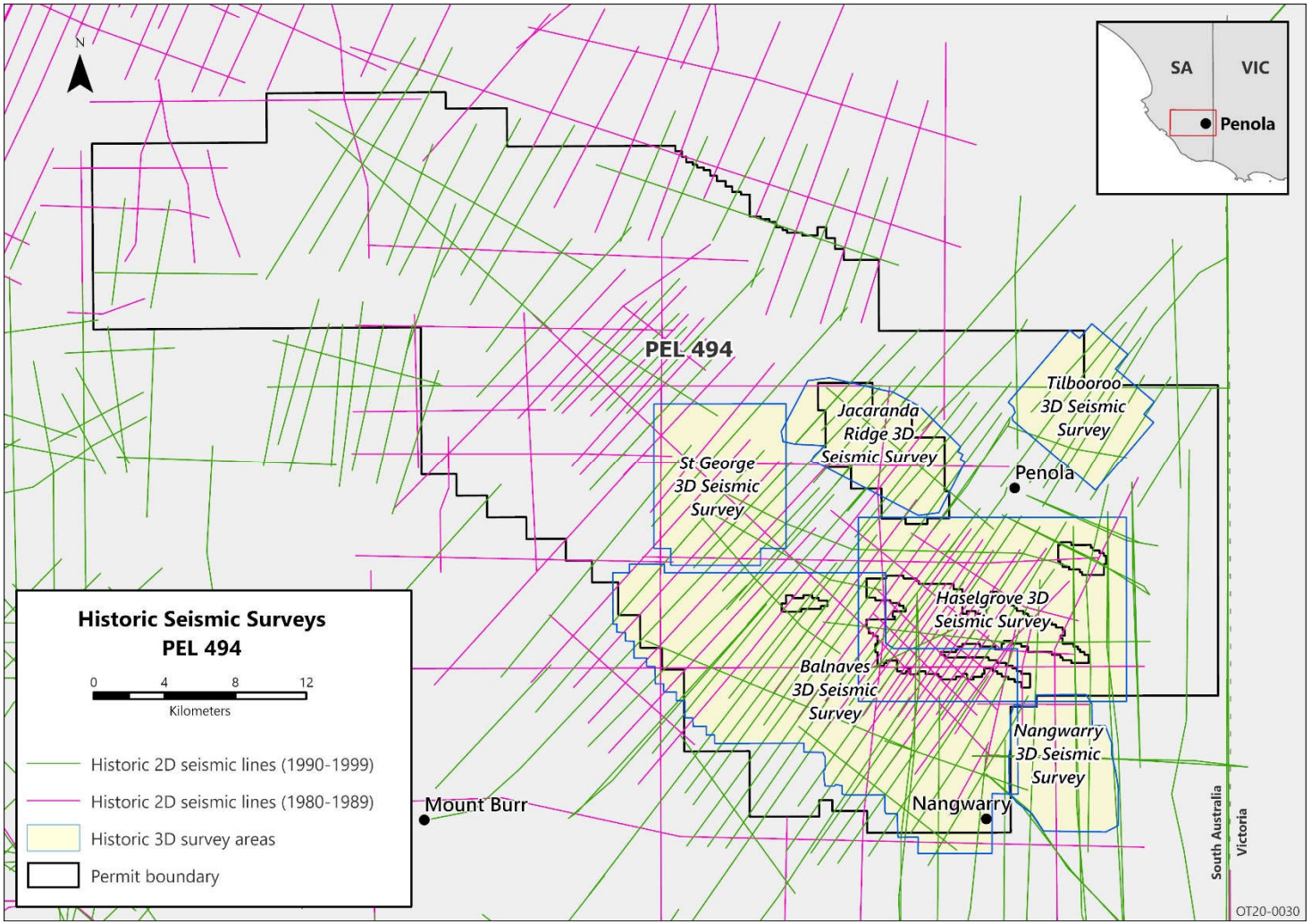
Figure 3-11: Truck mounted uphole drilling rig (Source: Santos, 2018)

3.5 History of Seismic Surveys in the Licence Area

Extensive 2D and 3D seismic surveying using vibroseis and buried sources has been undertaken in the onshore Otway Basin in the South East of South Australia. As discussed in Section 1.3, seismic surveys were first undertaken in the South East by Beach and other exploration companies in the early 1960's. To date, seventy-four 2D and nine 3D seismic surveys have been recorded across the broader Otway Basin in the South East. These surveys recorded approximately 10,500 km of 2D seismic survey line data, and approximately 780 km^2 of 3D seismic survey data.

Within the Beach licence area, thirty-six 2D and six 3D seismic surveys have been undertaken between 1960 and 2010, recording approximately 2,238 km of 2D survey data, and approximately 514 km^2 of 3D data. Of these surveys, nine used buried sources and thirty-three used vibroseis to provide the sound energy source. Seismic surveys using buried sources were first undertaken in the licence area in the 1960's and then again in the early 1990's. The last survey to use buried sources in the licence area was the 2010 Weatherall 2D Seismic Survey, which used a combination of vibroseis and buried energy sources. The location of historic 2D / 3D seismic surveys in the Beach licence area are shown in Figure 3-12 and a detailed list of historic seismic surveys undertaken in the licence area is provided in Appendix A.

Figure 3-12: Historic seismic surveys in the licence area



3.6 Description of Seismic Survey Planning and Operations

3.6.1 Planning

Once a seismic survey program is proposed, the survey area is evaluated using a range of methods and desktop tools to identify and avoid sensitive areas and constraints. Typical desktop tools and resources include detailed maps, a Geographical Information System (GIS), satellite or aerial imagery, biological databases and spatial data for a range of infrastructure and landscape features.

The proposed locations of access tracks, camp sites, seismic lines and / or shot holes are assessed and modified using desktop tools to avoid sensitive infrastructure and environments such as high quality remnant vegetation, known cultural heritage sites, significant wetland areas, groundwater wells, stock yards and other agricultural infrastructure, buildings and houses. All potential disturbances are preferentially located to minimise impacts to sensitive locations and maximise placement in pre-disturbed areas.

The safety of field personnel is also a primary consideration alongside the logistical, environmental and economic viability of the proposed survey during the planning stage.

3.6.2 Aboriginal Cultural Heritage Surveys

Cultural heritage inspections / surveys are carried out with the relevant Aboriginal heritage group in accordance with any formal agreements between Beach and the group, and Beach cultural heritage procedures. The survey method varies from project to project, and the method utilised for a particular project will be decided in consultation with the relevant Aboriginal heritage group.

3.6.3 Access Track and Seismic Survey Preparation Activities

As discussed in Section 3.6.1, planning is undertaken to minimise new disturbance and prioritise use of pre-disturbed areas wherever practicable. However, areas with limited access for vehicles or lacking other development (e.g. petroleum wells or production facilities) may require at least minor access track and seismic survey preparation activities to be undertaken (dependent on the proposed survey method). Following cultural heritage survey, access track and seismic survey preparation activities can commence.

<u>Access Tracks</u>

Seismic surveys in the South East predominantly utilise existing roads and access tracks. Where required, access tracks are typically 4 m wide, except on bends and at entry and exit points to a camp site where the width may be as wide as 8 m. If grass adjacent to access tracks is dry, a graded or ploughed firebreak along each side of the access track may also be constructed. Where particular access tracks may experience increased traffic loads (e.g. main access tracks leading into the survey area or a camp site), it may be necessary to lightly pave these tracks with gravel (imported from a licensed quarry) to prevent significant soil disturbance. Paving materials are usually removed during rehabilitation (unless the landholder requests they are retained) and stockpiled topsoil is re-spread over the site.

<u>Seismic Survey Line Preparation</u>

Light vehicles (e.g. 4WD vehicles), vibroseis trucks and drilling rigs generally require access along seismic lines in order to lay out geophones and input sound energy at source points. Vehicle access is less important for laying out receiver points (geophones) as walk-in methods can be utilised. Seismic lines are generally surveyed on the ground using GPS technology, and some surveys are also marked out using small pin flags or water-based paint so the 'grid' can be easily navigated.

As noted in Section 3.4.1, seismic lines are generally 3 m to 5 m wide, and in previously cleared agricultural land they typically do not require any line preparation. In areas of particularly tall or dense pasture grass, an agricultural slasher or vegetation mulcher (Figure 3-14) may be used to remove the top layer of vegetation (retaining rootstock and groundcover, and minimising disturbance to soil (Figure 3-15). This process may also be required to mitigate potential bushfire risk i.e. fire risk associated with vehicle exhausts.

In rough or highly vegetated terrain, seismic lines may require light preparation by earthmoving or vegetation slashing machinery to enable safe and efficient vehicle and equipment access. Large tree limbs overhanging existing access roads and tracks may need to be trimmed (using a chainsaw) to allow safe vehicle access. Appropriate impact management strategies will also be implemented as detailed below.

Disturbance to areas of remnant or significant vegetation, fauna habitat, cultural heritage sites, watercourses and waterbodies is avoided wherever practicable. Where sensitive areas such as remnant vegetation, swamps and lakes cannot be avoided, small low impact vehicles (e.g. quad bikes or off-road buggies) and hand carrying (walk-in) by field personnel can be used to transport and install geophones to avoid traversing the area with large vehicles. Where disturbance to native vegetation is unavoidable, ecological surveys and appropriate clearance permitting processes will be undertaken.

Seismic lines do not need to be perfectly straight and are regularly 'offset' and 'weaved' around environmental sensitivities such as large trees and areas of intact vegetation wherever practicable. This process also reduces the visual impact (linearity) of seismic lines (Figure 3-13). The location of seismic lines (including tolerances for weaving around sensitivities) is typically pre-programmed into a GPS linked computer display located in the cabin (this will generally be a tracked bobcat or similar machine (see Figure 3-14)). In this manner, the vehicle operator can weave seismic lines within set tolerances to avoid obstacles and maintain compliance with cultural heritage conditions. In areas where visual impact is an issue, seismic lines may also be weaved every 75 m to 100 m to reduce the linearity of seismic lines where appropriate (however, weaving may be avoided on steep, fragile or wet soils as it may increase rutting and soil disturbance).

Preparation of seismic lines is undertaken to minimise ground and vegetation disturbance and allow natural processes and rainfall to rehabilitate the area in a short timeframe following completion of survey activities. In some cases, minor re-spreading of soil and vegetation following the completion of the activities may be required. Beach respects the rights and requirements of all landholders and will engage directly with landholders regarding the preparation and remediation of survey lines.

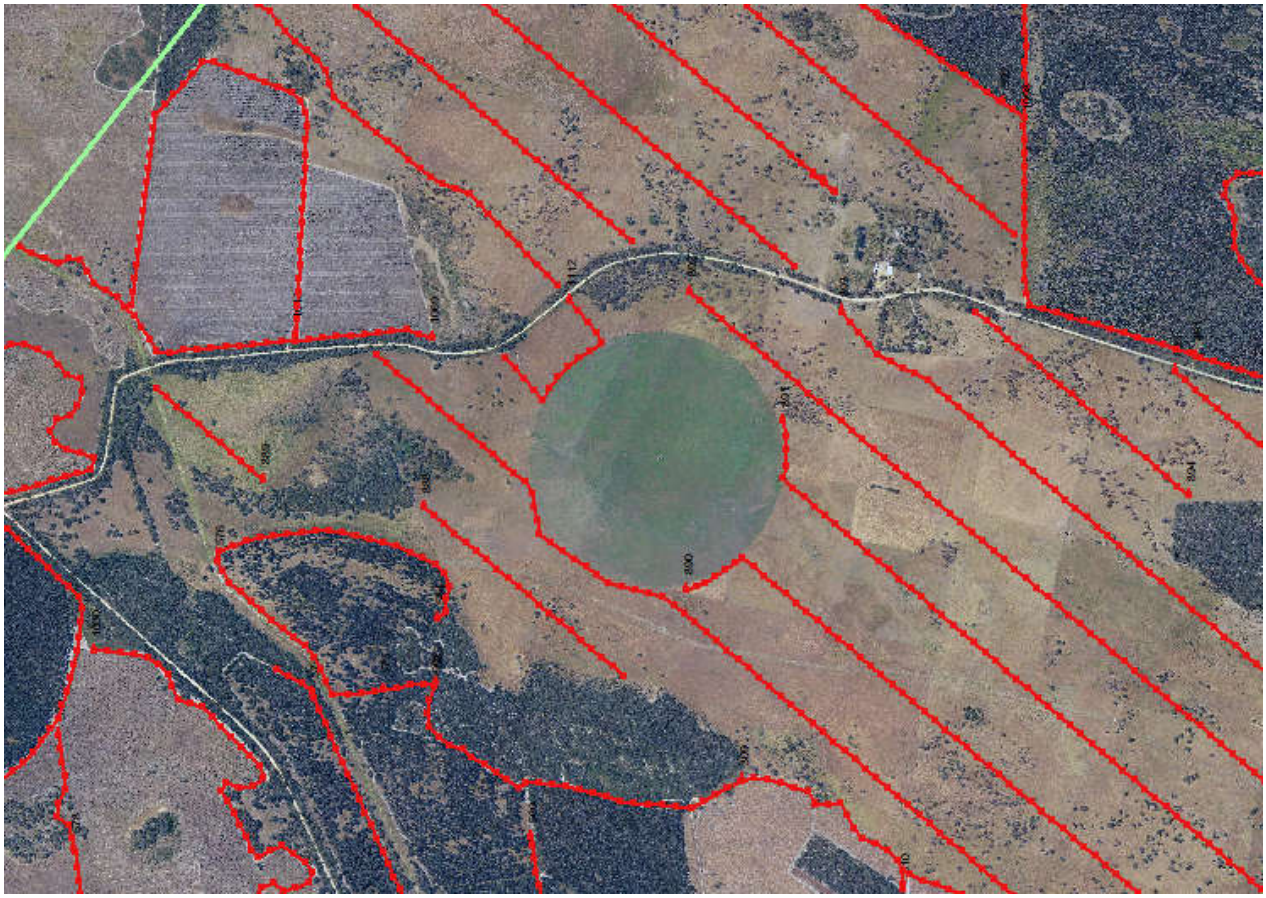


Figure 3-13: Example of deviation of seismic lines to avoid sensitive areas

Figure 3-14: Bobcats with vegetation mulching attachments (Source: Roberts, 2001)

Figure 3-15: Prepared seismic line following use of Bobcat mounted vegetation mulcher in tall / dense pasture grass

Drilling Activities for Seismic Surveys

As discussed in Section 3.3.1, areas with limited access for large vehicles or challenging near surface geological conditions, may require use of buried sources as an alternative to vibroseis. This would typically involve the drilling of a sparse irregular pattern of shot holes across a given survey area. Drilling operations can take several weeks or months to complete dependent on the number of shot holes required for the survey. A single drilling rig (full size water bore drilling rig or similar) can complete up to 10 holes to a depth of approximately 40 m to 60 m per day. Multiple drilling rigs may be used to reduce time required.

Minimal site preparation is typically required to prepare drilling locations and shot holes can typically be located in areas with pre-existing disturbance (e.g. cleared paddocks) using existing access tracks and roads wherever possible. Shot hole locations only require an area large enough to accommodate a truck-based drilling rig and drilling sites located on previously cleared agricultural land typically require limited to no site preparation. Seismic line preparation methods discussed above may be used in areas of particularly tall or dense pasture grass (Figure 3-14). This process may also be required to mitigate potential bushfire risk i.e. fire risk associated with vehicle exhausts and drilling equipment.

In sensitive environments shallow shot holes can be drilled using hand portable drilling rigs with no vegetation clearing required. Where disturbance to native vegetation is unavoidable, ecological surveys and appropriate clearance permitting processes will be undertaken and obtained. Appropriate impact management strategies will also be implemented as detailed below.

Following the completion of drilling each shot hole, the drill rig will mobilise to the next drilling location, and a charge preparation team will prepare and insert the charge into the bottom of the hole as described in Section 3.3.1. Following

charge detonation, wiring is cut off a few centimetres below surface level, and any subsidence in the hole is remediated using native soil.

Monitoring bores (e.g. fibre optic monitoring bore holes) may also be drilled using similar drilling techniques. A standard truck mounted mud or air drilling rig would typically be used to drill to a maximum depth of several hundred metres. Bores would be cased with PVC and cemented in place. Fibre optic cable would be placed in the well bore and then the hole would be filled with cement to within a few metres of the surface then backfilled with soil or other suitable material. Further detail on buried source surveys and reinstatement / rehabilitation processes is provided in Sections 3.3.1 and 0 respectively.

Impact Mitigation / Management Strategies

Where disturbance to native vegetation is unavoidable, ecological surveys and management strategies will be implemented to mitigate impacts to priority areas, species and / or habitat. Appropriate clearance permits will also be obtained. Management strategies may include (but are not limited to) the following:

- extensive line weaving
- reduced seismic line disturbance width
- use of smaller vibroseis machines
- use of walk-in methods or small low-impact off-road vehicles to install receiver points
- use of seismic charges as the source energy rather than vibroseis
- use of hand portable drilling rigs to drill shallow shot holes with no vegetation clearing required
- tree limbs trimmed on existing access roads / tracks (using a chainsaw) rather than clearing trees
- use of handheld or bobcat mounted vegetation mulching / slashing equipment and techniques; and
- vegetation rolling / flattening equipment and techniques.

Using these methods, vegetation clearance is reduced, topsoil and groundcover is generally not disturbed, and vegetation rootstock is retained (Figure 3-15). These methods have been shown to facilitate rapid natural vegetation rehabilitation / regeneration rates compared with standard vegetation clearing methods (Williams *et al,* 1993). It should be noted that in sensitive areas, low impact vehicles (e.g. quad bikes and off-road buggies) and hand carrying by field personnel can be used to transport and install geophones on receiver lines with limited to no line preparation required. Walk-in methods are commonly used to lay out geophones in sensitive areas such as swamps and dense remnant vegetation.

Furthermore, all machine operators are required to undertake cultural heritage and environmental inductions prior to starting work on a particular seismic survey project. Line preparation machinery operators are also required to maintain vigilance for the presence of cultural heritage sites not identified during cultural heritage surveys. Any new site discoveries must be reported immediately to the Beach Field Supervisor and work must stop in that area.

Following completion of seismic survey operations, evidence of operations is typically limited to weaved lines of lower height vegetation, some localised disturbance at drilling sites, and minor wheel tracks. These disturbances generally naturally rehabilitate within a short period of time following natural processes e.g. rainfall and regrowth vegetation. Further detail on reinstatement and rehabilitation processes is provided in Section 0.

3.6.4 Surveying Operations

Surveying typically commences shortly before the start of seismic line preparation and drilling. Surveying is required to ensure all source and receiver point locations are accurately recorded.

Surveying typically involves a team of field surveyors recording the location of all source and receiver points using high accuracy GPS technology. Source and receiver points are commonly referred to as 'stations'. The location of stations may also be marked on the ground using biodegradable paint, pin flags or wooden pegs. Line detours may also be marked with biodegradable flagging tape, which is removed on completion of recording. However, mark-less systems using GPS technology are also commonly used. If pins or pegs are used, these are removed on completion of recording.

Each survey team (one to two surveyors in a 4WD light vehicle, quad bike or off-road buggy) typically makes one pass over any given section of seismic line or source / receiver station area. Field surveyors may also need to walk into sensitive areas to survey and mark stations. Field survey crews may also use this period to construct temporary gates and fence crossings at property and paddock boundaries along seismic lines (where required or requested by the landholder). Pre-existing gates are used if possible.

3.6.5 Recording Operations / Data Acquisition

The commencement of recording activities (data acquisition) varies with seismic survey type. For 2D / 3D surveys using vibroseis, recording typically commences 1-3 weeks after the start of seismic line preparation. Surveys that use buried sources can require a significantly longer period of time between the start of drilling activities and the commencement of recording, depending on drilling rates and the number and depth of shot holes. As discussed in Section 3.6.3, this may require several weeks or months to complete, and it will vary based on the number of shot holes required and the number of drilling rigs utilised. The recording phase is the largest part of a seismic survey program in terms of personnel and vehicles required. A recording team will typically consist of:

- 2D surveys: 20-30 personnel and 10-16 vehicles; and
- 3D surveys: 40 to 80 personnel and up to 20 vehicles.

These figures will vary with survey size, recording technique, terrain, season and amount of access. Vibroseis surveys require drivers and mechanics to support 4 to 10 vibroseis trucks; whereas a seismic survey only using buried sources may require fewer personnel as they typically only require a small team of 'shot-firers'.

2D / 3D seismic operations commence with deployment of geophones. The geophones are installed into the ground by personnel on foot. In areas with harder soils, geophones may be installed using hand tools or small motorised augers to dig small holes to place geophones. As discussed above, geophone placement is typically a very low impact activity, and geophones can typically be placed in sensitive areas on foot, or with use of low impact vehicles. Seismic field crews are inducted and fully informed of all environmental requirements, and the need to respect the rights and interests of landholders and land users.

Recording for 2D and 3D surveys would normally commence when sufficient geophones have been laid out in accordance with the arrangements described in Section 3.4.1. This layout is termed 'the spread' and a pre-selected 'live' section of the spread will record energy reflected from subsurface layers while source energy is being input to that area. Prior to the start of data recording, the spread and all recording systems are tested. Once the spread is live, the chosen source energy will begin to be input to the ground.

Where the energy source is vibroseis, an array of one (1) to four (4) vibroseis trucks are typically used. The trucks are electronically synchronised to vibrate in phase with each other. The trucks line up along a source line separated by a few

metres and centred on a source point. Each unit inputs one or more frequency sweeps into the ground at each source point. Each sweep lasts for only a few seconds. On completion of each source point the vibroseis trucks move to the next source point.

Where a buried source is used, the process is similar, but it involves a field crew traversing the survey area and detonating each individual shot hole charge. Charges are detonated using specialised equipment. A successful detonation should result in nothing more than the sound of a small thud at the surface.

The live spread is the only part of the survey area where data is recorded for any given source position. The live spread is moved as the vibroseis trucks or shot firers move across the survey area. As sections of the spread become redundant, geophones are picked up and transported to the front end of the line. This cycle continues until the line is completed. Data recorded during this process is typically stored on internal memory modules within each geophone.

All operational vehicles stay on seismic lines. Non-operational vehicles are required to park off-line to avoid causing interference with collected data. Non-operational vehicles include 4WD vehicles for personnel access / transport, spare vibrators, vibrator service truck (if vibroseis is used) and a recording truck (if required).

Along any single seismic line, the following vehicle passes can be expected to occur during normal operations:

- Vibroseis trucks and service truck (if vibroseis is used), 1 pass per truck
- recording truck, 1 pass (if required); and
- light vehicles, 4-20 passes in total.

Vibroseis trucks and associated equipment may use 3D receiver lines for access from one source line to the next, and so traffic on 3D receiver lines will be very similar to a 2D seismic line. However, 3D source lines carry limited traffic in comparison to a 2D line i.e. traffic is limited to vibroseis trucks, potentially a service truck as required, and minor light vehicle traffic. All operational vehicles stay on existing access tracks and roads during recording operations. Non-operational vehicles are required to park away from geophones to avoid causing interference with collected data. Non-operational vehicles may include a small number of 4WD vehicles for personnel access / transport.

3.6.6 Camp Sites and Associated Activities

Depending on the size and location of a seismic survey program, temporary camp sites may be required to house seismic survey personnel, and they may be used to locate a site office and store equipment and vehicles. Smaller seismic survey operations may utilise existing local private accommodation.

Temporary camps typically accommodate 15 to 80 personnel and require an area of up to 80 m x 50 m for locating self-contained re-locatable buildings equipped with wastewater processing facilities. Camps are typically established in pre-existing areas of disturbance (e.g. existing laydown areas) or on cleared agricultural land located as close as possible to existing access tracks / roads (see Figure 3-16 for an example of a typical camp). Disturbance to the soil surface will be kept to a minimum. It may be necessary to lightly pave the camp area and access track with gravel to prevent significant soil disturbance. Appropriate council permits / approvals will be attained for temporary camps (and for associated waste management requirements).

Aside from housing survey personnel, the camps may also act as a laydown / depot to store equipment, vehicles, site offices, and a rendezvous point for the crew each morning prior to commencing works. Equipment stored at camps may include vehicles, diesel fuel and lubricants (minor storage), vehicle maintenance equipment, star pickets / droppers and wooden stakes, plant and equipment components and materials. Where local private accommodation is used rather than

an onsite camp, a lightly paved laydown area / depot will typically be required to be located near the survey area to store equipment, diesel fuel and a site office (as described above). For larger seismic surveys, two to three temporary camp sites may be required to be in operation at any one time. These camps may include a drilling camp, line preparation / survey crew camp and recording camp.

Seismic surveys utilising buried sources will require an explosives magazine (e.g. a transportable shipping container type structure) to be located within or in close proximity to the survey area to safely store explosives in accordance with relevant industry standards / guidelines and the *Explosives Act 1936* and *Explosives Regulations 2011*. Magazines may require construction of a small lightly paved site similar to a laydown area in size. Refer to Section 5.4 for further detail on explosive storage and handling.

Spill and drip trays are provided to address minor drips and spills resulting from re-fuelling operations. Storage and handling of fuel and chemicals is undertaken in accordance with Safety Data Sheets (SDS), and relevant standards and guidelines such as the *EPA Bunding Guidelines* and Australian Standard 1940. Potential spill containment practices include containment of fuel drums within portable bunding. The storage of fuel at camp sites is contained within tankers utilising safety features such as double-skins, safety cut-off valves, top accessing etc. to minimise or eliminate the potential for spills.

Potable water for use at camps and operational sites may be obtained from commercial suppliers, landholders or appropriately licensed water bores. Sewage wastes are handled using septic tanks or self-contained on-site treatment systems that are approved and managed under the *South Australian Public Health (Wastewater) Regulations 2013* and in compliance with the South Australian Health On-site Wastewater Systems Code. Toilet facilities with wastewater processing units and septic tanks will be provided at camp sites. Where septic tanks are used to contain wastewater (black water and grey water), they will be pumped out by licensed contractors as required for disposal at a licensed facility consistent with the requirements of the *Environment Protection (Water Quality) Policy 2015*. Small pits may be constructed to house the tanks which will be removed after operations are completed. Any necessary approvals (e.g. local council) for the installation of the septic tanks will be obtained.

Following completion of survey activities, all camp buildings, laydowns and fuel and equipment stores will be removed. Hardstand areas will either be rehabilitated as described in Section 0 or handed over the landholder if requested.

Figure 3-16: Seismic survey camp (Source: Roberts, 2001)

3.6.7 Rehabilitation / Restoration

The majority of land disturbance associated with seismic survey operations does not require active rehabilitation / restoration following survey completion. This is because a key objective of seismic exploration is to prepare and utilise survey areas in such a way that minimises significant disturbance to land and allows for rapid natural recovery.

However, instances that can require active rehabilitation / restoration may include:

- presence of subsidence at shot holes following detonation
- wheel ruts caused after wet periods
- minor windrows caused by displacement of soil
- rehabilitation / restoration of gravelled 'hard stand' areas (if not retained by landholder)
- presence of excess drill cuttings at drilling sites
- compaction of topsoil at campsites or drilling sites; and
- disturbance to soil due to heavily trafficked routes between camp sites and the nearest public track / road.

Rehabilitation / restoration methods for these disturbances may include:

- reinstatement of subsidence at shot holes
- ripping of compacted soil
- removal of gravel from hard stand areas using loaders and excavators
- removal of excess drill cuttings at drilling sites
- windrow material re-spread and smoothed using a grader; and
- wheel rut material used to infill impacted areas.

Rehabilitation / restoration will typically be carried out immediately following completion of seismic survey activities.

All rehabilitation / restoration activities will be undertaken in consultation with, and to the satisfaction of the landholder. If the landholder wishes to retain suitable infrastructure such as access tracks or gravelled hard stand areas, they may be handed over under a deed of transfer or similar.

Areas prepared with gravel (e.g. some access tracks, camp sites, laydown areas and magazines) that the landholder does not want to retain, will have gravel removed and then be deep tine ripped, before being covered with stockpiled topsoil. This process alleviates soil compaction and enables good natural rehabilitation back to pasture or crops. Small stones not picked up by front end loaders or excavators (during initial gravel removal) will be rolled into the soil as is common farming practice. A final shallow ploughing / harrowing will be carried out to ensure soil aeration and permeability. A crop / pasture will then be sowed for additional soil stabilisation. Perimeter fencing may also be left in place until vegetation is well established. Rehabilitation / restoration of gravelled areas may be carried out in autumn to avoid the summer heat and dry soil conditions. and to make the best use of autumn and winter rains to achieve the maximum vegetation regrowth.

Following detonation of each shot hole, the detonation wiring is cut off a few centimetres below the surface level, and any subsidence in the hole is remediated using native soil. Excess drill cuttings will be removed from site and disposed of at a licensed waste management facility unless otherwise agreed with the landowner. Localised disturbance at drilling sites will generally naturally rehabilitate within a short period of time following natural processes e.g. rainfall and regrowth vegetation.

Backfilling and plugging of all drill holes will be undertaken in accordance with relevant industry standards and guidelines including the SA Earth Resources Information Sheet M21 - *Mineral Exploration Drillholes — General specifications for construction and backfilling* (DSD, 2012). This specification outlines how drilling activities are to be undertaken when drill holes encounter unconfined and confined groundwater resources in South Australia. The specification requires drill holes that penetrate a single unconfined aquifer are backfilled with drill cuttings, clean fill containing clay, or cement. Drill holes that penetrate a single confined aquifer must be plugged from the level at which the aquifer was penetrated, with cement grout back to a minimum of 15 m into the confining bed above; and then backfilled with clean fill as described above. These requirements will be implemented as standard practice for all shot holes and upholes.

3.6.8 Monitoring and Auditing

Prior to, during and subsequent to geophysical survey operations, assessments may be undertaken to ensure operations have been conducted in compliance with the SEO (Beach Energy, 2020) and applicable regulatory requirements. These assessments can be implemented in several different ways. The following briefly describes the method utilised successfully by Beach and several other operators in the Cooper Basin and by Beach in the Otway Basin, and which would be applied in the licence area.

Prior to the commencement of any survey, several Environmental Monitoring Points (EMPs) are selected to provide a balanced representation of the environment of the survey area. EMP locations are positioned adjacent to existing roads or tracks to minimise any future access impacts upon the environment. EMP locations are recorded using a GPS and typically marked using star droppers prior to the start of seismic line preparation or drilling activities. Photographs are taken at these locations along the proposed seismic lines to provide a view of the terrain prior to any disturbance. All photographs should be captured using a standard setting to ensure consistent comparison. The process is repeated after line preparation / drilling and again after recording. These EMPs are then photo monitored over the ensuing five-year period to provide a visual representation of the natural gradual rehabilitation process. EMP revisit intervals are generally one year, two years and five years although the return period is determined by weather / road conditions and current activity in the region.

Additional photo monitoring points at a regular interval can also be utilised to monitor rehabilitation over time. The subsequent photo point report provides a more extensive photographic record of seismic survey activity and allows for a more liberal selection of locations for subsequent visits to record the rehabilitation of disturbed areas. Additional photo points are also useful if the original EMPs are difficult to access due to road damage or changes in land use over time.

4 Description of the Environment

This section provides an overview of the environment of the lower South East of South Australia, with a focus on the region encompassed by Beach's licence area.

4.1 Climate

The climate of the South East of South Australia is described as Mediterranean, with warm dry summers and cold wet winters (SE NRM Board, 2010).

The Coonawarra climate data indicate that mean daily maximum temperatures across the Beach licence area ranges from approximately 13.9°C in the coolest months (June to August) to 27.5°C in the hottest months (December to March). Mean daily minimum temperatures range from 5.1°C in the cooler months to 11.8°C in the hottest months. Winds tend to come from the south during the morning, and from the east and north east during the afternoon.

The southern coastal zones of the region typically experience high average rainfall which gradually decreases inland and towards the north. Annual rainfall ranges from approximately 850 mm in the south, to approximately 450 mm further north. Average annual rainfall at Coonawarra is 569 mm. Maximum rainfall occurs during July and August. The highest monthly rainfall recorded was 168.9 mm in June 2003. The highest daily rainfall event on record (79.6 mm) occurred in January 2007.

A summary of climate records for Coonawarra is provided in Table 4-1.

Table 4-1: Temperature and Rainfall Records for Station #026091 at Coonawarra (refer to Figure 4-1)

	J	F	M	A	M	J	J	A	S	O	N	D	Annual
Mean Daily Max (°C)	27.4	27.5	25.0	21.0	17.2	14.5	13.9	14.8	16.9	19.6	22.7	25.0	20.5
Mean Daily Min (°C)	11.7	11.8	10.2	7.8	6.9	5.4	5.1	5.3	6.5	7.3	8.9	10.1	8.1
Mean Rainfall (mm)	28.9	17.9	27.4	37.5	54.4	74.3	80.5	82.3	62.4	45.4	35.3	36.8	568.7
Median Rainfall (mm)	20.0	17.6	21.6	31.3	51.0	68.8	76.6	82.8	63.2	42.8	34.5	26.8	545.6
Highest Rainfall (mm)	101.7	55.6	80.0	83.6	120.2	168.9	143.0	160.8	134.4	90.8	80.3	105.4	746.4

Source: BOM, 2018

4.2 Bioregions and Topography

The South-East of South Australia is located in the Naracoorte Coastal Plain (NCP) IBRA region. The licence area is located in the Lucindale and Glenelg Plain IBRA sub-regions of the broader NCP bioregion. The South East has a low relief with unique landforms originating from a long, complex geological history. The region is still gradually rising, preserving the record of fluctuating sea levels over the last 700,000 years in a series of calcarenite ranges or stranded dunes, 2-10km apart and 20-50 m above the plains parallel to the current coast south-west of Naracoorte (Croft *et al,* 1999; Roberts, 2001).

The NCP bioregion is broadly categorised as a coastal plain of Tertiary and Quaternary sediments. The topography of the region is characterised by a regular series of stranded dunes separated by inter-dune swales, with clayey lagoon deposits and closed limestone depressions. Adjacent to the coast are indurated dunes of calcareous sand and dunes of orange sand. In some areas, particularly within the Dismal Swamp IBRA association of the Glenelg Plain sub-region, are plains that are locally veneered with sand, frequent swamps and lakes backed by low lunettes (crescent shaped clay dunes).

The general gradient of land towards the coast is 1: 1600, and to the north less than 1: 5000. Thus, surface water moves slowly towards the coast until a range directs it northwards along the eastern side of the range, resulting in extensive swamps and lakes, prevalent at the time of European settlement. The region is therefore naturally predisposed to waterlogging, and prior to large drainage programs, much of the bioregion was subject to seasonal waterlogging each winter (Roberts, 2001).

Approximately 90% of the bioregion has been cleared for agriculture. Major remnant vegetation types include mallee shrublands and woodlands, heath and other shrublands, sedgelands, chenopod and samphire shrublands and eucalypt woodlands and open woodlands (Croft *et al,* 1999).

The region also hosts an extensive network of limestone sinkholes and caves, including the World Heritage-listed Naracoorte Caves (located approximately 30 km north of the licence area).

4.3 Land Systems and Soils

The licence area is predominantly located within the Millicent subregions of the broader South East biophysical region. Minor sections of the Gambier, Keith and Francis subregions are also located in the licence area.

Dominant land systems within the licence area include Atlantic Heath (23% are the licence area), Monbulla (12.9%), Nangwarry (9.7%), Kalangadoo (9.4%) and Krongart (9.2%). These land systems are broadly characterised as gently undulating plains with occasional sandy rises and dunes, with areas prone to waterlogging and swampy flats in swales (DEW 2019; 2019a).

Soils in the broader region vary from sandy pedal mottled-yellow duplex soils, red weakly structured sandy soils, bleached sands and black organic soils. Wetland areas, such as Bool Lagoon (located approximately 5 km north of PEL 494) are black self-mulching cracking clays. Dunes are comprised of a mix of deep sands (with marine shell fragments) and interdunal flats characterised by either heavier clays, that overlie limestone or sands that overlie clay. In places, sands have been hardened to rock by percolating groundwater. The swamps are comprised of medium and fine textured saline soils. Along the coast soils are mostly calcareous sand with some small areas of acidic and alkaline peats (SENRCC, 2003). Soils in the licence area are dominated by thick acidic sands over clay with areas of wet leached sands, that can be susceptible to seasonal waterlogging (DEW 2019; 2019a). A summary of land systems and associated soils present in the licence area is provided in Appendix B.

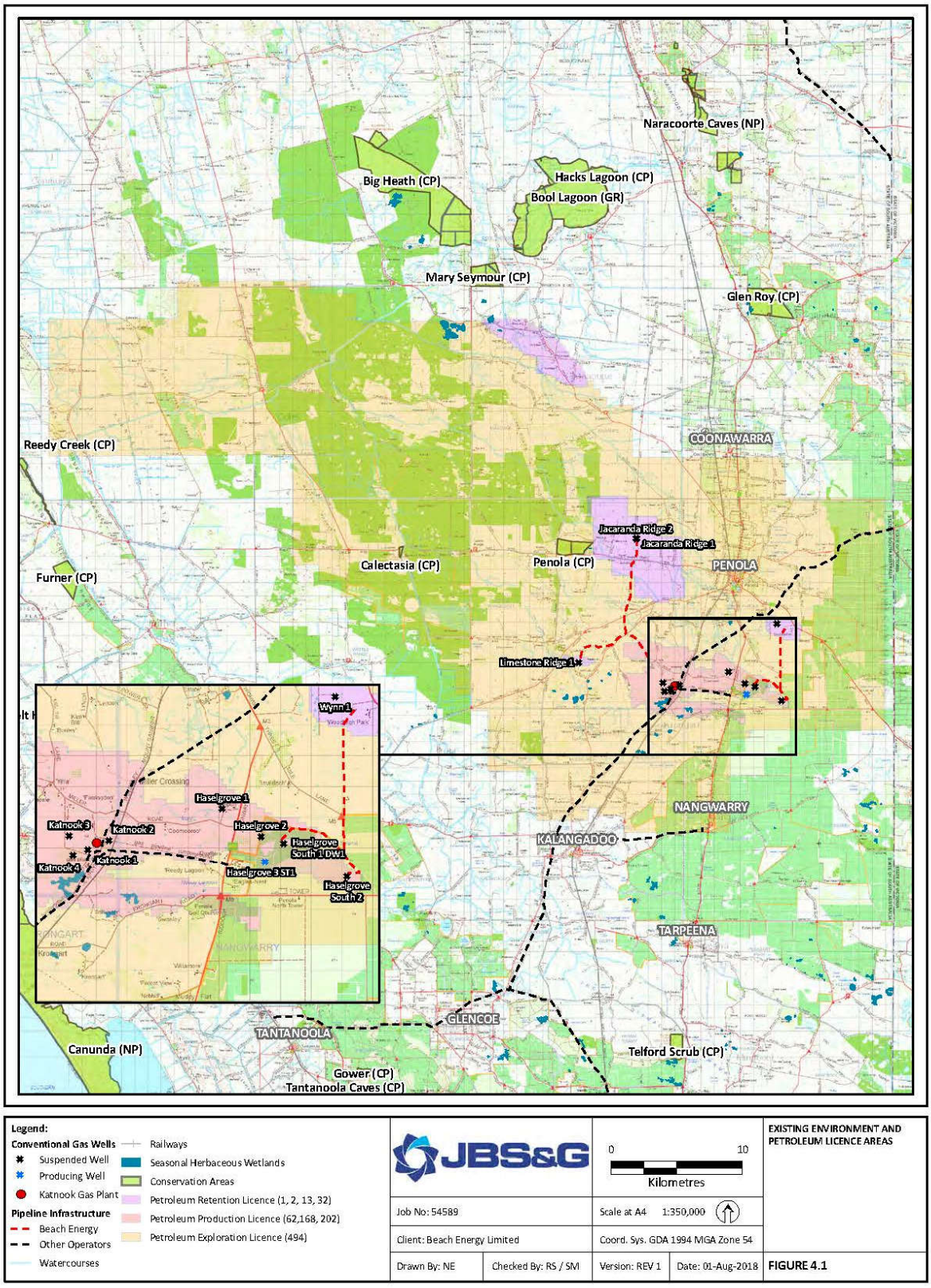


Figure 4-1: Existing environment and Beach Petroleum Licence Area

4.4 Petroleum Geology

The Otway Basin began to form in the Late Jurassic / Early Cretaceous as Australia began to separate from Antarctica about 145 million years ago.

Basement in the Otway Basin generally consists of Paleozoic igneous rocks and metasediments of the Kanmantoo Fold Belt. Some minor hydrocarbon recovery has occurred from fractured basement sections, when the fault geometry is favourable.

The earliest sediments to be deposited in the subsiding basin were shales of the Casterton Formation. This unit was deposited in a low energy environment (Kopsen and Schofield 1990) such as a lake and the organic material within is interpreted to be the source of the gas, condensate and oil discoveries in the South East of South Australia.

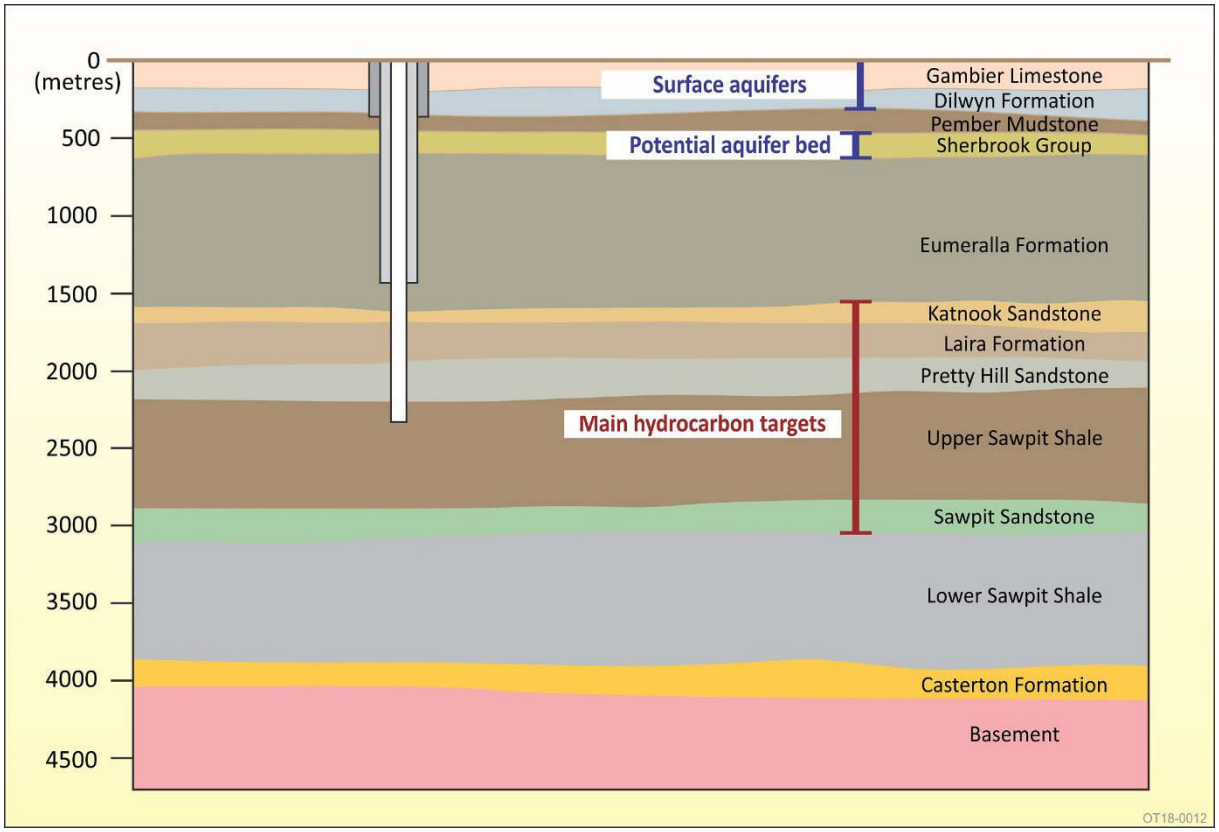


Figure 4-2: Indicative cross-section in the onshore Otway Basin, showing geological formations, shallow aquifers and the main hydrocarbon targets

Overlying the Casterton Formation are the Lower Sawpit Shale, Sawpit Sandstone, Upper Sawpit Shale, Pretty Hill Sandstone, Laira Formation and Katnook Sandstone. These were deposited during episodic rifting, driving crustal extension during the Lower Cretaceous. Like the Casterton Formation, the Lower Sawpit Shale was also deposited in a low energy environment and it may also be the original source of oil, gas and condensate discoveries.

The overlying Sawpit Sandstone and the younger sand units, the Pretty Hill Sandstone and Katnook Sandstone, are interpreted to be deposited in a braided stream environment and these units have traditionally been the main target of oil and gas exploration in the South East of South Australia as they are reservoir rocks. All three units have flowed gas or

gas / oil and condensate upon testing. For example, the Katnook Field produces gas that flows out of the Pretty Hill Sandstone reservoir.

The Upper Sawpit Shale and Laira Formations are comprised of siltstone and shale and were deposited in a low energy environment such as a floodplain or lake. Both of these units are important as they act as seals to the Sawpit Sandstone and Pretty Hill Sandstone respectively thereby trapping hydrocarbons at depth and isolating the reservoirs from the shallower aquifers.

A period of structural geological activity occurred after the Katnook Sandstone was deposited about 125 million years ago. The surface was uplifted and eroded before this period of activity waned and a thick sequence of interbedded shales, siltstones and fine-grained sandstones of the Eumeralla formation was deposited on a fairly low relief, slowly subsiding surface possibly in an expansive system of shallow lakes.

The overlying Sherbrook Group of Late Cretaceous age is a thin sandstone sequence in the northerly part of the South Australian Otway Basin, but in the south and particularly offshore, it thickens and can be subdivided into lithological units representing the facies of a delta system.

The overlying Tertiary aged sediments are also relatively thin onshore, consisting mainly of sandstones of the Dilwyn Formation and shales of the Pember Mudstone and fossiliferous limestones of the Gambier Limestone. The Dilwyn, Pebble Point and Pember formations were probably deposited in a fluvial-deltaic setting (Gravestock et al. 1986) and the overlying Gambier Limestone in a prograding marine sequence. All the Tertiary units thicken offshore. The Gambier Limestone and the Dilwyn Formation are important aquifers for the South East of South Australia.

Figure 4-2 shows an indicative cross-section in the onshore Otway Basin. Geological formations and near-surface aquifers of the Gambier Limestone and Dilwyn Formation are shown, along with the deeper formations targeted by Beach for conventional gas exploration.

4.5 Flora and Fauna

4.5.1 Vegetation Communities

There has been widespread vegetation clearance across the South East region. Remnant vegetation cover in the broader region is limited to approximately 10% of pre-clearance landcover. Remnant vegetation cover is highly variable and ranges from as low as 2.5% in the Mount Muirhead Hundred (north of Millicent) to 19% in the Waterhouse Hundred. Remnant vegetation mapping available for the licence area indicates vegetation cover ranges from approximately 8% to 14% (NatureMaps, 2019). Broad vegetation communities present include Eucalypt woodland and forest, Mallee, coastal shrublands, heath, shrublands, coastal tussock grasslands, sedgeland, and fernland (Croft *et al,* 1999). A list of floristic communities mapped in areas of remnant vegetation in the licence area is provided in Appendix C .

4.5.2 Biodiversity Values

The South East of South Australia, together within adjacent areas in Victoria, is considered one of Australia's 15 national biodiversity hotspots (DEE 2019). The South East region includes two Ramsar listed wetlands, with one (Bool Lagoon) located approximately 5 km north of PEL 494. A second Ramsar wetland, Piccaninnie Ponds Karst Wetland, is located at the coast approximately 55 km south of the PEL 494 southern boundary. The region is a transition zone, grading from the temperate climate to a more arid landscape in the west. As a result, species adapted to temperate environments as well as species adapted to more arid environments are both present.

More than 1,300 native flora species and 750 native fauna species have been recorded in the South East (Croft *et al,* 1999). Many of these species are restricted to the South East region, including 4% of the plants, 16% of the mammals, 9%

of the birds (excluding vagrants and seabirds), 8% of the reptiles (excluding sea turtles), 4% of the frogs and 5% of the fish.

4.5.3 Threatened Ecological Communities

As a result of widespread land clearance, several ecological communities in the South East are considered threatened. Of the 34 ecological communities that have been mapped in the South East, 27 are considered to be Threatened Ecological Communities (TECs) (i.e. they have less than 10% of pre-European settlement area remaining) (Croft *et al,* 1999).

South East TECs are typically grasslands, grassy woodlands, or are associated with wetlands and interdunal flats. These communities are now mainly confined to roadsides, railways, drainage reserves and small areas of Crown Land such as water reserves. These areas constitute significant areas of remnant vegetation (Croft *et al,* 1999).

A search of the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) Protected Matters Search Tool (PMST) (DEE, 2019a) for the licence area and surrounding region identified four nationally listed TECs that may or are likely to occur in the search area (refer to Table 4-2).

Table 4-2: EPBC Act listed TECs potentially occurring in the search area

TEC	EPBC Act Status	Type of Presence
Buloke Woodlands of the Riverina and Murray-Darling Depression Bioregions	E	May occur within area
Grey Box (*Eucalyptus microcarpa*) Grassy Woodlands and Derived Native Grasslands of South-eastern Australia	E	May occur within area
Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains	CE	Likely to occur within area
White Box-Yellow Box-Blakely's Red Gum Grassy Woodland and Derived Native Grassland	CE	May occur within area

Key: EPBC Act / NPW Act Conservation Status: R = Rare; V = Vulnerable; E = Endangered; CE = Critically Endangered

An area of Buloke Woodland is mapped to occur approximately 5 km north-east of the PEL 494 north-eastern boundary. The nearest mapped occurrences of White Box-Yellow Box-Blakely's Red Gum or Grey Box Grassy Woodlands are located approximately 10 km north-east of the PEL 494 north-eastern boundary (Naturemaps, 2019; DEE, 2019b).

Review of Commonwealth TEC and South Australian vegetation mapping indicates several mapped occurrences of Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains in the licence area. This ecological community was formally listed as a Critically Endangered TEC under the EPBC Act in March 2012 (TSSC 2012). The wetlands occur on lowland plains, where they are generally associated with fertile, poorly draining clays; in some cases, including Gilgai (shrinking / swelling mounded clay soil formations). The wetlands typically fill and dry annually, however, in a drought or unseasonal wet phase they may appear respectively ephemeral or permanent for occasional periods. They are generally very fresh, with salinities of less than 1,000 mg/L, however, during drying it is possible that they may evapo-concentrate, with salinities increasing up to 3,000 mg/L (Dickson *et al,* 2014). A Seasonal Herbaceous Wetland TEC is present approximately 150 m south of the Katnook gas plant site boundary. This area has been fenced to control stock access, particularly when the wetland is filled.

4.5.4 Threatened Flora

The South East supports a large number of threatened plant species, which predominantly occur within patches of remnant native vegetation. Several species listed under the EPBC Act and South Australian *National Parks and Wildlife Act 1972* (NPW Act) are recorded or predicted by databases to occur in the region. Searches of the Biological Database of South Australia (BDBSA) and the EPBC Act PMST were undertaken for records of listed flora in the licence area using a 5

km search buffer beyond the licence area boundary (henceforth referred to as the 'search area') (NatureMaps, 2019; DEE, 2019a).

The BDBSA search identified records for 148 flora species listed under the *National Parks and Wildlife Act 1972* (NPW Act) in the search area. The results included records for 28 Endangered, 35 Vulnerable and 85 Rare species. Further detail on listed species recorded in the search area is provided in Appendix C.

The PMST search identified 21 EPBC Act listed flora species that may potentially occur or have suitable habitat in the search area. BDBSA records indicate 8 EPBC Act listed flora species have been recorded in the search area (refer to Table 4-3).

Table 4-3: EPBC Act listed flora species recorded in the search area

Species	Common Name	Conservation Status	
		EPBC	SA
Caladenia formosa	Elegant Spider-orchid	V	V
Caladenia versicolor	Grampians Spider-orchid	V	E
Dipodium campanulatum	Bell-Flower Hyacinth Orchid	E	V
Dodonaea procumbens	Trailing Hop-bush	V	V
Glycine latrobeana	Clover Glycine	V	V
Prasophyllum spicatum	Dense Leek-orchid	V	E
Thelymitra epipactoides	Metallic Sun-orchid	E	E
Thelymitra matthewsii	Spiral Sun-orchid	V	E

Key: EPBC Act / NPW Act Conservation Status: R = Rare; V = Vulnerable; E = Endangered; CE = Critically Endangered

4.5.5 Threatened Fauna

The South East supports a range of threatened fauna species, and several species listed under EPBC Act NPW Act are recorded or predicted by databases to occur in the region. Searches of the BDBSA and the EPBC Act PMST were undertaken for records of listed fauna in the search area (as defined in Section 4.5.4) (NatureMaps, 2019; DEE, 2019a).

The BDBSA search identified records for 54 fauna species listed under the NPW Act in the search area. The results included records for 11 Endangered, 15 Vulnerable and 28 Rare species. Further detail on listed species recorded in the search area is provided in Appendix C.

The PMST search identified 25 EPBC Act listed fauna species that may potentially occur or have suitable habitat in the search area. BDBSA records indicate nine EPBC Act listed fauna species have been recorded in the search area (refer to Table 4-4).

Table 4-4: EPBC Act listed fauna species recorded in the search area

Species	Common Name	Conservation Status	
		EPBC	SA
Birds			
Botaurus poiciloptilus	Australasian Bittern	E	E
Calyptorhynchus banksii graptogyne	Red-tailed Black-cockatoo (south-eastern)	E	E
Hirundapus caudacutus caudacutus	White-throated Needletail	V	V
Rostratula australis	Australian Painted Snipe	E	E
Frogs			
Litoria raniformis	Southern Bell Frog	V	V
Mammals			
Miniopterus orianae bassanii	Large Bent-wing Bat / Southern Bent-wing Bat	CE	E
Fish			
Bidyanus bidyanus	Silver Perch	CE	-
Galaxiella pusilla (*G. toourtkoourt*)	Little Galaxias	V	-
Nannoperca obscura	Yarra Pygmy Perch	V	-

Key: EPBC Act / NPW Act Conservation Status: R = Rare; V = Vulnerable; E = Endangered; CE = Critically Endangered

4.5.6 Significant Migratory Species

Searches of the BDBSA and the EPBC Act PMST were undertaken for records of EPBC Act listed Migratory species in the search area (as defined in Section 4.5.4) (NatureMaps, 2019; DEE, 2019a).

The PMST search identified 19 EPBC Act listed Migratory species that may potentially occur or have suitable habitat in the search area. BDBSA records indicate four EPBC Act listed Migratory species have been recorded in the search area (refer to Table 4-5).

Table 4-5: EPBC Act listed Migratory recorded in the search area

Species	Common Name	Conservation Status	
		EPBC	SA
Apus pacificus	Fork-tailed Swift	MiG / MAR	-
Gallinago hardwickii	Latham's Snipe	MiG / MAR	R
Hirundapus caudacutus caudacutus	White-throated Needletail	MiG / MAR	V
Myiagra cyanoleuca	Satin Flycatcher	MiG / MAR	E

Key: EPBC Act / NPW Act Conservation Status: R = Rare; V = Vulnerable; E = Endangered; CE = Critically Endangered; MiG = Migratory; MAR = Marine.

4.5.7 Introduced Species

Weed Species

Twenty-two (22) weed species declared under the *Natural Resources Management Act 2004* (NRM Act) (now *Landscape South Australia Act* 2019 (LSA Act)) have been identified for priority management by the South East Natural Resources Management (SE NRM) Board (SE NRM Board, 2018) (now Limestone Coast Landscape Board). The Limestone Coast Landscape Board in accordance with the Limestone Coast Landscape Plan (previously South East NRM Plan) aims to eradicate two of these species from the region, significantly reduce the extent of a further five of these species and prevent the ongoing spread of fifteen of these species in the region. An additional 34 declared species have been identified as alert species, which although not present in the Limestone Coast Landscape Board region (or present in very limited numbers) are species with the potential to cause significant negative impacts if they become established (SE NRM Board, 2018).

Several weeds declared under the LSA Act and recognised as Weeds of National Significance (WoNS) have been recorded in the licence area and surrounding region. A search of the BDBSA was undertaken for records of listed weeds in the search area (as defined in Section 4.5.4) (NatureMaps, 2019). A summary of listed weeds recorded in the search area is provided in Table 4-6, and a list of priority and 'Alert' weed species in the Limestone Coast Landscape Region is provided in Appendix C.

Table 4-6: LSA Act and WoNS listed weed species recorded in the licence area

Species	Common Name	Status	
		NRM Act	WoNS
Asparagus asparagoides	Bridal Creeper	Declared	Yes
Cenchrus macrourus	African Feather-grass	Declared	No
Chrysanthemoides monilifera ssp. *monilifera*	Boneseed	Declared	Yes
Convolvulus arvensis	Field Bindweed	Declared	No
Crataegus monogyna	Hawthorn	Declared	No
Echium plantagineum	Salvation Jane	Declared	No
Eragrostis curvula	African Love-grass	Declared	No
Fraxinus angustifolia ssp. *angustifolia*	Desert Ash	Declared	No
Genista monspessulana	Montpellier Broom	Declared	Yes
Lepidium draba	Hoary Cress	Declared	No
Leptospermum laevigatum	Coast Tea-tree	Declared	No
Lycium ferocissimum	African Boxthorn	Declared	Yes
Marrubium vulgare	Horehound	Declared	No
Moraea flaccida	One-leaf Cape Tulip	Declared	No
Nassella leucotricha	Texas Needle Grass	Declared	No
Polygala myrtifolia	Myrtle-leaf Milkwort	Declared	No
Rosa canina	Dog Rose	Declared	No
Rosa rubiginosa	Sweet Briar	Declared	No

Species	Common Name	Status	
		NRM Act	WoNS
Rubus fruticosus sp. *aggregate*	Blackberry	Declared	Yes
Silybum marianum	Variegated Thistle	Declared	No
Solanum elaeagnifolium	Silver-leaf Nightshade	Declared	Yes
Ulex europaeus	Gorse	Declared	Yes
Watsonia meriana var. *bulbillifera*	Bulbil Watsonia	Declared	No
Xanthium spinosum	Bathurst Burr	Declared	No

Source: NatureMaps 2019

Pest Fauna Species

Twelve (12) key pest fauna species declared under the LSA Act have been identified by the Limestone Coast Landscape Board for priority management in the region. The goal of the Board is to eradicate two of the species from the region, significantly reduce the extent of occurrence of six species, and prevent ongoing spread of four species in the region (SE NRM Board, 2018). A list of the priority pest fauna species of the South East NRM Region is provided in Appendix C.

Pathogens

Pathogens of potential concern in the region include the soil-borne fungus *Phytophthora cinnamomi,* which affects a wide range of native plant species but is yet to be recorded in the region (SE NRM Board 2010), the grape vine insect pest *Phylloxera* (which has to date been excluded from South Australia), and diseases such as Ovine / Bovine Johne's Disease (OJD / BJD).

4.6 Water Resources

4.6.1 Surface water

The South East region has a low relief, with a general gradient toward the coast of 1:1600 and to the north less than 1:5000 (Croft *et al,* 1999). Across most of the region, surface water historically moved slowly towards the coast until meeting one of the ranges (the north-north-west trending low ridges), where it was directed northwards along the eastern side of the range. This resulted in extensive swamps and lakes, which were prevalent at the time of European settlement. There is generally a lack of surface streams and rivers, but where they exist, such as Morambro, Mosquito and Naracoorte Creeks, their catchments originate in western Victoria. Mosquito Creek discharges into the Ramsar listed wetlands of Bool and Hacks Lagoons.

Over the years an extensive drainage system has been constructed throughout the lower South East region to drain water from inundated land. This network has altered the movement of surface water, directing it in an east–west direction and discharging it to wetlands, lakes or the coast. The implementation of the drainage system has allowed formerly inundated land to be developed, minimising the effects of water logging and removing salt from the region. In some areas the drainage network has prevented wetlands from receiving water thus altering the usual wetting and drying process typical of these ecosystems. This has caused a decline or change in the biodiversity in some areas (Paydar *et al,* 2009).

4.6.2 Groundwater

Groundwater is the primary source of water for the South East and the region's economy, environment and community are all reliant upon this resource. Water resources in the area are also important from a social perspective as they provide drinking water, support recreation activities and enhance the appearance of the landscape. Many ecosystems are dependent on the groundwater of the region including wetlands, riparian vegetation and near coastal marine environments which are important tourist attractions that contribute to the regional economy (Brown *et al,* 2006).

The groundwater resource that underlies the South East encompasses some of the largest groundwater systems in Australia (Brown *et al,* 2006). The resource is made up of two distinct systems, an upper unconfined aquifer referred to as the Tertiary Limestone Aquifer (TLA) and a deeper confined aquifer referred to as the Tertiary Confined Sand Aquifer (TCSA). The flow of groundwater is generally in an east to west direction and originates from the topographic high of the Dundas plateau located in south-western Victoria (Paydar *et al,* 2009). Low permeability aquitards separate the two aquifers. Leakage through the aquitard has been assumed to be generally very low, except in areas where the aquitard is very thin, absent or fractured, such as around Tarpeena-Nangwarry (SE NRM Board, 2010). However, recent work has revealed moderate to good hydraulic connection between the two aquifers and indicated that they are more highly connected than previously assumed (SE NRM Board, 2013). The unconfined TLA is utilised more extensively than the TCSA, however there has been increased interest in the resource of the lower TCSA due to the recent allocation of most of the available groundwater from the TLA.

<u>Tertiary Limestone Aquifer (unconfined)</u>

The unconfined TLA is comprised mostly of Gambier Limestone with a water table depth varying from 2 m to greater than 20 m. The aquifer thickness varies over the region with a maximum of 300 m occurring south of Mount Gambier. As well as primary porosity, the aquifer has significant secondary porosity resulting from karstic features within the limestone. The secondary porosity creates paths for preferential flow and gives rise to high transmissivity (200 m^2 / day to 10,000 m^2 / day). Groundwater flow at the local scale can vary, largely as the result of spatial variability of recharge and discharge (Paydar *et al*, 2009).

Recharge of the aquifer occurs primarily through the diffusion of rainfall on the flats and dunal ranges. Local contributions include seepage from wetlands and swamps, surface water discharge into sinkholes and returns from irrigation drainage. Upward seepage of water from the TCSA may also recharge the TLA in locations where differences in hydraulic head between the aquifers permit flow. Mean annual rates of recharge vary from a few mm / year to more than 150 mm / year with higher rates occurring in locations of higher rainfall or highly permeable soils. Groundwater discharge from the TLA occurs mostly to the sea in the area south of Mount Gambier. Some minor drainage also occurs via drains, wetlands, streams, springs and seeps.

Groundwater salinity varies extensively over the aquifer with less than 500 mg/L found in the south and 3,000 mg/L to 7,000 mg/L in the north and is increasing at a significant rate in some locations.

Wells located between the townships of Naracoorte and Penola commonly exceed the resource salinity trigger value of 2% increase per year defined in the Water Allocation Plan (South East NRM Board, 2013). The increase in salinity levels is likely to be due to either the recycling of irrigation drainage water, vegetation clearance or forestry harvesting with the resulting mobilisation of salt caused by an increase in vertical recharge (South East NRM Board, 2013).

The water table has declined in some areas over the last 30 to 40 years and in other areas it has risen. In the area surrounding the Hundred of Stirling (located approximately 105 km north of PEL 494), the water table has fallen due to a drier climate and extraction of groundwater for irrigation, whereas in the upper South East, until recently, the water table was rising due to land clearing (Paydar *et al*, 2009). Throughout the Lower Limestone Coast, a review of the change in

depth to the water table in the 10 years to March 2012 revealed a general increase in depth to water, ranging from 0.5 metres to greater than two metres (South East NRM Board, 2013).

Tertiary Confined Sand Aquifer

The TCSA occurs in the Dilwyn Formation within an interbedded sequence of sands, gravel and clays. The aquifer has varying depth and increases in thickness towards the south reaching more than 500 m near the coast. The flow of groundwater is generally in a westerly or southerly direction towards the sea. The aquitard separating the TCSA from the upper TLA is comprised of clay and marl units at the base of the Gambier Limestone and a clay unit at the top of the Dilwyn Formation (SENRCC, 2003).

Recharge of the TCSA occurs at a slow rate (Brown et al. 2001), primarily on the eastern edge of the aquifer in Victoria and over some areas in SA. As there are very few areas in which the TCSA is exposed at the surface, vertical recharge is primarily through downward leakage of groundwater from the above TLA. This occurs mostly in the east where the head differences between the aquifers and the confining layer permit flow. The opposite is found in the west and south where the hydraulic head gradient provides the potential for upward flow of groundwater from the TCSA to the TLA (Brown *et al*, 2001).

Salinity of the groundwater within the TCSA is generally low, associated with low total dissolved solids (TDS) (less than 700 mg/L); however, there are areas where high salinity levels are found (associated with TDS of more than 1,500 mg/L) (Brown *et al*, 2001).

Deeper Units

Beneath the Dilwyn Formation is a number of deeper aquifers from the Late Jurassic, Early and Later Cretaceous and Tertiary ages of variable water quality and lateral extent down to over 4000 m, which demonstrate increasing salinity with depth (South East NRM Board, 2015). These aquifers are not used for irrigation, industrial or town water supplies due to their depth and generally high salinity (South East NRM Board, 2015). The aquifers within these deeper formations are noted in the Lower Limestone Coast Water Allocation Plan (South East NRM Board, 2015) as being of potential value as targets for petroleum and geothermal exploration and production.

4.7 Land Use

4.7.1 General Land Use

The South East region of South Australia is comprised of exceptionally fertile land accounting for three-quarters of the State's forests and one-third of its pastures. The area supports a diverse range of industries including wool, meat, dairy, cereal cropping, wine grapes, horticulture crops and crop and pasture seed production, all of which are heavily dependent upon water resources in the region. In general, the northern areas of the South East are used for cropping and the cooler, wetter southern areas are used for livestock grazing and forestry (Binks, 2000). Beef cattle are found throughout the region and are the most prominent livestock in the South East.

There are approximately 2,300 farms in the South East region with over 80,000 ha of this land being irrigated. Crops include cereals, pasture for seed, vegetables, vegetable seeds, oil seed, fruit and nuts and fodder crops. The largest areas of grapevines are seen in the long-established Coonawarra district and more recently in the Padthaway area (to the north of the licence area). The vineyards are located on slightly elevated areas within the plains in friable, highly permeable clays of moderate to high fertility. The lucerne seed industry is concentrated around the town of Keith (north of the licence area) and there is limited horticultural activity on the loams derived from volcanic ash and drained clay soils of Mount Gambier and Millicent respectively.

Since the establishment of forestry plantations in the late nineteenth century, the commercial forestry industry, has thrived in the area with over 150,000 ha currently planted, representing 84% of the State's total, encapsulating 35% of employment in the region and contributing an estimated $759 million and directly and indirectly to gross regional product (PIRSA 2017). Radiata Pine (*Pinus radiata*) and Tasmanian Blue Gum (*Eucalyptus globulus*) are the species most commonly planted and are located in the areas of highest rainfall on sandy soils.

Tourism is a large contributor to the local economy, with over 550,000 visitors to the South East region per year, directly employing 1,800 people (South Australian Tourism Commission 2017). Key attractions include coastal resorts at Robe and Beachport, Naracoorte Caves and Tantanoola Caves, Coonawarra, Wrattonbully, Padthaway and Mount Benson wine regions, Bool Lagoon and the Blue Lake (South Australian Tourism Commission, 2017).

Gas production occurs at Beach's Katnook Gas Processing Facility (located approximately 10 km south of Penola), which is fed by a network of pipelines from approximately 12 wells in surrounding gas fields. The Katnook Gas Processing Facility feeds into the South East Pipeline System, which supplies gas to regional industries and the town of Mount Gambier. Gas production from the Katnook facility had declined in recent years, with the majority of the gas fed into the South East pipeline system being obtained from the SEA Gas pipeline via the SESA pipeline, which runs from Poolaijelo in Victoria to Katnook.

In 2018, Beach Energy announced the discovery of a conventional natural gas field at the Haslegrove-3-ST1 well, located approximately 6 km to the east of Katnook. In January 2020, the Haselgrove-3-ST1 well flowed gas into the Katnook Gas Processing Facility and became the sole source of gas supply into the South East market. Origin Energy's 86 MW Ladbroke Grove power station is located adjacent to the Katnook facility, and it provides peak power from its gas-fired turbines during periods of high demand for electricity.

4.7.2 Conservation Areas

The Limestone Coast Landscape Region contains three National Parks, 53 Conservation Parks and four Game Reserves established under the NPW Act (SE NRM Board, 2010). Nine reserves established under the NPW Act are located in the vicinity of, within or overlap the licence area and are shown in Figure 4-1:

- Big Heath Conservation Park (6 km north of PEL 494)
- Bool Lagoon Game Reserve (5 km north of PRL 13)
- Hacks Lagoon Conservation Park (12 km north of PRL 13)
- Mary Seymour Conservation Park (2.5 km north of PRL 13)
- Glen Roy Conservation Park (14 km east of PRL 13)
- Penola Conservation Park (within PEL 494 and immediately to the west of PRL 32)
- Calectasia Conservation Park (within PEL 494)
- Reedy Creek Conservation Park (2 km west of PEL 494)
- Furner Conservation Park (8 km south west of PEL 494).

This EIR and the SEO do not cover activities in reserves established under the NPW Act or exploration activities immediately adjacent to a Marine Park established under the *Marine Parks Act 2007*.

The region also includes a number of other protected areas, including Native Forest Reserves established under the *Forestry Act 1950* and Heritage Agreement Areas established under the *Native Vegetation Act 1991*.

Bool and Hacks Lagoons are listed as wetlands of international importance under the 1971 Ramsar Convention and are consequently covered by the Commonwealth EPBC Act.

The World Heritage-listed Naracoorte Caves are located in the Naracoorte Caves National Park and lie to the north of the licence area. This site is also covered by the EPBC Act.

4.8 Social Environment

The Limestone Coast Landscaperegion covers seven local government areas (LGAs), and the Beach licence area is situated in two LGA including:

- Wattle Range Council
- Naracoorte Lucindale Council.

Penola is the largest population centre in the licence area. Penola has a population of approximately 3,117 people (ABS 2016). Other population centres in proximity to the licence area include Naracoorte (located to the north of PEL 494), Millicent (located to the south of PEL494), Lucindale (located to the north of PEL 494), as well as popular holiday destinations including Robe and Beachport along the coast.

Population statistics for the LGAs are provided in Table 4-7. Census data from 2016 for the LGAs indicates the population of 19,968 is distributed relatively evenly across ages 0 to 64. However, there is a steady proportional population decline in older age cohorts. The median weekly household income across the two LGAs ranged from $1,023 to $1,203 (in 2016); this compares to a median weekly household income of $1,206 across South Australia.

Table 4-7: Population by Local Government Area

Local Government Area	Male	Female	Total
Wattle Range Council	5,893	5,784	11,677
Naracoorte Lucindale District Council	4,308	3,984	8,291

Source: Australian Bureau of Statistics Census Data 2016

The main industries of employment in the region are agriculture, forestry and fishing, with manufacturing employing the second highest number of workers. The high levels of employment within the agriculture, forestry and fishing industry reflects the economic importance of agricultural production within the region.

4.9 Aboriginal Cultural Heritage

Beach's petroleum licences are located within the First Nations of the South East#1 (SC2017/002) Native Title claim area (Registered November 2017). The South Australian Native Title Services (SANTS) are the contact group for the claim, and the claimants have instructed Beach that the South East Aboriginal Focus Group will continue to manage heritage matters for Beach's operational area.

Aboriginal Affairs and Reconciliation (AAR), Department of the Premier and Cabinet, advised Beach in June 2019 that the Central Archive and the Register of Aboriginal Sites and Objects, currently holds records for four Aboriginal sites located

in the licence area (Figure 1-1). Three of these sites are archaeological sites, while the fourth is culturally significant. Importantly, it should be noted that this register is not comprehensive, and it does not capture undiscovered sites.

As discussed in Section 2.2, the *South Australian Aboriginal Heritage Act 1988* (Act) provides protection for all Aboriginal sites, objects and remains across South Australia. Beach complies with this legislation, by ensuring that all first or additional surface disturbance activities are assessed by the local Aboriginal group or other appropriate specialists as required before disturbance commences (refer to Section 3.6.2). Further, Beach land access and cultural heritage procedures ensure that any sites identified are not disturbed during petroleum activities through compliance with Beach inductions, pre-works checklists, and field site identification pickets.

4.10 Non-Aboriginal Cultural Heritage

A desktop review of South Australian heritage places was undertaken using the South Australian Heritage Places GIS dataset (DEW, 2019b). The datasets provide a comprehensive listing and spatial location of State and Local heritage places. A search of the licence area identified 18 State Heritage Places and 87 Local Heritage Places. The majority of these heritage places are buildings (including houses, churches, cottages, art galleries, libraries, schools, barns, hotels and shops) located in or near Penola. There are three isolated heritage places located within 10 km of the boundary of Beach's PRLs and PPLs. The Yallum Park homestead and Austin Cottage dwelling are located approximately 3 km north East of PPL 168, and Kalangadoo House is located approximately 9 km south west of PPL 202.

State Heritage Places located in the region vary with sites including former dwellings, farming homesteads, railway stations, schools, churches, hotels and cemeteries. Local heritage places located in the region are also diverse, ranging from houses, sheds, homesteads and churches to bridges, shopping centres, and recreational parks.

A search of the Australian Heritage Database (AHD, 2019) did not identify any World, Commonwealth or National Heritage listed places in the licence area.

The Australian Fossil Mammal Sites (Riversleigh / Naracoorte), which is a registered World Heritage and National Heritage site, is located in close proximity to the licence area, with the majority of the site located approximately 19 km north of the PEL 494 northern boundary.

5 Environmental Impact Assessment

This section discusses potential environmental impacts related to undertaking geophysical survey activities in the onshore Otway Basin.

The discussion is supported by an environmental risk assessment. The risk assessment is presented in Table 5-1 (in Section 5.8), which outlines the key hazards, management measures and resulting level of risk.

The following discussion summarises key management measures that will be implemented, with the detail provided in Table 5-1.

Reference is made to the results of the risk assessment where relevant throughout the discussion.

5.1 Soil and Groundwater

Potential impacts to soil and groundwater arise mainly from:

- Earthworks for infrastructure construction (access track, camp site, laydown and magazine) and rehabilitation / restoration activities (e.g. erosion, inversion, compaction);
- Minor disturbance to soil due to seismic survey and drilling activities;
- Spills or leaks associated with storage and handling of fuel, oil and chemicals, seismic survey machinery and drilling equipment;
- Storage, handling and disposal of waste; and
- Drilling and use of explosives.

<u>Earthworks</u>

Earthworks for infrastructure construction and rehabilitation / restoration activities have the potential to cause localised impacts to soil through inversion, compaction or increased erosion risk.

In order to minimise surface impacts and facilitate rehabilitation, landholders will be consulted regarding the earthworks required, the location of seismic lines, drilling sites, access tracks, camp sites, laydown yards, explosive storage magazines and other relevant issues.

Topsoil is removed from areas planned to be paved with gravel (e.g. some camp sites, laydowns, magazines and access tracks will be paved) and stockpiled for use in rehabilitation / restoration. Paving material (gravel) is imported from a licensed quarry. The bulk of paving materials are usually removed during rehabilitation / restoration (unless the landholder requests they are retained) and stockpiled topsoil re-spread over the site.

Disturbance to soil from site preparation, and construction activities, is relatively localised and restricted to a defined and agreed survey or work area. Rehabilitation / restoration will be undertaken in consultation with the landholder, with measures such as ripping of compacted soils, replacement of topsoil that has been removed, restoration of soil profiles and contours, and reseeding implemented to ensure rehabilitation success (refer to Section 0 for further detail).

Minor disturbance to soil due to seismic survey activities

Following completion of seismic survey operations, some localised disturbance to soil (e.g. wheel rutting, compaction) at drilling sites and on seismic lines may be present. These disturbances generally rehabilitate naturally within a short period of time following natural processes e.g. rainfall and regrowth vegetation. These impacts are minimised through planning processes to avoid sensitive areas (as discussed in Section 3.6.1) and there is usually a high spatial tolerance to orientate survey designs to minimise surface disturbance and utilise pre-disturbed areas.

Spills or leaks

Improper transportation, storage and handling of fuel, oil and chemicals has the potential to result in localised contamination of soil and shallow groundwater. In order to minimise this risk, fuel, oil and chemicals stored on site are stored and handled in accordance with relevant standards and guidelines (e.g. AS 1940, EPA guideline *080/16 Bunding and Spill Management* and the Australian Dangerous Goods Code), and Safety Data Sheets (SDS). Fuel, oil and chemicals will be stored in their product containers with appropriate secondary containment (e.g. lined, bunded areas or on self-bunded pallets). Bulk storage and handling of fuel and chemicals is restricted to designated areas i.e. typically paved laydown or camp areas.

Vehicles, drilling equipment and associated seismic survey equipment have the potential to cause minor leaks of fuel and chemicals during the course of geophysical survey operations. All vehicles, drill equipment and associated equipment will be operated and maintained in accordance with specifications to minimise the potential for a spill or leak (e.g. oil leak or hydraulic hose failure).

Chemical and fuel storage procedures, including signage, are reviewed and monitored in audit process in accordance with relevant Beach standards.

Appropriate emergency / spill response procedures will be in place for any losses of containment, and spills will be immediately cleaned up and any contaminated material removed off-site for appropriate treatment or disposal at an EPA licensed facility. All losses of containment and spills, no matter how minor, will be immediately reported to the Beach Operations Supervisor.

If larger scale spills occur, that cannot be immediately contained and cleaned-up, they would be assessed and remediated in accordance with the *National Environment Protection (Assessment of Site Contamination) Measure 1999*, amended 2013 (NEPM). Affected areas would be fenced if a threat is posed to people, stock or wildlife.

Storage, handling and disposal of waste

Inappropriately managed waste has the potential to result in localised disturbance or contamination of soil and shallow groundwater. Storage of waste and transport to licensed disposal or recycling facilities will be undertaken in accordance with relevant legislation and guidelines. Waste generation will be minimised where practicable, waste will be securely stored and licensed waste transport contractors will be used.

As discussed in Section 3.6.6 , all wastewater will be stored and disposed of in accordance with the *South Australian Public Health (Wastewater) Regulations 2013* or to the satisfaction of the Department of Health) and consistent with the *Environment Protection (Water Quality) Policy 2015*.

Excess drill cuttings will be removed from site and disposed of at an appropriately licensed waste management facility unless otherwise agreed with the landowner.

Drilling and use of explosives

Drilling fluids in the down-hole environment have the potential to invade freshwater aquifers near the drill hole and cause localised contamination. Water based drilling muds will be used if mud drilling is undertaken to avoid contamination of the freshwater aquifers near the drill hole. Drilling, backfilling and plugging of all drill holes will be undertaken in accordance with relevant industry standards and guidelines to avoid aquifer contamination or crossflow, as discussed in Section 3.6.3. Any monitoring bores that are drilled (e.g. fibre optic monitoring bore holes) will also be constructed in accordance with relevant industry standards to ensure that crossflow between aquifers is prevented.

If buried explosive charges fail to detonate, there is potential for localised impact on aquifer water quality in the vicinity of the charge. Seismic charges are encased in sealed hard-plastic shells, which limits the potential for migration of water-soluble components such as TNT prior to detonation, however undetonated charges could release these components over time. Practices for installation and detonation (e.g. multiple detonators, appropriate waterproofing) minimise the chance of detonation failure, and failure rates are very low (e.g. significantly less than 1%). Seismic charges such as Geoprime dBX are also designed with micro-organisms incorporated directly into the charge to facilitate bioremediation of undetonated explosive when submerged in water.

Adequate buffer distances (vertical and horizontal) between buried seismic charges and groundwater wells will be incorporated into survey design. Additional monitoring or mitigation (e.g. sympathetic detonation) could be implemented for unexploded charges if required to manage any risks identified.

Physical impact of buried explosive charges on the surrounding formation is very limited, with detonation resulting in a small radius of rock around the charge to be fractured (typically less than 2 m) and with the implementation of adequate buffer distances this would not impact groundwater infrastructure, and would not affect aquifer transmissivity.

Risk Assessment

The level of risk has been assessed as low for most of these potential hazards (see Table 5-1). A medium risk is assigned for spills or leaks; although it is unlikely to occur, the consequence is moderate (see Table 5-1). A medium risk is also assigned for use of buried seismic charges; although it is not likely to occur with the measures in place, the consequence of localised contamination is moderate. Note: Risks have been assessed taking into consideration the high importance of groundwater (the unconfined Tertiary Limestone Aquifer) in the region.

5.2 Surface Water

Potential impacts to surface water arise mainly from:

- Earthworks for infrastructure construction (access track, camp site, laydown and magazine) and rehabilitation / restoration activities (e.g. disturbance to natural drainage patterns, increased erosion / sedimentation risk)
- Minor disturbance to surface water due to seismic survey and drilling activities (e.g. minor disturbance to natural drainage patterns, increased erosion / sedimentation risk)
- Spills or leaks associated with storage and handling of fuel, oil and chemicals, seismic survey machinery and drilling equipment; and
- Storage, handling and disposal of waste.

Earthworks

Earthworks for infrastructure construction and rehabilitation / restoration activities have the potential to alter natural drainage patterns or result in increased sedimentation of surface water features. This can potentially impact native vegetation and fauna (particularly wetland communities) as discussed in Section 5.3.

Geophysical survey areas and associated infrastructure will be located, prepared and / or constructed to avoid significantly impacting surface drainage patterns or surface water features. Where necessary, temporary culverts will be installed to ensure natural surface drainage is maintained. Landholders are consulted regarding crossings of features such as drainage channels and appropriate measures (e.g. culverts) are installed where required. 'Water affecting activities' (as defined by the LSA Act and Limestone Coast Landscape Plan) are not undertaken unless relevant permits have been obtained. Sites will be rehabilitated to restore natural surface profiles and original drainage patterns.

The soil types, general lack of defined drainage and relatively flat nature of the licence area result in a relatively low risk of erosion or sedimentation. Sediment and erosion control structures such as sediment fences are typically not necessary, but they would be installed where required (e.g. if in close proximity to drains or surface water features). Any requirements for sediment and erosion control measures are specified in site specific documentation prepared at the regulatory activity notification stage.

Minor disturbance to surface water due to seismic survey and drilling activities

Following completion of drilling and seismic survey operations, some localised disturbance to soil and areas of natural surface water movement (e.g. wheel rutting) at drilling sites and on seismic lines may have potential to cause minor impacts to surface water e.g. minor disturbance to natural drainage patterns / surface water flow, increased erosion / sedimentation risk. These disturbances generally rehabilitate naturally within a short period of time following natural processes e.g. regrowth of vegetation to stabilise soil and mitigate erosion and sedimentation risk. These impacts are minimised through planning processes to avoid sensitive areas such as drainage crossings (as discussed in Section 3.6.1) and there is usually a high spatial tolerance to orientate survey designs to minimise surface disturbance and utilise pre-disturbed areas. However, as discussed in the Earthworks section above, erosion and sedimentation control measures and restoration of natural drainage profiles will be undertaken as required to mitigate potential impacts.

Spills or leaks

The principal risk to surface water results from the transport and handling of fuels, oils, chemicals and the potential movement off-site of contaminated material from spills or leaks. Measures discussed in Section 5.1 will be implemented to ensure safe storage and handling of fuel and chemicals. Spill containment and clean-up equipment would be present on-site during operations. Refer to Section 5.1 for further detail on spill and leak management. Potential runoff from bunded fuel or chemical storage areas would be similarly contained, and spills / contaminants would not be allowed to drain off-site.

Storage, handling and disposal of waste

Measures to ensure secure storage and handling of waste will be implemented as outlined in Section 5.1.

Risk Assessment

The level of risk has been assessed as low for identified potential impacts to surface water (see Table 5-1). A medium risk is assigned for spills or leaks; although it is unlikely to occur, the consequence is moderate (see Table 5-1).

5.3 Native Vegetation and Fauna

Potential impacts to native vegetation and fauna arise from:

- Earthworks and vegetation clearing activities for infrastructure construction (access track, camp site, laydown and magazine) and rehabilitation / restoration; and minor vegetation disturbance associated with seismic survey and drilling activities
- Disturbance from site activities (e.g. light, noise, vibration, presence of machinery, camp sites and personnel)
- Use of roads and movement of heavy vehicles and machinery
- Access to contaminants (e.g. spills and leaks) and waste by wildlife (and stock)
- Risk of weed introduction; and
- Fire.

<u>Earthworks and vegetation clearing activities, and minor vegetation disturbance associated with seismic survey and drilling activities</u>

Earthworks and vegetation clearing activities have the potential to damage native vegetation and wildlife habitats (including wetland communities) and disturb or injure fauna. In the onshore Otway Basin, a large proportion of the native vegetation has been cleared or heavily modified for agriculture and forestry. Consequently, the clearance of native vegetation for access tracks, camp sites, laydowns and magazines can generally be avoided by locating this infrastructure in previously cleared or disturbed areas.

As discussed in Section 5.1, there is generally significant spatial tolerance to locate geophysical survey designs and associated infrastructure to minimise surface disturbance, and prioritise use of pre-disturbed areas. Typically, environmental sensitivities such as remnant native vegetation, presence of listed species or habitat and significant wetland areas are identified early during the planning process (refer to Section 3.6.1), and appropriate modifications are made to ensure activities are located to minimise disturbance to sensitive areas and maximise use of pre-disturbed areas.

Geophysical surveys are also subject to environmental assessment during the planning and regulatory approvals process to ensure sensitivities and environmental values are identified and disturbance avoided. Disturbance to large trees, hollow bearing trees, high quality native vegetation and significant wetland areas will be avoided[5]. Low quality native vegetation will also be avoided unless there are no viable alternatives (e.g. use of adjacent cleared areas). Where minor disturbance to vegetation is unavoidable, appropriate avoidance and/or impact mitigation strategies will be developed and implemented, including use of impact mitigation / management strategies (e.g. use of vegetation slashing and mulching machinery) as described in Section 3.6.3.

As discussed in Section 5.2, erosion and sedimentation control measures and restoration of natural drainage profiles will be undertaken as required to mitigate potential impacts, which will avoid/mitigate potential indirect impacts on native vegetation, fauna and particularly wetland communities as result of earthworks activities.

[5] Site-specific assessment by an appropriately qualified specialist would be used to determine whether vegetation meets these parameters.

Disturbance from site activities

Potential disturbance to wildlife from site activities (e.g. light, noise, vibration, presence of machinery, camp and personnel) is short term, localised and generally of limited significance in the region given the existing land uses and extent of vegetation clearance and habitat modification. The environmental assessment undertaken during the planning process will identify whether there are specific issues within a particular survey area (e.g. breeding of the Endangered Red-tailed Black-Cockatoo, or likely indirect impacts to adjacent conservation reserves), and changes to the survey design, and / or mitigation measures, would be made / developed to avoid potential impacts. Relevant agencies (e.g. DEW, DAWE) would be consulted during regulatory environmental approvals process where required.

The presence of excavations / voids on site (e.g. drill holes, small pits for septic tanks) may present short-term potential for localised impacts to wildlife (and stock). The presence of site personnel and the typically short period of time these voids would be accessible will generally preclude impacts to medium to larger species, with some minor short-term risk posed to smaller species. Where required to be left open for an extended period (e.g. overnight), any voids would be appropriately covered or fenced to mitigate potential for impacts.

Use of roads and movement of heavy vehicles and machinery

The movement of vehicles and machinery along roads and access tracks has the potential to impact wildlife, principally through collisions. This is likely to be relatively insignificant due to the level of existing traffic, the short-term nature of the activities and the limited extent of significant fauna habitats in the licence area. Transport procedures (e.g. speed restrictions, limitation of movements at night) will also reduce the potential level of impact.

Access to contaminants (e.g. spills and leaks) and waste by wildlife (and stock)

The potential for wildlife (and stock) to access contaminants and waste is limited. As discussed in Section 5.1, fuel, oil and chemicals will be stored in their product containers with appropriate secondary containment (e.g. lined, bunded areas or on self-bunded pallets). Bulk storage and handling of fuel and chemicals is restricted to designated areas. Contaminants from spills or leaks are likely to be confined to designated areas (e.g. camp sites, laydowns), and will be immediately cleaned up. Waste will be stored in covered bins before being transported off-site for disposal.

Risk of weed introduction

The introduction of weeds or pathogens by vehicles and equipment (particularly earthmoving and vegetation slashing / mulching equipment) poses a potentially significant impact to land and biodiversity. A range of measures will be undertaken to manage the potential for the introduction or spread of weeds or pathogens (refer to Section 5.4 for further information).

Fire

Fire initiated by site activities (e.g. sparks from vehicles or equipment) has the potential to impact large areas of vegetation. Measures will be in place to prevent fires including firebreaks, restriction of vehicles to tracks, seismic lines and cleared areas, maintenance of suitable fire-fighting equipment on site and liaison with the CFS.

Risk Assessment

The level of risk has been assessed as low for these potential hazards (see Table 5-1).

5.4 Land Use

Potential impacts to land use arise from:

- Earthworks for infrastructure construction (access track, camp site, laydown and magazine) and rehabilitation / restoration; and minor surface disturbance associated with seismic survey and drilling activities
- Disturbance from site activities (e.g. light, noise, vibration, presence of machinery, camp sites and personnel)
- Use of roads and movement of heavy vehicles and machinery
- Access to contaminants (e.g. spills and leaks) and waste by stock
- Risk of weed introduction; and
- Fire.

Further detail on noise and vibration, and other potential impacts to landholders are discussed under 'Landholders and local community' in Section 5.5.

Earthworks and surface disturbance associated with seismic survey and drilling activities

Earthworks for infrastructure construction and rehabilitation / restoration and minor surface disturbance associated with seismic survey and drilling activities have the potential to affect land use through disturbance to soil, groundwater, vegetation and surface water within the footprint of the activity (as discussed in Sections 5.1 to 5.3). Measures discussed in these previous sections will be implemented to ensure impacts are minimised and appropriate rehabilitation / restoration is undertaken.

Poor planning and execution of site preparation, construction and rehabilitation / restoration activities also pose the potential to cause impacts to land use beyond the activities' direct footprint, for example, if access tracks or camp sites are not sited to minimise disruption to overall property access and management. Landholders will be consulted regarding the location, management and timing of proposed activities and infrastructure, with the aim of minimising disturbance. Ongoing liaison with landholders is carried during all stages of operations.

Appropriate locations for geophysical survey infrastructure, particularly any access tracks, are chosen in consultation with landholders, and any deterioration of property tracks or infrastructure as a result of geophysical survey related traffic and activities is rectified. Previous experience in the Otway Basin has indicated that any access tracks required can generally be located so they can become valued infrastructure, provide additional all-weather access across a property, and provide a long-term benefit to property operations.

Disturbance from site activities

Geophysical survey activities and transport moves have the potential to disturb and possibly injure stock or interfere with other land use activities. Consultation with landholders is undertaken to ensure that the location and timing of activities minimise the potential for impact. Measures in place to minimise impacts include speed limits, fencing of access tracks if required, positioning lighting to minimise light emanating from camp sites, and prompt removal of machinery and equipment and camps from site following the completion of operations.

The presence of excavations / voids on site (e.g. drill holes, small pits for septic tanks) may present short-term potential for localised impacts to stock (and wildlife). The presence of site personnel and the typically short period of time these

voids would be accessible will generally preclude impacts to medium to larger species, with some minor short-term risk posed to smaller species. Where required to be left open for an extended period (e.g. overnight), any voids would be appropriately covered or fenced to mitigate potential for impacts.

Use of roads and movement of heavy vehicles and machinery

The movement of vehicles and machinery along roads and access tracks has the potential to impact land use and infrastructure through increased risk of road hazards to local road users, generation of noise and dust, potential for interactions with domestic stock and agricultural operations, and degradation of unsealed roads and tracks.

Transport procedures (e.g. speed restrictions, limitation of movements at night) will also reduce the potential level of impact. Liaison with landholders will occur to ensure use of roads and tracks is undertaken to minimise impacts to landholders wherever practicable. Impacts of road use are generally short term, with peak traffic movements occurring during initial and final mobilisation to and from a project location. Landholders, local councils, potentially affected residents and police will be informed of significant activities such as initial project mobilisation and final demobilisation. Warning signs and traffic management measures will be installed where appropriate near survey locations. Project mobilisations will be restricted to daylight hours as far as possible. Any deterioration of property tracks or infrastructure as a result of geophysical survey related traffic will be rectified in consultation with landholders.

Access to contaminants (e.g. spills and leaks) and waste by stock

The potential for stock to access contaminants and waste is limited. As discussed in Section 5.1, fuel, oil and chemicals will be stored in their product containers with appropriate secondary containment (e.g. lined, bunded areas or on self-bunded pallets). Bulk storage and handling of fuel and chemicals is restricted to designated areas. Contaminants from spills or leaks are likely to be confined to designated areas (e.g. camp sites, laydowns), and will be immediately cleaned up. Waste will be stored in covered bins before being transported off-site for disposal.

Risk of weed introduction

The introduction of weeds or pathogens by vehicles and equipment (particularly earthmoving and vegetation slashing / mulching equipment) poses a potentially significant impact to land use (and biodiversity). A range of measures will be undertaken to manage the potential for the introduction or spread of weeds or pathogens, including:

- consultation with landholders and Limestone Coast Landscape Board officers to identify any potential issues or specific management requirements
- ensuring that vehicles and equipment arriving at the site are clean and free of soil and plant material
- assessment of vehicles and equipment entering the region or moving between sites (especially from weed or pathogen infested areas into non-infested areas) for the risk of transporting weeds and pathogens and cleaning them down where appropriate
- using local earthworks contractors where possible rather than bringing in equipment from outside the region
- sourcing of any paving / drill hole backfilling materials from licensed quarries that are free of weeds
- monitoring sites and access tracks for new weed infestations, with treatment undertaken as necessary in accordance with requirements of the landholder, and if appropriate the Limestone Coast Landscape Board.

Under the Petroleum and Geothermal Energy Act, landholders have rights to compensation under specific circumstances where impacts to land use occur and compensation agreements are agreed and put in place before undertaking any activities.

Compensation is payable where there is:

- deprivation or impairment of the use and enjoyment of the land
- damage to the land (not including damage that has or will be made good by the licensee)
- damage to, or disturbance of, any business or other activity lawfully conducted on the land; and
- consequential loss.

Fire

Fire initiated by site activities (e.g. sparks from vehicles or equipment) has the potential to significantly impact land use (e.g. via damage to pasture, forestry, crops and infrastructure). Measures discussed in Section 5.3 will be in place to prevent fires including firebreaks, restriction of vehicles to tracks, seismic lines and cleared areas, maintenance of suitable fire-fighting equipment on site and liaison with the CFS.

Risk Assessment

The level of risk has been assessed as low for these potential hazards (see Table 5-1).

5.5 Landholders and Local Community

Potential impacts to landholders and the broader local community arise principally from:

- Disturbance from site activities (e.g. presence of seismic survey activities, equipment and machinery, camp sites and personnel) and generation of noise, light, dust and vibration
- Increased traffic, use of roads and movement of vehicles and heavy machinery
- Explosive use, storage and handling
- Potential for unauthorised site access; and
- Fire.

Disturbance from site activities and generation of noise, light, dust and vibration

Disturbance from site activities (e.g. seismic lines and drilling locations, and the presence of machinery and equipment, camp and personnel) can result in potential for short term impacts to landholders and nearby residents. A range of measures will be implemented to manage these potential impacts. Landholders and other stakeholders (e.g. the local council) will be consulted regarding proposed activities where appropriate, with the aim of identifying potential issues and minimising disturbance. Construction and survey preparation activities will be restricted to daylight hours.

The timing and location of geophysical survey activities (e.g. seismic lines and drilling locations) is typically undertaken in consultation with landholders to minimise economic impacts and disruption to landholder activities. Disturbance to areas

of importance to landholders (e.g. agricultural land, vineyards, forestry plantations, dams, stock yards and residential areas) is typically avoided by relocating or offsetting the location of seismic survey activities.

Furthermore, as noted in Section 5.4, landholders have rights to compensation under specific circumstances where impacts to land use occur, and compensation agreements are agreed and put into place before any activities are undertaken.

Noise limitations will be included as part of induction procedures, with a focus on noise minimisation during early morning and evening activities (e.g. unnecessary use of horns, reversing of machinery). Adequate buffer distances will be maintained between activities and residences, and systems will be in place for logging stakeholder complaints to ensure that issues are addressed as appropriate. Assessment of potential noise impacts from a site-specific activity will be undertaken as appropriate during design and planning stages.

Lighting will be positioned to minimise light emanating from camp sites during operations. Machinery, equipment and camps will be promptly removed from site following the completion of operations, particularly in visible locations.

Generation of dust during geophysical survey and site construction activities, and general use of unsealed roads and tracks, can result in temporary and localised impacts to air quality. Dust generation will be minimised by restriction of speeds on unsealed roads and spraying of unsealed roads with water to moderate the potential for dust generation where required.

Generation of vibration associated with geophysical survey activities is largely associated with localised disturbances associated with vibroseis trucks and buried sources. As discussed in Section 3.3.1, vibroseis produces a low energy density, which allows it to be used in cities and other built-up areas. Vibroseis has been used in sensitive locations without damaging buildings or the environment (APPEA, 2019).

Detonation of seismic charges in shot holes results in a minor localised sound (i.e. small thud). Implementation of adequate buffer distances will be maintained to ensure vibrations generated by the proposed activities do not result in significant disturbance to the community and residences or damage to infrastructure, and systems will be in place for logging stakeholder complaints to ensure that issues are addressed as appropriate.

Explosive use, storage and handling

Explosives use, storage, handling and disposal will be undertaken in accordance with relevant industry codes, standards and guidelines (e.g. Australian Dangerous Goods Code), and the requirements of the South Australian *Explosives Act 1936* and *Explosives Regulations 2011*.

Explosives will only be handled and utilised by appropriately trained and licensed personnel (i.e. holders of a SafeWork SA Blaster's Licence).

Explosives are required to be stored in an approved receptacle, store or magazine. Magazines will typically take the form of a transportable shipping container type structure. A licence to store explosives and a magazine licence may also be required depending on the volume of explosive stored at any one time.

Increased traffic, use of roads and movement of vehicles and heavy machinery

The use of roads for geophysical survey operations has the potential to increase noise disturbance to the community and can result in an increased road hazard to local road users. Use of roads and tracks for geophysical operations, particularly unsealed roads or farm tracks can also cause damage or degradation. Any deterioration of property tracks or infrastructure as a result of geophysical survey related traffic will be rectified.

Impacts of road use are generally short term, with peak traffic movements occurring during initial and final mobilisation to and from a project location. Landholders, local councils, potentially affected residents and police will be informed of significant activities such as initial project mobilisation and final demobilisation. Project mobilisations will detour around town centres where possible. Project mobilisations will be restricted to daylight hours as far as possible.

All necessary transport / road use permits will be obtained, and warning signs and traffic management measures will be installed where appropriate near survey locations. Traffic management measures will be implemented where required (e.g. road crossing locations) in accordance with local council and State government requirements.

Potential for unauthorised site access

Unauthorised or uncontrolled access to a geophysical survey site could expose members of the public to potential harm. Access to the survey area will be restricted (as far as is reasonably practicable) during operations (e.g. gates kept closed and appropriate signage displayed at key locations such as site entry points, main access tracks and operations specific work sites).

Fire

Fire initiated by site activities (e.g. sparks from vehicles or equipment) has the potential to significantly impact landholders and the community through damage to property or possibly loss of life. Measures discussed in Section 5.3 and 5.4 above will be implemented to manage fire risk.

Risk Assessment

The level of risk has been assessed as low for most of these potential hazards (see Table 5-1). A medium risk is assigned for the use of roads and movement of heavy machinery; although it is unlikely to occur, the consequence is major. Similarly, a medium risk is assigned for fire resulting from activities; although the likelihood is remote, the consequence is major (see Table 5-1).

5.6 Cultural Heritage

Potential impacts to cultural heritage arise predominantly from earthworks and vegetation clearing activities during seismic survey line and site preparation, construction, and rehabilitation / restoration activities. Cultural heritage inspections / surveys will be carried out where surface disturbance earthworks are required or as otherwise agreed with the local Aboriginal group. Any identified sites will be avoided and flagged off where necessary (as discussed in Section 3.6.2).

Damage, disturbance or interference to any Aboriginal sites, objects and remains is avoided unless authorisation has been obtained under the *Aboriginal Heritage Act 1988*. Heritage registers and the Heritage Branch, DEW will be consulted regarding the location of non-Aboriginal heritage sites where appropriate. Cultural heritage issues will be covered in inductions and a procedure will be in place to respond in the event that any sites are discovered during activities, in accordance with the requirements of the Aboriginal Heritage Act as discussed in Section 2.2.

Risk Assessment

The level of risk to cultural heritage has been assessed as low (see Table 5-1).

5.7 Economic Impact

Many of the identified environmental risks also have potential for negative economic impacts on landholders and other stakeholders. Application of measures discussed in Sections 5.1 to 5.6 to minimise environmental risk will also minimises economic risks posed to landholders and other stakeholders. Furthermore, the proposed activities also pose a number of potential economic benefits for landholders, the community and the State, including:

- Camp sites, laydown yards and access tracks can often be of use to landholders as all-weather access tracks and storage areas and may save construction costs to the landholder and enhance property management.
- Potential for utilisation of local food, fuel and accommodation which has direct benefits to business owners and the regional economy.
- Potential for engagement of local contractors for activities such as vegetation slashing, drilling, earthworks and fencing.
- Potential for royalties to be paid if exploration is successful, and project economics are favourable, which benefits the State.
- Potential for enhanced gas supply to the region, which currently relies on gas imported from Victoria via the SEA Gas pipeline.
- Potential enhancements or increased maintenance to infrastructure such as roads, dependent on success and ongoing activity.
- Increased understanding of geological zones resulting from exploration activities, which provides information for other licensees in the area once data becomes open file.

5.8 Environmental Risk Assessment Summary

As discussed above, Beach has undertaken an environmental risk assessment for undertaking geophysical operations in the onshore Otway Basin. This section summarises the process and results of the assessment.

Environmental risk is a measure of the likelihood and consequences of environmental harm occurring from an activity. Environmental risk assessment is used to separate the minor acceptable risks from the major risks and to provide a basis for the further evaluation and management of the major risks.

The risk assessment process involves:

- identifying the potential hazards or threats posed by the project
- categorising the potential consequences and their likelihood of occurring
- using a risk matrix to characterise the level of risk[6].

[6] The risk assessment process is iterative for many hazards. For example, the risk assessment may initially indicate that risks are unacceptably high, based on minimum or familiar management practices. In such cases, management practices are reviewed to identify additional management options to lower risk and/or improve environmental outcomes (e.g. elimination, substitution, reduction, engineering controls and management controls). The risk is then re-assessed based on these additional management options. This EIR details the final or residual risk after management options have been applied.

The level of risk has been assessed based on the assumption that the management measures that are discussed in this EIR will be in place. The risk assessment was carried out by Beach and JBS&G, based on knowledge of the existing environment, understanding of proposed operations and extensive knowledge and experience derived from undertaking previous geophysical survey activities in the onshore Otway Basin, as well as other areas such as the Cooper Basin in northern South Australia (refer to Section 1.3).

The risk assessment process was based on procedures outlined in Australian and New Zealand Standard AS/NZS ISO 31000:2009 (Risk Management) and HB 203:2012 (Managing environment-related risk).

The risk assessment uses the risk matrix and definitions for consequences and likelihood contained in Appendix D. These tables use:

- five categories of consequence (Negligible to Critical) to describe the severity, scale and duration of potential impacts
- five categories of likelihood of potential environmental consequences occurring (Remote to Almost Certain). The likelihood refers to the probability of the particular consequences eventuating, rather than the probability of the hazard or event itself occurring.
- a risk matrix to characterise the risk associated with each hazard as low, medium or high.

Risks are generally considered acceptable if they fall into the low category without any further mitigation measures, and 'tolerable' if they fall into the medium risk category and are managed to reduce the risk to a level 'as low as reasonably practicable'. Risk reduction measures must be applied to reduce high risks to tolerable levels. A summary of the level of environmental risk for geophysical survey activities is provided in Table 5-1 below. The level of risk has been assessed based on the assumption that the management measures outlined in this EIR will be in place.

Table 5-1: Environmental risk assessment for geophysical survey activities in the Otway Basin, South Australia

Risk Event / Hazard	Potential Environmental Impacts	Key Management Measures / Comment	Consequence	Likelihood	Residual Risk
Seismic line and drilling site preparation Infrastructure construction (access track, camp site, laydown and magazine) and rehabilitation / restoration activities Drilling activities	Impacts to soil (e.g. erosion, inversion, compaction) Visual impact	Planning has been undertaken to minimise impacts of activities, and records are available for audit. Where possible, existing tracks or roads are used for access. Disturbance to soil during seismic line and drilling site preparation is minimised to as low as practicable. Seismic lines are kept to a maximum width of approximately 4 m. Locate seismic survey lines and drilling sites and associated infrastructure (camps / laydowns / magazines) to minimise disturbance to soil. Areas subject to inundation are assessed for conduciveness to support vehicles prior to access. Balloon tyres or tracked vibroseis trucks are used to reduce ground pressures and minimise impact on soil where necessary. Survey line and drilling site preparation techniques are monitored and documented to minimise soil disturbance. Landholders to be consulted about earthworks required, and location of infrastructure to minimise surface damage and facilitate rehabilitation / restoration. Soil removed during infrastructure construction to be stored on site, and returned to its original stratigraphic level upon rehabilitation / restoration. Separate storage of topsoil, subsoil and clays will be undertaken to assist in regeneration of pasture or crops where appropriate. Soil profile and contours will be reinstated following completion of operations. Infrastructure sites to be rehabilitated following completion of activities, or handed over to the landholder under a deed of transfer or similar where appropriate. Restoration / rehabilitation of disturbances to be approved by the landholder, or undertaken in accordance with landholder's wishes, should retention of specific areas of parts of infrastructure be requested (e.g. part of an access track). During rehabilitation / restoration of gravel paved areas, excess gravel is removed, and soils are then ripped (where appropriate), before returning stockpiled topsoil. Imported paving materials (gravel) are removed from site, and soil profiles and contours restored unless otherwise agreed with the landholder. Required remediation work carried out as soon as possible after completion of all activities. Excess drill cuttings will be removed from site and disposed of at an appropriately licensed waste management facility unless otherwise agreed with the landowner.	Minor	Unlikely	Low
	Disturbance to natural drainage patterns Sedimentation of surface waters	Geophysical surveys and associated infrastructure appropriately located/prepared and constructed to avoid surface water features such as swamps, significant wetland areas, and to maintain pre-existing surface water flows. Where necessary, temporary culverts will be installed to ensure natural surface drainage is maintained. Landholders are consulted regarding crossings of features such as drainage channels and appropriate measures (e.g. culverts) are installed where required. Sediment and erosion control measures (e.g. sediment fences) installed where necessary (e.g. if in close proximity to drains or surface water features). Original drainage patterns will be restored. Low impact or hand carry / walk-in seismic survey methods used wherever practicable in sensitive aquatic environments. All access through watercourses/ drainage lines / water features are carefully assessed to determine the locations of least impact.	Minor	Unlikely	Low
	Introduction and spread of weeds or pathogens	All reasonable and practical endeavours taken to minimise the risks of introducing weeds, exotic pest fauna and pathogens into the areas of operations. Appropriate consultation regarding weeds or pathogens carried out with landholders and Limestone Coast Landscape Board officers. Vehicles and equipment arriving at the site must be clean and free of soil and plant material. Vehicles and equipment entering the region or moving between sites (especially from weed or pathogen infested areas into non-infested areas) will be assessed for the risk of transporting weeds and pathogens and cleaned down where appropriate. Biosecurity procedures implemented as agreed with landholders. All records of vehicle or equipment inspections and cleaning will be kept for auditing. Imported paving materials (gravel) will be sourced from licensed quarries that are free of weeds. Any new weed species / infestations as a result of activities are treated as necessary in accordance with requirements of the landholder, and if appropriate the Limestone Coast Landscape Board. Records of detection, monitoring or eradication of weeds or pathogens introduced by activities are kept and available for review.	Minor	Unlikely	Low

Risk Event / Hazard	Potential Environmental Impacts	Key Management Measures / Comment	Consequence	Likelihood	Residual Risk
	Damage to native vegetation and wildlife habitats Disturbance to wildlife	Appropriately trained and experienced personnel have assessed or scouted proposed geophysical survey areas and infrastructure locations to identify and flag significant (or listed) species and communities (including wetland communities). Native vegetation clearance avoided or minimised by locating and orientating geophysical surveys and associated infrastructure appropriately. Vegetation is trimmed (e.g. using a chainsaw) rather than removed where possible. Vegetation, ground cover and root stock are retained on seismic lines as far as practicable. Removal of large trees (including dead trees with hollows) is avoided. Prioritise location of geophysical survey activities and infrastructure in areas of existing disturbed land wherever practicable. Significant disturbance to areas of high quality or significant[7] remnant vegetation or Heritage Agreement Areas are avoided. Significant disturbance to areas of lower-quality native vegetation is avoided unless there are no viable alternatives (e.g. adjacent cleared areas). Seismic lines are weaved through vegetation if the plant density is sparse enough to allow it. Low impact seismic survey methods used to minimise impacts to vegetation wherever practicable e.g. walk-in methods, use of vegetation slashing / mulching equipment. Activities are not carried out in parks or reserves established under the National Parks and Wildlife Act. If proposed activities are located in close proximity to a park or reserve established under the National Parks and Wildlife Act and indirect impacts are likely, consultation is undertaken with DEW to determine appropriate mitigation measures. All drill holes are immediately covered, capped and backfilled on completion of survey activities to prevent injury or death to wildlife and stock in accordance with relevant industry standards and guidelines (e.g. SA Earth Resources Information Sheet *M21 - Mineral Exploration Drillholes — General specifications for construction and backfilling*). Where excavations are required to be open for an extended period (e.g. overnight), they will be covered or fenced to exclude wildlife and stock. Areas that present risk (chemical storage or contaminated areas) to wildlife and stock are appropriately fenced to minimise access. If threatened species (e.g. Red-tailed Black-Cockatoos) are detected or likely to occur near proposed activities or infrastructure locations, specialist advice is sought regarding measures to mitigate potential impacts, particularly during breeding season. Undertake detailed assessments and EPBC Act referral (if required) if avoidance of species or habitats is not possible. Fauna mortality (if it occurs) to be captured by incident reporting system and advice from an ecologist if required. Feeding of wildlife is not permitted. No domestic pets allowed at camps or operational sites. No unauthorised off-road or off-line driving or creation of shortcuts. Areas of native vegetation disturbed by proposed activities are rehabilitated in consultation with DEM, DEW and other relevant stakeholders.	Minor	Unlikely	Low

7 Significant in this context includes listed plant species, listed communities or important fauna habitat

Risk Event / Hazard	Potential Environmental Impacts	Key Management Measures / Comment	Consequence	Likelihood	Residual Risk
	Light generation Noise generation Dust generation Vibration generation Damage to infrastructure Disturbance to stock Disturbance to land use Disturbance to local community	Lighting will be positioned to minimise light emanating from sites during operations. Machinery, equipment and camps will be promptly removed from site following the completion of operations, particularly in visible locations. Noise limitations will be included as part of induction procedures, with a focus on noise minimisation during early morning and evening activities (e.g. unnecessary use of horns, reversing of machinery). Equipment operated and maintained in accordance with manufacturer specifications. Transport trucks to be restricted to daylight hours as far as possible. Heavy truck drivers to be instructed not to use engine brake near dwellings. Adequate buffer distances will be maintained between activities and residences. Assessment of potential noise impacts from a site-specific activity will be undertaken as appropriate during design and planning stages. Dust generation will be minimised by restriction of speeds on unsealed roads and spraying of unsealed roads with water to moderate the potential for dust generation where required. If necessary, unsealed roads will be sprayed with water as required to minimise dust generation. Implementation of adequate buffer distances to ensure vibrations generated by the proposed activities do not result in significant disturbance to the community and residences or damage to infrastructure. In the case of a decommissioned restored site (e.g. camp site), the entire area will be restored to original land surface topography with no irregularities likely to cause injury to stock, unless otherwise agreed with the landholder. All drill holes are immediately covered, capped and backfilled on completion of survey activities to prevent injury or death to wildlife and stock in accordance with relevant industry standards and guidelines (e.g. SA Earth Resources Information Sheet *M21 - Mineral Exploration Drillholes — General specifications for construction and backfilling*). Where excavations are required to be open for an extended period (e.g. overnight), they will be covered or fenced to exclude wildlife and stock. Areas that present risk (chemical storage or contaminated areas) to wildlife and stock are appropriately fenced to minimise access. During restoration / rehabilitation of gravel paved areas, excess gravel is removed, and soils are then ripped, before returning stockpiled topsoil. This will include removal of imported materials from site, and soil profiles and contours restored unless otherwise agreed with the landholder. Landholders are consulted regarding the location and timing of proposed activities. Ongoing landholder liaison during and following operations. In the survey planning phase, consult landholders on location and schedule of seismic survey activities in order to minimise economic impacts and disruption to landholder activities. Compensation agreements are agreed and put into place before any activities are undertaken. Activities are restricted to agreed / defined areas / times. All gates left in the condition in which they were found (open / closed). Temporary gates in fences are restored in accordance with landholder requirements. Seismic survey and Infrastructure construction, activities restricted to daylight hours. Systems in place for logging stakeholder complaints to ensure that issues are addressed as appropriate. Compliance with Part 10 of the Petroleum and Geothermal Energy Act (Notice of Entry requirements).	Minor	Unlikely	Low
	Damage to cultural heritage sites	Culltural heritage inspection of proposed geophysical survey areas and infrastructure locations undertaken with the relevant Aboriginal heritage group. Known sites identified and protected from operations using temporary flagging, fencing or exclusion zones to prevent damage, disturbance or interference. Cultural heritage awareness and issues covered in inductions. Key personnel (e.g. supervisors, machinery operators) receive appropriate cultural heritage training. Procedures consistent with the relevant obligations under the Aboriginal Heritage Act are in place to appropriately report and respond to any sites discovered during activities. Records of sites forwarded to the Aboriginal Heritage Branch in compliance with the Aboriginal Heritage Act. Records relating to sites of cultural heritage significance kept and available for audit. Where damage, disturbance or interference to Aboriginal sites, objects or remains is unavoidable, then an application for authorisation pursuant to section 23 of the *Aboriginal Heritage Act 1988* (Act) will be sought from the Minister for Aboriginal Affairs and Reconciliation (the Premier). Appropriate consultation with Aboriginal groups, traditional owners or Aboriginal persons with interests in the matter, as well as the State Aboriginal Heritage Committee, will be conducted by AAR in relation to the application (as per section 13 of the Act). Heritage site registers and Heritage Branch, DEW, consulted regarding the location of non-Aboriginal heritage sites where appropriate.	Moderate	Remote	Low

Risk Event / Hazard	Potential Environmental Impacts	Key Management Measures / Comment	Consequence	Likelihood	Residual Risk
Physical presence of machinery, equipment and camp and personnel. Light emissions Vibration emissions	Visual impact Disturbance to wildlife Disturbance to stock Disturbance to land use Disturbance to local community	Landholders and relevant stakeholders (e.g. local council, industry associations) consulted regarding location of proposed activities where appropriate. Activities are restricted to agreed / defined areas. Machinery, equipment and camps removed from site promptly following completion of activities, particularly in visible locations. Systems in place for logging stakeholder complaints to ensure that issues are addressed as appropriate. Adequate buffers maintained between proposed activities and residences. Refer to measures listed under light and vibration generation, disturbance to stock, wildlife, land use and local community listed above.	Minor	Unlikely	Low
Air emissions	Reduction in local air quality	Equipment operated and maintained in accordance with manufacturer specifications. If necessary, unsealed roads will be sprayed with water as required to minimise dust generation. Refer to measures listed under dust generation above.	Minor	Unlikely	Low
Noise emissions	Disturbance to wildlife Disturbance to stock Disturbance to local community	Equipment operated and maintained in accordance with manufacturer specifications. Transport trucks to be restricted to daylight hours as far as possible. Heavy truck drivers to be instructed not to use engine brake near dwellings. Assessments of potential noise impacts undertaken as appropriate during design and planning stages. Noise limitation (particularly during early morning and evening) to be included as part of induction procedures (e.g. unnecessary use of horns, reversing of machinery). Systems in place for logging stakeholder complaints to ensure that issues are addressed as appropriate. Adequate buffers maintained between proposed activities and residences. Refer to measures listed under noise generation, disturbance to stock wildlife and local community above.	Minor	Unlikely	Low
Use of roads; movement of vehicles and heavy machinery	Injury or death of stock or wildlife Dust generation Noise generation Damage to third party infrastructure Disturbance lo local community	Control production and dispersion of dust on unsealed roads and tracks. Compliance with relevant speed restrictions on access roads and tracks. Warning signage and traffic management measures installed where appropriate. If necessary, unsealed roads will be sprayed with water as required to minimise dust generation. Driver behaviour and vehicle speed limits to be included in compulsory induction. Vehicle speed limits to be observed.	Minor	Unlikely	Low
	Road hazard / disturbance to local road users	Refer to measures listed under dust and noise generation, damage to infrastructure, disturbance to stock wildlife and land use above. Landholders, local councils, potentially affected residents and emergency services will be informed of significant activities such as initial mobilisation and final demobilisation from project sites. All required authorisations (e.g. local council, DPTI, police) obtained where required for movement of heavy vehicles (and transport of dangerous goods) along public roads, including joint inspections of roads before and after transport moves if necessary. Project site mobilisation and demobilisations to detour around town centres where possible. Any deterioration of property tracks or infrastructure as a result of operational traffic is rectified.	Major	Unlikely	Medium
Drilling activities	Contamination of aquifers or crossflow between aquifers	Drilling activities, backfilling, and plugging of all drill holes will be undertaken in accordance with relevant industry standards and guidelines including the SA Earth Resources Information Sheet M21 - *Mineral Exploration Drillholes — General specifications for construction and backfilling.* Appropriate barriers in place to protect separate aquifer systems that are typically in natural hydraulic isolation from each other where necessary (e.g. deeper fibre optic monitoring bores). Water based drilling muds used if mud drilling is undertaken. All unnecessary chemical agents stored / utilised away from drilling sites. Refer to measures listed under spills or leaks below.	Minor	Unlikely	Low
Spills or leaks associated with: • storage of fuel, oil and chemicals • refuelling operations and high-pressure hydraulic systems	Localised contamination of soil, surface water and groundwater Damage to native vegetation and wildlife habitats Access to contaminants by stock and wildlife	All fuel and chemical storage areas will be in accordance with EPA guidelines *080/16 Bunding and Spill Management*. Hazardous materials stored, used and disposed of in accordance with relevant legislation on dangerous substances. All hazardous materials including fuels, oils and chemicals are to be stored in approved containers in polythene lined bunded areas or on bunded pallets. Bunded areas must have sufficient freeboard. No refuelling outside designated refuelling or servicing areas. Appropriate drip capture / spill capture methods implemented in refuelling areas (e.g. use of drip trays or liners). Generators to be appropriately located to contain any spills (e.g. in polyethylene lined bunded areas or with suitable alternative spill containment).	Moderate	Unlikely	Medium

Risk Event / Hazard	Potential Environmental Impacts	Key Management Measures / Comment	Consequence	Likelihood	Residual Risk
		Appropriate spill response equipment is available on site. Personnel have received training in the use of spill response equipment. Spills or leaks are immediately reported and clean up actions initiated. All contaminated soil will be removed for treatment / disposal at an EPA approved facility. If larger scale spills occur, that cannot be immediately contained and cleaned-up, they would be assessed and remediated in accordance with the *National Environment Protection (Assessment of Site Contamination) Measure 1999*, amended 2013 (NEPM). Affected areas fenced if a threat is posed to livestock or wildlife. Records of spill events and corrective actions are maintained. Safety Data Sheet information readily available on site.			
Unauthorised access by third parties	Injury / danger to health and safety of employees, contractors and third parties	Signage warning of dangers associated with geophysical operations placed at the entry to access tracks or at geophysical operations specific work sites as appropriate. Additional signage installed at operational areas where required / appropriate. Survey manager / site manager given authority to refuse entry of unauthorised third parties to geophysical operational areas. All minor excavations (e.g. for septic tank) to be backfilled following completion of operations. All drill holes are immediately covered, capped and backfilled on completion of survey activities to prevent injury or death to wildlife and stock in accordance with relevant industry standards and guidelines (e.g. SA Earth Resources Information Sheet *M21 - Mineral Exploration Drillholes — General specifications for construction and backfilling*). Refer to measures listed under storage, handling and use of explosives.	Moderate	Remote	Low
Fire (resulting from activities)	Danger to health and safety of employees, contractors and possibly the public	Confinement of flammable sources, restrictions on certain procedures and ready access to suitable fire-fighting equipment (e.g. fire unit consisting of trailer with water tank, pump and hoses in high fire danger season). Liaise with CFS regarding operations to ensure fire concerns are addressed and any Fire and Emergency Services Act requirements are met (e.g. permits for 'hot work' on fire ban days if required). Where necessary (e.g. in fire danger season), fire break constructed around camps/operational sites. Response to fire included in Emergency Response Plan. Emergency response procedures included in staff training. Ensure fire risk is included in the induction and all personnel are fully informed on the fire danger season and associated restrictions.	Major	Remote	Medium
	Loss of vegetation and habitat Disturbance, injury or death of wildlife / stock Atmospheric pollution Damage to infrastructure Disruption to land use		Moderate	Remote	Low
Storage, handling and disposal of waste	Localised contamination of soil, surface water and groundwater Damage to vegetation and habitat Attraction of scavenging animals (native / pest species) and access to contaminants by stock and wildlife Litter / loss of visual amenity	EPA's Waste Hierarchy model (avoid, reduce, reuse, recycle, recover, treat, dispose) should be complied with and waste management undertaken with regard to the *Environment Protection (Waste to Resources) Policy 2010*. Covered bins are provided for the collection and storage of wastes. All loads of rubbish are covered during transport to an approved waste facility. Waste streams are segregated on site and transported to appropriate facilities to maximise waste recovery, reuse and recycling. Production of waste is minimised by purchasing reusable, biodegradable or recyclable materials where practical. All waste disposal is at an EPA licensed facility. Hazardous wastes handled in accordance with relevant legislation and standards. Licensed contractors used for waste transport. Sewage wastes are handled using septic tanks or self-contained on-site treatment systems that are approved and managed under the *South Australian Public Health (Wastewater) Regulations 2013* and in compliance with the South Australian Health On-site Wastewater Systems Code. Toilet facilities with wastewater processing units and septic tanks will be provided at camp sites. Where septic tanks are used to contain wastewater (black water and grey water), they will be pumped out by licensed contractors as required for disposal at a licensed facility. Small pits may be constructed to house the tanks which will be removed after operations are completed. Wastewater is not allowed to drain to surface water drainage features such as swamps. Any necessary approvals (e.g. local council) for use of wastewater disposal systems / installation of the septic tanks will be obtained. Survey areas and operational sites kept free of litter and rubbish.	Minor	Unlikely	Low

Risk Event / Hazard	Potential Environmental Impacts	Key Management Measures / Comment	Consequence	Likelihood	Residual Risk
Storage, handling and use of explosives	Injury / danger to health and safety of employees, contractors and possibly the public.	Explosives use, storage, handling and disposal will be undertaken in accordance with relevant industry codes, standards and guidelines (e.g. Australian Dangerous Goods Code), and the requirements of the South Australian Explosives Act 1936 and Explosives Regulations 2011. Explosives will only be handled and utilised by appropriately trained and licensed personnel (i.e. holders of a SafeWork SA Blaster's Licence) in accordance with Beach health and safety and applicable legislative requirements. Explosives are required to be stored in an approved receptacle, store or magazine. Magazines will typically take the form of a transportable shipping container type structure. A licence to store explosives and a magazine licence may also be required depending on the volume of explosive stored at any one time. Ensure risks and requirements associated with explosive storage, handling and use is included in the induction and all personnel are fully informed of risks and associated restrictions. Emergency response procedures included in staff training. Adequate buffer distances will be maintained between activities and residences. Activities are restricted to agreed / defined areas / times. Seismic survey activities restricted to daylight hours. Systems in place for logging stakeholder complaints to ensure that issues are addressed as appropriate. Seismic charges will be solid (not a liquid or emulsion) and encased in sealed hard-plastic shells to limit interaction with groundwater and soil. Detonator installation practices (e.g. multiple detonators, appropriate waterproofing) to minimise chance of charge detonation failure. Seismic charges designed to biodegrade if not detonated. Detonation of buried charges results in a small radius of rock around the charge to be fractured (typically less than 2 m radius). Adequate buffer distances (vertical and horizontal) between buried seismic charges and groundwater wells incorporated into survey design. Buried seismic charges will not be placed near aquifer boundaries. Risk assessment for any unexploded charges to identify whether additional monitoring or mitigation measures are required (e.g. monitoring bore, sympathetic detonation). Note: Frequency of failure of charge detonation is very low – typically less than 0.5%. Refer to measures listed under Impacts to groundwater resources and localised contamination of soil, surface water and groundwater, use of roads; movement of vehicles and heavy machinery, storage, handling and disposal of waste, fire (resulting from activities), noise and vibration generation, disturbance to land use and local community listed above.	Major	Remote	Medium
	Localised contamination of soil, surface water and groundwater Noise generation Vibration generation Disturbance to land use Disturbance to local community		Minor	Unlikely	Low
	Localised contamination of aquifers Crossflow between aquifers		Moderate	Possible	Medium
			Minor	Unlikely	Low

6 Environmental Management Framework

Geophysical operations will be undertaken in accordance with Beach's Health, Safety and Environment Management System (HSEMS). The HSEMS is a key tool in the management of Beach and associated contractors' environmental responsibilities, issues and risks. The HSEMS also provides a framework for the coordinated and consistent management of environmental issues by ensuring the:

- establishment of environmental policy (see http://www.beachenergy.com.au/)
- identification of environmental risks and legal and other requirements relevant to the 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.

Key components of the HSEMS are discussed in the following sections.

6.1 Environmental Objectives

Environmental objectives have been developed based on the information and issues identified in this document. These objectives have been designed to provide a clear guide for the management of environmental issues and are detailed in the accompanying SEO (Beach Energy, 2020).

6.2 Responsibilities

Environmental management and compliance will be the responsibility of all personnel. The indicative organisation and responsibilities for personnel overseeing environmental management are detailed in Table 6-1. The exact nature and title of these roles may vary and positions may be amalgamated or the responsibilities shared under a modified arrangement.

The overall responsibility for environmental compliance lies with Beach. Beach will maintain a high level of on-site supervision. Geophysical survey contractors and individuals will also be responsible and accountable through their conditions of employment or contract. The training of all personnel will ensure that each individual is aware of their environmental responsibility.

Table 6-1: Indicative roles and responsibilities

Role	Responsibility
Beach Executive Management	Licence holders Hold overall responsibility for Beach activities and environmental management
Beach Exploration Manager	Responsible for coordinating the management of the activities, including all environmental aspects Responsible for overall implementation of EHS Responsible for the overseeing and fulfilling of commitments contained in EIR and SEO Overall responsibility for reporting on environmental performance and due diligence Coordinates environmental incident internal reporting and investigation Incident notification to Authorities
Beach Health, Safety and Environment Personnel	Oversee implementation of EIR and SEO Monitor the activities of geophysical survey contractors and assesses compliance with the SEO Coordinates the monitoring and audit program Environmental internal reporting and incident investigation
Beach Landholder Liaison	Landholder liaison Monitors seismic survey activities and rehabilitation / restoration
Survey Manager "Bird Dog" (contractor)	Responsible for ensuring that works meet regulatory requirements and all environmental objectives contained in the SEO Directly responsible for the overseeing and fulfilling of commitments contained in relevant approvals, EIR and SEO Responsible for ensuring adequate resources are provided for constructing and maintaining environmental controls Inspection of work areas / survey area to ensure appropriate environmental management Environmental internal reporting and incident investigation Reports to Beach Exploration Manager or alternative Beach company representative

6.3 Environmental Management Procedure

All Beach employees and contractors are responsible for ensuring compliance with the Beach environmental procedures which are embedded within the integrated HSEMS. The procedures have been developed to set minimum operating standards to ensure Beach and its contractors comply with the relevant environmental legislation. The environment related HSE procedures cover all activities undertaken by Beach in Australia including exploration, drilling, well operations, and production.

Beach conducts periodic environmental audits to assess the appropriateness of the HSE procedures to monitor performance to verify Beach is meeting its policies, legislative requirements and environmental objective commitments and whether the procedures have been properly implemented and maintained.

6.4 Job Safety Analysis and Permit to Work

Job Safety Analysis (JSA) is a process used to identify hazards associated with a job, by assessing the risks and implementing control measures to ensure the job can be conducted in a safe manner. Beach conducts JSAs for tasks where a work procedure does not exist, where the task has not previously been conducted by the personnel assigned to the task, or where additional hazards are present.

Beach operates a single use, multi-purpose Permit to Work (PTW) system covering all areas of operations. The purpose of this PTW procedure is to summarise the Beach safety control mechanism designed to identify hazards, assess risks and to prevent accidents associated with task specific activities requiring a Permit prior to the work commencing.

6.5 Induction and 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 which also includes safety procedures. Site specific environmental requirements will be documented in the work program or work instruction. A record of induction and attendees will be maintained.

6.6 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 they apply, and that there will be a rapid and effective response in the event of a real emergency occurring.

6.7 Environmental Monitoring and Audits

Monitoring and auditing of geophysical survey operations will be undertaken to determine whether significant environmental risks are being managed, minimised and where reasonably possible, eliminated.

Monitoring and auditing undertaken will assess aspects such as:

- compliance with regulatory requirements, particularly the SEO (Beach Energy, 2020)
- visual impact of the operations
- impact upon land use
- impact on flora and fauna
- integrity of bunding and containment systems
- site contamination
- site rehabilitation / revegetation following program completion and any restoration
- contractor performance.

6.8 Incident Management, Recording and Corrective Actions

Beach and its contractors 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 also provides a mechanism for recording 'reportable' incidents, as defined under the Petroleum and Geothermal Energy Act and associated regulations.

6.9 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 Beach.

External reporting (e.g. incidents, annual reports) will be carried out in accordance with Petroleum and Geothermal Energy Act requirements and the SEO (Beach Energy, 2020). Annual reports are available for public viewing on the DEM website.

7 Stakeholder Consultation

The South East region of South Australia is comprised of exceptionally fertile land accounting for three-quarters of the State's forests and one-third of its pastures. The high levels of employment within the agriculture, forestry and fishing industry reflects the economic importance of agricultural production within the region.

It is a requirement under the Petroleum and Geothermal Energy Regulations that information on consultation with relevant landholders, Aboriginal groups or representatives, government departments or agencies, or any other interested person or parties is outlined in an EIR.

Stakeholders in the Otway Basin region include landholders and the local community, native title groups, regulatory agencies, local councils, industry groups and environmental organisations.

Beach's long-term sustainability is contingent upon maintaining strong and meaningful relationships with the communities in which Beach operates. As such, Beach maintains a permanent presence in Penola to ensure these relationships are fostered and maintained. This ensures that Beach can create a legacy as an environmentally and socially responsible organisation across the regions in which it operates. Beach maintains ongoing engagement with a wide range of stakeholders in the region. A list of stakeholders and the frequency of engagement is provided in Table 7-1.

Beach's approach to supporting communities is guided by various policies, including the Aboriginal Engagement Policy, the Community and Stakeholder Engagement Policy as well as the Community Investment Guidelines, all of which can be viewed on Beach's website. Beach also actively engages with community members via regular and informal meetings, information sessions and community events.

Importantly, Beach aims to continue to engage stakeholders for the duration of its activities in the region to ensure that all potential concerns are identified and appropriately addressed.

7.1 Community Consultation

[Note: This section currently outlines planned consultation – it will be completed following public consultation]

The legislative requirements for preparation of the EIR and SEO include the identification and management of environmental impacts, which include socio-economic impacts to stakeholders. An extensive stakeholder engagement plan (SEP) has been developed by Beach to identify local people and regional communities that could be impacted by the activities outlined in the EIR and SEO.

The SEP was developed prior to the impacts of COVID-19 and included an assessment of engagement methods, resources and tools for community consultation on the draft EIR and SEO. Early engagement with key stakeholder groups commenced in March 2020. As the global COVID-19 pandemic unfolded and restrictions on non-essential gatherings were imposed, Beach Energy in consultation with the Department for Energy and Mining adapted its approach to engagement to comply with social distancing requirements. With these requirements in place, engagement would be adapted to include:

- an increase in online engagement and the use of online engagement tools
- an extended EIR / SEO consultation period
- the use of teleconferences with stakeholders to replace drop-in sessions
- increased promotion of consultation through local newspapers and the local radio.

An extensive media campaign will be undertaken to communicate and promote the online consultation activities Beach will undertake as part of the approvals process for the Geophysical Operations EIR and SEO. This media coverage will extend across print media, in particular The Border Watch, The Pennant (Penola), The South-Eastern (Millicent) and The Naracoorte Herald, as well as local ABC South East Radio. These outlets combined, have an audience catchment of approximately 56,000 people extending from Padthaway in the mid-South East to Port MacDonnell on the South East coastline.

The advertisements in the print publications will run in the two weeks leading into the consultation period, with additional advertisements placed during the consultation period. The advertisements will direct community members to the website address where online copies of the draft SEO and EIR can be viewed, and where online comments or questions can be asked.

Beach will also make the draft EIR and accompanying SEO publicly available on its website for all stakeholders to review. At the conclusion of the consultation period, comments will be addressed in the EIR and the SEO and a summary of all comments received, and responses will be provided in the final version of the EIR and the SEO in Appendix E.

Table 7-1: Stakeholders and frequency of engagement

Stakeholder	**Frequency of Engagement**			
	Weekly	**Fortnightly**	**Monthly**	**3-Monthly**
Wattle Range Council			X	
Naracoorte-Lucindale Council			X	
City of Mount Gambier				X
District Council of Robe				X
District Council of Grant				X
Local Landholders		X		
First Nations of the South East				X
RDA – Limestone Coast			X	
LGA – Limestone Coast			X	
Primary Producers SA				X
PIRSA Regions SA				X
Limestone Coast Landscape Board				X
Coonawarra Vignerons				X
Forestry SA				X
The Border Watch / Penola Pennant / South Eastern Times	Consultation on an 'as requested / required basis'			
ABC South East Radio	Consultation on an 'as requested / required basis'			
Naracoorte Herald	Consultation on an 'as requested / required basis'			
Penola Community Groups				X
Local Penola Businesses			X	
CFS – Region 5 & Penola			X	
SAPOL – Penola & Millicent			X	

Stakeholder	Frequency of Engagement			
	Weekly	Fortnightly	Monthly	3-Monthly
Limestone Coast Protection Alliance (LCPA)	Consultation on an 'as requested / required basis'			
Community Reference Group			X	

7.2 Formal Petroleum and Geothermal Act Consultation Process

The EIR and SEO will be formally submitted to DEM after being updated to address the comments raised during stakeholder consultation. DEM, through concurrence with EPA and DEW, will then classify the level of impact of the activity. Government agencies will be subsequently formally consulted by DEM under the Petroleum and Geothermal Energy Act process.

A summary of the issues raised by government agencies in the formal consultation process, along with Beach responses, will be provided in Appendix F. The EIR, SEO and the accompanying Explanatory Note will be updated where relevant.

8 References

ABS (2016). *2016 Census data and analysis.* Accessed: April 2018. Available at: http://www.abs.gov.au/websitedbs/censushome.nsf/home/2016 Australian Bureau of Statistics. Canberra, ACT.

AHD (2019). *Australian Heritage Database* (online search tool). Australian Government, Department of the Environment and Energy, Canberra, ACT. Accessed: 1 January 2020. Available at: https://www.environment.gov.au/heritage/publications/australian-heritage-database.

APPEA (2019). *Seismic Surveys.* Accessed: 28 December 2019. Available at https://www.appea.com.au/oil-gas-explained/operation/seismic-surveys/. Australian Petroleum Production & Exploration Association. Canberra, Australian Capital Territory.

Backhouse, G.N. & J.A. Jeanes (1995). *The Orchids of Victoria.* Carlton: Miegunyah Press, Melbourne University Press.

Bates R.J. (2011). *South Australia's Native Orchids*. E-book. Native Society of South Australia Inc., Adelaide.

Beach Energy (2015). *Submission from Beach Energy Limited (Beach) in relation to the Parliament of South Australia, Natural Resources Committee Inquiry into Unconventional Gas (Fracking)*. Accessed: December 28 2019. Available at: https://www.parliament.vic.gov.au/images/stories/committees/EPC/Submission_478_-_Beach_Energy_-_file_3.pdf. Beach Energy Ltd, Adelaide, South Australia.

Beach Energy (2020). *Statement of Environmental Objectives Geophysical Operations in the Otway Basin, South Australia.* April 2020. Beach Energy Ltd, Adelaide, South Australia.

Binks, B. (2000). *Profile of the South East Irrigation Industry*. South East Catchment Water Management Board, South Australia, September 2000.

BirdLife International (2009). *Apus pacificus* In: IUCN 2009. IUCN Red List of Threatened Species. Version 2009.2. *Apus pacificus*. IUCN Red List.

Bishop, A. (1996). *Field Guide to Orchids of New South Wales and Victoria.* Sydney, NSW: University of New South Wales Press.

Blakers, M., Davies S.J.J.F. & Reilly, P.N. (1984). *The Atlas of Australian Birds.* Melbourne, Victoria: Melbourne University Press.

BoM (2018). *Climate Data Online.* Accessed: March 2018. Available at: http://www.bom.gov.au/climate/data/. Bureau of Meteorology, Australia.

Boult, P.J. & Hibburt, J.E. (2002). *The Petroleum Geology of SA Volume 1: Otway Basin*, 2nd edition, August 2002. South Australian Government.

Brown, K., Harrington, G., and Lawson, J. (2006). Review of groundwater resource condition and management principles for the Tertiary Limestone Aquifer in the South East of South Australia. South Australia. Department of Water, Land and Biodiversity Conservation. DWLBC Report 2006/2.

Brown, K., Love, A., and Harrington G. (2001). Vertical groundwater recharge to the Tertiary confined sand aquifer, South East, South Australia, Department of Water Resources South Australia, Report Book DWR 2001/002 (unpublished).

Carter, O. (2010). *National Recovery Plan for Trailing Hop-bush Dodonaea procumbens*. Department of Sustainability and Environment, Melbourne, Victoria.

Coleman, R. A., Hoffman, A. A. & Raadik, T. A. (2015). *A review of Galaxiella pusilla (Mack) (Teleostei: Galaxiidae) in south-eastern Australia with a description of a new species.* Zootaxa: 4021 (2): 243-281.

Croft. T.S., Carruthers, S., Possingham, H., Inns, B. (1999). *Biodiversity Plan for the South East of South Australia.* Department for Environment, Heritage and Aboriginal Affairs, Adelaide, SA.

Crook, A., Stephenson, P. and Sandanayake, C. (2015). *Land Seismic Acquisition Testing Strategies and Results – Southern Chad, Africa 2013-2015.* Recorder. Vol. 40 No. 10. Accessed: February 2020. Available at: https://csegrecorder.com/articles/view/land-seismic-acquisition-testing-strategies-results-southern-chad-africa

Crowley, G.M. & S.T. Garnett (1998). *Vegetation change in the grasslands and grassy woodlands of central Cape York Peninsula*. Pacific Conservation Biology. 4:132-148.

Davies, R.J.P. (1986). *Threatened Plant Species of the Mt Lofty Ranges and Kangaroo Island Regions of South Australia.* Conservation Council of South Australia.

Davies, R.J.P. (1992). *Threatened Plants of the Murray Mallee, Mt Lofty Range and Kangaroo Island Region of South Australia.* Conservation Council of South Australia.

Dean, T. & Sweeney, D. (2019). *Recent advances in nodal land seismic acquisition systems*. Conference paper, Australian Exploration Geoscience Conference, Perth Western Australia. Accessed: 8 January 2020. Available at: https://2019.aegc.com.au/programdirectory/docs/382.pdf.

DEE (2018a). *Species Profile and Threats Database: Glycine latrobeana – Clover Glycine, Purple Glycine.* Accessed: May 2018. Available at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=13910. Department of the Environment and Energy, Canberra.

DEE (2018b). *Species Profile and Threats Database: Calyptorhynchus banksii graptogyne — Red-tailed Black-Cockatoo (south-eastern).* Accessed: May 2018. Available at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=25982. Department of the Environment and Energy, Canberra.

DEE (2018c). *Species Profile and Threats Database: Litoria raniformis — Growling Grass Frog, Southern Bell Frog, Green and Golden Frog, Warty Swamp Frog.* Accessed: May 2018. Available at: http://www.environment.gov.au/cgibin/ sprat/public/publicspecies.pl?taxon_id=1828. Department of the Environment and Energy, Canberra.

DEE (2018d). *Species Profile and Threats Database: Isoodon obesulus obesulus – Southern Brown Bandicoot (Eastern).* Accessed: May 2018. Available at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=68050 . Department of the Environment and Energy, Canberra.

DEE (2018e). *Species Profile and Threats Database: Miniopterus schreibersii bassanii — Southern Bent-wing Bat.* Accessed on May 2018 at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=76606. Department of the Environment and Energy, Canberra.

DEE (2019). *Australia's 15 National Biodiversity Hotspots.* Australian Government, Department of the Environment and Energy, Canberra, ACT. Available online at: http://www.environment.gov.au/biodiversity/conservation/hotspots/national-biodiversity-hotspots#hotspot6 Accessed: 30 December 2019.

DEE (2019a). *EPBC Act Protected Matters Search Tool* (online database). Department of the Environment and Energy, Canberra. Searched 30 December 2019. Available at: http://www.environment.gov.au/epbc/pmst/index.html.

DEE (2019b). *Ecological Communities of National Environmental Significance Database (Public Grids)* (GIS dataset) Department of the Environment and Energy, Canberra. Searched: 30 December 2019. Available at: http://www.environment.gov.au/fed/catalog/search/resource/details.page?uuid=%7B184A3793-2526-48F4-A268-5406A2BE85BC%7D .

DEE (2020). *Species Profile and Threats Database: Galaxiella pusilla — Eastern Dwarf Galaxias, Dwarf Galaxias.* Accessed on January 2020 at: http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=56790. Department of the Environment and Energy, Canberra.

DEE (2020a). *Species Profile and Threats Database: Nannoperca obscura — Yarra Pygmy Perch.* Accessed on January 2020 at http://www.environment.gov.au/cgi-bin/sprat/public/publicspecies.pl?taxon_id=26177. Department of the Environment and Energy, Canberra.

DEM (2019). *Otway Basin Prospectively*. Government of South Australia, Department for Energy and Mining, Adelaide. Accessed: 23 December 2019. Available at: http://www.energymining.sa.gov.au/petroleum/prospectivity/otway_basin.

DEM (2019a). *South Australian Seismic Survey Datasets* (GIS datasets). Government of South Australia, Department for Energy and Mining, Adelaide. Accessed: 19 December 2019. Available at: https://map.sarig.sa.gov.au/.

DEW (2019). *Soil Landscape Map Units of Southern SA* (GIS Dataset). Government of South Australia, Department of Environment and Water, Adelaide. Accessed: 19 December 2019. Available at: https://data.sa.gov.au/data/dataset/soil-landscapes.

DEW (2019a). *Land System Reports, DEW Soil and Land Program*. Government of South Australia, Department of Environment and Water, Adelaide. Accessed: 19 December 2019. Available at: https://data.environment.sa.gov.au/Content/Land-System-reports/Forms/AllItems.aspx

DEW (2019b). *SA Heritage Places* (GIS dataset). Government of South Australia, Department of Environment and Water, Adelaide. Accessed: 1 January 2020. Available online at: https://data.sa.gov.au/data/dataset/sa-heritage-places.

Dickson, C.R., Farrington, L & Bachmann M. (2014). *Survey and description of the Seasonal Herbaceous Wetlands (freshwater) of the Temperate Lowland Plains in the South East of South Australia.* Nature Glenelg Trust.

DSD (2012). *South Australia Earth Resources Information Sheet - Mineral Exploration Drillholes - General specifications for construction and backfilling,* Department of State Development, Government of South Australia, Adelaide. Accessed: 19 December 2019. Available online at: https://sarigbasis.pir.sa.gov.au/WebtopEw/ws/samref/sarig1/image/DDD/ISM21.pdf.

DSEWPC (2011). *Environment Protection and Biodiversity Conservation Act 1999 referral guidelines for the endangered southern brown bandicoot (eastern) Isoodon obesulus obesulus.* Department of Sustainability, Environment, Water, Population and Communities, Canberra, ACT.

Duncan, M. (2010). *National Recovery Plan for the Dense Leek Orchid Prasophyllum spicatum*. Department of Sustainability and Environment, Melbourne.

Dyno Nobel (2017). *Geoprime dBX Technical Data Sheet.* Accessed: March 3 2020. Available at: https://www.dynonobel.com/~/media/Files/Dyno/ResourceHub/Technical%20Information/North%20America/Seismic/Geoprime_dBX.pdf.

EBS (2011). *Case Study: Southern Bell Frog Surveys.* Available at: http://www.ebsecology.com.au/documents/StateGovernment- SouthernBellFrogSurveys_000.pdf.

EPA (2016). *Bunding and spill management, EPA Guideline 080/16*. Environment Protection Agency, South Australia.

Felton & Jackson (1987). *Hydrocarbon generation potential in the Otway Basin, Australia*, BMR Journal of Australian Geology & Geophysics. 10: 213-224.

Frith, H.J., F.H.J. Crome & B.K. Brown (1977). *Aspects of the Biology of the Japanese Snipe Gallinago hardwickii.* Australian Journal of Ecology. 2:341-368

Garnett, S.T., & S. Shephard 1997. *Cape York Peninsula, Australia, as a stopover site for Latham's Snipe Gallinago hardwickii.* Stilt. 30:54-55.

Garnett. S.T., Crowley, G.M. (2000). *The Action Plan for Australian Birds. Environment Australia and Birds Australia.* Available at: http://www.environment.gov.au/biodiversity/threatened/publications/action/birds2000/index.html

Gravestock, D.I., Hill, A.J. and Morton, J.G.G. 1986. *A review of the structure, geology and hydrocarbon potential of the Otway. Basin in South Australia.* South Australia. Department of Mines and Energy. Report Book, 86/77.

Grimes, K.G. *The South-East Karst Province of South Australia.* Geo 23, 134–148 (1994).

Hill, R., Burnard, T. (2001). *Habitat Management Plan for the South-eastern Red-tailed Black- Cockatoo.* Red-tailed Black-Cockatoo Recovery Team. Birds Australia, Melbourne, Victoria.

Kopsen, E. and Scholefield, T. (1990). *Prospectivity of the Otway Supergroup in the central and western Otway Basin*. APEA Journal, 30:263-279.

Littler, F.M. 1910. *A Handbook of the Birds of Tasmania and its Dependencies.* Launceston: Published privately.

Marchant, S., Higgens. P.J. (1990). *Handbook of Australian, New Zealand and Antarctic Birds.* Volume One – Ratites to Ducks. Oxford University Press, Melbourne, Victoria.

Mari J.L., Chapellier D., (1999). *Geophysics of Reservoir and Civil Engineering*, Editors: EAGE and Technip Editions, CD Rom from the book: "*Geophysics of Reservoir and Civil Engineering*", Technip Editions, 1997.

Naarding, J.A. (1981). *Latham's Snipe (Gallinago hardwickii) in Tasmania.* Wildlife Division Technical Report. 81/2. Tasmania: National Parks and Wildlife Service.

Naarding, J.A. (1985). *Latham's Snipe (Gallinago hardwickii) in Australia and Japan.* Wildlife Division Technical Report. 85/2. Tasmania: National Parks and Wildlife Service.

NatureMaps 2019. *Naturemaps* (online search tool). Government of South Australia, Department of Environment and Water, Adelaide. Accessed: 19-31 December 2019. Available at: http://www.naturemaps.sa.gov.au/.

Orica (2017). *Technical Data Sheet, Pentex BC Cast Boosters.* Accessed: February 2020. Available at: http://www.oricaminingservices.com/us/en/product/products_and_services/initiating_systems/pentex_bc_cast_boosters/1393

Orica (2020). Pento-Seis Boosters. Accessed: February 2020. Available at: http://www.oricaminingservices.com/za/en/product/products_and_services/seismic/osx/page_orica_seismic_explosive_range_-_osx/pento-seis/500

Paydar, Z., Chen, Y., Xevi, E., and Buettikofer, H. (2009). *Current understanding of the water cycle in the Limestone Coast region.* Cooperative Research Centre for Irrigation Futures. Technical Report No. 03/09.

PIRSA (2017). *Forestry in South Australia brochure.* Government of South Australia. Primary Industries and Regions SA.

Roberts, D. (2001). *Environmental impact report for seismic operations in the Otway Basin, South Australia*. 2nd edn; DCR Geoconsulting report for the Office of Minerals and Energy Resources, Primary Industries and Resources South Australia. Report Book 2001/010.

Santos (2018). *South Australia Cooper / Eromanga Basin Environmental Impact Report: Geophysical Operations.* Santos Ltd, Adelaide, South Australia.

SE NRM Board (2010). *Natural Resource Management Plan, Part One: Regional Description.* South East Natural Resource Management Board, Government of South Australia.

SE NRM Board (2013). *Draft Water Allocation Plan for the Lower Limestone Coast Prescribed Wells Area.* Prepared by the South East Natural Resources Management Board, March 2013.

SE NRM Board (2015). *Water Allocation Plan for the Lower Limestone Coast Prescribed Wells Area.* Prepared by the South East Natural Resources Management Board.

SE NRM Board (2018). *Pest Management Strategy Summary*. South East Natural Resources Management Board. Government of South Australia.

SENRCC (2003). *South East Natural Resource Management Plan, A plan for the integrated management of natural resources in the South East, Consultation Report*. South East Natural Resource Consultative Committee.

Sercel (2020). *Sercel Vibroseis Truck.* Accessed: 8 January 2020. Available at: http://www.sercel.com/about/Pages/default.aspx

South Australian Tourism Commission (2017). *South East Regions*. Accessed: April 2018. Available at: http://tourism.sa.gov.au/.

Todd (2000). *Recovery Plan for Twelve Threatened Spider-orchid Caladenia taxa (Orchidaceae: Caladeniinae) of Victoria and South Australia 2000 – 2004.* Department of Natural Resources and Environment, Melbourne, Victoria.

TSSC (2012). *Approved Conservation Advice for the Seasonal Herbaceous Wetlands (Freshwater) of the Temperate Lowland Plains.* Threatened Species Scientific Committee. Accessed: December 2019. Available at: http://www.environment.gov.au/biodiversity/threatened/communities/pubs/97-conservation-advice.pdf.

TSSC (2013). *Approved Conservation Advice for Rostratula australis (Australian painted snipe).* Threatened Species Scientific Committee. Accessed: December 2019. Available at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/77037-conservation-advice.pdf.

TSSC (2013a). *Approved Conservation Advice for Bidyanus bidyanus(silver perch).* Threatened Species Scientific Committee. Accessed: January 2020. Available at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/76155-conservation-advice.pdf.

TSSC (2016). *Approved Conservation Advice for Caladenia versicolor.* Threatened Species Scientific Committee. Accessed: December 2019. Available at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/24392-conservation-advice-16122016.pdf.

TSSC (2016a). *Approved Conservation Advice for Thelymitra epipactoides.* Threatened Species Scientific Committee. Accessed: December 2019. Available at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/11896-conservation-advice-16122016.pdf.

TSSC (2019). *Approved Conservation Advice for Hirundapus caudacutus.* Threatened Species Scientific Committee. Accessed: December 2019. Available at: http://www.environment.gov.au/biodiversity/threatened/species/pubs/682-conservation-advice-04072019.pdf.

Weston, M.A. (1995). *Snipers band together in the suburbs*. Geo. 17:18-19.

Williams, M.L., Boulton, A.J., Hyde, M., and Kinnear, A.J., 1993. An Environmental Audit of seismic exploration in the South East of South Australia for South Australian department of Mines and Energy. Michael Williams and Associates Pty Ltd.

9 Abbreviations and Glossary

Abbreviation	Definition
AAR	Aboriginal Affairs and Reconciliation, Department of Premier and Cabinet (South Australia)
ABS	Australian Bureau of Statistics
AS 1940	Australian Standard AS 1940 Storage and Handling of Flammable and Combustible Liquids
BDBSA	Biological Databases of South Australia
BoM	Bureau of Meteorology
bund	An earth, rock or concrete wall constructed to prevent the inflow or outflow of liquids.
CFS	Country Fire Service
conventional gas	Natural gas trapped in underground structures in highly permeable sandstones
DAS	Distributed Acoustic Sensing
DAWE	Department of Agriculture, Water and the Environment
DEE	Department of the Environment and Energy
DEH	Department for Environment and Heritage (South Australia) (now DEW)
DEM	Department for Energy and Mining
DENR	Department for Environment and Natural Resources (South Australia) (now DEW)
DEW	Department of Environment and Water (South Australia)
DEWNR	Department of Environment, Water and Natural Resources (now DEW)
DMITRE	Department for Manufacturing, Innovation, Trade, Resources and Energy (formerly PIRSA) (now DEM)
DPTI	Department of Planning, Transport and Infrastructure
Drill hole	A hole that is drilled using a mechanical device (e.g. a drilling rig). In the context of a seismic survey this would be for the purposes of installing seismic energy sources or receivers
DSEWPC	Department of Sustainability, Environment, Water, Population and Communities (now DAWE)
EHS	Environment Health and Safety
EIR	Environmental Impact Report prepared in accordance with Section 97 of the South Australian *Petroleum and Geothermal Energy Act 2000* and Regulation 10
EPA	Environment Protection Authority (South Australia)
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999* (Commonwealth)
ephemeral	Existing for only a short time, often dependent upon climatic influences.
h	hour
ha	Hectare
HSEMS	Health, Safety and Environment Management System
IBRA	Interim Biogeographical Regionalisation for Australia
ISO	International Standards Organisation
JSA	Job Safety Analysis
km	kilometre

Abbreviation	Definition
km/h	kilometres per hour
LGA	Local Government Authority
LSA Act	*Landscape South Australia Act* 2019
m	metre
m^2/day	square metres per day
m^3	cubic metre (=10^3 litres or one kilolitre)
mg/L	milligrams per litre
mm	millimetre
Native Vegetation Council	A council established under the *South Australian Native Vegetation Act 1991* to assess vegetation clearance applications.
NEPM	National Environmental Protection Measure
NPW Act	*National Parks and Wildlife Act 1972* (South Australia)
NRM Act	*Natural Resources Management Act 2004* (South Australia)
NRM Plan	Natural Resource Management Plan prepared under the Natural Resources Management Act
ºC	degrees Centigrade
PEL	Petroleum Exploration Licence
PIRSA	Department of Primary Industries and Regions, South Australia
PPL	Petroleum Production Licence
PRL	Petroleum Retention Licence
Ramsar wetland	A Wetland of International Importance listed under the Ramsar Convention (held in Ramsar, Iran 1971).
Ripping	The use of machinery to rake or shallow plough soil to relieve compaction and aerate soil.
SANTS	South Australia Native Title Services
SENRCC	South East Natural Resource Consultative Committee
SEO	Statement of Environmental Objectives
Shot hole	Drilled hole into which small explosive charges are placed to generate a 'buried source' of energy for a seismic survey
TCSA	Tertiary Confined Sand Aquifer
TLA	Tertiary Limestone Aquifer
Uphole	Drilled hole in which an underground seismic receivers (geophones) are placed during uphole seismic surveys

10 Document information and history

Document history

Rev	Date	Changes made in first document	Reviewer/s	Consolidator	Approver
A	29/01/20	Draft for Review	AC / GB / BW	AC	BW
B	10/03/2020	Revised draft issued for review	CK / JC	AC	BW
C	25/03/2020	Updated for downhole survey	SM / BW	BW / AC	SM
D	23/04/2020	Updated following Beach review	ZB/J Cocker/J Conti / WM/TH	AC/BW	SM
E	14/7/2020	Internal Review	RM/CB	CK	
F	5/8/20	Updates and internal JV review	WM/J Cocker/CT/JV	CK	
0	18/08/2020	Issued for Public Consultation	CK	CK	TF

Appendix A Historic Seismic Survey Activity in the Licence Area

Table 10-1: Historic seismic survey activity in the licence area

Year	Survey Name	Company	Energy Source
2D Seismic Surveys			
1960-61	Gambier Sunklands Seismic Survey	Beach Petroleum Nl	Buried Source (9 - 18 m deep)
1961-64	Gambier Basin Study	SADME	Buried Source – Shallow Shot Holes
1964	Penola Seismic Survey	Alliance Oil Development Aust Nl	Buried Source – Shallow Shot Holes
1965	Kalangadoo-Lucindale Seismic Survey	Alliance Oil Development Aust Nl	Buried Source (6 – 49 m deep)
1965	Otway Basin Experimental Seismic Survey	Bureau Of Mineral Resources	Buried Source – Shallow Shot Holes
1966	Caroline-Killanoola Seismic Survey	Alliance Oil Development Aust Nl	Buried Source – Shallow Shot Holes
1971	O71A Land Seismic Survey	Esso Exploration & Production (Aust)	Vibroseis
1981	LSA-81 / OTSA-81 Seismic Surveys	Australian Aquitane Petroleum P/L	Vibroseis
1985	Kalangadoo Seismic Survey	Ultramar Australia Inc	Vibroseis
1985	Konetta North Seismic Survey	Hartogen Energy Ltd	Vibroseis
1985-86	Lucindale Seismic Survey	Hartogen Energy Ltd	Vibroseis
1986	Riddoch Seismic Survey	Ultramar Australia Inc	Vibroseis
1987	Baker Range	Ultramar Australia Inc	Vibroseis
1988	Bool Lagoon Seismic Survey	Hartogen Energy Ltd	Vibroseis
1988	Penola Seismic Survey	Ultramar Australia Inc	Vibroseis
1990	Coonawarra Seismic Survey	Ultramar Australia Inc	Vibroseis
1990	Killanoola Seismic Survey	Oil Company Of Australia Nl	Vibroseis
1990	St Clair Seismic Survey	Gas And Fuel Exploration Nl	Vibroseis
1991	BMR Otway Basin 1991	Bureau Of Mineral Resources	Buried Source (15 – 37 m deep)
1991	Mount Bruce Seismic Survey	IW Partnership Pl	Vibroseis
1991	Oakwood Seismic Survey	Oil Co Of Aust Nl	Vibroseis
1991	Rouge Homme Seismic Survey	Ultramar Australia Inc	Vibroseis
1992	BMR Otway Basin 1992 Profiles	Bureau Of Mineral Resources	Buried Source (10 – 40 m deep)
1992	Sawpit Seismic Survey	Oil Company Of Australia	Vibroseis
1994	East Avenue Seismic Survey	GFE Resources Ltd	Vibroseis
1995	Cadara Seismic Survey	Oil Company of Australia	Vibroseis
1995	Redman Seismic Survey	Sagasco Resources	Vibroseis
1996	East Avenue Detail Seismic Survey	GFE Resources	Vibroseis
1996	Kanawinka Seismic Survey	Santos Ltd	Vibroseis
1996	Viewbank Seismic Survey	Oil Company of Australia Ltd	Vibroseis
1998	Mount Burr Seismic Surveys	Boral Energy Resources Ltd	Vibroseis

Year	Survey Name	Company	Energy Source
1999	Mt McIntyre Seismic Surveys	Boral Energy Resources Ltd	Vibroseis
2001	Nampara Seismic Survey	Origin Energy Resources Ltd	Vibroseis
2010	Weatherall Seismic Survey	Adelaide Energy	Vibroseis and Buried Source (10 - 28 m deep)
3D Seismic Surveys			
1993	Tilbooroo	Oil Company Of Australia	Vibroseis
1995	Haselgrove	Sagasco Resources	Vibroseis
2000	Balnaves	Origin Energy Resources	Vibroseis
2001	St George	Origin Energy Resources	Vibroseis
2008	Jacaranda Ridge	Adelaide Energy	Vibroseis
2008	Nangwarry	Rawson Resources	Vibroseis

Source: DEM, 2019a

Appendix B Land Systems and Associated Soils in the Licence Area

Table 10-2: Land systems and associated soils in the licence area

Land System	Landscape Description	Main Soils Description	Licence Area (%)
Atlantic Heath	Poorly drained plains near Wattle Range with sand over clay soils mostly, occasionally with calcrete in the subsoils. Deep sands on the plains are often waterlogged. Low beach ridge remnants divide the plains in places.	G3 Thick sand over clay B7 Shallow sand over clay on calcrete I2 Wet highly leached sand	23.0
Monbulla	Corridor plains southwest of Bool Lagoon, with sandy rises and low dunes and swampy flats	G3 Thick sand over clay N3 Wet soil (non to moderately saline) B7 Shallow sand over clay on calcrete G4 Sand over poorly structured clay	12.9
Nangwarry	Gently undulating plain with deep sandy soils, mostly well drained with only occasional dunes and swamps in swales. Occasional limestone (calcarenite) rises occur with shallow red soils.	I2 Wet highly leached sand G3 Thick sand over clay I1 Highly leached sand	9.7
Kalangadoo	Gently undulating plain with low rises. Small swamps are common. Occasional higher dunes and calcreted rises also occur. Relief is only a few metres.	G3 Thick sand over clay G5 Sand over acidic clay	9.4
Krongart	Plains with mainly dark coloured, medium to fine textured soils. Small swamps are common	G3 Thick sand over clay N3 Wet soil (non to moderately saline) M4 Deep hard gradational sandy loam F2 Loam over poorly structured brown or dark clay E3 Brown or grey cracking clay	9.2
Glen Roy	Flat plains west and north of the Penola land system, with stony rises and swampy flats. Relief is less than 2 m.	B5 Shallow dark clay loam on limestone E3 Brown or grey cracking clay B2 Shallow calcareous loam on calcrete C5 Gradational dark clay loam	7.0
Short	Plains south west of Penola and a corridor plain east of Lucindale, with mainly sand over clay soils with some parallel dunes, calcarenite rises and swamps.	G3 Thick sand over clay G4 Sand over poorly structured clay	6.9
Maoope	The Maoope Land System is a plain with minor lunettes, swamps and lagoons such as Bool Lagoon, Hacks Lagoon, Moyhall Swamp and Cockatoo Lake. The plains are imperfectly to poorly drained. The groundwater table may be at the surface for some time in the year.	Variable, typically clay loamy/clayey surfaces and calcrete within 50 cm of the surface. Shallow dark clays with smaller areas of deep dark clays	4.6
Furner	Dune corridor, stony plains and swamps extending from Furner to east of Kingston, with mainly dark coloured, fine textured soils. Occasional stony banks.	B5 Shallow dark clay loam on limestone B2 Shallow calcareous loam on calcrete C5 Gradational dark clay loam	4.4
Cave Range	Disjunct linear dune ranges and low ridges south east of Lucindale, including the southern parts of Cave Range, Stewarts Range and Bakers Range.	H3 Bleached siliceous sand B6 Shallow loam over red-brown clay on calcrete G3 Thick sand over clay	4.1

East Avenue	Dune range of low rises with swampy flats between the Kennion and Lucindale ranges, with some salinity in the northern end.	H3 Bleached siliceous sand B7 Shallow sand over clay on calcrete I1 Highly leached sand B6 Shallow loam over red-brown clay on calcrete	2.9
Penola	Gentle rises and plains with some calcrete outcrops, extending from south of Penola to north of Coonawarra; often referred to as the "Coonawarra strip". Slightly karstic with indistinct depressions in places. Occasional low sand dunes.	B4 Shallow red loam on limestone B6 Shallow loam over red-brown clay on calcrete	2.2
Lucindale	Undulating plains, near Lucindale, with low narrow, north-south oriented, remnant calcarenite ridges.	B6 Shallow loam over red-brown clay on calcrete B3 Shallow sandy loam on calcrete B4 Shallow red loam on limestone	1.1

Source: DEW, 2019; 2019a. Note: Land systems representing <1% of the licence area (these include Kennion, Naracoorte Range, Spence, Conmurra, Baker Range and Young) have been excluded from this table.

Appendix C Flora and Fauna Information

This appendix provides additional detail on the vegetation communities, threatened and migratory species and weeds that are summarised in Section 4.5 of the EIR. The information in this appendix is derived largely from a draft report prepared for Beach by Coffey Environments in 2012.

C. 1. Vegetation communities

Floristic communities mapped in areas of remnant native vegetation within Beach's licence area include:

- *Eucalyptus camaldulensis var. camaldulensis* mid woodland over *Leptospermum continentale* shrubs over *Hypochaeris radicata, Hydrocotyle laxiflora, Ranunculus robertsonii, Schoenus apogon* forbs (most widespread association of the area).
- *Eucalyptus fasciculosa* low woodland over *Acacia longifolia* ssp. *sophorae*, *Banksia marginata* shrubs over *Xanthorrhoea caespitosa*.
- *Eucalyptus obliqua* mid woodland over *Acacia melanoxylon* shrubs over *Pteridium esculentum, Leucopogon parviflorus*, *Hypochaeris radicata, Hydrocotyle laxiflora* ferns.
- Emergent *Eucalyptus obliqua* trees over *Xanthorrhoea caespitosa*, *Leptospermum continentale* mid open shrubland over *Leucopogon virgatus var. virgatus*, *Astroloma conostephioides, Isopogon ceratophyllus, Hypolaena fastigiata, Epacris impressa, Tetratheca ciliata*.
- *Eucalyptus leucoxylon* ssp. mid open woodland over *Acacia pycnantha* shrubs over *Astroloma humifusum, Hibbertia australis, Kunzea pomifera, Danthonia* sp. shrubs.
- *Baumea juncea*, *Gahnia trifida* mid sedgeland.
- *Melaleuca brevifolia, Leptospermum continentale* mid shrubland over *Apodasmia brownii, Baumea juncea* sedges.
- *Melaleuca halmaturorum* tall shrubland over *Gahnia filum* sedges over *Comesperma volubile, Samolus repens*.
- *Cyperaceae* sp., *Gramineae* sp. mid sedgeland.
- Emergent *Eucalyptus* sp. trees over *Pteridium esculentum* mid closed fernland.

C. 2. Details for Selected EPBC Act Listed Plant Species

A selection of the EPBC Act-listed flora species that have been recorded within the licence area (based on BDBSA records) are discussed in further detail below. For the selected species, habitat requirements, key threats thought to have led to the species' decline, and key recovery actions are discussed. Not all listed species are discussed however the selected species provide examples of threats and recovery actions consistent with the other species.

Elegant Spider-orchid

The Elegant Spider-orchid (*Caladenia formosa*) occurs in western Victoria and south-eastern South Australia, and is now restricted to isolated public land forest blocks south of Edenhope and north of Cavendish, and adjoining properties in Victoria, in Mt Scott and Mt Monster Conservation Parks, and private properties in the Naracoorte, Coonawarra and Kingston regions. The habitats *Caladenia formosa* typically occupy include damp-sands with herb-rich woodlands, with sedges, which may be seasonally inundated. Key threats to the species include disturbance (through timber harvesting,

rabbit burrow ripping, horse riding and trail bikes), inappropriate fuel reduction burning in autumn, as well as weed invasion, and grazing from both native and exotic herbivores (Todd, 2000).

Grampians Spider-orchid

In South Australia, the species *Caladenia versicolor* is likely extinct, and records in the south east of the state consist of 3 historic records in the Penola-Naracourte region. The presence of this species, beyond the Penola-Naracoorte region, in South Australia is unknown. In 2010, the species was known from a single population located south-west of Stawell in Victoria. This population comprised an estimated 800 plants, spread over an area of approximately 50 hectares, in State Forest. The species is typically found on deep grey sands or limestone in stringybark (*Eucalyptus baxteri /arenacea*) woodland with an understorey of bracken fern (*Pteridium esculentum*), *Acacia* species. The species produces a single green leaf that grows from the base of the stem with reddish spots, sparsely hairy and grows to 10 cm in length.The flower stem grows has one or two white, pale pink or purplish flowers. Key threats to the species include clearing and fragmentation of existing habitat, trampling and grazing pressures, road side maintenance, competition from weed species and illegal picking by the public (TSSC, 2016).

Bell-flower Hyacinth Orchid

In South Australia, the species *Dipodium campanulatum* is restricted to the south east of the state on an ancient shoreline extending parallel to 10–20 km from the Victorian border; from near Padthaway south to the Glenelg River and was once common around Naracoorte. The bell-flower hyacinth orchid is typically found on deep grey sands or limestone in stringybark (*Eucalyptus baxteri /arenacea*) woodland with an understorey of bracken fern (*Pteridium esculentum*), *Acacia* species (Bates, 2011). Key threats to the species include clearing and fragmentation of existing habitat, trampling and grazing pressures, road side maintenance, competition from weed species and illegal picking by the public.

Trailing Hop-bush

There are 55 known populations of the Trailing Hop-bush (*Dodonaea procumbens*) across Victoria, New South Wales, and South Australia. Little is known about the species, and population occurrences and population estimates are not fully understood. In South Australia, there are populations near Port Lincoln, Clare and Burra in the Mid North, Kangaroo Island, and a small population on a roadside near Penola in the South East. Habitats within which the species has been recorded are often low-lying areas, typically wet in winter, of woodland, low open forests, heathlands and grasslands, on sands and clays. The South Australian populations have been recorded in *Eucalyptus camaldulensis*, *Eucalyptus fasciculosa* and *Eucalyptus leucoxylon* woodland, and in native grasslands of *Lepidosperma viscida, Themeda triandra, Austrodanthonia* sp., *Austrostipa* sp., and shrubs of *Acacia acinacea, Dodonaea viscosa*, and *Bursaria spinosa* (Carter, 2010).

Clover Glycine

The Clover Glycine (*Glycine latrobeana*) is distributed across south-eastern Australia, including south-eastern South Australia. The overall extent of occurrence is calculated at 351,350 km2, whilst the actual area of occupancy is estimated to be 131 km2. In South Australia, the species has been found on undulating plains, gentle west facing slopes and lower south facing river valley slopes. In the south-east, it has been recorded in *Eucalyptus baxteri* woodlands with *Banksia* species (Davies 1986). Threats to *Glycine latrobeana* include small population size, inappropriate fire regimes, grazing by both native and introduced stock, habitat fragmentation, Phytophthora and weeds. Ensuring key populations and their habitat are identified and protected has been identified as a key objective of the species recovery plan (DEE 2018a).

Dense Leek-orchid

Prasophyllum spicatum is endemic to south-eastern Australia, where it is distributed from the South Gippsland region of Victoria to the far south-east of South Australia, in the Naracoorte Coastal Plain and South East Coastal Plain IBRA

bioregions. Species occurs in coastal and near-coastal heathland and heathy woodlands. Species is a deciduous, perennial, terrestrial orchid emerging annually from an underground tuber. It has a single, terete, erect, slender, dark green leaf to 60 cm long, with a reddish-purple base. Habitat destruction and disturbance, principally for agricultural and more recently urban development, have been the key causes of the decline of the species (Duncan, 2010).

Metallic Sun-orchid

Thelymitra epipactoides occurs across south-eastern Australia from the Eyre Peninsula (in South Australia) to East Gippsland west of Bairnsdale (Victoria). Formerly, the species was also found in the Mount Lofty ranges, although the species is considered extinct in this area. In 2005, the South Australian population consisted of 89 individuals distributed across 10 populations in the Murraylands, Eyre Peninsula and the south-east of the state. The metallic sun-orchid is found primarily in mesic coastal heathlands, grasslands and woodlands, but may also be found in drier inland heathlands, open forests and woodlands. Species grows 21 – 52 cm tall and produces one long, fleshy, narrow leaf which is tubular at the base. Typically, the metallic sun-orchid bears between seven and 31 flowers, which can be highly variable in size and colour; brown, copper, blue and green are the main colour groups observed in the flowers. The removal of fire as a natural disturbance regime is likely to be the primary threat to this species, allowing invasive weed species to outcompete the orchid (and other flowering members of the ecological community), reducing the likelihood of attracting native pollinators, which are themselves in competition with introduced pollinators less suited to pollination of the species. Grazing pressure on the metallic sun-orchid, once limited to native species, has been exacerbated by a range of invasive herbivorous species; human impact also constitutes a significant threat, both directly through damage to individuals, and indirectly through changes to the ecology of the landscape (TSSC, 2016a)

Spiral Sun Orchid

The Spiral sun orchid (*Thelymitra matthewsii*) is currently known to occur in Victoria, South Australia and New Zealand. Throughout its range the species is rare and of sporadic distribution. The species favours open forests and woodlands in well-drained sand and clay loams. It is a post-disturbance coloniser that is usually found in open areas around old quarries and gravel pits, on road verges, disused tracks and animal trails (Backhouse & Jeanes ,1995). It has been recorded as growing on gravely soils in disturbed areas of low coastal forest (Bishop, 1996), in swampy soils, on lateritic podsol on gently sloping plateaus or from sand overlying limestone on undulating plains (Davies, 1986; 1992). Current threats include disturbance to or destruction of plants and habitat, altered fire regimes, grazing/predation and weed invasion.

C. 3. Details for Selected EPBC Act Listed Fauna Species

A selection of the EPBC Act-listed fauna species that have been recorded within the licence area (based on BDBSA records) are discussed in further detail below. For the selected species, habitat requirements, key threats thought to have led the species' decline, and key recovery actions are discussed. Not all listed species are discussed however the selected species provide examples of threats and recovery actions consistent with the other species.

Australasian Bittern

The Australasian Bittern (*Botaurus poiciloptilus*) occurs in Australia, New Zealand and New Caledonia. Within South Australia, the species is confined to the south-east, ranging from north of the River Murray and west to southern Eyre Peninsula, with the greatest population densities within the licence area at Bool Lagoon (Marchant and Higgens, 1990). The species occupies densely vegetated freshwater wetlands, and occasionally estuarine habitats. Key habitat preferences are wetlands with tall dense vegetation, allowing for foraging in still, shallow water. Vegetation communities often occupied by the species are dominated by sedges, rushes, and reeds (of the genera *Phragmites, Cyperus, Eleocharis, Juncus, Typha*). The key threat to *Botaurus poiciloptilus* is loss or alteration of suitable habitat through diversion of water from wetlands for irrigation, and the salinisation of swamps (Garnett and Crowley, 2000).

Red-tailed Black-cockatoo (South-eastern)

The Red-tailed Black-cockatoo (south-eastern) (*Calyptorhynchus banksii graptogyne*) has a restricted distribution, confined to the south-east South Australia and neighbouring areas in western Victoria. It is considered widespread, but rare within its range. Preferred habitats include *Eucalyptus arenacea* and *Eucalyptus baxteri* woodlands on plains, as well as *Eucalyptus camaldulensis*, *Eucalyptus leucoxylon* and *Allocasuarina luehmannii* woodlands (DEE 2018b). A key habitat requirement is large hollows in eucalypt trees, preferably hollows of dead trees over live trees, with entrances facing upwards, preferably vertical or near vertical, higher than 6 m from the ground, with an entrance 15 – 50 cm in diameter (Hill and Burnard, 2001). Key threats to the species are food shortages (due to impact of fire on food, loss of feeding habitat, grazing impacts on foraging sites, fragmentation of foraging habitat), nest site availability, firewood harvesting, nest predators, and human interference with nests.

White-throated Needletail

The White-throated Needletail is a large swift with a thickset, cigar-shaped body, stubby tail and long pointed wings. There are two recognised subspecies of *Hirundapus caudacutus:*

- subspecies *caudacutus* occurs in central and eastern Siberia, northern Mongolia, northern China and the Korean Peninsula, Sakhalin and Japan, and migrates to spend the non-breeding season in Australasia.
- subspecies *nudipes*, which breeds in the Himalayas from northern Pakistan to Assam and south-western China and is largely resident and does not occur in Australasia.

Species is widespread in eastern and south-eastern Australia. In eastern Australia, the species is recorded in all coastal regions of Queensland and NSW, extending inland to the western slopes of the Great Dividing Range and occasionally onto the adjacent inland plains. Further south on the mainland, it is widespread in Victoria, though more so on and south of the Great Dividing Range, and there are few records in western Victoria. The species occurs in adjacent areas of south-eastern South Australia, where it extends west to the Yorke Peninsula and the Mount Lofty Ranges. It is widespread in Tasmania. Breeding distribution is fragmented, with two subspecies occurring in different parts of Asia. Subspecies *H. c. caudacutus* breeds from northern Japan west to central and eastern Siberia, while subspecies *H. c. nudipes* breeds from south-western China to northern Pakistan and is largely resident. Species is largely aerial, from heights of less than 1 m up to more than 1000 m above the ground. Although they occur over most types of habitat, they are recorded most often above wooded areas, including open forest and rainforest, and may also fly below the canopy between trees or in clearings. Species roosts in trees amongst dense foliage in the canopy or in hollows. Key threats include loss of roosting and breeding habitat (forest logging in Russia), collision with wind turbines, overhead wires and possibly use of insecticides (TSSC, 2019).

Australian Painted Snipe

The Australian Painted Snipe (*Rostratula australis*) is a stocky wading bird approximately 240–300 mm in length, with a wingspan of 500–540 mm and weighing 125–130 g. Species occurs in shallow freshwater (occasionally brackish) wetlands, both ephemeral and permanent, such as lakes, swamps, claypans, inundated or waterlogged grassland/saltmarsh, dams, rice crops, sewage farms and bore drains, generally with a good cover of grasses, rushes and reeds, low scrub, *Duma* spp. (lignum), open timber or samphire. It has been recorded at wetlands in all states and territories and is most common in eastern Australia. The main identified threat to the species is loss and degradation of wetlands, through drainage and the diversion of water for agriculture and reservoirs. Other threats include loss of breeding habitat in the Murray-Darling Basin, grazing and the associated trampling of wetland vegetation/nests, predation by feral animals, coastal development, replacement of native wetland vegetation by invasive weeds (TSSC, 2013).

Southern Bell Frog

The distribution of the Southern Bell Frog (*Litoria raniformis*) covered sections of New South Wales, Victoria, Tasmania and South Australia. The species has undergone substantial declines in abundance and has become locally extinct in many areas of its former range. In the south-east of South Australia, the species occurs at Bool and Hacks Lagoons, which are within the licence area. In 2011 there was a notable population increase of *Litoria raniformis* at Bool Lagoon, Hacks Lagoon and Lake Ormerod (EBS 2011). Preferred habitat typically includes emergent vegetation of *Typha* sp., *Phragmites* and *Eleocharis* sp., in or surrounding the edges of still or slow-moving lagoons, swamps, lakes, ponds and dams. Threats to the species include habitat loss and degradation, altered flooding regimes, disease, predation from introduced fish, and salinisation (DEE, 2018c).

Southern Brown Bandicoot (Eastern)

The Southern Brown Bandicoot (eastern) (*Isoodon obesulus obesulus*) is found in New South Wales, Victoria, and South Australia. The subspecies was once widely distributed along a broad coastal band from Eyre Peninsula in South Australia, through southern Victoria and south-eastern New South Wales to just north of Sydney. The current range has contracted, and the species is now patchily distributed in isolated populations throughout the former range (DSEWPC 2011). In South Australia, the subspecies is found in the Mount Lofty Ranges, Kangaroo Island, and the south-east. There is little information on the habitats the subspecies utilises in the south-east, but in the Mount Lofty Ranges it inhabits eucalypt forests and woodlands with heath understoreys. Vegetation communities inhabited include *Eucalyptus obliqua*, *Eucalyptus fasciculosa*, *Leptospermum continentale*, *Leptospermum myrsinoides*, and *Banksia marginata*. Dense shrub understories, with at least 50% groundcover are preferred. Key threats are loss or habitat or modification, fragmentation, inappropriate fire regimes and extensive wildfires, and predation from introduced animals, as well as the isolation of the populations (DEE, 2018d).

Southern Bent-wing Bat

The Southern Bent-wing Bat (*Miniopterus schreibersii bassanii*) is found in wetland and river basins of in south-eastern South Australia and Victoria. The Naracoorte area is thought to be the species' most southern distribution in South Australia, with the key maternity cave located within Naracoorte Caves National Park. The species' preferred habitat is associated with the availability of foraging areas, and proximity to suitable roosting caves. Habitat loss, disturbance and modification are the key threats to the species (DEE, 2018e).

Silver Perch

Silver perch (*Bidyanus bidyanus*) are an elongate fish with a laterally compressed, oval-shaped body. They have a pointed head and snout and a relatively small mouth with equal jaws and narrow bands of very fine villiform (needle-like) teeth. Very large specimens assume a slightly disproportionate appearance with a strongly humped forehead, strong lateral compression and a more distinctly pointed, almost beak-like head and snout. Silver perch are endemic to the Murray-Darling system (including all states and sub-basins). Silver perch formerly utilised a diversity of habitats within the Murray-Darling system. Silver perch are commonly described as a lowland species that are not found in the cooler upper reaches of rivers. Silver perch are consistently reported by anglers and researchers to show a general preference for faster-flowing water, including rapids and races, and more open sections of river, throughout the Murray-Darling Basin. Key threats include river regulartion, blackwater events, habitat degradation and alien pathogens and fish (TSSC, 2013a).

Little Galaxias

The Eastern Dwarf Galaxias *Galaxiella pusilla* (*G. toourtkoourt* included following species revision, see Coleman *et al,* 2015) is a tiny, slender, freshwater fish that averages 30-40 mm in length. Like other Galaxiidae, it has all soft-rayed fins, a body lacking scales, and a single dorsal fin positioned well back on the body. A genetic study has identified two distinct genetic

groups of Eastern Dwarf Galaxias, from the eastern (Victoria east of the Otway Ranges and Tasmania) and western (South Australia and Victoria west of, and including, the Otway Ranges) regions of the species' range. Species has broad habitat requirements and occurs in slow flowing and still, shallow, permanent and temporary freshwater habitats such as swamps, drains and the backwaters of streams and creeks, often (but not always) containing dense aquatic macrophytes and emergent plants. In larger pools, the species is usually found amongst marginal vegetation. Key threats the Eastern Dwarf Galaxias include historical and continued (particularly on the urban fringe) degradation and loss of habitat throughout its range, caused by wetland drainage, wetland inundation, fouling by livestock, ploughing, concreting of waterways, chemical pollution, introduced fish species e.g. Carp (*Cyprinus carpio*) associated degradation (DEE, 2020).

Yarra Pygmy Perch

The Yarra Pygmy Perch (*Nannoperca obscura*) is a dusky, pale, brownish-grey, sometimes greenish fish with a pale belly, spots along the midline, and clear, faint yellow to black fins. It has been known to grown up to 7.5 cm but more commonly grows to about 6.5 cm. Species is known from 42 locations between the Bunyip River basin in West Gippsland west through southern Victoria and in south-eastern South Australia, as far west as Lake Alexandrina and the Finniss River, near the mouth of the Murray River. Within this range, distribution is patchy and highly fragmented. Species typically occurs in lakes, ponds and slow-flowing rivers, but prefers small-medium sized, relatively shallow (1-2 m) freshwater streams with moderate to high flow. It is a demersal species that completes its life cycle in freshwater. It is usually associated with large amounts of aquatic vegetation (particularly emergent vegetation) and log snags in clear, fresh to slightly brackish water. Major threats to the species include wetland drainage, habitat damage through grazing and lack of regeneration, altered hydrology and introduced fish (DEE, 2020a).

C. 4. Details for Significant Migratory Species

The following section discusses a selection of the migratory species that have been recorded within the licence area (based on BDBSA records). For the selected species, habitat requirements and key threats are discussed. Not all listed migratory species are discussed however the selected species provide examples consistent with the other species.

Fork Tailed Swift

In South Australia the Fork-tailed Swift (*Apus pacificus*) is widespread from the Victorian border west to the Spencer Gulf. It is also common in coastal parts of Eyre Peninsula as far west as Franklin Island, off Streaky Bay and to the north. There have been a few recently published records beyond these bounds, such as in Flinders Ranges and the Lake Eyre Drainage Basin from Billa Kallina Station, Lake Eyre South and Marree. Sightings have also been recorded north to Moorayepe and east to Innamincka and Moomba (Higgins, 1999). In Australia, they mostly occur over inland plains but sometimes above foothills or in coastal areas. There are no significant threats to the Fork-tailed Swift in Australia. Potential threats include habitat destruction and predation by feral animals. Due to the wide range of the species the potential impacts are thought to be negligible (Birdlife International, 2009).

Latham’s Snipe

Latham's Snipe (*Gallinago hardwickii*) is a non-breeding visitor to south-eastern Australia and is a passage migrant through northern Australia (Higgins & Davies 1996). The species has been recorded along the east coast of Australia from Cape York Peninsula through to south-eastern South Australia (including the Adelaide plains and Mount Lofty Ranges, and the Eyre Peninsula). Historically, the greatest threats to Latham's Snipe in Australia have been a loss of habitat caused by the drainage and modification of wetlands, and excessive mortality due to hunting (Frith *et al,* 1977; Littler 1910; Naarding 1985). The current major threat to the species appears to be the ongoing loss of habitat. The wetland habitats occupied by Latham's Snipe are threatened by a variety of processes including pollution, drainage, diversion of water for storage or agriculture, development of land for urban or other purposes, and land management practices such as mowing of habitat during summer (Frith *et al,* 1977; Garnett & Crowley, 2000; Naarding, 1981; 1985; Weston, 1995). The

habitat is also potentially threatened by vegetational replacement (Crowley & Garnett, 1998; Garnett & Shephard, 1997; Garnett & Crowley, 2000). Collisions with vehicles could be a potential minor threat to some snipe, as birds are known to roost at times beside roadside puddles.

Satin Flycatcher

The Satin Flycatcher (*Myiagra cyanoleuca*) are occasionally recorded, mostly in the lower south-east, occasionally as far north as Naracoorte (Blakers *et al,* 1984). They generally inhabit heavily vegetated gullies in eucalypt-dominated forests and taller woodlands, and on migration, occur in coastal forests, woodlands, mangroves and drier woodlands and open forests. Populations of the Satin Flycatcher are said to have been reduced by clearing and logging of forests in south-eastern Australia, mainly the loss of mature forests (Blakers *et al,* 1984).

White-throated Needletail

Refer to Section A3.

C. 5. Introduced Species

Table 10-3: Priority pest weeds and alert weeds identified by the Limestone Coast Landscape Board

Common name	Scientific name	LSA Act status: Limestone Coast Landscape Board management aim
Bridal veil	*Asparagus declinatus*	Declared: eradicate from region
Golden dodder	*Cuscuta campestris*	Declared: eradicate from region
Blackberry	*Rubus fruticosus*	Declared: destroy infestations
Western Cape bridal creeper	*Asparagus asparagoides*	Declared: destroy infestations
Innocent weed	*Cenchrus incertus / C. longispinus*	Declared: destroy infestations
Pampas grass	*Cortaderia spp*	Declared: destroy infestations
Silverleaf nightshade	*Solanum elaeagnifolium*	Declared: destroy infestations
Asparagus fern	*Asparagus scandens*	Not Declared: destroy infestations
Tree of heaven	*Ailanthus altissima*	Not Declared: destroy infestations
White weeping broom	*Retama raetam*	Not Declared: destroy infestations
African feathergrass	*Pennisetum macrourum*	Declared: contain the spread
Aleppo pine	*Pinus halepensis*	Declared: contain the spread
Bathurst burr	*Xanthium spinosum*	Declared: contain the spread
Boneseed ssp. *monilifera*	*Chrysanthemoides monilifera*	Declared: contain the spread
Caltrop	*Tribulus* sp.	Declared: contain the spread
Cape tulip	*Homeria* sp.	Declared: contain the spread
Creeping knapweed	*Rhaponticum repens*	Declared: contain the spread
Gorse	*Ulex europaeus*	Declared: contain the spread
Hoary cress	*Lepidium appelianum*	Declared: contain the spread
Salvation jane	*Echium plantagineum*	Declared: contain the spread
Three corner jack	*Emex australis*	Declared: contain the spread
Three horned bedstraw	*Galium tricornutum*	Declared: contain the spread
Variegated thistle	*Silybum marianum*	Declared: contain the spread
Yellow burweed	*Amsinckia calycina*	Declared: contain the spread
Noogoora burr	*Xanthium strumarium*	Declared: contain the spread
Bluebell creeper	*Sollya heterophylla*	Non-declared: contain the spread
Dolichos pea	*Dipogon lignosus*	Non-declared: contain the spread
Erica	*Erica baccans*	Non-declared: contain the spread
Radiata pine	*Pinus radiata*	Non-declared: contain the spread
Sallow wattle	*Acacia longifolia* ssp.	Non-declared: contain the spread
Alisma	*Alisma lanceolatum*	Declared: alert weed
Alligator weed	*Alternanthera philoxeroides*	Declared: alert weed

Common name	Scientific name	LSA Act status: Limestone Coast Landscape Board management aim
Arrowhead	*Sagittaria montevidensis*	Declared: alert weed
Azzarola	*Crataegus sinaica*	Declared: alert weed
Broadkernel espartillo	*Amelichloa brachychaeta*	Declared: alert weed
Broomrape	*Orobanche ramosa*	Declared: alert weed
Cabomba	*Cabomba caroliniana*	Declared: alert weed
Calomba daisy	*Oncosiphon suffruticosum*	Declared: alert weed
Cane needlegrass	*Nassella hyalina*	Declared: alert weed
Chilean needlegrass	*Nassella neesiana*	Declared: alert weed
Coolatai grass	*Hyparrhenia hirta*	Declared: alert weed
Elodea	*Elodea canadensis*	Declared: alert weed
Eurasian watermilfoil	*Myriophyllum spicatum*	Declared: alert weed
Horsetail	*Equisetum hyemale*	Declared: alert weed
Hydrocotyle	*Hydrocotyle ranunculoides*	Declared: alert weed
Lagarosiphon	*Lagarosiphon major*	Declared: alert weed
Leafy elodea	*Egeria densa*	Declared: alert weed
Mexican feathergrass	*Nassella tenuissima*	Declared: alert weed
Nightstock	*Matthiola longipetala*	Declared: alert weed
Pheasant's eye	*Adonis microcarpa*	Declared: alert weed
Plumerillo	*Jarava plumosa*	Declared: alert weed
Poison buttercup	*Ranunculus sceleratus*	Declared: alert weed
Primrose willow	*Ludwigia peruviana*	Declared: alert weed
Ragwort	*Senecio jacobaea*	Declared: alert weed
Rhus tree	*Toxicodendron succedaneum*	Declared: alert weed
Sagittaria	*Sagittaria graminea*	Declared: alert weed
Salvinia	*Salvinia molesta*	Declared: alert weed
Senegal tea plant	*Gymnocoronis spilanthoides*	Declared: alert weed
Serrated tussock	*Nassella trichotoma*	Declared: alert weed
Texas needlegrass	*Nassella leucotricha*	Declared: alert weed
Water caltrop	*Trapa natans*	Declared: alert weed
Water dropwart	*Oenanthe pimpinelloides*	Declared: alert weed
Water hyacinth	*Eichhornia crassipes*	Declared: alert weed
Water soldier	*Stratiotes aloides*	Declared: alert weed
Blue mustard	*Chorispora tenlla*	Declared: alert weed
Parrot's feather	*Myriophyllum aquaticum*	Declared: alert weed

Common name	Scientific name	LSA Act status: Limestone Coast Landscape Board management aim
Water primrose	*Ludwigia peruviana*	Declared: alert weed

Table 10-4: Priority pest fauna identified by the Limestone Coast Landscape Board

Common name	Scientific name	LSA Act status: Limestone Coast Landscape Board management aim
Wild dog	*Canis lupus*	Declared: eradicate
Goat	*Capra hircus*	Declared: eradicate
Chital	*Axis axis*	Declared: significantly reduce the extent
Rusa deer	*Cervus timorensis*	Declared: significantly reduce the extent
Sambar deer	*Cervus unicolour*	Declared: significantly reduce the extent
Red deer	*Cervus elaphus*	Declared: significantly reduce the extent
Wapiti deer	*Cervus canadensis*	Declared: significantly reduce the extent
Mallard	*Anas platyrhynchos*	Declared: significantly reduce the extent
Hog deer	*Axis porcinus*	Declared: prevent ongoing spread
Brown rat	*Rattus norvegicus*	Declared :prevent ongoing spread
Fallow deer	*Dama dam*	Declared :prevent ongoing spread
Rabbit	*Oryctolagus cuniculus*	Declared :prevent ongoing spread

Appendix D Environmental Risk Assessment Tables

The risk assessment summarised in this EIR (Section 5.8) uses the Beach risk matrix and definitions for consequences and likelihood presented below.

D. 1. Definition of Consequences

To describe the severity, scale and duration of potential impacts, the five categories of consequence listed in the following table are used. The columns in the table that are directly related to impact to the environment have been used to assess consequence levels in the risk assessment; those that are not directly related to impact to the environment (e.g. reputation) are used as guidance only for the purposes of this EIR.

Table 10-5: Consequence definition

		CONSEQUENCE CATEGORY				
		People	Environment	Reputation	Financial	Legal
		Impact to Beach or contracting personnel	Natural environment	Community safety, reputation/social licence, media, items of cultural significance	Financial impact (e.g due to loss of revenue, business interruption, asset loss etc.)	E.G Breach of law, prosecution, civil action
CONSEQUENCE	6 Catastrophic	Multiple fatalities >4 or severe irreversible disability to large group of people (>10)	Catastrophic offsite or onsite release or spill; long-term destruction of highly significant ecosystems; significant effects on endangered species or habitats; irreversible or very long-term impact	Multiple community fatalities; complete loss of social licence; prolonged negative national media; complete loss of items of cultural significance	> AUD$500m	Prolonged and complex civil and/or regulatory litigation; potential jail terms and/or very high fines and/or damages claim
	5 Critical	1 -3 fatalities or serious irreversible disability (>30%) to multiple persons (<10)	Significant offsite or onsite release or spill; eradication or impairment of the ecosystem; significant impact on highly valued species or habitats; widespread long-term impact	Community fatality; significant loss of social licence; negative national media for 2 or more days; significant damage to items of cultural significance	>AUD$100m & ≤ $500m	Civil and/or regulatory litigation; potential significant fines and/or damages claim
	4 Major	Serious permanent injury/ illness or moderate irreversible disability (<30%) to one or more persons	Major Offsite or onsite release or spill; very serious environmental effects, such as displacement of species and partial impairment of ecosystem; major impact on highly valued species or habitats; widespread medium and some long-term impact	Serious permanent injury to community member; major damage to social licence; negative national media; major damage to items of cultural significance	>AUD$10m & ≤ $1 00m	Civil and/or regulatory litigation; potential major fine and damages claim
	3 Serious	Serious reversible/ temporary injury/illness; Lost Time Injury >5 days or Alternate/Restricted Duties > 1 month	Minor offsite or onsite release or spill; serious short-term effect to ecosystem functions; serious impact on valued species or habitats; moderate effects on biological or physical environment	Serious reversible injury to community member; serious damage to social licence; negative state media; serious damage to items of cultural significance	>AUD$1m & ≤$1 0m	Serious potential breach of law; report and investigation by regulator; possible prosecution or regulatory notice (e.g. improvement notice or equivalent), or possible civil litigation and serious damages claim
	2 Moderate	Reversible temporary injury/ illness requiring Medical Treatment; Lost Time Injury ≤ 5 days or Alternate/Restricted Duties for ≤ 1 month	Event contained within site; short-term effects but not affecting ecosystem functions; some impact on valued species or habitats; minor short-term damage to biological and/or physical environment	Moderate injury to community member; moderate impact to social licence; negative local media; moderate damage to items of cultural significance	>AUD$100,000 & ≤ $1m	Potential Breach of law or non-compliance; inquiry by a regulator leading to Low-level legal issues; possible civil litigation and moderate damages claim
	1 Minor	First Aid Injury/illness	Spill limited to release location; minor effects but not affecting ecosystem functions; no impact on valued species or habitats; low-level impacts on biological and physical environment	Minor injury to community member, public concern restricted to local complaints, minor damage to items of cultural significance	≤AUD$1 00,000	Minor potential breach of law; not reportable to a regulator; on the spot fine or technical non-compliance

D. 2. Definition of Likelihood

The likelihood of potential environmental consequences occurring is defined using the five categories shown in the following table. The likelihood refers to the probability of the particular consequences eventuating, rather than the probability of the hazard or event itself occurring.

Table 10-6: Likelihood definition

LIKELIHOOD					
1. Remote	2. Highly unlikely	3. Unlikely	4. Possible	5. Likely	6. Almost Certain
<1% chance of occurring within the next year, Requires exceptional circumstances, unlikely event in the long-term future. Only occur as a 100-year event	>1% chance of occurring within the next year. May occur but not anticipated. Could occur years to decades.	>5% chance of occurring within the next year. May occur but not for a while. Could occur within a few years.	>10% chance of occurring within the next year. May occur shortly but a distinct probability it won't. Could occur within months to years.	>50% chance of occurring within the next year. Balance of probability will occur. Could occur within weeks to months.	99% chance of occurring within the next year. Impact is occurring now. Could occur within days to weeks.

D. 3. Characterisation of Risk

The risk associated with each hazard was characterised as low, medium or high, using the matrix below.

Table 10-7: Environmental risk matrix

CONSEQUENCE	LIKELIHOOD: 1. Remote	2. Highly Unlikely	3. Unlikely	4. Possible	5. Likely	6. Almost Certain
6. Catastrophic	High	High	Severe	Severe	Extreme	Extreme
5. Critical	Medium	Medium	High	Severe	Severe	Extreme
4. Major	Medium	Medium	Medium	High	Severe	Severe
3. Serious	Low	Medium	Medium	Medium	High	Severe
2. Moderate	Low	Low	Medium	Medium	Medium	High
1. Minor	Low	Low	Low	Medium	Medium	Medium

D. 4. Risk Assessment Summary Table

A summary of the level of environmental risk for geophysical survey activities is provided in Table 5-1 in the EIR. The level of risk has been assessed based on the assumption that the management measures outlined in the EIR will be in place.

Appendix E Summary of Issues Raised During Stakeholder Consultation undertaken by Beach Energy (#### 2020)

Table 10-8: Stakeholder Comments

No.	Submitter	EIR / SEO Reference	Comment / Issue Raised	Response
General				
EIR				
SEO				

Appendix F Summary of Issues Raised During Formal Petroleum and Geothermal Energy Act Consultation Process (#### 2020)

Table 10-9: Comments Raised During Formal Petroleum and Geothermal Energy Act Consultation Process

No.	Submitter	EIR / SEO Reference	Comment / Issue Raised	Response
General				
EIR				
SEO				