Part II – Potential Environmental Impacts and Mitigation

The introductory chapter (Chapter 5 – "Overview") outlines the environmental and management context for the SEA Gas Project. Proceeding chapters (6-11) focus on specific environmental issues:

- Soil and Terrain
- Hydrology
- Emissions
- Ecology
- Cultural Heritage, and
- Socio-Economic Issues.

Discussion within each of these issue-specific chapters follows a consistent framework:

- description of the **existing environment**
- identification of **potential impacts**, and
- recommended measures for **impact mitigation**.

In each case, specific environmental goals and objectives are outlined. Each goal has been assigned a number to allow cross-referencing in the South Australian Statement of Environmental Objectives (see Section 2.2).

5 Overview

This chapter forms the basis for discussion of specific environmental issues in subsequent chapters, by providing an overview of:

- the Project area, including bioregions and climatic conditions, and
- the strategic approach to managing environmental issues adopted by the SEA Gas Project.

5.1 The Project Area

5.1.1 Bioregions

The SEA Gas Project traverses a variety of landscape types. To assist in describing the character of the existing environment, various researchers, planners and management authorities have divided all or part of Australia into units with common characteristics[1]. Generally, the resultant units reflect the purpose for which they were created. Similarly, SEA Gas has taken the approach of dividing the Project area into bioregions (or landsystems) based on broad land characteristics relevant to the Project. As a result, eight bioregions have been identified with similar geological, topographical, biological and / or landuse characteristics.

The bioregions have been used as a basis for discussing the environmental issues associated with the Project in each of the proceeding chapters in Part II. The bioregions are listed in Table 5-1 and illustrated in Figure 5-1. The following discussion broadly describes the characteristics of the SEA Gas Project bioregions.

Coastal Southwestern Victoria

The Coastal Southwestern Victoria bioregion extends from Port Campbell to the Hopkins River at Allansford. The bioregion is characterised by gently undulating plains formed on flat-lying uplifted Cenozoic[2] marine sediments sloping gently to the east. Significant watercourses traversed by the pipeline corridor include the Curdies and Hopkins rivers. Ill-defined drainage, swampy tracts and small boggy basins are common. The land is largely cleared to pasture and supports sheep, cattle and dairying.

Volcanic Plains

The Volcanic Plains bioregion extends from Allansford to Grassdale, incorporating Willatook and Macarthur. Broad undulating plains, interrupted in places by low rounded hills and scattered volcanic cones dominate the region. Steep sided but shallow valleys occupied by swampy watercourses, and patches of broken country where younger lavas outcrop in the characteristic stony rises are also typical of the region.

Major watercourses traversed by the corridor include the Merri, Moyne, Eumeralla and Crawford rivers. The northern portion of the Condah Swamp complex is also within the corridor. Other standing water features within the region include volcanic lakes, such as Lake Cartcarrong and Lake Wangoom, and numerous ephemeral wetlands.

The plains were previously dominated by open grasslands and sedgelands with a mosaic of woodland, grassland, swamps and small patches of forest (Willis, 1964). The region has been predominantly cleared and developed for pasture.

Table 5-1: SEA Gas Project Bioregions

No.	Bioregion	Extent
1	Coastal Southwestern Victoria	Port Campbell – Allansford
2	Volcanic Plains	Allansford – Grassdale
3	Dundas Tablelands	Grassdale – Casterton
4	Wimmera Plains	Casterton – Naracoorte
5	Southern Mallee	Naracoorte – Cooke Plains
6	Murraylands	Cooke Plains – Palmer
7	Mount Lofty Ranges	Palmer – Gawler
8	Northern Adelaide Plains	Gawler – Torrens Island

1 For example, the Interim Biogeographic Regionalisation for Australia (IBRA) for use in planning the National Reserves System (Thackway & Creswell eds, 1995).

2 The Cenozoic Era extends from 66 million years ago to the present day.

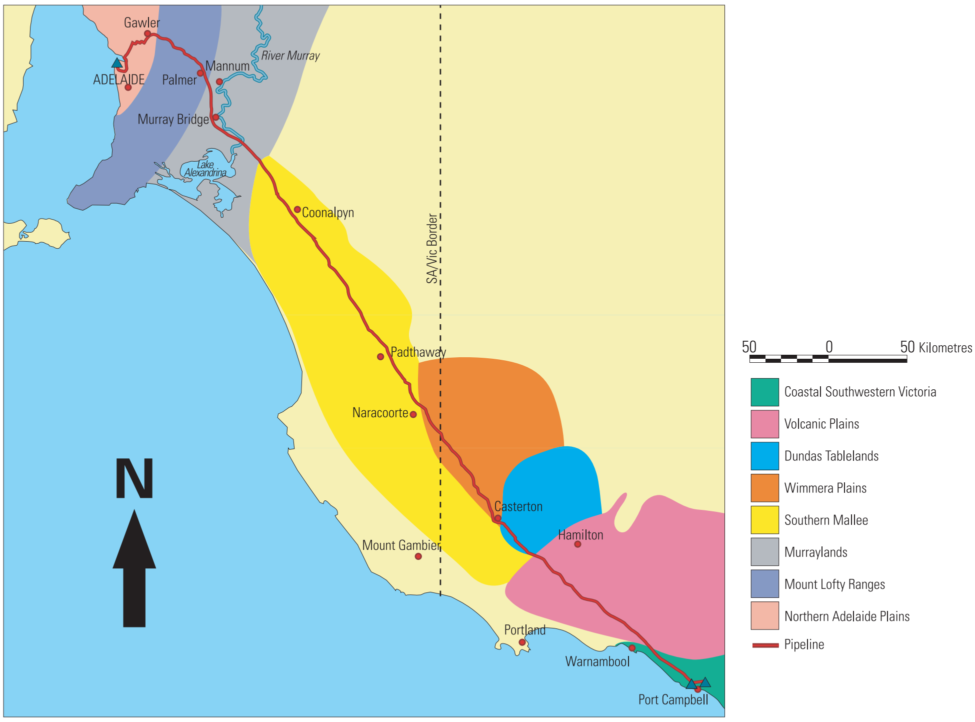

Figure 5-1: SEA Gas Project Bioregions

Dundas Tablelands

The bioregion extends from Grassdale to Casterton, incorporating the regional centre of Merino. Landscapes within the Dundas Tablelands are developed on soft, easily eroded Lower Cretaceous[3] sediments and include small remnant tableland sections standing above deep, broad valleys. Major watercourses include Merino and Deep creeks and the southern section of the Wannon River. The region has mostly been cleared of native vegetation and is predominantly used for sheep and cattle grazing.

Wimmera Plains

The Wimmera Plains bioregion traverses a large tract from Casterton to Naracoorte. The eastern section of the Wimmera Plains comprises a relatively flat surface developed on Tertiary[4] limestones and laterised Pliocene[5] sands and capped by recent siliceous sands and swamp deposits. Watercourses include Glenelg River and upper reaches of the Wannon River and their tributaries, which include Salt and Red Cap creeks.

Major surface drainage through the Dergholm region includes Mosquito and Salt creeks. Native vegetation communities are likely to have been dominated by open woodlands of River Red Gum over the heavier clay soils of interdune corridors and along major stream courses, lakes and swamps.

The western extension of the Wimmera Plains is comprised of a flat dune-free plain in the south, and a dune covered sand plain in the north. Substantial swampy depressions, such as Benoch and Groker swamps, and smaller depressions and sinkholes are common throughout. Several intermittent streams also traverse the plain and these include Mosquito,Yelloch and Naracoorte creeks.

The land is largely cleared to open parkland and pastures dominate. Remnant forest and woodland are occasionally preserved around the lakes, swamps and creeklines and in Forest Reserves south of Dergholm.

Southern Mallee

The corridor traverses the Southern Mallee immediately north of Naracoorte to approximately Cooke Plains, south of Tailem Bend. The Southern Mallee contrasts markedly to other bioregions, and is characterised by flat, featureless landscape of impermeable soils derived from marl, clay and silt. These areas are subject to seasonal flooding with lakes, swamps and poorly drained soils common. Morambro Creek represents the only significant watercourse and some artificial drainage has also been constructed. The land has been extensively cleared and the plains are generally devoid of remnant vegetation apart from roadside mallee remnants and small stands of tea tree around the more swampy areas. Pastoral and agricultural land-uses dominate.

Murraylands

The corridor traverses this bioregion between Cooke Plains and Palmer. Near the Murray River, the plain becomes increasingly sandy with low dunes and frequent

3 The Cretaceous period extended from 66 to 144 million years ago.
4 The Tertiary period extended from 2 to 66 million years ago.
5 The Pliocene Epoch extended from 2 to 5 million years ago.

calcrete outcrops. The floodplain is under intensive dairying and is highly modified. However, a variety of fluvial forms can still be recognised. The dominant remnant vegetation is mallee woodlands with broombush or heath understorey. Remnant stands are commonly restricted to dune ridges. Grazing or cereal cultivation are the principal land-uses.

Mount Lofty Ranges

The Mount Lofty bioregion extends from Palmer to Gawler, incorporating the Mount Pleasant, Mount Crawford, Williamstown and Barossa areas. Landscapes vary from undulating plains to steep dissected marginal hills, gullies and gorges, escarpments and strike ridges. Marginal hills overlook broad alluvial footslopes.

Intermittent streams, such as Milendella Creek, are dominant features, while waterholes and soakages are common. The upper catchment of the South Para River is located within this bioregion. However, the watercourse crossing occurs immediately south of Gawler, in the Northern Adelaide Plains bioregion. The corridor skirts the southern margin of the Barossa Valley.

The bioregion contains larger areas of remnant vegetation on private properties and conservation parks. However, the corridor traverses areas that have been extensively cleared leaving a landscape of open woodland and isolated trees. The principal landuses in the region are grazing, forestry, viticulture, mining and conservation.

Northern Adelaide Plains

The corridor traverses the Northern Adelaide Plains between Gawler and Torrens Island. The region incorporates the northern and northwestern suburbs of Adelaide. The alluvial slopes bounding the western edge of the Mount Lofty Ranges adjoin the coastal plain that extends to a flat, poorly drained landscape. The plains have been almost completely cleared of native vegetation to allow agricultural and more recently residential and industrial landuses. The coastline originally was bounded by a belt of coastal ephemeral wetlands (or outwash swamps). These have largely been reclaimed through drainage and development. Areas of mangrove remain in the coastal margins.

5.1.2 Regional Climate

Climate is an important consideration when scheduling and managing pipeline construction. The broad climatic conditions of each of the bioregions is described below.

Southwestern Victoria/Volcanic Plains/Dundas Tablelands

The entire southwest region of Victoria is characterised by a Mediterranean type climate, of hot, dry summers and cool, wet winters. Mean daily minimum – maximum temperatures are approximately 4°C – 13°C in July and 12°C – 28°C in the hottest months of January and February (Bureau of Meteorology, 2001). Average annual rainfall across the region varies from 500-910 mm per year, predominantly occurring throughout May to September.

Wimmera Plains/Southern Mallee

These regions experience cool, wet winters and long, mild, dry summers. Mean daily minimum – maximum temperatures are 4°C – 14°C in July and 13°C – 29°C in January, with extreme recorded temperatures of –4°C and 46°C. The hottest months are between January and March, and coolest between May and September (Bureau of Meteorology, 2001).

Rainfall decreases northwards away from the coast. For example, annual rainfall is 850mm near Mount Burr, 578mm at Naracoorte and 450mm near Bordertown. May to October are the wettest months with January to March the driest (Croft *et al.*, 1999).

Wind rose data for southeast South Australia indicate that northerly winds most frequently occur on summer afternoons, with winter winds predominately from the south and east. Spring afternoon winds are mainly from the east to northeast (Bureau of Meteorology, 2001).

Murraylands

The Murraylands are characterised by cool, wet winters and dry, hot summers. Temperatures can range from –5°C to 46°C, and mean daily minimum – maximum temperatures are 5°C – 16°C in July and 14°C – 30°C in January. From November to March, mean maximum temperatures exceed 25°C over the region. The coolest months occur from May to September (Murray Plains Soil Conservation Board, 1995; Bureau of Meteorology, 2001).

Rainfall across the Murraylands is lower, with annual means of 376mm at Tailem Bend, and 347mm at Murray Bridge. The highest rainfall occurs between May to October (Bureau of Meteorology, 2001). Rainfall can be unreliable and drought conditions are common.

April to July is generally calm, when winds have a northerly or westerly component. In the south of the region, wind may increase to moderate speeds during the day. From July, strong southwesterly to northwesterly winds are common, changing to hot northerly winds from September to October. Light to moderate southeast to westerly winds occur from October to March (Murray Plains Soil Conservation Board, 1995). Wind speeds generally range between 6.5 to 13.5 km/hr throughout the year and are strongest in spring (Bureau of Meteorology, 2001).

Mount Lofty Ranges/Northern Adelaide Plains

The bioregions share a Mediterranean type climate with long, hot summers and cool winters, with the Northern Adelaide Plains experiencing warmer conditions than the Mount Lofty Ranges. Average daily minimum – maximum temperatures in the Mount Lofty Ranges are 3°C – 12°C in July and 11°C – 28°C in January, with extreme recorded temperatures of –7°C and 43°C. The Northern Adelaide Plains mean daily minimum – maximum temperatures are 6°C – 15°C in July and 16°C – 30°C in January, with extreme temperatures of –2°C and 46°C.

The Mount Lofty Ranges is a high rainfall area dominated by winter seasonal rainfall. Annual rainfall can range from 340mm to 1500mm (Brown, 2001). Specifically, Mount Crawford receives an annual average rainfall of 756mm (Bureau of Meteorology, 2001). The Northern Adelaide Plains receives substantially less rainfall, on average ranging between 400mm and 500mm per annum (Northern Hills Soil Conservation Board, 1996).

Wind roses indicate that during the summer months, afternoon winds are predominantly from the north and east, decreasing in intensity through autumn when they change to predominantly southeasterly winds. Afternoon spring wind roses indicate northeasterly winds are dominant. Wind speeds are strongest in the spring to summer months (Bureau of Meteorology, 2001).

5.2 SEA Gas Environmental Management Strategy

5.2.1 Introduction

Traditionally, pipeline projects develop through a sequence of seven phases:

- pre-feasibility
- assessment
- approval
- detailed design
- construction
- operation, and
- decommissioning.

During each phase, an increasing level of detail is acquired with the aim of achieving the overall Project objectives (see Section 3.1), including minimising environmental impacts. Therefore, it is important to recognise that the pipeline alignment will continue to be refined during subsequent Project phases. The key to the success of this process is sufficiently defining the project prior to approval to confidently predict impacts and to ensure that any changes are minor and occur within an agreed management framework. SEA Gas believes that the framework outlined below addresses these needs.

In regard to the environmental management aspects, project refinement over time principally affects:

- the pipeline corridor (and the alignment within it)
- the pipeline design
- construction techniques, and
- the impact mitigation procedures.

The process of continual review, assessment and refinement is iterative and occurs within an agreed framework. Underpinning this approach are the principles that any refinement:

- must improve the Project's performance against its stated objectives, including the need to minimise environmental impacts, and
- is subject to a range of "checks and balances" that ensure that the Project meets both its legislative requirements and the reasonable expectations of the community.

As the Project proceeds through the various development phases, these refinements become progressively smaller.

This section outlines the broad framework for project refinement and describes the processes to be applied to mitigate environmental impact.

5.2.2 Management Framework

The principal environmental management objective for the SEA Gas Project is **to minimise and where practicable avoid significant environmental impacts,** by:

- ensuring that adverse effects on the environment are appropriately managed to reduce environmental damage
- eliminating as far as reasonably practicable the risk of significant long term environmental damage, and
- ensuring that land adversely affected is appropriately rehabilitated.

The most important strategy for achieving this objective is the selection of the most appropriate alignment. Once this has been achieved, the following strategies will be adopted (in order of priority):

- modify the construction process
- develop mitigation procedures, and
- develop rehabilitation procedures or off-set strategies.

The processes by which these strategies are developed and refined are iterative. For example, the pipeline will be located in a corridor generally considered to be 100m wide. In some areas the exact alignment is known at present and is unlikely to change. However, refinements are likely to be made in other areas within the corridor during subsequent Project phases. Such refinements may occur up to, and in some instances during, construction as discussions with landowners and stakeholder groups continue and engineering and environmental field studies provide greater site-specific detail.

The sequence of events and the key documentation and approvals built into this process are summarised in Table 5-2.

As a case study, the following outlines the manner in which the pipeline alignment has been selected and will continue to be refined.

Pre-feasibility Phase

In December 2000, the SEA Gas Joint Venture partners commissioned a team of engineering, land management and environmental personnel to conduct a pre-feasibility assessment. The aim of the assessment was to select a preferred pipeline corridor between Port Campbell and Adelaide that met the partner's technical, commercial and environmental objectives. A preliminary pipeline corridor was determined using aerial photography, mapping, field inspection and aerial reconnaissance. The aim was to identify a corridor that met the following criteria:

- was reasonably direct, as a shorter route may offer economic, environmental, social and logistical benefits
- avoided major terrain constraints, as the presence of unduly steep terrain, extensive rock areas and difficult river crossings increase technical risks, construction costs and may influence the scale of potential environmental impact
- avoided major areas set aside for conservation such as national parks and conservation reserves and world, national or state heritage areas
- utilised existing easements, as these may reduce potential impacts to environmentally sensitive areas, and
- provided opportunities for future connection to gas reservoirs or markets.

This process resulted in the definition of a 20 kilometre wide corridor around a preliminary alignment. This became the basis for further studies to refine the alignment.

Assessment Phase

Over the three-month period May – July 2001, Project landholder liaison officers, engineers, surveyors and specialist consultants conducted an intensive field program. Central to this process were initial discussions with 600 landowners whose properties are to be traversed by the pipeline. In addition to landowner consultation, discussions were held with regulatory agencies, land management authorities, local government, community and special interest groups (see Chapter 12). These activities were part of an ongoing process where alternative alignment options and site-specific issues were identified, considered, discussed, assessed and decided on. As a result, numerous refinements were made to the preliminary alignment, the aim of which was to find a technically feasible and environmentally acceptable alignment. Key considerations in this regard were the need to minimise impacts to:

- third party property and infrastructure
- landuse
- remnant vegetation
- sensitive ecological communities
- sites of cultural heritage significance, and
- public safety.

Concurrently, due consideration was given to the presence of:

- difficult terrain, particularly side slope
- rock
- dispersive or erodible soils
- high water table areas, and
- difficult watercourse crossings.

The environmental studies that form the basis of this EER/EIR were part of this iterative process. This process resulted in the selection of a preliminary alignment within a 100m wide corridor.

Approval Phase

Comments from landowners, government and other stakeholders may contribute to minor refinements of the pipeline route and environmental objectives.

Detailed Design Phase

Following Project approval, planning and design activities would continue over an eight month period leading up to

Table 5-2: The Phases of Pipeline Development

Project Phase	Schedule (Start Date)	Key Activities	Outcomes	Documentation		Approvals	
				Internal	External	SA	Vic
Pre-feasibility	Dec 2000 – Feb 2001	Desk-top review – maps, aerial photos Research broad sensitivities and constraints – available literature Field reconnaissance – ground and aerial inspections Consultation – high level discussions with primary regulatory agencies	Preliminary Corridor (20km) Understanding of scale and likely acceptability of environmental impact	Assessment report Preliminary mapping (1:250,000)			
Assessment	Mar 2001 – Sept 2001	Field reconnaissance – of preliminary alignment Discussions with potentially affected landowners / managers Consultation with regulatory agencies and land management authorities Consultation with non-government organisations and wider community Flagging preliminary alignment Environmental assessment of alignment Identification of environmental issues Development of broad management and mitigation strategies	Preliminary alignment within a 100m corridor Proposed alignment Broad management and mitigation strategies	Interim assessments Mitigation options	Preliminary Survey Licence Application (with EIR/SEO) Notice of Intent Pipeline Permit Application (Vic) Pipeline Licence Application (SA) EER/EIR SEO (SA)	Preliminary Survey Licence Significance assessment Authority to advertise	Level of assessment determination Authority to advertise
Approval	Oct 2001 – Jan 2002	Public exhibition of EER/EIR, pipeline permit and licence applications and Statement of Environmental Objectives Agency and public review of applications and supporting documentation Agency and public comment on project Agency decision on acceptability of Project	Approved alignment within a 100m corridor Project approval		Response to submissions Revised EER/EIR (if required) Revised SEO (if required)	Approved SEO Pipeline Licence	Pipeline Permit

Table 5-2 (continued) : The Phases of Pipeline Development

Project Phase	Schedule (Start Date)	Key Activities	Outcomes	Documentation		Approvals	
				Internal	External	SA	Vic
Detailed Design	Feb 2002 – July 2002	Permit and/or Licence grant Detailed engineering studies Supplementary environmental studies Ongoing stakeholder consultation Refinement of alignment Development of detailed management and mitigation strategies Development of construction management systems	Construction alignment Detailed management strategies Detailed construction documentation	Alignment Sheets Line List Construction Management System Training packages Application for subsequent approvals	CEMP Pipeline Licence Application (Vic)	Acceptance of CEMP Subsequent approvals (eg. cultural heritage clearances)	Acceptance of CEMP Pipeline Licence Subsequent approvals (eg. watercourse crossings, FFG approvals, cultural heritage clearances
Construction	Aug 2002 – Dec 2003	Environmental inspection Environmental monitoring Environmental auditing Environmental reporting Development of detailed operations and maintenance procedures	'As-built' alignment Implementation of agreed construction and rehabilitation practices and procedures	Inspection Reports Monitoring Reports Incident Reports (minor)	Audit Reports Incident Reports (major) Operations EMP	Receipt of documents	Receipt of documents
Operations	Jan 2004	Easement inspection and maintenance / rectification Environmental auditing	Implementation of agreed construction and rehabilitation practices and procedures	Inspection Reports Maintenance program Rectification Plans	Audit Report	Receipt of document	Receipt of document

construction. In particular, detailed survey, geotechnical investigations, design and site specific environmental investigations would assist in further reducing impact and overcoming construction constraints.

In addition, input from stakeholders, particularly in response to this EER/EIR and accompanying SEO, would lead to refinement of the preliminary alignment.

It is anticipated that any refinements to the alignment at this stage would be very minor and would take place within an agreed management and approval framework (see Figure 5-2).

Construction Phase

Minor alterations may be required during construction if clearing or trenching processes identify previously unknown issues of significance. The unexpected exposure of archaeological material is the factor most likely to affect the route alignment during construction. Following consultation with regulatory authorities and the Aboriginal community, minor route deviations would be undertaken, if considered necessary. As discussed above, any potential change to the alignment will occur within an agreed management and approval framework (see Figure 5-2).

5.2.3 Outcomes

The process of ongoing Project refinement is undertaken within an agreed management and approval framework. The process involves the development of management systems and key documents and is governed by a range of checks and balances. The following sections provide greater detail on these elements.

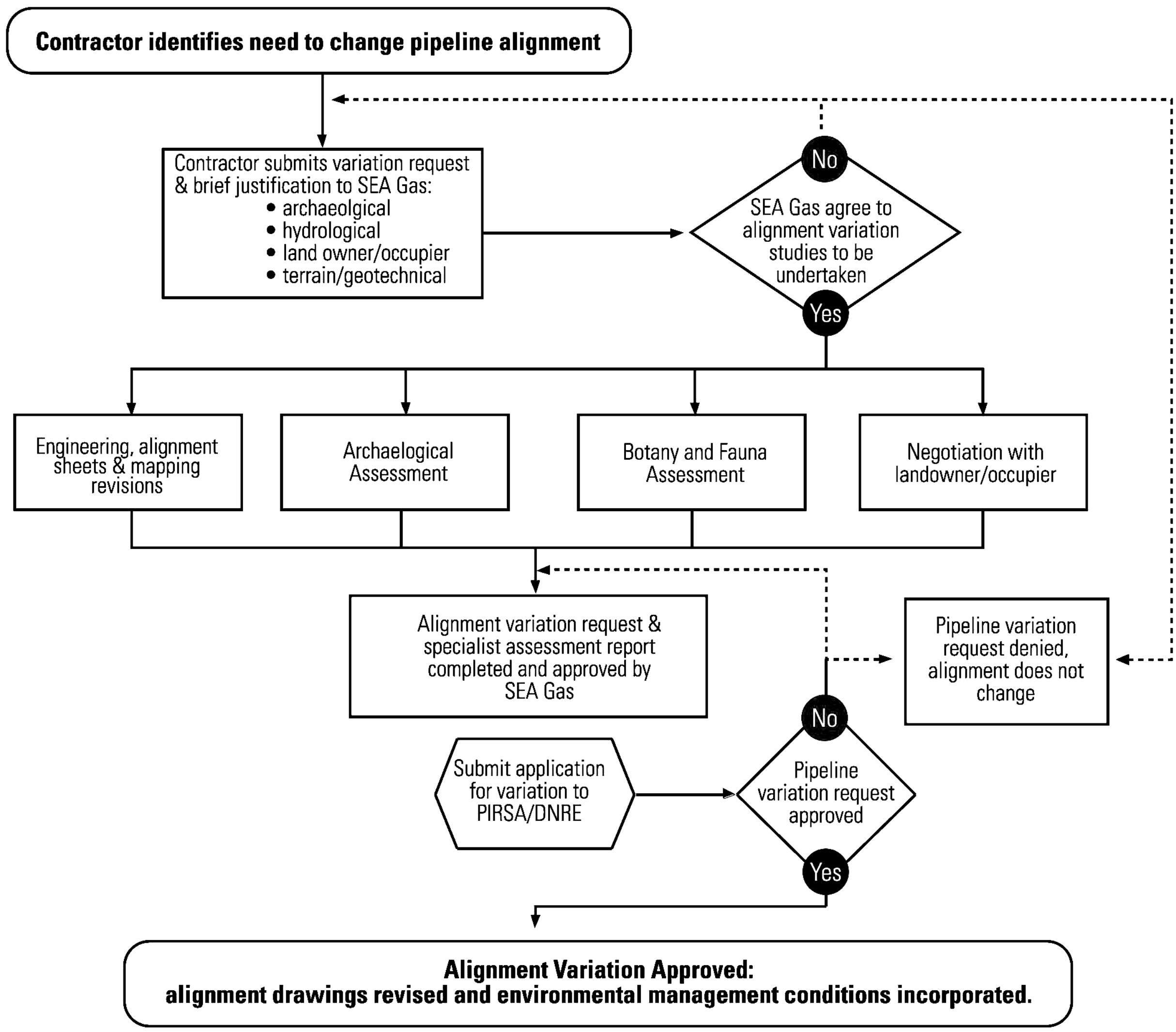

Figure 5-2: Management and Approval Framework for Refining the Alignment

Key Documents

Statement of Environmental Objectives

In South Australia, the SEO applies to all activities associated with the construction, operation, and the eventual decommissioning of the SEA Gas Project.

The intent of the SEO is to outline the environmental objectives to which construction and operating activities must conform and the criteria upon which achievement of these objectives will be assessed.

Objectives have been developed based on the information provided in this EER/EIR. Detailed management measures and conditions will be developed and implemented to ensure these objectives are achieved. Management measures and conditions will be detailed in Project Specific Construction and Operations Environment Management Plans.

Construction Environmental Management Plan

The Construction Environmental Management Plan (CEMP) will be developed during the detailed design phase based on:

- the results of environmental impact assessment conducted during the current (Assessment) phase
- the defined commitments, environmental objectives, performance assessment criteria and broad management strategies outlined in the EER/EIR and SEO
- comments received (particularly in response to the public exhibition of the EER/EIR and SEO), and
- licence and permit conditions.

The CEMP will outline the management system to be adopted during construction and provide an integrated summary of the responsibilities of the construction contractor and SEA Gas. The CEMP will contain a comprehensive set of procedures intended to provide clear and practical guidance to the construction workforce. As such, the procedures will be structured according to the activity (or task). The CEMP effectively provides an instrument to ensure Project objectives and goals are achieved.

A CEMP will be developed and submitted to DNRE and PIRSA for review. In Victoria, the CEMP will need to be approved prior to construction.

Alignment Sheets

Alignment sheets show sections of the pipeline and construction right-of-way in plan view at sufficient detail to indicate site-specific construction requirements. Traditionally, the content was limited to engineering and design specifications, such as the width of the right-of-way, depth of burial and sections of heavy wall pipe, and the diagrams were based solely on survey information. A number of recent projects have used aerial photograph mosaics as the basis for alignment drawings and incorporated areas of cultural or environmental sensitivity. The diagrams reference typical and site-specific engineering drawings.

Typical and Site-Specific Drawings

These are engineering drawings that provide construction specifications for common construction requirements, such as watercourse, road and utility crossing. Drawings are also prepared for environmental management techniques such as topsoil stripping, erosion and sediment control and fencing. Drawings may be "typical" and apply to most situations, or site specific for unusual or unique circumstances.

Line List

The line list provides contractors with a comprehensive tabulation of the specific requirements for each landowner (private and public). The line list uses property numbers and kilometre post references and includes the requirements to notify authorities regarding entry or certain actions.

'Checks and Balances'

Minor refinements to the Project design, alignment and proposed construction measures take place within an agreed framework. Many refinements will require specific approvals from regulatory authorities.

Section 2.4 lists the activities requiring subsequent approval and the relevant agencies. For example, in Victoria any disturbance to rare or threatened species requires approval from the Department of Natural Resources and Environment under the *Flora and Fauna Guarantee Act 1988* and construction in a watercourse requires the approval of the relevant Catchment Management Authority under the *Water Act 1989*. Likewise, in South Australia, activities such as the disturbance of an Aboriginal relic requires the approval of the Department of State and Aboriginal Affairs under the *Aboriginal Heritage Act 1988*.

In addition, as noted above the CEMP and SEO require respective approval of Department of Natural Resources and Environment in Victoria and Primary Industries and Resources South Australia.

System of Environmental Management

Environmental management will be approached in a systematic manner consistent with accepted industry practice. That is, a project specific system of management will be developed consistent with AS/NZS ISO 14001:1996, Environmental Management Systems), which will comprise the following elements:

- a corporate **policy** stating SEA Gas' commitment to conduct activities in an environmentally responsible manner (see Appendix 1)
- clearly stated **objectives** consistent with this commitment
- practical **procedures** to achieve the objectives
- clearly defined **responsibilities** for personnel to indicate their obligations regarding environmental management
- appropriate **induction** and **training** of personnel
- comprehensive **monitoring** and **auditing** programs to assess compliance with procedures and the achievement of objectives
- a system of **reporting** for recording of data and notification of relevant personnel, and
- ongoing **consultation** to seek input from and inform all parties of relevant issues.

Environment Policy

SEA Gas is committed to responsible environmental management for the construction and operation of the pipeline project and believes that all potential adverse environmental effects can be effectively managed in a manner that complies with the requirements of this document.

SEA Gas also recognises its obligation to the community to take all practicable steps to ensure that its operations and activities are conducted in an efficient and environmentally friendly manner. In addition, SEA Gas recognises the key role of its employees in achieving good environmental performance and actively encourages staff participation in the development, implementation and maintenance of its environment program.

Environmental Objectives

Environmental objectives are the clear statement of the outcomes intended. Broad objectives have been identified in regard to the management of the physical, biological, social and cultural aspects of the environment. The SEA Gas Project is committed to achieving a range of environmental objectives and goals based on broad environmental aspects. The SEO defines assessment criteria upon which achievement of these objectives will be assessed. Whereas, detailed management measures and conditions outlines the manner in which these objectives are achieved.

Objectives and goals for each aspect of the environment are outlined in Chapters 6 – 11 and in the accompanying SEO.

Environmental Procedures

The mitigation measures presented in this document provide the broad framework within which management will be approached. Detailed procedures will be developed during the Detailed Design Phase and documented in the Construction Environmental Management Plan.

Responsibilities

SEA Gas will be responsible for environmental management of the pipeline construction and operation. However, all personnel and contractors are accountable through conditions of employment or contracts. Each individual is responsible for ensuring that their work complies with the stated procedures.

The individual responsibilities outlined in Table 5-3 indicate the proposed organisation and accountabilities. While it is not the present intention, it should be noted that one or more positions may be amalgamated or the responsibilities shared under a modified arrangement.

Induction and Training

Construction and operations personnel will be required to attend environmental induction and training programs. These will be conducted to ensure that all personnel are aware of their environmental responsibilities and have the necessary knowledge and skills to fulfil them.

Before construction and operations commence, Environmental Inductions will be conducted covering general environmental management issues, including:

- management of sensitive areas
- erosion and sediment control
- management of acid sulphate soils
- protection of water quality
- vegetation and habitat management
- weed and pathogen control
- heritage management
- protecting existing utilities and infrastructure
- traffic and access
- waste management
- protecting the amenity of landholders, and
- emergency response.

It will be the responsibility of the construction contractor to prepare and implement the environmental induction program. Approval from SEA Gas must be obtained prior to implementation.

Environmental Inspection

Appropriate construction personnel will inspect construc-

Table 5-3: Personnel Responsibilities

Position	Responsibilities
Project Manager	• Directly responsible for the management of the Project, including all environmental aspects. • Reports directly to the SEA Gas Executive Management.
Construction Manager	• Directly responsible for the overseeing and fulfilling of commitments contained in construction procedures. • Reports to the Project Manager regarding the Project's environmental performance and due diligence.
Construction Contractors	• Responsible for ensuring that works comply with the contractual agreements, meet regulatory requirements, and that all environmental objectives contained in the contracts are attained.
Construction Inspectors and Field Engineers	• Field based personnel responsible for ensuring construction complies with the Project's objectives.
Lands and Environment Manager	• Field based employee responsible for the landowner consultation. • Provides advice to the workforce, through the Construction Manager, regarding the implementation of the procedures. • Coordinates the monitoring and audit program.
Environmental Auditors	• External to SEA Gas and contracted to conduct periodic audits according to the principles of procedures and relevant environment legislative compliance. • The Auditors are coordinated by the Lands and Environment Manager but report to the Project Manager.
Environmental / Heritage Advisers (if appropriate)	• Specialist external contractors used in the field to provide advice on specific environmental and cultural heritage matters on an as-needs basis. • Report to the Lands and Environment Manager.
Heritage Monitors	• Aboriginal community representatives engaged to assist with cultural heritage site management in nominated areas during construction.

tion activities on a daily basis and complete Inspection Checklists, in accordance with the Statement of Environmental Objectives and the Construction Environmental Management Plan.

Environmental inspection during all phases of the Project will form part of SEA Gas' normal program. Any non-compliances with the SEO and CEMP will be remediated as appropriate by the construction contractor.

Monitoring

SEA Gas will install Environmental Monitoring Stations (EMS) at representative locations prior to construction commencing. Photographs will be taken prior to construction, prior to each main construction phase and immediately following restoration.

Auditing

Environmental audits will be undertaken independently of the monitoring program by suitably qualified external environmental auditors. Audits will be conducted twice during construction and once within 12 months of commissioning to assess compliance with regulatory requirements and licence conditions. External audits will be made available to relevant regulatory authorities.

In addition, SEA Gas will prepare a public Annual Report, including audit results, for submission to PIRSA as a requirement under the Pipeline Licence.

Records and Reporting

During all phases of the Project an appropriate and auditable record system will be maintained. Environmental reporting will be conducted in accordance with licence conditions. Environmental records will include:

- non-conformance reports
- remedial actions taken following incident reports
- inspection reports
- training and induction attendance
- consultation records and meeting notes
- audit reports, and
- monitoring results.

Environmental incidents and identified instances of non-compliance will be recorded and reported on a 'Non-conformance Report proforma'.

6 Soils and Terrain

This Chapter broadly describes the geology, geomorphology and soils of the pipeline corridor, identifies potential impacts and outlines proposed avoidance and mitigation strategies. In addition, the Chapter highlights aspects of the soils and terrain within the Project area that may constrain the development.

The soils and terrain assessment has been based on a review of literature and geological mapping, supplemented by field observations (ground-truthing) (Rosengren, 2001). Further to this assessment, a geotechnical survey will be undertaken as part of the detailed engineering design phase.

The SEA Gas route passes through a range of soil and terrain conditions. Details of this existing environment are described in:

- an overview of geological, geomorphological, soils and sites of geological significance, and
- eight bioregions (or landsystems), which detail specific soils and terrain information for each of the following regions:
  - Coastal Southwestern Victoria
  - Volcanic Plains
  - Dundas Tablelands
  - Wimmera Plains
  - Southern Mallee
  - Murraylands
  - Mount Lofty Ranges
  - Northern Adelaide Plains

SEA Gas acknowledges the environmental and community importance of the soils and terrain of the Project area and is committed to their protection. It recognises that appropriate management of the Project is required to avoid or mitigate a range of potential impacts. These potential impacts are categorised and discussed under the following subheadings:

- trench subsidence, erosion and sedimentation
- mass movement
- soil inversion
- soil compaction
- soil contamination
- acid sulphate soil formation, and
- disturbance to significant geological features.

SEA Gas is confident that with the application of appropriate avoidance and mitigation strategies, all impacts to the soils and terrain of the Project area can be reduced to an acceptable level.

6.1 Existing Environment

6.1.1 Overview

Geology

The surface geology for much of the corridor consists of unconsolidated or deeply weathered materials. Basement rock exposure is restricted to small areas near Casterton and in the hills between Palmer and Gawler.

From Port Campbell to the approaches to the Mount Lofty Ranges, the route crosses surfaces principally of Cainozoic (Tertiary and Quaternary) geology. Much of this is calcareous rock (limestone and marl), including the section from Port Campbell to the Hopkins River and from south of Naracoorte to the Murray River. A wide area of Pliocene/Pleistocene volcanics with enclaves of stony rises occurs between the Hopkins River and Grassdale. From Grassdale to Dergholm, weathered Lower Cretaceous rocks are exposed in the deeper valleys and there is a small outcrop of the coarse-grained Dergholm Granite south of Poolaijelo. Basement rocks of Proterozoic and Palaeozoic age are exposed across the Mount Lofty Ranges. These rocks occur in north-south trending belts and are predominantly highly deformed and metamorphosed sedimentary and granitic rocks. Outcrops are restricted to ridge crests and steep side slopes and incised channels of the small gorges that dissect the ranges.

Geomorphology

The majority of the corridor traverses plains, low hills and tablelands with gentle to moderate slopes. Steeper terrain is encountered south of Casterton where the Glenelg River and tributaries incise the southern edge of the Dundas Tableland and there are locally steep sections in the Mount Lofty Ranges. These areas also contain several wide, deep valleys, although the watercourse channels contained in these are small and have intermittent flow.

Temperate climate and moderate to low rainfall across most of the Project area restricts the rate of geomorphic processes. Many of the landscape features, such as deepened valleys and dune ridges, are relict features from wetter or drier climates or result from geologically young tectonic and volcanic activity.

Soils

Soil variation along the corridor is a reflection of parent materials and climate. A predominant characteristic of the soils of the Cainozoic geology is the presence of clearly differentiated A and B horizons, the B horizon containing a much higher content of clay relative to the A horizon. The boundary between the horizons in these texture contrast soils or duplex soils (Northcote, 1979) is relatively sharp, occurring over an interval of 10 cm or less. These soils occur on a range of parent materials including limestone, basalt, sandstone and mudstone.

Soils recorded in the SEA Gas Project area are described in accordance with Australian Soil Classification system (Isbell, 1996; Isbell *et al.*, 1997). The predominant soil types are outlined in Table 6-1.

Sites of Geological Significance

Significant geological and geomorphological sites display an unusual, rare or unique material, landform or process. Sites range in size from those extending over kilometres (for example, Mount Eccles and the associated eruption points and lava flows) to sites of few metres where a rare fossil or mineral is known.

Sites are rated as significant at levels ranging from "local" to "international" depending on the contribution to the understanding of geology, the rarity of the feature, the quality of the display and the state of preservation (Rosengren, 1984).

A detailed inventory and assessment of all geological sites along the proposed pipeline route was not undertaken. Assessment of sites of geological significance is based on expert knowledge of the project area and observations made during the field survey (Rosengren, 2001). A number of features of "local" significance were identified from the field survey. Examples of locally significant sites include small sinkhole depressions occurring in coastal southwestern Victoria, the terraced floodplain of the Merri River, the alluvial fan at the Curdies River crossing and metamorphic textures displayed in the Rathjen Gneiss at Reedy Creek. The most significant geological feature that is known to occur within the SEA Gas alignment is the stony basalt surface of the Harman Valley Flow (lava) near Wallacedale (see Ecology Site 17, Map 5); this is an area of "state" significance. In other locations outside the SEA Gas corridor, the lava flow is considered to be of "national" significance. This flow is regarded as one of the youngest lavas in Victoria (approximately 20 000 years) and displays unusual mounds (tumuli), ridges and depressions.

6.1.2 Bioregions

The following descriptions of the soils and terrain of the Project area are based on the bioregions (or landsystems) described in Section 5.1.

Coastal Southwestern Victoria

This land system extends from Port Campbell to the Hopkins River and is underlain by limestone and marl formations of the Heytesbury Group with a veneer of Hanson Plain Sand. It is a gently undulating and weakly dissected plain with shallow sinkholes and other small

Table 6-1: Location and Description of Predominant Soil Types

Soil Type	Description	Location
Sodosols	Widespread texture contrast soils that are sodic with dispersable clay subsoils	Widespread
Kurosols	Widespread texture contrast soils that are strongly acidic	Widespread
Chromosols	Texture contrast soils but not sodic or acidic	Mount Lofty Ranges
Podsols	Soils with leached sandy A horizon and strongly coloured iron-enriched subsoils	Scattered
Calcarosols	Calcareous soils formed from calcareous parent materials	East and north of Naracoorte
Vertosols	Clay soils with marked shrink-swell capacity	South of Casterton Siliceous
Sands	A veneer of leached windblown siliceous sands	Widespread along the route including areas where the substrate is of calcareous or volcanic (i.e. non-siliceous) materials

closed depressions. The terrain is more dissected between Port Campbell and the Curdies River where small tributaries are incised up to 10m below the plain surface, producing valley side slopes of 12° to 20°. Limestone outcrop is restricted to valley edges. Northeast of Port Campbell, the Iona – Minerva section of the pipeline traverses steeply incised valleys, where slope instability is a common feature.

The surface materials and soils of the land system are sandy clays and clay loams with minor gravels and some laterite development. Black clay loams including minor occurrences of cracking clays and peaty clays occur along streams. Despite the limestone substrate, surface sands are siliceous rather than calcareous and texture contrast sodosols are the predominant soils.

The Curdies River occupies a wide, steep-sided valley and at the crossing selected for the pipeline there is a broad alluvial fan in a tributary valley. Inundation of the floodplain occurs as a result of the Curdies River mouth at Peterborough, usually closed by a sand bar, and the water level in the inlet backs up the river valley.

A broad, well-defined sinkhole with a clay floor occurs along the proposed route immediately north of the Princes Highway crossing. The proposed alignment has been selected to avoid all such features, generally remaining at least 5-10m from sinkholes or karst depressions.

The Hopkins River is a deep, permanent water body with steep-sided banks bordered by a well-defined, narrow terraced floodplain. The river follows the southern boundary of the Pliocene – Pleistocene volcanics and the river channel is probably cut into basalt rock.

Volcanic Plains

This land system extends from the northern side of the Hopkins River to near Grassdale. It is a terrain formed on Pliocene and Pleistocene newer volcanics basalts with minor additions of tuff and scoria near Lake Wangoom. Inliers of Heytesbury Group limestone occur in valleys that are incised more deeply into the older volcanic rocks but not filled by younger lava flows. In the southeast, the surface is flat to undulating with occasional low lava ridges and incised only by the valley of the Merri River. To the northwest the terrain is more dissected by the Moyne, Shaw and Crawford rivers. Surface materials are predominantly clay loams and both gradational and duplex profiles occur. Heavy, black cracking clays and peaty soils occur along floodplains and depressions. The volcanics are mostly deeply weathered with some residual boulders outcropping and basalt stones and ironstone gravels occur in soils. Near Wallacedale the route crosses the Harman Valley lava flow from Mount Napier (one of the youngest lava flows in Victoria) and there is a narrow section of stony ridges and depressions and unusual lava mounds (tumuli).

Dundas Tablelands

This bioregion extends from approximately Grassdale to Casterton enclosing the southern-most section of the Dundas Tableland. It lies east of the Kanawinka Fault, a major fault lineament with a low escarpment that separates the Tableland from the Follett Plains to the south. The Dundas Tableland is dissected here by the Wannon and Glenelg rivers, producing a landscape of broad ridges terminating in low escarpments above wide, shallow valleys with extensive terraced alluvial flats. The underlying Mesozoic sedimentary rocks are exposed in the deeper valleys and are overlain on the plateau by Dorodong Sand, a leached and ferruginised micaceous fine sand. Both formations are deeply weathered and many plateau and tableland surfaces have a capping of laterite. A number of active mass movement sites (mainly earth flows) occur on steeper valley slopes and there are gullies in the colluvial and alluvial deposits. On the plateau surface, locally thick sand bodies have developed on the laterites. Some of these are probably dune forms but many are a result of leaching and elluviation of clays from originally more complex sedimentary bodies.

Wimmera Plains

This region extends from near Casterton to the southeast of Naracoorte. The region comprises a broad, level plain elevated by the Kanawinka fault about 30 metres above the Follett coastal plains. The Wimmera Plains have a surface of Tertiary sediments (Loxton Sand and Parilla Sand) that mask all underlying materials apart from one small outcrop of the coarse-grained Dergholm Granite along Salt Creek.

The predominant surface materials are leached acid white sands and laterites (ironstone). The relief on the Plain is provided by the gently sloping sand sheets and sand ridges, weakly incised streams and shallow depressions with remnant drained swamps. The more prominent sand ridges are arcuate lunettes on the eastern edges of the swamps and ephemeral lakes. Soils of the sand sheets and ridges are typically podosols and peaty podosols, with sodosols on parent materials with a higher clay and ironstone content.

Southern Mallee

The Southern Mallee extends from southeast of Naracoorte to the Coomandook / Cooke Plains area.

Topographically, the land system is part of the Pleistocene shoreline ridge sequence of the Naracoorte Range and is differentiated from the Wimmera Plains by including a small area of Gambier Limestone and more extensive of outcrops of Bridgewater Formation (calcareous dunes and dune limestones). There is a complex of former shoreline sediments in this bioregion, including calcareous sands, quartz sands, and the lagoonal and lacustrine muds of the Padthaway Formation.

The pipeline corridor parallels the Kanawinka Escarpment, and before crossing the northern end of the escarpment and travelling north-northwest between the former shoreline ridges of the Black Range and Mount Monster Range. Small enclaves of east-west aligned calcareous and siliceous dunes also occur. The topography and surface materials change character at Cooke Plains. A complex of sodosols exist in the region in response to the varied origin and composition of parent materials.

Murraylands

Named for its proximity to the Murray River, rather than indicating a riverine origin for the landforms, the Murraylands extends from near Cooke Plains to the foothills of the Mount Lofty Ranges near Reedy Creek. The region is bisected by the trench incised by the Murray River into Miocene limestones. The base of this trench extends well below present sea level and is now partially filled with alluvium. The river plain forms a distinct sub-unit in the land system. The surface away from the river trench is dominated by prominent ridged dunes and lake depressions with saline muds. Both calcareous and siliceous sands occur in the dunes and plates and nodules of calcrete (hardened layers of calcium and magnesium carbonate) are common.

Mount Lofty Ranges

The Mount Lofty bioregion extends from the eastern-most occurrence of basement outcrop along Reedy Creek to the western flank of the Mount Lofty Ranges at Gawler. This is an area of varied topography including rolling hills, broad valleys and some deeply incised watercourses with narrow terraced floodplains and alluvial fans.

The region has complex geology. Therefore, a variety of the geological units occurring in the Mount Lofty Ranges is crossed by the proposed route. Geological (lithological) boundaries are abrupt and the rocks are typically strongly folded and fractured. The eastern edge of the Ranges consists of highly metamorphosed Cambrian sedimentary rocks including brecciated (crushed) and marbleised zones, and Ordovician rocks including the high grade Rathjen Gneiss and the Palmer Granite. The siliceous character of the bedrock and the higher rainfall of much of the Ranges has produced yellow podsolic soils with strong texture contrast. Many of the cleared steeper slopes in the Mount Lofty Ranges show evidence of old and recent mass movements typically debris flows involving rock and weathered mantle.

Northern Adelaide Plains

The Northern Adelaide Plains bioregion extends from east of Gawler to the southeast of Torrens Island. It is a broad piedmont and plain built by alluvial fans and downwash from the Mount Lofty Ranges supplemented by fluvial sediments of the small streams that drained the western side of the Ranges.

The materials are sandy clays with lenses of gravel closer to the Ranges. Near the coast, sediments are of tidal flat, coastal barrier and mangrove and salt marsh origin. Urban development – particularly pavements, drainage channel realignment, landfill – has greatly altered the natural processes that produced this topography.

In addition to the area's natural geological features, historical land use practices in the Northern Adelaide Plains (and in particular the Salisbury area approaching the Torrens Island crossing location) have resulted in several contaminated sites.

The proposed SEA Gas alignment is located within the Port River Expressway development. Findings from the Expressway development environmental report indicate the presence of significant land contamination (Brown & Root, 2000). The Expressway development will import "clean" fill material to build the road alignment up to an appropriate height above sea level. SEA Gas propose to bury the pipeline in this "clean" fill material and hence avoid disturbing the contaminated soil in this region.

6.2 Potential Impacts

The following Project activities have the potential to affect the soils and terrain of the Project area:

- clear-and-grade operations
- trenching (including blasting)
- backfilling
- refuelling
- construction access, and
- construction (if required) and operation of the construction depot.

Appropriate management of the Project will prevent or successfully mitigate potential localised impacts to the soils and terrain of the Project area. Such impacts include:

- erosion and sedimentation
- mass movement
- soil inversion
- soil compaction
- soil contamination
- acid sulphate soil formation, and
- disturbance to significant geological features.

In addition, the soils and terrain of the Project area present potential constraints to pipeline construction and operation activities. In particular, these include:

- trench collapse during construction in sandy soils (siliceous sands) or wet soils
- areas of steep terrain
- areas of surface rock
- near-surface caves in limestone areas
- construction and safety constraints associated with contaminated soils, and
- subsidence of the trench.

Erosion and Sedimentation

Erosion and sedimentation are key potential environmental impacts associated with pipeline construction projects. Pipeline construction primarily consists of earth moving activities, which remove surface cover and disturb soil profiles. Therefore, there is potential for sedimentation of the adjacent environments if adequate controls are not implemented.

Rainfall events will predominately occur during the winter months. During this period the pipeline alignment is likely to be subject to erosion by water and subsequent transportation and deposition of this sediment off the alignment (sedimentation). Appropriate drainage controls, topsoil/spoil stockpile management and maintenance of erosion control devices will protect basin/drainage environments from erosion and sedimentation (Nelson, 1985).

Inadequate soil compaction over the trench line may also lead to trench subsidence and subsequent erosion, particularly in regions of heavy clays which have a high shrink/swell potential (such as the black soils). Soils that expand and contract naturally have the potential to subside if disturbed. Locations that display black soil components include isolated areas in the Coastal Southwestern Victoria and Volcanic Plains bioregions. Shrinkage may be a particular issue as reinstated sections of the trench may subside, changing the local surface flow patterns, which can lead to trenchline erosion. Limestone areas also may result in localised subsidence if construction activities result in localised collapse of caverns. Areas of particular sensitivity include the pipeline corridor between Iona Plant and the Curdies River (Coastal Southwestern Victoria bioregion) and the area around Naracoorte (Southern Mallee bioregion).

In addition, flood scouring has the potential to occur at a number of watercourse crossings resulting in bed incision (gully deepening or widening) or avulsion (channel change) (see Chapter 7).

During the summer months when rainfall is low, erosion (or aeolian scour) may result from wind action on soils where prolonged exposure occurs following initial clearing. Areas particularly sensitive to wind erosion are the dune ridges in the Wimmera Plains, Southern Mallee and Murraylands bioregions.

Mass Movement

Earthworks have the potential to aggravate local surface instability problems resulting in slope failure, land-slip and mass movement. Steep valleys, especially in the Dundas Tableland and Mount Lofty Ranges bioregions, northeast of Port Campbell, and at the main Victorian river crossings (the Curdies, Hopkins, Crawford and Glenelg rivers), are particularly susceptible to mass movement.

On a smaller scale, localised bank collapse may occur at watercourse crossings, particularly those with large red gums on the channel margins.

Soil Inversion

Topsoil may be "lost" during the construction process by:

- burial beneath, or mixing with, trench spoil during stockpiling
- covering with sediment washed in from adjacent areas, and
- returning trench spoil and topsoil to the trench in a sequence different to original profiles.

The loss of topsoil reduces the effectiveness of easement restoration and agricultural based land use activities by limiting the amount of available nutrients, biomass and productivity.

Soil Compaction

Pipeline construction requires compaction of the backfilled trench to prevent the disturbed soil from subsiding. However, vehicle traffic elsewhere on the construction easement can lead to soil compaction, in particular equipment and machinery laydown areas or areas of heavy vehicle traffic. Soil compaction may change local drainage patterns and prevent effective plant growth.

Soil Contamination

Contaminated soils are likely to be encountered in a number of areas on the Northern Adelaide Plains. Although laboratory analysis of soil samples has not been undertaken, previous studies indicate the presence of heavy metals (copper, lead, nickel, iron and mercury), nutrients (nitrogen and phosphorus), hydrocarbons, phenols, grease and oils, and pesticides from previous landfill, waste disposal and other industrial practices.

Potential issues associated with the presence of contaminated soils involve the health risks to workers and the public through exposure.

The potential also exists for Project related activities to result in localised soil contamination. The main potential sources of contamination are:

- minor spills of fuel or chemicals
- leachate from acid sulphate soils created by exposure to oxygen (oxidation) of soils during trenching
- discharged hydrotest water, and
- pumping of hypersaline water out of trenches (Northern Adelaide Plains).

Pipeline projects involve relatively small quantities of chemicals and likely volumes of spills are extremely low. Pipeline construction equipment (such as graders, bulldozers and side-boom tractors) will be refuelled on the right-of-way from a standard fuel truck. These fuel trucks hold approximately 16000 litres, however it is highly unlikely that a storage tank on a fuel truck would be breached and the entire contents be spilt.

As discussed below, the pipeline corridor traverses a number of areas of acid sulphate soils. Without adequate planning and management, localised impacts to soil quality are likely to occur.

Hydrotest water may contain low levels of corrosion inhibiting chemicals. Inappropriate disposal of this water may result in localised soil contamination.

Acid Sulphate Soil

Acid sulphate soils form where exposure of sulphate rich soils to oxygen results in the production of acid (sulphuric acid). Potential acid sulphate soils may be present in the following areas:

- Spring Lane (Volcanic Plains)
- the Murray River crossing (Murraylands), and
- coastal areas of the Northern Adelaide Plains.

The creation of acid sulphate soils can affect soil quality, water quality and land use.

Disturbance to Significant Geological Features

Construction activities, particularly earthworks, trenching and blasting have the potential to cause direct physical damage to locally significant geological features.

6.3 Impact Mitigation

Objective

The principal management objective is to minimise adverse impacts to the soils and terrain of the Project area.

Project Phase	Objectives*
Construction	1.a To appropriately minimise and manage adverse impacts and long term environmental risk to soils and terrain of the Project area
	1.b To appropriately reinstate soils and terrain of the Project area
Operation	17.a To appropriately minimise and manage adverse impacts to the soils and terrain of the easement
	17.b To appropriately monitor rehabilitation of soils and terrain on the easement
**Note: Objectives have been numbered to enable cross-referencing in the South Australian SEO.*	

Goals

The principal management goals are:

Project Phase	Goals*
Construction	1.1 To limit the occurrence and extent of trench subsidence, soil erosion and sedimentation
	1.2 To reinstate soil and terrain to pre-construction contours and conditions
	1.3 To prevent mass soil movement
	1.4 To avoid soil inversion
	1.5 To mitigate soil compaction if necessary by remedial action
	1.6 To appropriately protect soils from contamination and to plan for the constraints posed by pre-existing soil contamination
	1.7 To appropriately remediate soil contamination
	1.8 To avoid the exposure of potential acid sulphate soils where practicable and to mitigate impacts where avoidance is not possible
	1.9 To avoid disturbance to significant geological features
Operation	17.1 To limit the occurrence and extent of trench subsidence, soil erosion and sedimentation and to undertake remediation works where required
	17.2 To monitor the easement for soil inversion and to undertake remediation works where required
	17.3 To mitigate soil compaction and to undertake remediation works where required
	17.4 To appropriately protect soils from contamination and to plan for the constraints posed by pre-existing soil contamination
	17.5 To avoid disturbance to significant geological features
**Note: Goals have been numbered to enable cross-referencing in the South Australian SEO.*	

Mitigation Measures

SEA Gas has identified environmental management strategies that will be applicable to all phases of Project development and all aspects of the environment (see Section 5.2). In addition, potential impacts to soil and terrain are specifically addressed below in the various phases of the Project that is:

- pre-construction (Design Phase)
- construction, and
- reinstatement and post-construction (including inspection and hand over to operations).

Erosion and sedimentation

During pre-construction:

- work in close liaison with Catchment Management Authorities, Water Catchment Management Boards, the Victorian Department of Natural Resources and Environment and the South Australian Department for Environment and Heritage, PIRSA and affected landholders regarding the management of soils and terrain issues
- conduct geotechnical surveys during the detailed design phase to identify areas of potential subsidence or collapse, which may include seismic or resistivity surveys to identify caverns in the karst areas east of the Curdies River
- include the findings of the engineering geotechnical studies into pipeline design specifications and construction management plans, and
- avoid high, steep unstable dunes or active dunes, where practicable.

During construction:

- limit ground disturbance and vegetation clearing to the minimum extent necessary for safe pipeline construction
- install erosion and sediment control structures in accordance with the Construction Environmental Management Plan
- install diversion berms and cross ditches to divert water off the right-of-way
- direct discharge run-off water away from the trenchline at a non-erosive velocity onto adjacent stable ground
- routinely inspect and maintain erosion and sediment control structures, particularly after heavy or prolonged rainfall
- limit the period between clear-and-grade and restoration to the minimum practicable, and
- in areas more susceptible to water or wind erosion, limit the period between clear-and-grade and restoration.

During reinstatement and post-construction:

- compact the trench to a level consistent with surrounding soils
- implement appropriate physical and biological stabilisation and site rehabilitation measures in accordance with the Construction Environmental Management Plan
- install a low broad berm (or crown) over the trench line in areas subject to subsidence following agreement with the property owner
- leave periodic breaks in the crown to prevent channelling of run-off along the right-of-way
- routinely inspect and maintain erosion and sediment control structures, particularly after heavy or prolonged rainfall
- implement appropriate measures to permanently solve any recurring erosion problems
- regularly inspect the easement during operations to identify areas of subsidence, and
- implement appropriate rectification measures in areas where subsidence has occurred.

Mass movement

During pre-construction:

- select a pipeline alignment at watercourse crossings that avoids or minimises disturbance to tree root zones
- avoid areas susceptible to slope failure and mass movement where practicable, and
- identify areas susceptible to slope failure and mass movement on the Alignment Sheets.

During construction:

- implement slope compaction and stabilisation measures in accordance with the Construction Environmental Management Plan, and
- where practicable, construct during dry periods in areas susceptible to slope failure and mass movement.

During reinstatement and post-construction:

- compact the trench to a level consistent with surrounding soils
- implement appropriate physical and biological stabilisation and site rehabilitation measures in accordance with the Construction Environmental Management Plan, and
- routinely inspect and maintain erosion and sediment control structures, particularly after heavy or prolonged rainfall.

Soil inversion

During pre-construction:

- in the Construction Environmental Management Plan clearly identify the importance of stockpiling topsoil and trench spoil separately, and
- in the Construction Environmental Management Plan identify the importance of backfilling the trench in the appropriate soil horizon order.

During construction:
- stockpile topsoil and trench spoil separately, and
- where practical, return trench spoil in the appropriate horizon order.

During reinstatement and post-construction:
- at the completion of works, respread topsoil across the easement, and
- regularly inspect the easement to monitor rehabilitation.

Soil compaction

During pre-construction:
- identify access tracks and turn-around points for vehicles, and
- minimise the number of planned tracks and attempt to use existing tracks.

During construction:
- restrict all vehicles and equipment movements to the construction easement or designated access tracks and roads.

During reinstatement and post-construction:
- rip or scarify compacted areas where necessary to facilitate vegetation growth, and
- regularly inspect the easement to monitor rehabilitation.

Soil contamination

During pre-construction:
- include a spill prevention, response and cleanup procedure into the Construction Environmental Management Plan, including refuelling techniques and chemical storage and handling requirements
- conduct contaminated soils surveys during the detailed design phase to identify the location, nature and level of pre-existing contamination
- include site specific management strategies in the Construction Environmental Management Plan, and
- include the locations of all known sites of pre-existing contamination on the Alignment Sheets.

During construction:
- ensure the easement is kept free of consumable rubbish (such as lunch wrappers) and construction generated waste
- use drip tray and spill mats for refuelling truck
- use spill mats and spill containment equipment onsite where diesel pumps are required on the easement
- implement cleanup procedures if a spill occurs, and
- where contaminated sites are identified on the Alignment Sheets, carry out construction in accordance with the Construction Environmental Management Plan.

During reinstatement and post-construction:
- inspect easement to ensure any construction generated rubbish / equipment is removed, and
- inspect the easement to ensure that any spills which may have occurred are appropriately remediated.

Acid sulphate soil formation

During pre-construction:
- conduct a targeted soil survey of the final alignment during the detailed design phase to identify all areas of potential acid sulphate soils and include these locations on the Alignment Sheets, and
- incorporate acid sulphate soil management procedures into the Construction Environmental Management Plan. These may include measures to:
  - minimise the time that trench spoil is stockpiled
  - neutralise trench spoil with lime
  - contain runoff from stockpile areas in holding ponds or bunded areas
  - dispose of trench water only after analysis
  - re-bury soil below the water table
  - use inert capping (that is, placing inert, low permeability soil below the topsoil for a width of 3m), and
  - compact backfill to prevent acid leachate migration.

During construction:
- construction supervisor to check with the contractor and client Project environmental officer prior to commencing work in identified acid sulphate soil regions, and
- ensure the acid sulphate soil management procedures in the Construction Environmental Management Plan are implemented.

During reinstatement and post-construction:
- inspect the easement to monitor rehabilitation in acid sulphate soil regions.

Disturbance to significant geological features

During pre-construction:
- avoid significant geological features where practicable
- select the final alignment in the Harman Valley Lava Flow area to avoid disbursing or removing the natural stone mounds or filling the depressions, and
- include the locations of all known sites of geological significance on the Alignment Sheets.

During construction:

- ensure construction techniques in regions of identified geological significance are in accordance with Construction Environmental Management Plan.

During reinstatement and post-construction:

- inspect the easement to monitor rehabilitation in regions of geological significance.

6.4 Conclusion

The soils and terrain of the SEA Gas pipeline corridor have been assessed on the basis of a review of literature and geological mapping, supplemented by field observations (ground-truthing). A geotechnical survey will be undertaken as part of the detailed engineering design phase. A number of potential localised impacts to the soils and terrain of the Project area have been identified, including erosion and sedimentation, mass movement, soil inversion, soil compaction, soil contamination, acid sulphate soil formation, and disturbance to significant geological features. Strategies for avoidance or mitigation of these impacts have been outlined. SEA Gas is confident that with the application of appropriate avoidance and mitigation strategies, all impacts to the soils and terrain of the Project area can be reduced to an acceptable level.

7 Hydrology

SEA Gas acknowledges the ecological and social importance of the surface and groundwater resources of the Project area and is committed to their protection. It recognises that appropriate management of the Project is required to avoid or mitigate a range of potential impacts, such as:

- changes to shallow hydrogeological conditions
- interruption or modification to surface drainage patterns
- sedimentation of watercourses
- contamination
- disruption to third party use of surface waters, and
- disturbance to groundwater infrastructure.

SEA Gas is confident that by applying appropriate avoidance and mitigation strategies, all impacts to the water resources of the Project area can be reduced to an acceptable level.

7.1 Groundwater

This section broadly describes the hydrogeological conditions traversed by the pipeline corridor. In particular, the section focuses on shallow groundwater resources and the potential impacts associated with pipeline construction activities. The pipeline will not intersect or impact on deep aquifers and as such these are not discussed further.

7.1.1 Existing Environment

The pipeline corridor traverses eight broad hydrogeological units (see Table 7-1). Within these, shallow groundwater reserves occur in several regional locations, typically associated with:

- interdunal swale areas of coastal Victoria
- discharge areas, such as Naracoorte interdunal swales and the low lying areas of Cooke Plains
- irrigation areas in proximity to Mount Charles, Keith and the Murray River floodplain
- areas that experience significant and prolonged inundation near Naracoorte
- surface drainage features (for example seepages and springs) associated with fractured rock aquifers, particularly within Victoria's Grassdale to Poolaijelo region and South Australia's Mount Lofty Ranges, and
- coastal areas of the Northern Adelaide Plains (east of the Port River).

The areas of shallow groundwater are described in Table 7-1. Figure 7-1 indicates those areas where exposed or shallow groundwater is likely to be encountered.

The knowledge of groundwater quality is limited to the broad salinity range. Through much of Victoria's south-west, groundwater is fresh to brackish, with an upper limit of approximately 6000mg/l. Groundwater quality in South Australia (particularly through the South East region), exhibits highly variable salinity ranges, from less than 500mg/l to salinity levels in excess of seawater quality, at 35000mg/l.

In addition, in South Australia the pipeline corridor traverses seven Prescribed Wells Areas and one Moratorium Area (proclaimed under the *Water Resources Act 1967*). These areas have restricted licences issued based on permissible extraction volumes, and include:

- Border Share Zone
- Comaum – Caroline
- Naracoorte Ranges
- Lacepede – Kongorong
- Padthaway
- Tatiara
- North Adelaide Plains, and
- Tintinara and Coonalpyn Moratorium Area.

7.1.2 Potential Impacts

The following Project activities have the potential to affect the shallow groundwater resources within the Project area:

- construction of the pipeline trench
- de-watering of the trench to aid construction
- the storage and handling of small quantities of fuel and chemicals (which have the potential to be spilt), and
- the presence of the back-filled trench during operation.

Adequate management of the Project will prevent or successfully mitigate a range of potential impacts to the shallow groundwater resources found within the Project area. Such impacts include:

- changes to hydrological conditions
- contamination of groundwater, and
- disturbance to groundwater infrastructure.

The presence of shallow groundwater may also constrain standard construction activities.

Table 7-1: Hydrogeological Units

Unit	Location	Extent (km)	Unit Description	Shallow Groundwater
Coastal unconsolidated dunes and swales with associated shallow groundwater	Port Campbell to Allansford	45	Coastal marine deposits of unconsolidated sands over limestone. Local high rainfall produces lenses of fresh water, which may overlay brackish waters.	Shallow groundwater predominant in inter-dunal sections
Incised hard rock with deeper groundwater	Allansford to Grassmere	15	The corridor traverses deeply incised, very hard rock terrain.	Groundwater is not anticipated to be intersected, except at the crossing of surface drainage features.
Volcanic lenses and limestones with shallow groundwater	Grassmere to Willatook	25	Weathered volcanic layers overlying limestone.	Groundwater is likely to be encountered at very shallow depths in this section.
	Willatook to Wallacedale	40		It is anticipated that shallow groundwater and exposed water tables will be encountered in several locations.
Basalts and deep groundwater	Wallacedale/ Branxholme to about Grassdale	25	Basalts with deeper groundwater.	No shallow groundwater is likely to be encountered
Hard rock and deep groundwater	Grassdale to Poolaijelo	80	Local terrain is commonly of unconsolidated sandstones and limestones over consolidated rock types of the Otway Group. Local high rainfall recharges the fractured rock aquifers. Local drainage features transport a significant proportion of groundwater from the highlands to the surrounding slopes and plains.	Shallow groundwater is present through the region as near surface drainage features (seepage and springs).
Remnant coastal dunes, swales and lowlands, having poorly drained swampy areas associated with watertable interspersed with dunes.	Poolaijelo to Tepko	350	Sedimentary clays, sands, marls and limestones that comprise the Murray Basin dominate the terrain. Commonly the surficial geology is of unconsolidated to weakly cemented sands, which exist to depths greater than 2m interspersed with pockets of hard limestones.	Groundwater is present near surface in several places, including a 20km section around Naracoorte where the watertable can be exposed during winter. Extensive rainfall can cause localised flooding for prolonged periods.
Aquifers lie within the Mount Lofty Ranges sequence of rock types.	Tepko to Elizabeth North	50	Well-consolidated meta-sediments. The area is a recharge zone for the Murray Basin, on the Ranges' eastern slopes. Low rainfall limits the recharge rate. Groundwater from the western slopes recharges the North Adelaide Plains.	Springs and salinised portions of the landscape have the potential to produce long-term flows should the pipeline intersect. Potentially long lasting effects on the landscape and integrity of the pipe may result, due to low pH and high salinity of some seepage water. Long-term water logging could also result down gradient of these springs and seepages.
Sedimentary sequences that comprise the rich horticultural areas of the North Adelaide Plains.	Elizabeth North to Pelican Point	20	Quaternary sediments with perched water tables, fed by streams.	High salinity groundwater varying from 18 000mg/l to as much as 130 000mg/l is found on the east of the Port River. This groundwater can be found between 0.2m and 4.0m from the surface.

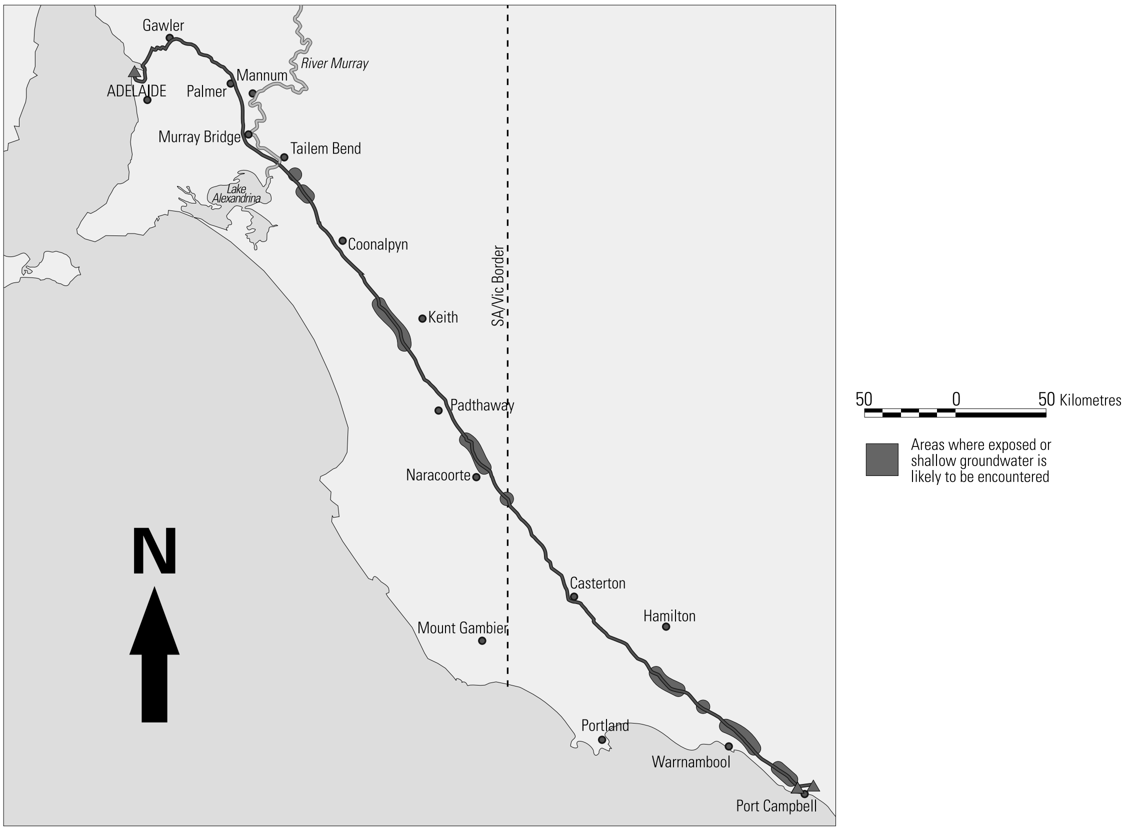

Figure 7-1: Areas of Shallow Groundwater

Due to the nature of pipeline construction activities and operational conditions, no impacts to deep aquifers are likely to occur.

Changes to Hydrological Conditions

The intersection of shallow groundwater by the open trench has the potential to create localised disturbance to flow patterns, particularly in recharge or discharge zones. Due to the minor depth of the intrusion (approximately one metre) and the short period for which the trench is open (approximately one to three weeks, depending on the location), the resultant impact on groundwater flows is considered to be inconsequential. Similarly, no adverse impacts are expected to the values protected by the Prescribed Wells Areas and Moratorium Area.

To aid construction, it is common pipeline industry practice to pump any accumulated water from the trench. Impacts are local and short term and not anticipated to have any measurable effect on groundwater resources. The need to protect soils from potential erosion is discussed in Chapter 6.

Backfilling the trench after the pipeline has been laid aims to adequately compact returned trench spoil consistent with pre-existing conditions. If the backfilled trench is significantly less compacted than the surrounding soils, it may act as a horizontal conduit to water, altering the local hydrology. Alternatively, if sections of the trench are compacted more than the pre-existing (that is, sandy) conditions, lateral flows of groundwater may be impeded, potentially resulting in accumulation of saline groundwater at compacted surfaces.

Contamination of Groundwater

The potential exists for Project related activities to result in localised shallow groundwater contamination. The main potential sources of contamination are:

- minor spills of fuel or chemicals
- leachate from acid sulphate soils created by exposure (and oxidation) of soils during trenching, and
- discharged hydrotest water.

Pipeline projects involve relatively small quantities of chemicals and the risks to groundwater associated with minor spills are extremely low. Pipeline construction equipment (such as graders, bulldozers and side-boom tractors) will be refuelled on the right-of-way from a standard fuel truck. These trucks hold up to 16 000 litres, however it is highly unlikely that a storage tank on a fuel truck would be breached and the entire contents be spilt.

As discussed in Section 6, the pipeline corridor traverses a number of areas of acid sulphate soils. Without adequate planning and management, localised impacts to shallow groundwater are likely to occur.

Hydrotest water will contain low levels of corrosion inhibiting chemicals. Inappropriate disposal of this water may result in localised contamination of shallow groundwater.

Disturbance to groundwater infrastructure

The pipeline corridor passes through a number of areas containing groundwater observation wells. Observation wells are managed by the South Australian Department for Water Resources and the Victorian Catchment Management Authorities. These wells provide an indication of water levels and quality, and are often important in their contribution to regional and historic datasets. Impacts to such infrastructure (through physical damage during construction) are highly unlikely.

The Upper South East Integrated Catchment Management Program is currently investigating the feasibility of implementing a regional drainage scheme. Drainage schemes are developed to drain surface and groundwater from areas of prolonged inundation in often highly saline environments. The SEA Gas Project proposes to intersect the proposed drainage scheme at two locations.

Constraints to Standard Construction Activities

For much of the year (particularly during or after winter), saturated clays and sands may constrain construction at many of the identified shallow groundwater zones (see Table 7-1). Likewise, unconsolidated sediments coupled with shallow groundwater conditions in the Cooke Plains region, may constrain construction (due to possible collapse of the trench during construction and excessive water seepage).

In groundwater discharge areas, substantial outflow is likely to result in waterlogged trenches at some times of year. High shallow aquifer yields (in sections of the Murray Basin) are also expected to be problematic during construction, where trench de-watering rates will have virtually no effect on local groundwater seepage. If they are not avoided, springs and seepages in the Mount Lofty Ranges and the Grassdale to Poolaijelo region may also result in substantial flows of water into the trench.

7.1.3 Impact Mitigation

Objective

The principal management objective is to minimise adverse impacts to shallow groundwater resources.

Project Phase	Objectives*
Construction	2.a To appropriately minimise and manage adverse impacts and long term environmental risk to groundwater as a result of construction activities 2.b Where practicable, appropriately rehabilitate adverse impacts to groundwater as a result of construction activities
Operation	18.a To appropriately minimise and manage adverse impacts to shallow groundwater resources
**Note: Objectives have been numbered to enable cross-referencing in the South Australian SEO.*	

Goals

The principal management goals are:

Project Phase	Goal*
Construction	2.1 To prevent significant alteration to hydrological conditions 2.2 To appropriately protect groundwater quality from contamination by fuel, chemicals, acid sulphate soil leachate or other hazardous substances 2.3 To avoid damage to groundwater infrastructure 2.4 To plan for the constraints posed by shallow groundwater to standard construction activities
Operation	18.a To appropriately minimise and manage adverse impacts to shallow groundwater resources
**Note: Goals have been numbered to enable cross-referencing in the South Australian SEO.*	

Mitigation Measures

To mitigate potential impacts to groundwater, SEA Gas will:

- adopt the principles and practices outlined in the APIA Code
- integrate site specific management strategies into the Construction Environmental Management Plan
- where practicable, schedule construction during times of low water tables
- where practicable, align the pipeline to avoid direct impact to groundwater recharge and discharge areas
- compact the trench to a level consistent with surrounding soils
- install trench plugs to prevent longitudinal water flow within the trench
- include a spill prevention, response and cleanup procedure into the Construction Environmental Management Plan (which will include refuelling techniques and chemical storage and handling requirements)
- include acid sulphate soil management procedures into the Construction Environmental Management Plan (see Chapter 6)
- include the locations of shallow groundwater, groundwater recharge and discharge, acid sulphate soils and groundwater infrastructure on Alignment Sheets
- include the findings of the engineering geotechnical studies into pipeline design specifications and construction management plans, and
- work in close liaison with Catchment Management Authorities, Water Catchment Management Boards, Southern Rural Water and the Department for Water Resources regarding the management of groundwater issues.

7.2 Surface Water

This section broadly describes the regional surface water characteristics of the Project area, identifies potential impacts to these resources and presents a strategy by which impacts can be avoided or minimised. Issues specifically related to watercourse crossings are dealt with separately (see Section 7.3).

7.2.1 Existing Environment

Watercourses within the Project area range from small, turbulent streams in the steeply graded rocky gullies of the uplands to the broad, meandering rivers of the low hills and plains. Watercourses may be perennial (or permanent) streams, intermittent (or seasonal) streams or ephemeral streams, which only flow for short periods after heavy rain. The pipeline will cross many watercourses, which may contain water, depending on the time of year.

Lakes, swamps, wetlands and other natural drainage soaks form part of the surface resources of the Project area. SEA Gas has selectively avoided these to minimise impacts.

The following sections outline the relevant hydrological features of each bioregion traversed by the pipeline. Bioregions are illustrated in Figure 5-1, and the surface water features mentioned are shown on Maps 4 – 11.

Coastal Southwestern Victoria

The pipeline corridor through coastal southwestern Victoria traverses the Corangamite Basin surface water hydrological region (Hardie, 1997). Major watercourses traversed by the corridor include the Curdies and Hopkins rivers. Ill-defined drainage, swampy tracts and small boggy basins are common. The corridor crosses Port Campbell Creek north of Port Campbell.

Volcanic Plains

Primary watercourses traversed by the pipeline corridor within the Otway Basin include the Glenelg, Gellibrand and Moyne rivers. The Glenelg River is the main regional drainage feature, originating from the Grampians area, north east of Hamilton and discharging to the sea at Nelson. The pipeline crosses this river in the Wimmera Plains bioregion.

Other major watercourses traversed by the alignment include the Merri River, Manifold Creek, Moyne River, Back Creek, Shaw River, Eumeralla River, Louth/Weerangourt Creeks, Lyne Creek, the northern portion of the Condah Swamp complex, and the Crawford River. Other standing water features include volcanic lakes (for example, Lake Cartcarrong and Lake Wangoom) and numerous ephemeral wetlands.

Dundas Tablelands

Major watercourses traversed by the pipeline in this region include Palmer, Merino and Dwyer creeks. The Glenelg River transects this region, but the pipeline will not intercept this river until south of Casterton.

Wimmera Plains

The land surface is little dissected apart from the valleys of the Glenelg and Wannon rivers and their tributaries which include Salt, Red Cap and Deep creeks. The Glenelg and Wannon rivers are characterised by broad flat valley profiles often with steep, confining clifflines and slopes.

Major surface drainage through the Dergholm region includes Mosquito and Salt creeks.

From the border area through to Naracoorte, substantial swampy depressions, such as Benoch and Groker swamps, and smaller depressions and sinkholes commonly occur. Several intermittent streams also traverse the western section of the plains, and include Mosquito, Yelloch and Naracoorte creeks.

Southern Mallee

Although the South East region of South Australia has many seasonal and permanent swamps and water bodies, it is almost devoid of surface streams. Smaller depressions and water holes occur throughout, with shallow granites, uplifted along the Padthaway Ridge, providing a mechanism for water collection. Morambro Creek represents the only significant watercourse in the Southern Mallee and some artificial drainage channels have also been constructed as a result of common flooding.

Murraylands

The main drainage feature of the region, and the State, is the Murray River. Numerous streams flow easterly from the Mount Lofty Ranges towards the Murray River (Murray Plains Soil Conservation Board, 1995). The Murray River extends from North of Roma in Queensland to Goolwa in South Australia (Murray Plains Soil Conservation Board, 1995).

Mount Lofty Ranges

The Mount Lofty Ranges Catchment provides the major resource for Adelaide's reticulated water. Surface water throughout the Mount Lofty Ranges has deteriorated due to land use and urbanisation. The Torrens River is a key drainage feature of northern central region. The Reedy Creek, Long Gully and Milendella Creek catchments are found to the east of the northern Mount Lofty Ranges (Mount Lofty Ranges Catchment Program, 2001). Intermittent streams such as Harrison and Milendella creeks are dominant features while waterholes and soakages are also common. Reedy Creek is recognised for its geological significance and the crossing of this watercourse occurs prior to Palmer.

The upper catchment of the South Para River comprises a landscape of broad crested ridges and dissected slopes. However, the Project intercepts this river in the Northern Adelaide Plains bioregion.

Northern Adelaide Plains

The Northern Adelaide Plains encompass western Mount Lofty Ranges alluvial slopes and adjoins the flat, poorly drained landscape of the coastal plains. Outwash swamps that formerly occured along the slopes have largely been reclaimed through flood mitigation. The North Para River is the main source of the recharge to the Barossa Valley Basin. The pipeline corridor crosses the South Para River immediately south of Gawler.

The most important drainage features of this region are the Gawler River (and its two main tributaries, the North Para and South Para rivers), the Little Para River and the Dry Creek system.

Unsustainable water consumption, extensive land clearance, agriculture, industrial and urban development have led to altered stream flows, declining groundwater quality and levels, degradation of surface water quality, and degraded or lost habitat throughout this region.

7.2.2 Potential Impacts

The following Project activities have the potential to affect surface waters within the Project area:

- topsoil stripping
- trenching activities
- storage and handling of small amounts of fuel and chemicals
- hydrostatic testing, and
- watercourse crossings (discussed further in Section 7.3).

Adequate management of Project construction will prevent or successfully mitigate a range of potential impacts to surface water resources. Such impacts may include:

- increased sediment load and turbidity
- contamination
- interruption or modification to surface drainage patterns, and
- disruption to ecology and third party use of surface waters.

No impacts to surface water are expected during operation, following the successful restoration of surface contours and stability.

Increased Sediment Load and Turbidity

A temporary reduction in water quality caused by sediments entering streams and increasing turbidity is the most likely potential impact to occur during construction. The major source of sediment is erosion, transported by surface run-off, stream bank collapse and disposal of turbid trench water. The extent of sedimentation is determined by factors such as soil type, slope, run-off volume and velocity and vegetation cover.

In Victoria, sedimentation due to human activities is considered an important potential impact on streams reflected in listing under the *Flora and Fauna Guarantee Act 1998* as a potentially threatening process.

Contamination

The potential exists for Project related activities to result in localised surface water contamination. As with groundwater, the main potential sources of contamination are:

- minor spills of fuel or chemicals
- highly saline groundwater pumped out of the trench during construction
- leachate from acid sulphate soils created by exposure (and oxidation) of soils during trenching, and
- discharged hydrotest water.

Pipeline projects involve relatively small quantities of chemicals and the risks to water resources associated with minor spills are extremely low. Pipeline construction equipment (such as graders, bulldozers and side-boom tractors) will be refuelled on the right-of-way from a standard fuel truck. These trucks hold up to 16 000 litres, however it is highly unlikely that a storage tank on a fuel truck would be breached and the entire contents be spilt.

The pipeline corridor traverses several areas that contain shallow, highly saline groundwater (notably the area east of the Port River). Inappropriate disposal of saline groundwater (from de-watering of the trench during construction) may cause localised salinity increases in surface waters.

As discussed in Chapter 6, the pipeline corridor also traverses a number of areas of acid sulphate soils. Adequate planning and management is required to prevent or mitigate localised impacts to surface water (as discussed in Section 6.3).

Hydrotest water will contain low levels of corrosion inhibiting chemicals. Inappropriate disposal of this water may result in localised contamination of water resources.

Interruption or Modification to Surface Drainage Patterns

Construction activities may result in physical disturbance to defined watercourses and to overland flow. Watercourse crossings are discussed in Section 7.3. Impacts to surface drainage patterns associated with overland flow away from watercourses are less noticeable. If they occur, impacts are most likely to be associated with the presence of temporary linear stockpiles of topsoil and trench spoil and modifications to surface contours during earthworks, which may impede or change natural overland flows.

Disruption to Ecology and Third Party Use of Surface Waters

It is recognised that impacts to watercourses are not limited to the hydrological issues of water quality and quantity, but may also extend to:

- local ecology (terrestrial and aquatic fauna)
- domestic water users (private and town supplies)
- rural water users (stock and crop watering)
- recreational users (swimming and fishing), and
- local visual amenity.

These issues are discussed further in Chapters 9 and 11.

7.2.3 Impact Mitigation

Objective

The principal management objective is to minimise adverse impacts to surface water resources.

Project Phase	Objectives*
Construction	3.a To appropriately minimise and manage long term environmental risk to surface water resources as a result of construction activities 3.b To appropriately reinstate surface water contours and landforms
Operation	19.a To appropriately minimise and manage adverse impacts to surface water resources 19.b To appropriately monitor rehabilitation of surface drainage patterns on easement
**Note: Objectives have been numbered to enable cross-referencing in the South Australian SEO.*	

Goals

The principal management goals are:

Project Phase	Goal*
Construction	3.1 To minimise the amount of sediment entering surface water features 3.2 To appropriately protect surface waters from contamination by fuel, chemicals, highly saline groundwater, acid sulphate soil leachate or other hazardous substances 3.3 To minimise short term, and prevent long-term, interruption or modification to surface drainage patterns 3.4 Minimise disruption to third party use of surface waters
Operation	19.1 To appropriately protect surface waters from contamination by fuel, chemicals, acid sulphate soil leachate or other hazardous substances and to undertake remediation works where required 19.2 To monitor and remediate long-term, interruption or modification to surface drainage patterns resulting from SEA Gas Project activities 19.3 Minimise disruption to third party use of surface waters
**Note: Goals have been numbered to enable cross-referencing in the South Australian SEO.*	

Mitigation Measures

To mitigate potential impacts to surface water, SEA Gas will:

- adopt the principles and practices outlined in the APIA Code
- integrate site specific management strategies into the Construction Environmental Management Plan
- where practicable, select a pipeline alignment that avoids local surface water features such as lakes and wetlands
- remain vigilant for expected storm or flood warnings and develop a contingency plan for such events
- cease clear-and-grade activities at least 10m from banks of flowing watercourses
- conduct subsequent grading and trenching immediately prior to pipe laying (that is, after the pipe is welded)
- stockpile topsoil separately from trench spoil
- stockpile material in bunded areas away from the watercourse banks
- ensure adequate erosion and sediment controls are in place to protect water:
  - design erosion and sediment control measures that consider site conditions, slope, vegetation cover, proximity to sensitive environments, construction phase and climatic conditions
  - install diversion berms or drains along the top and at intermediate points down the slopes to the watercourse
  - install of silt fences as necessary for interim on-site erosion control
  - monitor, maintain and repair erosion and sedimentation controls to ensure they remain effective, particularly after heavy rainfall events and during periods of prolonged rainfall
- reinstate surface contours as soon as reasonably practicable
- prohibit vehicle refuelling within 50m of a watercourse
- ensure spill response and clean up equipment is on-site prior to commencing works
- include a spill prevention, response and cleanup procedure into the Construction Environmental Management Plan (which will include refuelling techniques and chemical storage and handling requirements)
- include acid sulphate soil management procedures into the Construction Environmental Management Plan (see Chapter 6)
- incorporate procedures for management of contaminated water (for example highly saline groundwater, leachate from acid sulphate soils or discharged hydrotest water) into the Construction Environmental Management Plan. These may include measures to:
  - contain and treat water on site
  - dispose of water after analysis
  - remove water off site
- incoporate prodedures for monitoring and maintenance of long term erosion and sediment controls into the Operation Environmental Management Plan
- implement appropriate measures to permanently solve any recurring erosion or sedimentation problems, and
- work in close liaison with Catchment Management Authorities, Water Catchment Management Boards, Southern Rural Water and the Department for Water Resources, Department of Natural Resources and Environment, Department for Environment and Heritage and Primary Industries and Resources and affected landholders regarding the management of surface water issues.

7.3 Watercourse Crossings

Currently, three principal construction techniques for pipe laying at watercourse crossings are used. These are:
- open cutting
- boring, and
- Horizontal Directional Drilling (HDD).

In addition to pipe laying, temporary watercourse crossings may also be constructed to facilitate the movement of construction vehicles along the pipeline easement over minor watercourses, particularly drainage lines.

The majority of watercourse crossings involve small watercourses or drainage lines and are expected to be constructed using standard open cut (trenching) construction. It is most suited to dry or low flow conditions, and involves establishing a stable working platform on either side of the watercourse and creating a trench with excavators. Flow diversion may be employed where higher volumes and flows of water are present.

The technique of boring is commonly applied to install pipelines beneath infrastructure such as roads, railways, buried utilities and in some circumstances for watercourse crossings. It is a low impact technique involving the drilling of short distances from below ground within an enlarged trench area, or bellhole, within the construction easement. The feasibility of using a bore is limited by site conditions, including depth of watercourse crossing, geology, landform and soil type.

The installation of the pipeline by HDD involves drilling a hole at a shallow angle beneath the surface through which the pipe is threaded. The feasibility of using HDD is strongly limited by site conditions including geology, landform, soil conditions, and available workspace. Although it may reduce above ground impacts, the technique introduces additional environmental considerations such as drill site sediment control and waste management. In addition to these considerations, the technique increases the construction duration at the specific location and the workforce required to complete the crossing.

A full description of these techniques is provided in Section 3.7.

7.3.1 Existing Environment

The construction of the SEA Gas pipeline will require the crossing of several watercourses, including rivers, streams, creeks and drainage lines. These are described in Section 7.2.

The method for most watercourse crossings will be determined during the pre-constuction phase. Figure 7-2 outlines the process used to determine suitable watercourse crossing techniques. It is expected that most major watercourses will be crossed by boring or horizontal drilling. Drilling has been identified as the crossing method at a number of significant rivers, including the Hopkins, Curdies, Glenelg and Murray Rivers.

7.3.2 Potential Impacts

Adequate management is required to prevent or mitigate in a range of potential impacts of watercourse crossings. General impacts to surface water are discussed in Section 7.2. Potential impacts of the three different watercourse crossing techniques are summarised in Table 7-2.

Table 7-2: Potential Impacts of Watercourse Crossing Techniques

Technique	Potential Hazard	Potential Impact
Open Cut	Inadequate sedimentation controls	Potentially high sediment release during backfilling if controls are not adequately in place
Horizontal Directional Drill	Loss of circulation, collapsed hole, stuck drill stem, lost tools	Failure leads to subsequentattempts and possible additional land requirements
	Drill mud seepage directly into land and water course	Prolonged sediment load and deposition
	Washout of cavities and collapse of right-of-way.	Sink holes on right-of-way and under water course
	Deviation of drill alignment	Potential third party damage
	General	Short-term visual impacts due to presence of equipment
Boring	Collapsed hole, stuck drill stem, lost tools	Failure leads to subsequent attempts and possible additional land requirements
	Washout of cavities and collapse of right-of-way	Sink holes on right of way and under water course
	General	Short term visual impacts due to presence of equipment
	Bellhole Dewatering	Discharge erosion, contamination

(Source: Canadian Watercourse Crossing Committee, 1999)

7.3.3 Impact Mitigation

Objective

The principal management objective is to minimise adverse impacts of watercourse crossings.

Project Phase	Objectives*
Construction	4.a To appropriately minimise and manage long term environmental risk to watercourse crossings as a result of construction activities 4.b To appropriately reinstate and rehabilitate watercourse crossing locations
Operation	20.a To appropriately monitor rehabilitation of watercourse crossing locations
**Note: Objectives have been numbered to enable cross-referencing in the South Australian SEO.*	

Goals

The principal management goals are:

Project Phase	Goal*
Construction	4.1 To minimise impacts on riparian, aquatic and water dependant biota 4.2 To minimise disturbance to watercourse bed and banks 4.3 To maintain water quality and water flow requirements 4.4 To minimise erosion, sedimentation and acidification impacts 4.5 To achieve long term site stability 4.6 Minimise disruption to third party use 4.7 Minimise visual impact at water crossing locations
Operation	20.1 To achieve long term site stability and appropriate site restoration
**Note: Goals have been numbered to enable cross-referencing in the South Australian SEO.*	

Mitigation Measures

To minimise potential impacts of watercourse crossings, SEA Gas will:

- adopt the principles and practices outlined in the APIA Code
- integrate site specific management strategies into the Construction Environmental Management Plan
- select a watercourse crossing point that minimises potential impacts
- select the most appropriate crossing technique in accordance with Figure 7-2, including boring or directional drilling significant rivers where practicable
- complete watercourse crossings within the shortest period practicable to minimise the period of open trench and subsequent environmental disturbance
- rehabilitate crossing points and banks within the shortest period practicable after works have been completed.
- avoid watercourse crossing works during periods of flood or heavy rainfall
- ensure all equipment necessary for the stream crossing is on-site and in good working order prior to commencing work
- ensure spill response and clean-up equipment is on site
- cease clear and grade activities at least 10m from banks of flowing watercourses
- carry out subsequent grading and trenching immediately prior to pipe laying, that is, after the pipe is welded and watercourse crossing site prepared as per approval requirements
- stockpile material in a bunded area away from the watercourse banks
- stockpile topsoil separately from trench spoil
- design erosion and sediment control measures to consider site conditions, slope, vegetation cover and proximity to sensitive environments
- place diversion berms or drains as necessary along the top and at intermediate points down the slopes to the watercourse
- place silt fences as necessary for interim on-site erosion control
- routinely inspect and maintain erosion and sediment control measures to ensure they remain effective, particularly after heavy rainfall events and during periods of prolonged rainfall
- locate HDD drill entry and exit points away from watercourse banks, sensitive vegetation and any heritage sites
- monitor drill entry and exit points for potential fracturing out of drilling mud
- dispose of drilling mud (bentonite) and cuttings as per approval requirements
- ensure HDD equipment is in good working order
- refuel a minimum of 50m from watercourses
- reinstate HDD entry and exit sites (revegetation of the easement aims to re-establish local indigenous plant species) in consultation with regulatory authorities
- incorporate procedures for monitoring and maintenance of long term erosion and sediment controls into the Operation Environmental Management Plan
- implement appropriate measures to permanently solve any recurring erosion or sedimentation probloms
- obtain approvals for watercourse crossings (including temporary crossings for vehicles) from the Glenelg Hopkins Catchment Management Authority and Corangamite Catchment Management Authority, and
- work in close liaison with Catchment Management Authorities, Water Catchment Management Boards, Southern Rural Water and the Department for Water Resources Department of Natural Resources and Environment, Department for Environment and Heritage, Primary Industries and Resources regarding the management of surface water issues.

7.4 Conclusion

The Project area encompasses a number of regions with shallow groundwater reserves, and crosses many watercourses. A number of potential impacts to the ground and surface water resources of the Project area have been identified, and watercourse crossings have been identified as a particular activity that may impact surface water resources. Strategies for avoidance or mitigation of potential impacts have been outlined. SEA Gas is confident that with the application of appropriate avoidance and mitigation strategies, all impacts to the water resources of the Project area can be reduced to an acceptable level.

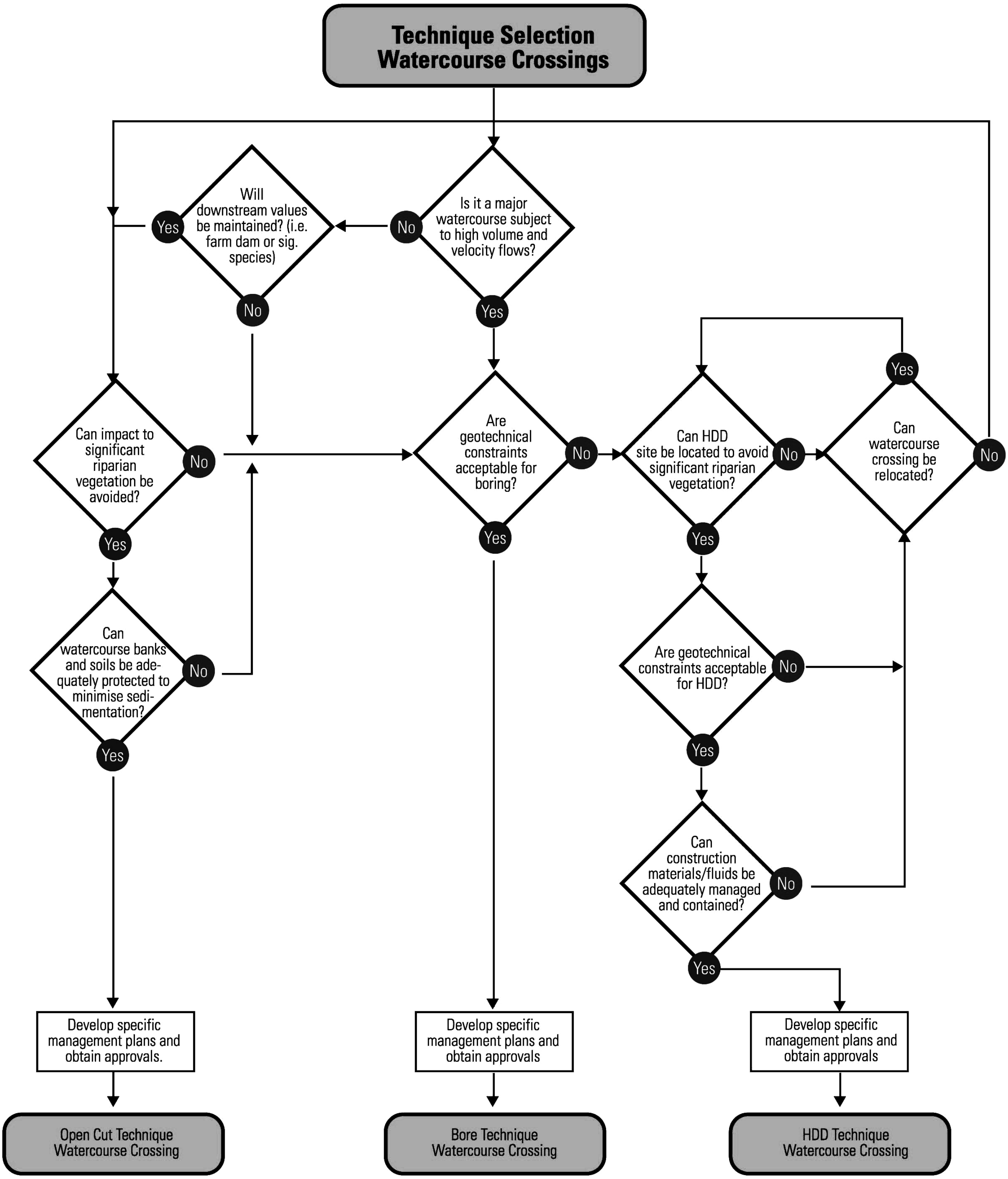

Figure 7-2: Watercourse Crossing Decision Process

8 Emissions

8.1 Air Emissions

SEA Gas acknowledges the environmental and community importance of the air quality of the Project area and is committed to its protection. It recognises that appropriate management of the Project is required to avoid or mitigate a reduction in air quality as a result of compressor emissions during operation and minor dust generation during construction.

SEA Gas is confident that with appropriate design and management all impacts to the air quality of the Project area can be reduced to an acceptable level.

8.1.1 Existing Environment

Ambient air quality data are only available for the metropolitan areas of Adelaide (including the Mount Lofty Ranges and Adelaide Plains regions). The closest Environment Protection Authority ambient air monitoring station to the Project area is at Geelong, some 190km to the northeast of Port Campbell. As such, quantified regional air quality data is not available for the majority of the pipeline corridor. Despite this, good air quality, at both the regional and local scale, is expected due to the lack of heavy industry and population centres and the prevailing moderate to strong winds, which are oceanic in origin. The National Pollution Inventory[1] (NPI) database confirms that there are no major industrial emissions between Port Campbell and Murray Bridge.

Ambient air quality in the Adelaide Plains region is particularly dependent on industrial emissions as well as daily and seasonal climatic conditions such as prevailing winds and atmospheric inversion layers. Industrial emissions of particular note include those from hydrocarbon storages, cement, battery and soda production and co-generation power production.

On a smaller scale, industrial emissions from the regional centre of Murray Bridge include those from the hydrocarbon, plastic and dairy production and meat processing industries.

The air environment of the proposed Yallamurray Compressor Station, northeast of Padthaway (see Figure 8-1) is typical of the rural broadacre farming environment within the region. Minor industrial emissions are limited to the small number of wineries in the local region.

8.1.2 Potential Impacts

The following Project activities have the potential to affect the air quality of the Project area:
- earthworks during construction
- construction vehicles and equipment
- operation of the Yallamurray Compressor Station, and
- operation of the pipeline and associated infrastructure.

Appropriate management of the Project will prevent or successfully mitigate a range of potential impacts to local air quality. Such impacts include:
- generation of dust from the construction right-of-way, access tracks and work areas
- minor reduction in air quality resulting from vehicle and equipment emissions, and
- localised reduction in air quality resulting from emissions from the compressor station and pipeline.

Dust Generation

The primary impact on the air quality during construction of the pipeline is likely to arise from dust generated through earthworks and vehicle movement. Low rainfall in the summer months may increase the likelihood of dust impacts. However, no dust issues are likely once the pipeline is in operation. Therefore, significant long-term nuisance to residents or a sustained deterioration in the local air quality as a result of potential dust impacts is unlikely considering:
- the scale of the Project (construction activities are likely to be completed within four weeks at any one location)
- the temporary nature of the work, and
- the availability of effective dust control measures.

Vehicle and Equipment Emissions

Minor air emissions of nitrous oxides, sulphur oxides and carbon monoxides associated with the exhaust of machinery and support vehicles will occur (Environment Protection Authority, 2000). However, these sources are likely to be negligible in the context of existing farming, transport and residential landuses of the Project area. No measurable impact is likely.

Pipeline Operation

The impact on air quality during operations is expected to

1 A Commonwealth requirement to report industry emissions.

be negligible. Minor emissions from the pipeline are likely at valve stations and scraper stations during maintenance operations.

Minor gas emissions from mainline valves will occur during remote valve operation, as gas pressure is used to drive the valve actuators. The valves are only operated in the event of damage or programmed maintenance. Minor emissions from scraper stations will occur during loading and removal of the pipe pig, which would normally occur once every five years.

Fugitive emissions are extremely low from pipeline operations. As discussed in Section 11.5, the risk of pipeline ruptures or leaks is also extremely low. As such, air emissions associated with such events are unlikely.

Compressor Station Operation – Air Quality Modelling

To assess the potential impacts associated with the operation of the proposed Yallamurray Compressor Station, an air quality modelling assessment was undertaken. The assessment aimed to predict ground level concentrations arising from air emissions and to determine compliance with South Australia's EPA requirements.

The air quality modelling results were obtained using the AUSPLUME (version 5.1) model. This model is generally accepted as being the best regulatory model for predicting the effects of industrial emissions on air quality in Australia. This model is a steady-state Gaussian plume model which can be used to assess pollutant concentrations for a wide variety of sources. Features include setting and deposition of particulates; downwash; point, area and volume sources; plume rise as a function of downwind distance; arbitrary orientation of sources; and terrain adjustment. The model is highly flexible with a range of emission types (gaseous and particulates), and has a range of options which allow the user to adapt the model to suit particular applications and make best use of available source and meteorological data.

The air impact assessment modelling results have been obtained using preliminary engineering design (refer Table 8-1) and the following meteorological input files supplied by South Australia's EPA:

- AUSPLUME meteorological data file (1997) for Cape Jaffa.
- AUSPLUME meteorological data file (1997) for Mount Gambier.

The Mount Gambier file is based on data from the Mount Gambier Airport, which is about 150km south of Padthaway, while Cape Jaffa is approximately 80km west-south-west. Mount Gambier Airport is about 30km inland, and as such, may be more representative of the inland location of Padthaway than Cape Jaffa, although the latter is closer. In this regard, the uncertainties with respect to 'site-representativeness' have been minimised by undertaking AUSPLUME modelling with both data sets to encompass the meteorological regimes from both locations.

The dispersion modelling results have been assessed against the National Environment Protection Measure[2] (NEPM, 1998) ambient air criteria. NEPM standards are regional levels and are not primarily designed for assessing impact issues arising from specific sources. However, the adoption of such standards is based on advice from the South Australian EPA, due to the context of the proposed compressor station – that is there are no other significant sources of the pollutants of interest in the local airshed surrounding the compressor station. NEPM standards applicable to likely air compressor pollutants are contained in Table 8-2.

Table 8-1: Compressor Stack Source Characteristics

Parameter	
Stack Height (m agl)	12.5
AMG coordinates (km)	(453.394, 5961.025)
Base elevation (m amsl)	104
Internal Stack Diameter (m)	1.245
Stack Gas Temperature (°C)	530
Stack Gas Exit Velocity (m/sec)	14.08
Mass emission rate of NO_X (g/sec)	2.35
Mass emission rate of CO (g/sec)	0.08

2 The NEPM sets national environment protection standards and goals for six pollutants.

Table 8-2: NEPM Standards – NO_2 and CO

Pollutant	Standards and Goals
Nitrogen Dioxide (NO_2)	• 1-hour average concentration of 248 mg/m^3 (0.12 ppm, 1 exceedance day per year)*. • Annual average concentration of 62 mg/m^3 (0.03 ppm).
Carbon Monoxide (CO)	• 8-hour average concentration of 11,250 mg/m^3 (9 ppm, 1 exceedance day per year).
* Note: *The conversions from ppm to mg/m^3 are at 0 degrees Celsius and 1 atmosphere pressure (STP)*	

Air modelling results of compressor station NO_2 emissions indicate that the predicted ground level concentrations (GLC) are well under the ambient criterion for NO_2, specifically:

- The predicted highest GLC at the site boundary is approximately 60% of the relevant NEPM ambient standard.
- The predicted highest GLC at the closest residences is less than 2% of the NEPM ambient standard.

The results also indicate that the predicted GLCs are a very small fraction of the ambient criterion for CO for an 8-hour average.

Therefore, the atmospheric dispersion modelling of emissions from the SEA Gas Project Yallamurray Compressor Station near Padthaway indicates that the predicted ground level concentrations for NO_2 and CO comply with relevant ambient standards for South Australia.

Stack source emissions of NO_2 (0.3g/m^3) and CO (0.1g/m^3) also comply with the maximum allowable levels of 0.35g/m^3 for NO_2 and 1g/m^3 for CO prescribed in the South Australian Environment Protection (Air Quality) Policy 1994.

Table 8-3: Emission Modelling Results – GLCs for NO_2 and CO

Emission	Emission Duration	Location Description	'Max.' Pred. GLC (µg/m^3)	NEPM Standard (µg/m^3)
Nitrogen dioxide (NO_2)	Predicted 1-hour Average 'Maximum	Site Boundary	150	248
		Worst-affected Residential Property	5.0	
	Predicted Annual Average 'Maximum'	Site Boundary	5.6	62
		Worst-affected Residential Property	0.2	
Carbon monoxide (CO)	Predicted 8-hour Average 'Maximum'	Site Boundary	4.5	11,250
		Worst-affected Residential Property	0.1	

8.1.3 Impact Mitigation

Objective

The principal management objective is to minimise adverse impacts to air quality.

Project Phase	Objectives*
Construction	5.a To appropriately minimise and manage short term impacts to air quality
Operation	21.a To appropriately minimise and manage adverse impacts to air quality as a result of operations 23.a To appropriately manage greenhouse emissions from associated processing plants and pipelines 34.b To minimise and manage adverse impacts to air quality and public amenity as a result of unplanned incidents
Note: Objectives have been numbered to enable cross-referencing in the South Australian SEO.	

Goals

The principal management goals are:

Project Phase	Goal*
Construction	5.1 To minimise dust emissions 5.2 To minimise air quality impacts from emissions from construction equipment
Operation	21.1 To minimise dust emissions 21.2 To minimise air quality impacts from emissions from operation equipment 21.3 To minimise excessive emissions from compressor station operations 21.4 To minimise emissions from pipeline and associated infrastructure 23.1 To ensure the Compressor Station conforms with EPA requirements
Note: Goals have been numbered to enable cross-referencing in the South Australian SEO.	

Mitigation Measures

To mitigate potential impacts to air quality, SEA Gas will:

Design

- adopt the principles and practices outlined in the APIA Code
- integrate site specific management strategies into the Construction Environmental Management Plan
- minimise the extent and period of exposed surfaces
- design and operate the compressor station to comply with South Australian EPA air emission requirements, and
- work closely with Catchment Management Authorities, DNRE, and PIRSA regarding the management of ground disturbing operations.

Construction

- minimise the extent and period of exposed surfaces
- implement dust suppression measures, such as water carts, as required during construction
- rehabilitate exposed surfaces as rapidly as practicable
- lay blue stone aggregate in the above ground facilities' easement to reduce dust, and
- keep all construction vehicles and equipment well maintained and comply with vehicle emission standards.

Operation

- design and operate the compressor station to comply with South Australian EPA air emission requirements
- monitor operations to ensure compliance with design requirements
- implement a program of regular monitoring, inspection and maintenance during operations to prevent pipeline rupture and reduce the occurrence of minor leaks from pipeline infrastructure, and
- work closely with PIRSA and the South Australian EPA regarding management of compressor station air emissions.

8.2 Noise Emissions

SEA Gas is committed to protecting the community and the environment of the Project area from adverse impacts of noise emissions. Adequate management of the Project will prevent or successfully mitigate impacts of noise emissions from the compressor station during operation and from equipment during construction.

SEA Gas is confident that with the application of appropriate design and management strategies all impacts to the noise levels of the Project area can be contained below legislated levels.

8.2.1 Existing Environment

Regional background ambient noise levels measurements and studies have not been conducted as part of the pipeline impact assessment due to the confidence in predicted impacts. The majority of the Project area is not densely settled and the pipeline corridor principally traverses agricultural land.

The corridor intentionally avoids densely populated areas. However, in some circumstances, the pipeline will be constructed within 50m of residences.

Between Port Campbell and Gawler, ambient noise conditions are dominated by incidental traffic and agricultural noise such as general landholder and resident activities (for example, vehicle and farm equipment movements). Anomalies within this broad hypothesis include larger rural townships located along the route such as Allansford, Casterton, Murray Bridge and Mount Pleasant, where an increase in traffic, residential and small industrial based noise is expected.

Between Gawler and Torrens Island the representative landscape and land uses change from rural-residential to urban-industrial. Traffic from major arterials, airport movements, heavy industry, and to a lesser extent local traffic vehicle noise, contributes significantly to the ambient noise environment.

8.2.2 Potential Impacts

The following Project activities have the potential to generate adverse noise impacts:

- the movement and operation of construction vehicles and equipment
- blasting of rock areas
- directional drilling
- operation of the Yallamurray Compressor Station, and
- operation of the pipeline and associated infrastructure.

Without adequate management the noise generated by the Project may disturb people, stock and wildlife in the immediate area. Impacts to stock and wildlife are discussed in Sections 11.2 and 9.3, respectively.

Construction vehicles and equipment

Pipeline construction activities result in a temporary increase in ambient noise levels within the immediate vicinity of the alignment. However, this impact is expected to be of short duration and intensity.

Noise levels generated by the various construction activities will vary in intensity and characteristics, depending upon the combination of equipment in operation at any one time and the location and duration of the individual activities. Pipeline construction machinery typically has noise levels of 90-95dB(A) at distances of 10m from the source. However, noise levels in some instances may be higher than usual due to the use of excavators with rock hammer equipment.

The Victorian EPA publication TG302/92 (*Noise Control Guidelines*) provides guidance for acceptable noise levels within the State. Under these Guidelines typical daytime hours are considered to be 0700 – 1800 Mondays to Fridays and 0700 – 1300 hours on Saturdays. However it should be noted that the guidelines have been developed to be applicable to stationary and longer term work sites, and is not the most suitable requirement for pipeline construction projects. Pipeline construction is estimated to be at any one location for up to three months. Pipeline construction activities may occur outside these times and above the suggested levels in order to reduce the time the construction phase will be in any one particular area.

In South Australia, construction at stationary and long-term work sites is permitted between 0700hrs and 1800hrs Monday to Saturday, and between 0900hrs and 1800hrs on Sunday (EPA Information Sheet IS No. 7, September 1999).

Blasting

Blasting of rock areas may be necessary during the construction phase. Preliminary surveying of the pipeline route suggests that blasting near populated areas, infrastructure or ecologically sensitive areas is unlikely.

Horizontal Directional Drilling

SEA Gas will aim to minimise the amount of time and disturbance associated with horizontal directional drilling activities. However, construction hours may need to be extended in some instances for short periods of time where it is critical that the drill string be maintained to prevent the hole collapsing. Prior to commencing drilling operations, SEA Gas will notify any nearby residences and businesses to discuss the activity and manage potential third party impacts.

Compressor Station Operations

In South Australia, noise levels from industrial premises are controlled by the *Environment Protection (Industrial Noise) Policy 1994.* This states that 'an occupier of non-domestic premises must not cause or permit excessive noise to be emitted from the premises'. A noise level is deemed to be excessive if it is greater than 5 dB above the background noise level and greater than the maximum level, which is stated to be 40 dB(A) at night in rural areas. However, this does not necessarily mean that a level less than 40 dB(A) at night in rural areas is not excessive.

The South Australian EPA have therefore been approached concerning the appropriate limit, and they have indicated that a night noise level due to the compressor station of 35 dB(A) at the nearest residence would be regarded as acceptable.

While acceptable daytime noise levels are higher, night-time levels are considered here as the compressor station will be designed to run 24hrs a day and so must meet the more stringent requirements.

Noise Modelling

Noise modelling techniques, locations and criteria are outlined in Appendix 2. Two alternative compressor station locations were considered, immediately northwest or immediately southeast of Yallamurray Road. Initial modelling showed the location northwest of Yallamurray Road to be the "worst-case" scenario, and the results for this location are presented here.

Table 8-4 presents noise levels predicted for the compressor station if the turbine package is unenclosed and the inlet and exhaust unsilenced. Table 8-5 presents results at this location for an enclosed package with silencers fitted to the inlet and exhaust. Noise generated by air coolers, stand-by generator and packaged compressor data are the same in both circumstances. The locations given are the closest residences to the compressor station (Locations 1 to 7, Figure 8-1).

Without any attenuation on the turbine, the turbine package dominated the predicted noise levels at receiver locations. It was typically 3-5 dB louder than the inlet or exhaust, 15-25 dB louder than the air coolers and 20 –30 dB louder than the stand-by generator or compressor. With an enclosure, and with silencers fitted to the inlet and exhaust, the turbine package still dominated where predicted levels were greater than 30 dB. In such circumstances it was typically 3-5 dB greater than the inlet, 6 dB greater than the exhaust or air coolers and 10-15 dB greater than the stand-by generator or compressor.

Table 8-4: Predicted Sound Levels (dB(A)) – Unattenuated Turbine

Location	Condition						
	1	2	3	4	5	6	7
1	32	42	48	29	43	31	37
2	32	41	47	28	42	31	41
3	18	22	15	38	16	28	16
4	17	20	<15	33	15	25	15
5	<15	21	27	<15	32	<15	32
6	21	25	20	38	18	42	18
7	30	35	36	28	41	27	41

Note: Shaded results are those that exceed likely South Australian EPA requirements.

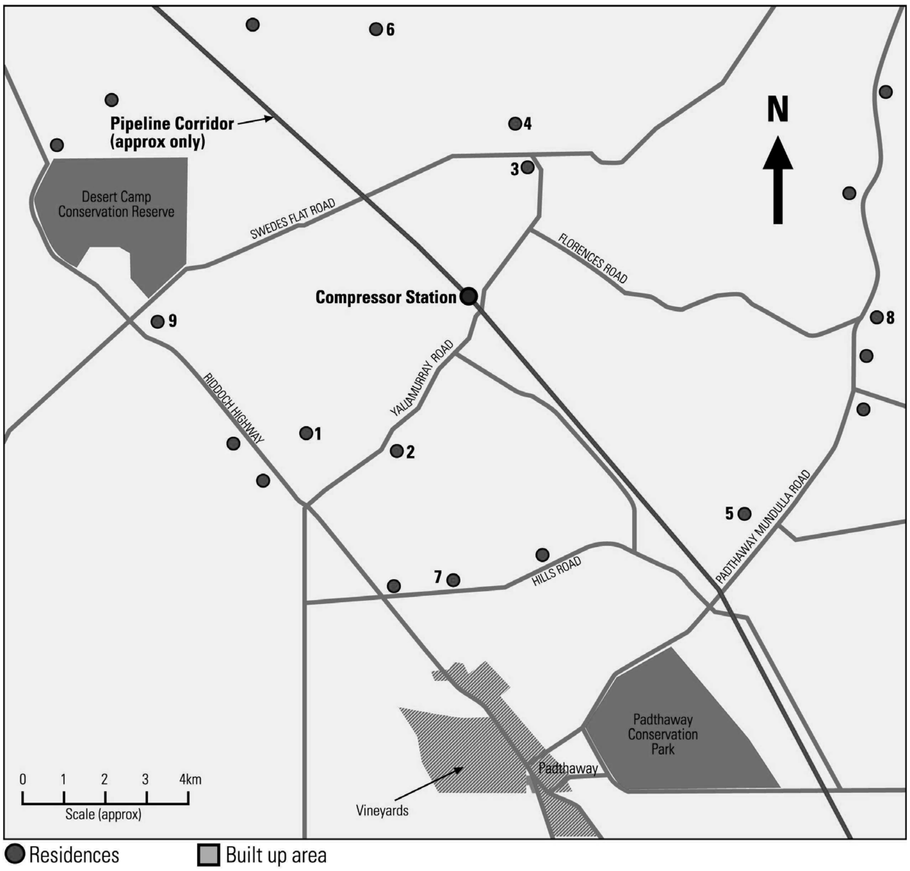

Figure 8-1: Proposed Location ofYallamurray Compressor Station

Table 8-5: Predicted Sound Levels (dB(A)) – Attenuated turbine

Location	Condition						
	1	2	3	4	5	6	7
1	19	28	34	15	29	18	24
2	19	27	33	15	28	18	27
3	<15	<15	<15	23	<15	15	<15
4	<15	<15	<15	19	<15	<15	<15
5	<15	<15	<15	<15	18	<15	18
6	<15	<15	<15	23	<15	27	<15
7	16	22	22	15	27	<15	27

Results indicated that with no noise control on the turbine and with wind conditions favourable for noise propagation, all locations (with the exception of two) experience noise levels in excess of 35 dB(A). Several locations also experience a level in excess of 35 dB(A) with a temperature inversion present.

However, with appropriate noise attenuation devices applied to the turbine package (that is, enclosed, and inlet and exhaust fitted with 16.A.1 and 17.A.1 silencers, respectively), none of the residences modelled experienced noise levels in excess of the recommended 35 dB(A).

Modelling of the compressor location southeast of the road (which is more likely to be the final location) also indicated that noise levels due to operation of the attenuated compressor would be below the recommended 35 dB(A) at all nearby residences. Minimal increases in noise levels were predicted at some locations, and a decrease in noise levels of 3-4 dB(A) was predicted at the two locations most affected by compressor noise (Locations 1 and 2). Modelling of two additional residences (Locations 8 and 9) predicted noise levels of 20 dB(A) or less.

Table 8-6: Noise Propagation Conditions Used in Modelling

Condition	Detail
General	All conditions assume a temperature of 5°C, 50% humidity and a rural landscape.
Condition 1:	Neutral – no wind, no temperature inversion.
Condition 2:	Inversion of 1°C per 100m, no wind.
Condition 3:	Propagation to Location 1 "Tambo Hills" and Location 2 "Woodlands Park" favoured by 3m/s wind from 30°.
Condition 4:	Propagation to Location 3 "Swede Flat" and Location 4 "Yalandro" favoured by 3m/s wind from 190°.
Condition 5:	Propagation to Location 5 "Lindholm Park" favoured by 3m/s wind from 315°.
Condition 6:	Propagation to Location 6 favoured by 3m/s wind from 130°.
Condition 7:	Propagation to Location 7 favoured by 3m/s wind from 310°.

Pipeline Operation

Minor noise emissions are generated at above ground facility sites such as mainline valves and scraper stations, particularly during testing, maintenance and emergency shutdowns. These will be negligible.

A workforce of seven field operators is expected for the entire pipeline. Noise impacts associated with access, inspection and general maintenance duties will be negligible.

8.2.3 Impact Mitigation

Objectives:

The principal management objective is to minimise adverse noise impacts to the amenity of local residents by containing noise emissions to an acceptable level.

Project Phase	Objectives*
Construction	6.a To appropriately minimise and manage short term adverse noise impacts to the amenity of local residents by containing noise emissions within EPA requirements
Operation	22.a To meet regulatory requirements for Compressor Station noise emissions
**Note: Objectives have been numbered to enable cross-referencing in the South Australian SEO.*	

Goals

The principal management goals are:

Project Phase	Goal*
Construction	6.1 To minimise noise impacts associated with the movement and operation of construction vehicles and equipment 6.2 Minimise noise and vibration impacts associated with blasting 6.3 Minimise noise impacts associated with directional drilling or boring
Operation	22.1 To minimise noise impacts associated with the movement of operation vehicles and equipment 22.2 Minimise noise emissions from the Yallamurray Compressor Station 22.3 Minimise noise impacts associated with operation of the pipeline and associated infrastructure
**Note: Goals have been numbered to enable cross-referencing in the South Australian SEO.*	

Mitigation Measures

To mitigate potential noise impacts, SEA Gas will:

- schedule normal construction in accordance with respective state EPA recommendations (for South Australia, EPA Information Sheet IS No.7 and No.9 1999; for Victoria, EPA publication TG302/92 1992)
- where practicable, restrict noisy activities for normal working hours
- consult with local residents when unavoidable out-of-hours work is required
- select appropriate equipment
- fit and maintain appropriate mufflers on earth-moving equipment and other vehicles on the site
- carry out blasting in accordance with state legislation and not close to any residential areas
- use drilling equipment with noise ratings suitable for use on public roads
- design compressor station to meet noise levels of 35dB(A) at all residences (requiring acoustic enclosure around the turbine package and silencers fitted to the inlet and exhaust)
- re-model noise emissions based on detailed compressor design
- consult with landholders on the purpose and function of blow off points
- work closely with residents, local government, DNRE and PIRSA regarding the management of construction noise, and
- work closely with PIRSA and the South Australian EPA regarding management of Compressor Station noise emissions.

8.3 Greenhouse Gas

8.3.1 Background

Natural gas for the SEA Gas Project will be sourced from either the Otway or Bass Strait Basins. Gas from the Otway Basin will initially come from the Minerva field. Potential exists to source gas from a range of on-shore prospects and future developments such as Thylacine and Geographe. The gas will be used for electricity generation using modern high-efficiency combined cycle gas turbine technology, and for reticulation to domestic users.

The benefit of the SEA Gas Project on electricity markets will be to provide additional security of supply to South Australia during peak demand periods, and to potentially meet increases in the base load required by industry. The impact on imports from Victoria will depend on South Australian load growth, other generation projects and power prices. Current Victorian brown coal generation exports will continue to be very competitive in South Australian markets.

8.3.2 Overview of Greenhouse Gas Intensity

As indicated in Table 8-7, when total emissions over the full fuel cycle are considered, natural gas remains the lowest source of emissions for fossil fuel combustion because of its inherent chemical characteristics. In electricity generation, natural gas results in the lowest emissions, with black and brown coal producing the highest greenhouse gas emissions, respectively. Within natural gas fired electricity generation, cogeneration has the lowest greenhouse gas intensity (kilotonnes of CO_2 equivalent/PJ)[3] and open cycle gas turbines (OCGTs) have the highest greenhouse gas intensity. Comparisons are set out in Table 8-7.

Greenhouse gas emissions from using energy source depends primarily on the inherent and internationally accepted greenhouse gas emissions' characteristics of the energy source. However, emissions associated with the extraction, processing and transport of fuels must also be taken into account during the assessment process. Gas basins are associated with different levels of emissions during extraction and processing, particularly with respect to the quantity of carbon dioxide extracted. Some fugitive methane losses are also associated with extraction, processing, transmission and distribution. According to the Australian Gas Association (AGA) these losses account for less than 2 per cent of Australian wellhead gas production.

8.3.3 Greenhouse Implications

The greenhouse implication of the SEA Gas Project will, like all gas pipeline projects, depend on three main factors:

- the development of new natural gas fields, associated processing plants and pipelines and greenhouse emissions from such projects
- increasing the use of natural gas in Australia, compared to more greenhouse intensive fossil fuels, and
- impact on renewable energy sources.

Project Associated Emissions

The greenhouse impacts of developing new natural gas fields and associated infrastructure is highly variable and depends on a number of factors. As indicated above, the composition of the gas from the field is critical, in particular its CO_2 content. The control of gas emissions in the

3 GHG intensity can also be expressed as tonnes of CO_2 /MWh or kilotonnes/GWh. For example 190.9 kt/PJ equates to 0.69 kt/GWh.

Table 8-7: Indicative CO_2 equivalent emission factors for typical Australian fuels, including fuel and processing emissions

Fuel	Emissions intensity			
	Processing	Fugitive	End-use combustion	Total
Natural gas	11.9	8.0	51.3	71.2
LPG	11.9	8.0	59.4	79.3
Diesel	14.0	8.0	70.0	92.0
Automotive gasoline	13.2	8.0	66.0	87.2
Fuel oil	14.7	8.0	73.3	96.0
Black coal – open cut	0.8	0.9	90.0	91.7
Black coal – underground	0.6	7.3	90.0	98.0
Brown coal	0.0	0.0	95.0	95.0
Derived electricity from:				
Natural gas[1] – OCGT	11.9	8.0	171.0	190.9
Natural gas[2] – CCGT	11.9	8.0	103.0	122.9
Distillate[3] – OCGT	14.0	8.0	233.0	255.0
Black coal[4] – underground	0.8	9.7	225.0	235.5
Brown coal[5]	0.7	0.0	290.0	290.7
Cogeneration[6]	11.9	8.0	71.0	90.9

Notes:
1. Open cycle gas turbine, 30 per cent efficiency.
2. Combined cycle gas turbine, 50 per cent efficiency.
3. Open cycle gas turbine, liquid fuel 30 per cent efficiency.
4. New supercritical coal-fired station, 40 per cent efficiency – fired with underground coal mine.
5. Typical existing brown coal stations, 33 per cent efficiency.
6. Typical new gas-fired cogeneration, 70 per cent efficiency.

Source: Greenhouse Emissions Trading, January 2000, a report prepared by the Allen Consulting Group for the Victorian Department of Premier and Cabinet, page 25.

gathering system is also essential, as is control of emissions at the processing plant (not assessed as part of this project).

Although natural gas is a fossil fuel, with associated greenhouse gas emissions, net-positive greenhouse gas outcomes can be achieved, depending on the intended use. The SEA Gas Project Gas will contribute to a reduction in greenhouse gas emissions in two main ways:

1. The SEA Gas project will introduce gas on gas competition into South Australian markets. The extent of this competition will depend on market gate prices compared with current market gate prices. The Project has the potential to lower real gas prices in South Australia over the 2004-15 period and beyond. This, in turn, will increase the market penetration of gas, displacing more greenhouse gas intensive (kg of CO_2e/GJ) fuels such as coal and petroleum products in a range of heating applications (particularly process, water heating).
2. Gas from the SEA Gas Project has the potential to displace more greenhouse gas intensive fuels in electricity generation through the use of open cycle gas turbines, combined cycle gas turbines, cogeneration plants (significant Origin plans) and/or micro gas turbines.

Increased Natural Gas Utilisation

Peak demands in South Australia are growing by 60-80 MW per year. Victorian base and peak domestic demands are also estimated to increase. If the Victoria to Tasmania Basslink Project proceeds, exports to South Australia may potentially decrease, increasing the need for South Australia to increase electricity generation capacity.

Impact on Renewable Energy Sources

Should the SEA Gas Project displace electricity derived from renewable sources, the Project would be considered to result in a negative greenhouse impact. However, this is very unlikely as the renewable electricity market is protected from fossil-fuel competition by the federal Mandated Renewable Electricity Target (MRET) legislation and voluntary purchases of Green Power. This market will require at least another 10,500 GWh of renewable energy (for MRET) and Green Power demands over 2001-10 (and probably higher thereafter). To meet this natural market, some plants are being built in South Australia – the Origin plantation wood plant (60 MW) at Tarpeena and the 30-60 MW Babcock-Brown wind plant at Lake Bonney.

Rigorous control of emissions from development facilities, both offshore and onshore, is critical. Although not directly related to this project, offset sink enhancement may also be undertaken by the primary offshore developer to achieve lower net emissions. However, these remedial measures are secondary to the abatement of greenhouse gas through emission management by the appropriate field operator. Rigorous management of pipeline related emissions will be undertaken by SEA Gas.

The SEA Gas Project has the potential to significantly reduce greenhouse gas emissions. The level of reduction depends on end-point gas usage, government policies and developments in the National Electricity Market (NEM).

8.4 Conclusion

A range of potential impacts to air quality of the Project area have been identified. These include generation of dust, minor vehicle and equipment emissions, and localised emissions from the compressor station and pipeline. Strategies for mitigation of these impacts have been outlined, and modelling of the Yallamurray Compressor Station indicates that emissions will comply with relevant ambient standards. SEA Gas is confident that with appropriate design and management all impacts to the air quality of the Project area can be reduced to an acceptable level.

Noise emissions generated by construction and operation of the Project have the potential to disturb people, stock and wildlife in the immediate area. Potential sources of noise include Project construction (relatively short duration and generally low intensity), operation of the compressor station, and operation of mainline valves and scraper stations (localised and minor noise emissions). Strategies for management of noise levels have been outlined, and modelling of the compressor station predicts that nearby residences will not experience noise levels in excess of the recommended 35 dB(A). SEA Gas is confident that with the application of appropriate design and management strategies all impacts to the noise levels of the Project area can be contained below legislated levels.

The SEA Gas Project has the potential to significantly reduce greenhouse gas emissions.

9 Ecology

SEA Gas acknowledges the importance of the ecological values of the Project area and is committed to their protection. It recognises that appropriate management of the Project is required to prevent or mitigate a range of impacts to flora and fauna species, communities and habitats. Such impacts may include:

- removal of remnant vegetation
- fauna mortality
- destruction of fauna habitats
- fragmentation of fauna habitats
- disruption to critical fauna lifecycle stages
- loss of biodiversity
- spread of ecological weeds, and
- spread of pathogens.

However, SEA Gas is confident that with the application of appropriate impact avoidance and mitigation strategies all potential adverse ecological effects can be reduced to an acceptable level.

This Chapter broadly describes the ecological setting of the Project area, identifies potential impacts and outlines proposed avoidance and mitigation strategies. It provides a bioregion-based overview of significant ecological issues and sensitivities, rather than presenting detailed flora or fauna data. Information on flora and fauna issues at specific locations is presented in Appendix 3. This appendix also outlines potential approaches to impact mitigation at these sites, and indicates where further survey work will be beneficial in refining the site specific management measures (which will be included in the Construction Environmental Management Plan).

9.1 Methodology

The ecological assessment was undertaken by Ecology Australia, using a streamlined bio-assessment approach, to identify key flora and fauna attributes. This provided a suitable technique for the identification and assessment of critical ecological issues associated with the Project area. As outlined in Chapter 5, this assessment is part of an iterative process. Project refinement over time will occur as engineering and environmental field studies provide greater site-specific detail. This will improve the resolution of the 100m wide pipeline corridor (and the alignment within it), as well as impacts and impact mitigation procedures at significant sites.

The bio-assessment consisted of the following:

- Desktop review:
  - available published and unpublished literature
  - regional conservation/biodiversity management plans, and those prepared for other development projects
  - State flora and fauna databases for the occurrence of listed species and communities within the proposed corridor, and
  - aerial photography analysis to identify potential features and areas of ecological significance (including remnant vegetation, watercourses, roadsides and wetlands).
- A field survey, undertaken over eight days in June 2001, which involved:
  - surveying the pipeline corridor, including areas identified during the desktop review as potentially being significant (such as areas of remnant vegetation)
  - inspecting some 200 locations (approximately 100 in each State), and
  - compiling specific information at 88 sites.
- An assessment report, which:
  - identified key sensitivities, communities and potential habitat locations
  - indicated the likelihood of these occurring in the Project corridor, and
  - provided a basis for management strategies.

Confidence of Assessment

The findings of the ecological assessment were based on a three-part bio-assessment approach, in association with a field survey conducted in winter. In view of supporting information, there is moderate to high level of confidence in the results of the principal findings, including:

- plant community description and condition assessment
- conservation status of plant community
- habitat assessment, and
- potential for rare or threatened fauna or flora.

The main limitations relate to the site inventories, particularly for rare or threatened plant species, and to a lesser extent, rare or threatened fauna. Spring or summer annual species may not have been detected in winter, and further surveys for some sites are recommended at the appropriate time of year. This will allow the presence of such species to be determined, and appropriate impact mitigation strategies to be refined.

9.2 Existing Environment

The area traversed by the pipeline corridor has largely been cleared of native vegetation and is primarily used for agriculture (refer to Section 11.1). Areas of remnant woodland and grassland that do remain are restricted to conservation parks, forest reserves, small stands of vegetation and isolated individual trees on private property, riparian corridors and road reserves. The pipeline corridor avoids all areas proclaimed for flora and fauna conservation and traverses land that is principally cleared and developed. It passes through a limited amount of degraded native vegetation, and only 1km of the 670km total length (0.15%) contains substantially intact vegetation that may be impacted by the pipeline.

It is within this context that the ecological assessment needs to be considered. That is, the following discussion by necessity focuses on remnant vegetation communities and ecologically sensitive areas. However, these areas are not representative of the environmental features of the pipeline corridor as a whole.

The following discussion is based on the eight bioregions as described in Section 5.1. Flora is discussed primarily on the basis of Ecological Vegetation Classes in Victoria and Floristic Community in South Australia (using the typology of Kahrimanis *et al.* (2001), Croft *et al.* (1999) and Robertson (1998). The conservation status of each vegetation class, as defined in these sources and by DNRE (unpublished data), Traill and Porter (2001) and Neagle (1995), is given as:

- Depleted (D)
- Rare (R)
- Vulnerable (V), and
- Endangered (E).

The conservation status of flora and fauna species is indicated using an abbreviation of the legislation that they are listed under:

- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC)
- Victorian *Flora and Fauna Guarantee Act 1988* (FFG), and
- South Australian *National Parks and Wildlife Act 1972* (NPW).

Species listed under the EPBC Act are also referred to in the text as having national conservation significance, and those listed under State legislation are referred to as having state conservation significance.

The locations of the field sites of potential significance referred to in the following sections are marked on Maps 4 to 11. Appendix 3 contains specific information on each site, including ecological issues, potential impacts and possible mitigation strategies. It also provides a summary of species and communities listed under the EPBC, NPW or FFG Acts that may occur at these sites.

Coastal Southwestern Victoria

The pipeline corridor in this bioregion is characterised by a substantially cleared agricultural landscape, with most vegetation occurring as isolated patches in paddocks, as roadside remnants or associated with watercourses. After 20km the corridor parallels the existing gas pipeline to Portland for 40km. The alignment avoids major patches of remnant vegetation on farmland and does not impact on any public reserves. Several roadside remnants are considered to comprise moderate to good quality vegetation. Watercourse crossings in this region include the degraded Spring and Port Campbell Creeks, the deep-water/estuarine Curdies River and the revegetated Hopkins River.

Sites 1-8 (Appendix 3) are located in this bioregion.

Key sensitivities include:

- crossings of the Curdies and Hopkins rivers, and
- remnant road reserve vegetation.

Flora

The principal Ecological Vegetation Classes (EVC) within the pipeline corridor include Swamp Woodland/Heath (V) and Riparian Scrub (V). Coastal Foothill Forest (D) is present in the region, but the pipeline corridor crosses only one roadside remnant of this EVC, between the Minerva and Iona gas plants.

No rare or threatened plant species were identified within the corridor, but potential species include *Dianella callicarpa* and *Diuris palustris*.

Fauna

Roadside remnants and watercourses represent potential habitat for a number of threatened species:

- Swamp Gums in road reserves and riparian corridors represent potential nectar sources for Swift Parrot (EPBC and FFG). However, literature suggests that there is a low likelihood of this species occurring in the Project area.
- Rufous Bristlebirds (FFG) are known to use strips of dense but narrow habitats along road reserves.

- The Chestnut-rumped Heathwren (Sites 2, 6), Eastern Pygmy-possum (Sites 2, 6) and Swamp Antechinus are known to use Swamp Woodland/Heath, but are not known to utilise road reserves.
- Yarra Pygmy Perch (EPBC, FFG) have previously been recorded in Spring Creek and Curdies River, although it is unlikely that these species are resident in the degraded sections of the pipeline crossing. The Curdies River is also known feeding habitat for the Great Egret (FFG), and potential habitat for other significant waterbirds (for example Pied Cormorant and Royal Spoonbill).
- Yarra Pygmy Perch other significant species, such as Australian Grayling (EPBC, FFG) and Dwarf Galaxias (EPBC, FFG), have previously been recorded in the Hopkins River. The River system also represents potential habitat for River Blackfish, Mountain Galaxias, Nankeen Night Heron, and Water Rat, with all species moderately to highly likely to reside in the vicinity of the pipeline crossing.

Volcanic Plains

This bioregion would have formerly supported grasslands and grassy woodlands, which through the process of pastoralisation and rural development have been significantly reduced to a relic of their former range. Most remnants along the pipeline corridor are now confined to road reserves and degraded riparian locations. Consequently, remaining examples are highly significant. Sites 9-21 (Appendix 3) are located in this bioregion.

Plains Grassland (FFG) is the major Ecological Vegetation Class present on the older volcanics and is mostly confined to road reserves. The pipeline corridor also traverses two younger larva flows, which would have supported quite different vegetation to the older volcanic plains, such as Manna Gum Woodlands. However, of these two younger flows, Harman Valley supports the only appreciable remnants, which include Tree Violet shrublands (*Hymenanthera* sp. aff. *dentata* – Volcanic Plains variant). Field surveys identified a substantial population of Curly Sedge *Carex tasmanica* (EPBC, FFG) at Breakfast Creek, northeast of Macarthur. In addition, the proposed corridor intersects a remnant of Damp Sands Herb-rich Woodland (identified from recent EVC mapping), approximately 8km northeast of Digby.

Key sensitivities identified along the pipeline corridor within this bioregion include:

- Plains Grassland in road reserves
- Curly Sedge population at Breakfast Creek floodplain, and
- Stoney Rises of the Harman Valley Volcanics – Tree Violet shrublands, potential Striped Legless Lizard (EPBC, FFG) habitat.

Flora

Two significant species listed under the provisions of the EPBC Act and FFG Act were recorded within the current alignment:

- *Carex tasmanica* (Curly Sedge) – A large population was identified from field survey on the floodplain of Breakfast Creek (Site 16, Plate 9-1). Published records also suggest possible occurrences south of Branxholme (Arrandoorong Creek).
- *Dianella amoena* (Matted Flax-lily) – This was located in Plains Grassland remnants at two road crossings and in the decommissioned rail reserve, south of Branxholme (Plate 9-2).

A number of other rare (and listed) grassland taxa potentially may occur in the identified remnants, including *Glycine latrobeana, Cullen parvum* and *Leucochrysum albicans* ssp. *albicans* var. *tricolor*.

Fauna

Survey findings identified several fauna habitats that may potentially support significant species:

- Plains Grassland in road and rail reserves (sometimes in association with *Poa* Grassland) may support Striped Legless Lizard (EPBC, FFG) and Fat-tailed Dunnart (FFG) (Sites 11, 12, 15, 20 and 21).
- The Stoney Rises of the Harman Valley Volcanics display significant reptile habitat, particularly for Striped Legless Lizard (EPBC, FFG) (Site 17) and Fat-tailed Dunnart.
- Breakfast Creek, where permanent streams with pools support dense stands of aquatic vegetation, is potential breeding habitat for the Southern Bell Frog (EPBC, FFG) and Dwarf Galaxias (EPBC, FFG). State to nationally significant waterbirds (Great Egret, Buff-banded Rail and Lewin's Rail), are also moderately to highly likely to occur during flooded conditions (Site 16).

Yarra Pygmy Perch (EPBC, FFG), has previously been recorded in the bioregion. Drysdale Creek, a tributary of the Merri River, is recorded to support this species. However, based on site inspection it is unlikely that the species is a resident in the degraded section of the pipeline crossing.

Brolga (FFG, NPW) have been recorded in this bioregion, feeding and nesting in seasonal freshwater meadows or marshes between July and December, and flocking to more permanent wetlands for the remainder of the year (Arnol *et al.*, 1984). The pipeline corridor has been selected to avoid such features.

Dundas Tablelands

The section of the pipeline corridor, along the southern edge of the Dundas Tableland, supports some remnants. Most are degraded examples of Grassy Woodland dominated by old growth Red Gum (*Eucalyptus camaldulensis*) in long-established pasture. The McCrae Creek and Glenelg River areas contain significant vegetation remnants, potentially supporting a wide range of fauna species. Sites 22-25 (Appendix 3) are located in this bioregion.

Key ecological sensitivities identified along the pipeline corridor in this bioregion include:

- widespread occurrence of Red Gums and their possible use by the Red-tailed Black-Cockatoo
- instream and riparian corridor of the Glenelg River, and
- Common Tussock Grass Grasslands south of McCrae Creek.

Flora

South of McCrae Creek, extensive Common Tussock Grass (*Poa labillardieri*) grassland occurs and is representative of a former grassy woodland environment (Site 22). The Glenelg River (Site 25) supports degraded but old growth Riverine Forest (that is, Red Gum populations).

Published data revealed no threatened plant species, although the rare Casterton variant of *Acacia verniciflua*, *Prasophyllum diversiflorum* and the rare grassland herbs listed for the Volcanic Plains may occur.

Fauna

Likely fauna habitat identified in the bioregion is generally restricted to watercourse corridors, grassland habitat and Red Gum and other eucalypt stands. Species known to occur within the Glenelg riparian corridor (Site 25) include:

- residents such as Koala, Water Rat, Variegated Pygmy Perch and Yarra Pygmy Perch
- Red-tailed Black-cockatoo (EPBC, FFG) and the bat species Southern Myotis associated with hollow-bearing trees and stags, and Woodland feeding habitat, and
- Dwarf Galaxias (EPBC, FFG), River Blackfish and Mountain Galaxias. However, shallow flow, low instream diversity (eg. vegetation, fallen timber, litter etc.) and degradation potentially precludes the occurrence of residents within the Project area.

During the field survey, the following habitat types were identified to potentially support significant species:

- Degraded *Poa labillardieri* Grassland (south of McCrae Creek) may support the Striped Legless Lizard (EPBC, FFG), although the likelihood of occurrence is considered low due to the degraded/grazed state (Site 22).
- The Glenelg River riparian corridor is habitat for Bush Stone-curlew (FFG), Brown Treecreeper, Black-chinned Honeyeater and Tree Goanna. In addition, Yellow-tailed Black-cockatoo are likely to occur due to the presence of breeding habitat (hollows).

Wimmera Plains

The Wimmera bioregion comprises extensive sandy plains and aeolian dune landforms extending from Casterton to Naracoorte. Prominent ecological attributes of these sands include extensive populations of old growth Red Gum (remnants of the former Grassy Woodlands) occurring on the plain, and heathy woodlands in dune systems (particularly in the Dergholm area). Many of the streams support contiguous, albeit degraded vegetation. Sites 26-49 (Appendix 3) are located in this bioregion.

Wide-ranging ecological sensitivities identified along the pipeline corridor include:

- the predominance of Red Gums, recognised for intrinsic values and as habitat for threatened fauna, particularly the threatened Red-tailed Black-Cockatoo
- road reserve vegetation supporting contiguous dense old growth Red Gums
- the presence of Damp Heathy Woodland/Damp Sand Heath
- riverine riparian corridors of Deep and Salt Creeks, and
- habitat values of State Forest (including Roseneath State Forest) near Dergholm.

Flora

Major Ecological Vegetation Classes (Victoria) and Floristic Communities (South Australia) recorded along the pipeline corridor in this section include:

- Plains Grassy Woodland (Vic) syn. *Eucalyptus camaldulensis* Woodland (SA) (V)
- Damp Heathy Woodland (Vic) (V)
- Damp Sand Heathland (Vic) (V), and
- *Eucalyptus arenacea/baxteri* Woodland (SA) (D).

Brown Stringy Bark and Sand Heath in excellent condition occur between Casterton and Dergholm, and are particularly evident in Roseneath State Forest (Plates 9-3, 9-4).

No rare or threatened plant species were recorded in the pipeline corridor, but database records indicate that the nationally significant species *Caladenia formosa, Glycine latrobeana, Pterostylis cucullata, Caladenea colorata and Dodonea procumbensi* may occur along the pipeline route.

Fauna

Red Gum Grassy Woodlands, Damp Heathy Woodlands and Sand Heath potentially support diverse avian communities. Key habitat areas include riparian corridors, Roseneath Forest and road reserve vegetation, in addition to isolated eucalypt stands.

The entire Wimmera bioregion provides an important feeding, breeding and nesting habitat for the Red-tailed Black Cockatoo. Locations in the pipeline corridor identified as most likely to support this species are associated with riparian habitat, Deep Creek (Site 26), Salt Creek (Site 37), Mosquito Creek (Site 43) and Roseneath State Forest (Site 29 – 34 and 36).

Deep Creek (Site 26), and Salt Creek (Site 37), ephemeral tributaries of the Glenelg River, may potentially contain Variegated and Yarra Pygmy Perch. However the likelihood of these species occurring is low to moderate. Koala and Water Rat are known resident species of the tributaries, and the riparian corridor may also potentially support species of national and state significance, such as Brown Treecreeper, Southern Myotis, Black-chinned Honeyeater, Tree Goanna, Yellow-tailed Black-cockatoo, and with lower certainty Bush Stone-curlew and Diamond Firetail.

Brown Stringybark Woodland and Sand Heath between Casterton and Dergholm, including Roseneath State Forest, represents potential habitat for many fauna species (Sites 29 – 34 and 36). Species with a moderate to high likelihood of occurring include the nationally significant Swift Parrot, Red-tailed Black-Cockatoo, Heath Mouse, Southern Brown Bandicoot, and several threatened woodland birds, including Flame Robin, Brown Treecreeper and Hooded Robin. In addition, the following state-significant species – Swamp Antechinus, Silky Mouse, Chestnut-rumped Heathwren, Tree Goanna, Southern Emu-wren, Western Pygmy-possum and Yellow-tailed Black-Cockatoo – are likely to occur, based on the presence of preferred habitat.

Brolga have also been recorded in this bioregion. The pipeline corridor passes within 100m of three degraded wetlands in grazing land, which may represent potential Brolga habitat, but avoids them by remaining on high ground. The closest of the more permanent wetlands is Lake Caranta, which is over 1km from the proposed alignment.

Southern Mallee

The pipeline corridor traverses remnant beach ridges, dunes and plains, characteristic of the Naracoorte Coastal Plain. Much of the former dominant Mallee and South Australian Blue Gum (*Eucalyptus leucoxylon*) Woodland communities from Naracoorte to Tailem Bend have been cleared. At a landscape scale, remnants are patchily distributed, isolated, with connecting links restricted to roadsides or watercourses. Within this bioregion, South Australian Blue Gum progressively replaces Red Gum as the dominant species of the plains ecosystem, with Red Gum confined to drainage lines and associated floodplains. Sites 50-63 (Appendix 3) are located in this bioregion.

Roadside remnants are often broad (>20m), contiguous and of moderate to good quality, representing habitat links in an otherwise denuded landscape. Most roadsides are dominated by Mallee species, but several have extant South Australian Blue Gum Woodland with scattered or co-dominant Rough Barked Manna Gum and/or Pink Gum.

The pipeline corridor passes through two regions designated as "Threatened Habitat Areas" (Croft *et al.*, 1999) – the Binnum-Hynam-Kybybolite Districts and the Keith-Willalooka Districts. The woodlands in these areas have been extensively cleared and are highly fragmented, poorly conserved, and remnants contain many species and plant communities of conservation significance. They require action to conserve existing habitats and rehabilitate and restore the native vegetation cover to prevent the extinction of these species and communities.

Key ecological sensitivities identified along the pipeline corridor within the bioregion include:

- Red Gum/South Australian Blue Gum Grassy Woodland associated with Morambro Creek
- isolated SA Blue Gum and Red Gum stands and individuals
- Mallee remnants, mainly on roadsides, and
- primary groundwater discharge locations supporting *Halosarcia/Melaleuca* shrubland communities.

Flora

Major Floristic Communites recorded along the pipeline corridor in this bioregion are:

- *Eucalyptus leucoxylon* ± *E. fasciculosa* Woodland (V)
- *Eucalyptus arenacea* Woodland on deep leached sands

- *Eucalyptus diversifolia* ± *E. incrassata* Mallee
- *Eucalyptus socialis* ± *E. dumosa* ± *E. gracilis* Mallee (D), and
- *Halosarcia pergranulata* ± *H. halocnemoides* ± *Melaleuca halmaturorum* Saline Shrubland.

Two rare plant species were recorded in roadside Mallee: *Melaleuca wilsonii* (Site 58) and *Eucalyptus behriana* (Site 63). Other rare or threatened species recorded on databases within 1-5km of the pipeline corridor include the nationally endangered *Acacia enterocarpa, Thelymitra epipactoides, Prostanthera eurybioides and Caladenia colorata*, the nationally vulnerable *Olearia pannosa* var. *pannosa*, and the state significant *Eutaxia microphylla* var. *microphylla, Leucopogon clelandii, Schoenus laevigatus, Eucalyptus leucoxylon* var. *megalocarpa, Choretrum spicatum, Carex invera invera, Juncus amabilis, Billardiera scandens scandens, Phebalium brachyphyllum, Zieia veronicea, Brachycome uliginosa and Brachycome parvula lissocarpa.*

Fauna

The field survey identified the following locations within the current SEA Gas Project corridor as providing significant or potential habitat:

- Red Gum/South Australian Blue Gum Grassy Woodlands associated with Morambro Creek and road reserves
- isolated South Australian Blue Gums scattered in pastures
- healthy Mallee remnants along roadsides
- old growth Mallee
- *Halosarcia* spp saline shrubland wetlands, and
- general road reserve locations.

The Red Gum/South Australian Blue Gum Grassy Woodland identified at Morambro Creek and in the adjoining road reserve (Site 50) provides potential habitat for the nationally significant Red-tailed Black-Cockatoo, Bush Stone-curlew and Swift Parrot, the state significant Koala, Little Lorikeet, Yellow-tailed Black-Cockatoo and Painted Button-quail, and the regionally significant Crested Shriketit. Sugar Gliders (NPW) may also occur at this location.

A South Australian Blue Gum Woodland remnant with *Banksia ornata* and *Xanthorrhoea* spp understorey occurs on a vegetated dune extending some 250m (Site 57), and potentially supports the bird species listed above. Scattered South Australian Blue Gums over pasture (Sites 50, 53-56) may also be utilised by these bird species, particularly Little Lorikeet, Yellow-tailed Black-Cockatoo and Crested Shriketit.

Red-necked Wallaby (NPW) may occur at Site 57, and may forage at Sites 49 and 51, which contain open pastures and have cover available nearby, in Grass Tree and Padthaway conservation parks.

Moderate to high quality Mallee roadside vegetation occurs at Sites 52, 58, 60 and 61, and may support many significant vagrant species (including the state significant Striped Honeyeater), but is less likely to support resident bird species. In addition to road reserves, Site 59 represents the largest intact stand of Mallee (*E. diversifolia/E. gracilis*) along the pipeline corridor, and provides potential habitat for the nationally significant Red-lored Whistler, Western Whipbird, Malleefowl, Hooded Robin and the regionally significant Southern Scrub-robin. Where a litter-layer or dense heath understorey is present (Site 52, 58 59 and 61), regionally significant Common Dunnart, Silky Mouse and Little and Western Pygmy-possums are likely to occur. Database records indicate sightings of Malleefowl (EPBC, NPW) and Diamond Firetail (NPW) in the Coonalpyn area, approximately 3km northeast and 3.5km southwest of the alignment respectively.

Records of state significant Blue-winged Parrot and Chestnut-rumped Heathwren occur from Padthaway/Grass Tree conservation parks, and these species are likely to occur in the adjoining areas (Sites 49, 50 and 51). In addition, road reserves provide recognised habitat for the Blue-winged Parrot (Sites 46, 47 and 48).

Although the Common Wombat (NPW) occurs in the Swede Flat area (8km southeast of Site 52), there appears to be a low likelihood of this species occurring regularly along the pipeline corridor in this bioregion.

Murraylands

The Murray River is the most significant feature of this bioregion. The river corridor has been designated as a Threatened Habitat Area (Kahrimanis *et al.,* 2001) due to its biological significance and degree of human impact. The proposed crossing point is highly modified and there are few ecological values associated with the terrestrial habitats at proposed drill sites. Adjoining landuse is intensive agriculture and dairy farming. The adjoining plains are extensively cleared and the corridor intersects few remnants, which are restricted to roadsides and creeklines. Site 74 (Appendix 3) is located in this bioregion.

Key ecological sensitivities identified along the pipeline corridor in the Murraylands bioregion include:

- Roadside Mallee and *Callitris* Woodland remnants
- instream and riparian corridor of the Murray River, and
- Reedy Creek National Estate values.

Flora

The major Floristic Communities occurring along the pipeline route in this bioregion are:

- *Eucalyptus porosa* Open Mallee
- *Eucalyptus incrassata* +/- *E. socialis* Mallee (on dune ridges)
- *Halosarcia* Saline Shrubland
- *Callitris* Woodland, which is severely depleted in this bioregion, and
- *Eucalyptus camaldulensis* var. *camaldulensis* Woodland, considered threatened in the region and recorded on Reedy Creek within the National Estate area (Site 74).

The rare *Eucalyptus behriana* (NPW) was recorded at Site 74. Other rare and threatened species recorded on databases within 5km of the pipeline corridor are the nationally endangered *Prostanthera eurybioides,* and the state significant *Eleocharis sphacelata, Lycopus australis, Brachycome basaltica gracilis, Ceratophyllum demersum* and *Hydrilla verticillata*

Fauna

Within the pipeline corridor in this bioregion, significant fauna species may occur in restricted habitats associated with Mallee and *Callitris* Woodlands, the Reedy Creek area or the Murray River.

The Striped Honeyeater (NPW) may potentially occur within mixed Mallee eucalypt communities (*E. socialis/E. incrassata*), which are found on dune ridges.

Site 74 includes Reedy Creek and patches of Mallee largely confined to gneissic (metamorphic rock) outcrops. The Mallee understorey is dominated by *Lomandra effusa* and significant species likely to occur in this ecosystem include the Dwarf Galaxias (EPBC, FFG) and the Southern Bell Frog (EPBC, FFG, NPW). However, although dense cover of instream vegetation is consistent with species habitat requirements, poor water quality, the effects of livestock grazing and shallow summer flows may preclude the presence of such species.

The Murray River potentially supports many significant fish species. Commonly occurring species include Silver Perch, River Blackfish and Southern Pygmy Perch. The status of the Murray Hardyhead, Freshwater Catfish and Short-headed Lamprey in the lower reaches of the Murray is unknown, although Trout Cod is now extinct in the South Australian section.

Mount Lofty Ranges

The steeply dissected granite terrain of the eastern Mount Lofty Ranges has been extensively cleared. This area has been designated as a Threatened Habitat Area (Kahrimanis *et al.,* 2001) due to the severe depletion and degradation of vegetation and habitats. Vegetation remnants along the pipeline corridor (including mature and old growth eucalypts) are few and the most common remnants are associated with ephemeral and weakly incised drainage lines. Drainage line vegetation appears secondary and invariably occurs as sedgeland, dominated by *Juncus* spp. and *Cyperus gymnocaulos*.

The western section of the route supports some remnants, albeit fragmented and degraded.

There is also a high potential for spreading a range of weed species, and the risk imposed by *Phytophthora* spp. or other pathogens requires further evaluation prior to construction and incorporation into appropriate management procedures.

Sites 67-73 (Appendix 3) are located in this bioregion.

Key ecological sensitivities identified along the pipeline corridor within the Mount Lofty Ranges bioregion include:

- newly identified *Carex bichenoviana* community at Milendella Creek
- significant road reserve vegetation, and
- woodlands, particularly Manna Gum Woodlands associated with Mt Crawford Forests.

Flora

Many plant communities within the Mount Lofty Ranges are considered threatened (Robertson 1998). While avoiding major remnants through the western Ranges, the pipeline route potentially traverses patches of the following Floristic Communities:

- *Eucalyptus fasciculosa* ± *E. viminalis* ssp. *cygnetensis* Woodland (V)
- *Enneapogon – Stipa – Paspalidium* Grassland (most likely a former Grassy Woodland formation) (V)
- *Eucalyptus camaldulensis* ssp. *camaldulensis* Woodland (V), and
- *Eucalyptus porosa* Woodland (E) (essentially an Adelaide plains community, but reaches the lower western slopes of the Mount Lofty Ranges).

In addition, a new sward of *Carex bichenoviana* has been recorded during field surveys at Milendella Creek (Site 73). This sward appears to be a remnant of a former lower slopes and valley floor sedge woodland. This vegetation has not been previously documented in regional surveys (Ann Prescott pers. comm.; Robertson, 1998) and to date, its conservation status remains uncertain.

No rare or threatened plants were recorded at sites along the pipeline corridor. The nationally endangered *Prostanthera eurybioides* (EPBC) is known from granite outcrops in the region. A number of other threatened species are known from within Hale Conservation Park and other areas of intact vegetation in the region, including the nationally endangered *Prostanthera eurybioides, Caladenia behrii, Caladenia rigida* and *Pterostylis* aff. *nana* – Hale, the nationally vulnerable *Prasophyllum pallidum, Corybas dentatus* and *Glycine latrobeana* and the state significant species *Correa eburnea, Deyeuxia minor, Baumea gunnii, Aristida personata, Aristida australis, Crassula peduncularis, Diuris behrii, Isolepis stellata, Prasophyllum constrictum, Prasophyllum fecundum, Prasophyllum pruinosum, Stipa breviglumis, Acacia iteaphylla, Prostanthera chlorantha, Phebalium hillebrandii, Cardamine paucijunga, Mentha diemenica, Ptilotus erubescens, Eucalyptus viminalis viminalis, Sphaerolobium minus* and *Helichrysum rutidolepis.*

Fauna

The Red-necked Wallaby (NPW) potentially occurs throughout the region. It was detected at Mount Crawford (near Site 70) and is likely to occur at Site 69, where Manna Gum forest over pasture adjoins pine forest, and at Milendella Creek (Site 73).

Manna Gum and Red Gum Grassy Woodland at Site 70 may also support feeding Yellow-tailed Black-Cockatoo (NPW) and potentially Koala (NPW) populations. However, the watercourse is more likely to provide a dispersal corridor for Koala, rather than resident habitat.

National and state significant bird species recorded in this bioregion are closely associated with Hale and Sandy Creek conservation parks, and include Striped Honeyeater, Blue-breasted Fairy-wren, Blue-winged Parrot and Bassian Thrush. Diamond Firetail (NPW), Black-chinned Honeyeater (NPW) and Crested Shriketit are likely to regularly occur at Sites 69 and 70 and in the Olive-infested River Red Gum Woodland associated with Lyndoch Creek (Site 68). The Painted Button-quail (NPW) is also likely to occur within diverse understorey of the *E. fasciculosa* – *E. viminalis* Woodland adjoining Mount Crawford State Forest. Although one sighting of the Orange-bellied Parrot (EPBC, NPW) is recorded 6km southwest of the pipeline corridor, the region does not contain preferred habitat for this species.

Records of state significant waterbird species, including Great Crested Grebe, Australasian Shoveler and Musk Duck, are primarily associated with either the Barossa or Warren Reservoirs (approximately 3km from the alignment).

Northern Adelaide Plains

This bioregion is highly urbanised in comparison to the previous ecological and rural regions. Grassy Woodlands were once extensive on the Northern Adelaide Plains. However, these have been cleared to allow grazing and agriculture and more recently, urbanisation. *Eucalyptus porosa* was a former dominant of these woodlands, intermixed with areas of *E. camaldulensis* and *E. largiflorens* on streamsides or poorly drained sites. Most were characterised by grassy understoreys and where remaining, these grassy ecosystems are considered Endangered (Kirkpatrick *et al.*, 1996). Sites 78-88 (Appendix 3) are located in this bioregion.

At the coastline adjacent to Barker Inlet, the pipeline corridor crosses the zone of reclaimed wetlands and salt evaporation ponds. Barker Inlet, including the eastern section of Torrens Island, supports extensive Mangrove and Samphire communities.

Key ecological sensitivities identified along the pipeline corridor within the Northern Adelaide Plains include:

- remnant vegetation on roadsides
- Roadside Significant Sites (RSS), as identified by Transport SA
- wetlands (Samphire Lowland Shrublands) and salt fields adjacent Barker Inlet, and
- reclaimed and reinstated wetland environments.

Flora

The floristic communities recorded along the route in this bioregion include:

- *E. porosa* Grassy Woodland (E)
- *E. camaldulensis* Grassy Woodland (E)
- *E. largiflorens* Grassy Woodland (E)
- *Stipa* ssp. Grassland (D)
- Wetland Mosaic associated with constructed wetlands (not threatened)
- *Sarcocornia* – *Sclerostegia* Samphire Shrubland (not threatened), and

- *Avicennia marina* var. *resinifera* Mangrove Woodland (not threatened).

Two sites within the pipeline corridor are listed as Transport SA Roadside Significant Sites (RSS) and contain significant individual trees. RSS 864 contains significant *Eucalyptus camaldulensis* trees (Site 82) and RSS 558 contains significant *Eucalyptus largiflorens* trees (Site 83).

Samphire Low Shrublands are listed as reasonably or moderately conserved in South Australia (Neagle, 1995). However, several plant species occurring in these ecosystems (Site 85) are listed as having vulnerable or unknown conservation status.

Rare or threatened species listed on databases from within the vicinity of the pipeline corridor include the nationally vulnerable *Halosarcia flabelliformisi* on Torrens Island*,* the state-significant *Crassula sieberiana* (endangered), *Stipa puberula, Eragrostis infecunda, Danthonia tenvior* and *Stipa multispiculis* (NPW).

Fauna

Key fauna locations have been identified from field surveys to include Salt Crystallisation Lagoons of the Penrice Salt Fields (Site 85), Greenfield/Barker Inlet Wetlands (Site 86) and the coastal foreshore of Torrens Island. The wetlands and saltfields are inhabited by a number of bird species during summer, and are utilised by international migratory waders/shorebirds listed under the CAMBA/JAMBA migratory bird agreements. The coastal foreshore of Torrens Island has supported a number of state significant bird species, including Fairy Tern, Pacific Gull, Pied Oystercatcher, Eastern Curlew, Glossy Ibis and White-necked Heron.

The Adelaide area formerly supported good numbers of Orange-bellied Parrots (EPBC, NPW) (Higgins, 1999). The most recent record of an Orange-bellied Parrot from the Adelaide area was collected in 1999 from the Onkaparinga River (Jon Starks, Birds Australia, pers. comm.). Although preferring habitat of coastal saltmarshes, and adjacent grasslands and shrublands (such as Barker Inlet *Sarcocornia – Sclerostegia* Samphire Shrubland,) the species now appears to be an infrequent visitor to the Adelaide area (low-moderate likelihood of occurrence).

9.3 Potential Impacts

The vast majority of the proposed pipeline route passes through cleared land, which carries introduced pasture and crops and has low ecological significance. However, some areas of ecological sensitivity, where impacts may occur, have been identified along the proposed route.

The following activities have the potential to affect the ecological values of the Project area:

- creation of construction access
- clear-and-grade operations (creation of the construction right-of-way)
- trenching (including blasting), and
- earthworks associated with creation of associated stockpiles, laydown or work areas and construction depots (if required).

Appropriate management of the Project will be required to prevent a range of impacts to the ecological values of the region. Such impacts include:

- removal of remnant vegetation
- fauna mortality
- destruction of fauna habitats
- fragmentation of fauna habitats
- disruption to critical fauna lifecycle stages
- loss of biodiversity
- spread of ecological weeds, and
- spread of pathogens.

A summary of these impacts is provided in the sections below, followed by strategies to mitigate these impacts. Potential impacts at significant sites are detailed in Appendix 3.

Removal of Remnant Vegetation

The pipeline corridor has been selected to avoid the need to clear significant areas of remnant vegetation. However, the corridor does encounter some areas of remnant vegetation, particularly when crossing road reserves. Although the final alignment (and methods used for crossing road reserves, as shown in Figure 9-1) will be designed to avoid or minimise remnant vegetation removal, some clearing may be required for the preparation of a safe construction area. The direct loss of vegetation will occur on the construction right-of-way, which is normally 25m, but can be reduced to 15m. The potential also exists for the loss of vegetation on associated work areas if they are not appropriately located. Vegetation removal also has the potential to cause localised loss of rare or threatened plants.

The field survey indicates that less than 1km (in total) of the remnant vegetation likely to be impacted by the pipeline is substantially intact. A further 1km of slashed heath in Roseneath State Forest (Site 31) along an existing power line easement may also be impacted.

Grasslands have been identified as a particular issue. The proposed corridor crosses five locations in Victoria where native grasslands, in varying condition, have been identified (Sites 11, 12, 14, 15 and 22). Impacts to these grasslands will be minimal, as they will either be avoided (using techniques such as boring under roadside remnants) or minimised (by restricting the right-of-way to 15m where practicable and selecting the alignment to avoid main areas of native grasses).

Fauna mortality

Due to the disturbed nature of the Project area, and the resultant low density of native fauna, the risks associated with mortality due to machinery operation or collision with vehicles are likely to be low. However, some species may be encountered in trenching or grading operations, notably the Striped Legless Lizard (EPBC, FFG, NPW). While potential habitats will be surveyed for the presence of this species and the alignment will be refined where practicable, there is a low possibility it may be encountered in degraded pasture, where trenching and grading operations have the potential to cause some mortality.

The most likely direct effect on fauna is entrapment in the open trench. It is possible that small mammals, reptiles and amphibians may fall into the trench and either perish through shock, as prey for larger animals (for example cats or raptors) or be buried beneath backfill.

Destruction of fauna habitats

Due to the extent of historical clearing and the pipeline corridor selection process, any destruction of remnant fauna habitats will be minor and restricted to a local scale. Habitat destruction is largely related to vegetation removal (see above). The main habitat types that may be impacted are isolated trees, disturbed woodland at the edge of existing easements, grassland areas and aquatic habitats (watercourses).

A number of fauna species are dependent on remnant trees as nesting, breeding and foraging habitat, particularly old growth Red Gum, South Australian Blue Gum (known as Yellow Gum in Victoria), and Brown Stringy Bark remnants. These remnants occur either as stands or isolated trees. The area between Casterton and Naracoorte is particularly important in this regard where old growth Eucalypts provide important habitats for species such as the Red-tailed Black-Cockatoo, which utilise tree hollows.

The location of the pipeline corridor (in mainly cleared land) and the selection of the final alignment will ensure that there will be no clearing of remnant old growth Eucalypts.

At watercourse crossings, direct impact to aquatic and riparian habitats may result from physical damage during earthworks. Indirect impacts may occur to downstream habitats as a result of the mobilisation of sediments and the subsequent increase in turbidity and sedimentation. The pipeline corridor has been selected to avoid direct impacts to wetland habitats.

Fragmentation of fauna habitats

Fragmentation is a potential issue inherent in all linear development projects. The pipeline has the potential to fragment remnant woodland, grasslands or vegetation corridors associated with roads or watercourses.

The pipeline avoids almost all areas of remnant woodland within the Project area. The most substantial section of woodland traversed is the Roseneath State Forest south of Dergholm. This area will be traversed using existing easements, thus avoiding the need to create new habitat fragmentation. It is expected that the Project will not cause a long-term barrier to wildlife movement subsequent to construction and rehabilitation.

Localised fragmentation of grassland habitats may occur. Any barrier effect or fragmentation of habitat is most likely to occur on a local scale, affecting local populations of small, ground dwelling mammals, reptiles and amphibians.

The pipeline crosses numerous linear vegetation corridors associated with road reserves and watercourses. These features provide valuable links between larger habitat areas and pathways for the movement of fauna. The potential exists to fragment these corridors during pipeline construction.

The fragmentation of habitats may also increase access by introduced predators such as the Red Fox and Feral Cat.

Disruption to critical fauna lifecycle stages

The presence and activity of construction equipment and personnel may impact critical lifecycle stages of some species. For example, prolonged or unusual noise or activity may discourage the use of local habitats for breeding. Species of conservation significance such as the Red-tailed Black Cockatoo or the Brolga have the potential to be disrupted by construction activities in this manner. Red-tailed Black Cockatoos breed between October and May, nesting within 2km of suitable feeding habitat. Males leave the nest to forage during the fledgling period and return in the evenings to provide food for females and/or young. Brolga (FFG, NPW) breed between July and December, in freshwater meadows or marshes, and flock to more permanent water from late December to May.

Loss of biodiversity

Significant species and communities can be affected by the direct loss during clearing activities. Indirect consequences include the loss of biodiversity through weed invasion, soil erosion, altered light, hydrological or ecological conditions. For example, old growth Red Gums are relied on by many nationally significant bird species for feeding, breeding and nesting. A significant loss of such values may potentially affect local, regional or even statewide biodiversity.

Spread of ecological weeds

This discussion focuses on ecological weeds, which are introduced plant species that are invasive in remnant vegetation. Agricultural weeds are discussed in Section 11.

The spread of weeds is an inherent problem for linear projects. Weeds may be spread within regions into nearby sites formerly free of the species or over a long distance between regions.

Examples of problematic weed flora include:

- *Nassella* spp. (Needle-grasses and Serrated Tussock) on the Volcanic Plains are progressively eliminating native grassland remnants throughout the region. There is a high potential for these to spread to unaffected sites and other regions.
- *Myrsiphyllum asparagoides* (Bridal Creeper), an exotic climber with a very broad range, is currently a major weed of Mallee communities on the Siliceous and Calcareous Sand Plains.
- *Olea europea* (Olive) and *Marrubium vulgare* (Horehound) are major weeds of the Mount Lofty Ranges. Although Olives are already widely spread by birds and foxes, both weed species can be readily dispersed by machinery.

Potential impacts of the spread of ecological weeds include:

- inhibition of regeneration of indigenous species on the disturbed site, forming a longer term, perhaps permanent, weed cover, and
- invasion of adjoining, non-disturbed vegetation, particularly by species not currently present.

Spread of Pathogens

Two plant diseases are of particular ecological importance in the Project area: *Phytophthora* and Mundulla Yellows.

Phytophthora cinnamomi is a soil-borne organism that causes root rot of exotic and native plants. Infection often results in the death of the plant, with early symptoms including wilting, yellowing and retention of dried foliage, and darkening of young feeder roots and occasionally the larger roots. *Phytophthora cinnamomi* requires moist soil conditions and warm temperatures to be active, but damage caused by the disease most often occurs in summer when plants are drought stressed. *Phytophthora* grows through the root destroying the tissue, which is then unable to absorb water and nutrients. Zoospores are produced in sporangia, particularly when the soil is moist and warm, and are released into the soil. Consequently zoospore numbers can build up quite rapidly. Zoospores move in water and may infect neighbouring plants, especially those down slope from a site of infection. These spores are easily transported in run-off water, in contaminated soil and on earthmoving equipment, tools, footwear and vehicles.

Most of the bioregions along the pipeline route are considered as moderate risk areas for *Phytophthora*. The Mount Lofty Ranges are regarded as a high-risk area, and the Murraylands low risk.

Mundulla Yellows is a condition affecting native vegetation around southern Australia. It affects eucalypts and a range of other native species, and occurs in both young and old trees. Symptoms are yellowing of foliage, starting at the leaf tips, followed by foliage loss. Affected trees often resprout from epicormic buds, and this foliage is also yellow. Trees exhibiting these symptoms have never been observed to recover full health, and often die. The cause of Mundulla Yellows remains unknown, although a transmissible agent such as a phytoplasma, viroid, virus or bacteria is suspected. The methods of transmission are not understood, but may involve a vector such as an insect, although the possibility of transmission through soil, water or contact with infected plant material have not been discounted.

The spread of these diseases into non-contaminated areas has the potential to cause damage to remnant native vegetation.

9.4 Impact Mitigation

Objective

The principal management object is to minimise adverse impacts to the ecological values of the Project area.

Project Phase	Objectives*
Construction	7.a To appropriately minimise and manage impacts to the ecological values of the Project area 7.b To appropriately rehabilitate the easement to pre-construction condition, as reasonably practical
Operation	24.a To appropriately minimise and manage adverse impacts to ecological values of the easement 24.b To appropriately monitor rehabilitation of the easement
**Note: Objectives have been numbered to enable cross-referencing in the South Australian SEO.*	

Goals

The principal management goals are:

Project Phase	Goal*
Construction	7.1 To minimise and where practicable avoid clearing of remnant vegetation 7.2 To keep fauna fatalities to as low as possible 7.3 To avoid destruction of significant fauna habitats 7.4 To minimise and where practicable avoid fragmentation of fauna habitats 7.5 To minimise disruption to critical fauna lifecycle stages 7.6 To minimise loss of biodiversity 7.7 To avoid the spread of environmental and proclaimed weeds 7.8 To undertake appropriate actions to destroy environmental and proclaimed weeds 7.9 To avoid the spread of animal and plant pathogens, by undertaking practicable control and prevention procedures, and undertaking remediation works where required
Operation	24.1 To avoid clearing of remnant vegetation 24.2 To avoid the spread of environmental and proclaimed weeds 24.3 To avoid the spread of pathogens 24.4 To effectively monitor rehabilitation of the easement
**Note: Goals have been numbered to enable cross-referencing in the South Australian SEO.*	

Regional Goals

In addition to the more general goals outlined above, the following regional-specific goals apply. These address the key ecological sensitivities identified for each bioregion.

Bioregion	Goal
Coastal South-western Victoria	• To avoid or minimise the loss and fragmentation of roadside remnants • To minimise the loss of Swamp Gums from roadside remnants and streamside corridors • To avoid impacts to in-stream environments of Curdies and Hopkins Rivers, where practicable
Volcanic Plains	• To avoid impacts to Plains Grassland and Matted Flax-lily populations, where practicable • To avoid significant impacts to Curly Sedge population at Breakfast Creek • To identify and utilise the least sensitive route through the Harman Valley Volcanics
Dundas Tablelands	• To avoid undue removal of Red Gums (or other indigenous eucalypts), where practicable • To avoid impacts to Common Tussock Grass grassland south of McCrae Creek, where practicable • To prevent significant impacts to in-stream values of the Glenelg River
Wimmera Plains	• To avoid clearing old growth eucalypts • To minimise clearing of Red Gums and Yellow Gums (South Australian Blue Gums) • To minimise impacts to the Damp Heath Woodland ecosystem (Roseneath State Forest)
Southern Mallee	• To avoid clearing old growth eucalypts • To minimise impacts to roadside Mallee remnants • To protect soil stability in dune systems
Murraylands	• To avoid impacts on the in-stream habitat of the Murray River • To avoid impacts where practicable, or to minimise adverse effects, to *Lomandra effusa* Grassland • To minimise impacts on downstream National Estate values associated with the Reedy Creek area
Mount Lofty Ranges	• To avoid impacts to good quality remnants of threatened plant communities • To minimise impacts to indigenous vegetation • To prevent the spread of weeds and disease as result of construction related activities
Northern Adelaide Plains	• To avoid impacts on significant vegetation • To minimise impacts to areas of significant but artificial habitat (i.e. constructed wetlands and salt ponds) known to support migratory and resident shorebirds • Minimise impacts to the Samphire – Mangrove Complex in Barker Inlet and Torrens Island

Mitigation Measures

Mitigation measures will follow the procedures outlined below. Potential approaches for ecologically sensitive sites identified during the field survey are listed in Appendix 3. As indicated, some of these sites will require further survey and refinement of mitigation strategies during the detailed design stage, to ensure that impacts are avoided or limited to an acceptable level.

General

To mitigate potential impacts, SEA Gas will:

- adopt the principles and practices outlined in the APIA Code
- conduct further survey work during the detailed engineering phase at optimum survey times (for example spring surveys in grasslands) as input to the final alignment and management strategies
- integrate site specific management strategies into the Construction Environmental Management Plan (Construction Environmental Management Plan)
- work in consultation with the Victorian Department of Natural Resources and Environment (DNRE) and the South Australian Department for Environment and Heritage (DEH) to obtain necessary approvals for vegetation clearing , and
- work in close liaison with DNRE, DEH and Primary Industries and Resources South Australia (PIRSA) regarding the management of ecological issues.

Remnant Vegetation

To mitigate potential impacts, SEA Gas will:

- in areas containing remnant vegetation, select the final alignment with input from suitably qualified ecologists, and in consultation with DNRE or DEH officers, with the aim of minimising and where practicable avoiding clearing remnant vegetation (for example by utilising existing easements or gaps in vegetation)

- where practicable, drill or bore under significant roadside vegetation (in accordance with Figure 9-1)
- carry out surveys prior to construction at optimal times (for example, spring) to check sensitive sites for rare or threatened plants, and use the results of these surveys to develop avoidance or mitigation strategies, such as modifying pipeline alignment, marking or fencing plants to avoid damage, or developing salvaging or propagation protocols
- restrict disturbance to the 25m right-of-way and designated work areas
- reduce the right-of-way to 15m in areas of higher ecological significance (such as selected roadside reserves, grasslands and watercourse crossings) as determined by the ecological assessment (Appendix 3) and by consultation with DNRE and DEH
- trim branches that overhang the right-of-way rather than remove complete trees, whilst ensuring that safe access is maintained
- indicate areas of reduced right-of-way on the Alignment Diagrams
- immediately prior to clear-and-grade operations, employ a qualified ecologist to flag areas of reduced right-of-way and trees to be trimmed or retained
- implement protocols for mitigating impacts of tree or hollow branch removal
- incorporate education of construction workers on the value of grasslands into the Construction Environmental Management Plan
- develop and implement site specific rehabilitation procedures to reduce the duration of potential impact, to be developed in consultation with landholders, regulatory agencies and other key stakeholders
- comply with the DNRE net gain policy, and
- offset loss of native vegetation by carrying out suitable revegetation, in consultation with DNRE or DEH.

Avoiding Fauna Mortality

To mitigate potential impacts, SEA Gas will:

- in areas of higher ecological sensitivity, construct the trench in shorter sections with ramps (or slopes) at each end to facilitate fauna escape
- minimise the period for which the pipeline trench is open (no more than one week in areas of higher ecological significance)

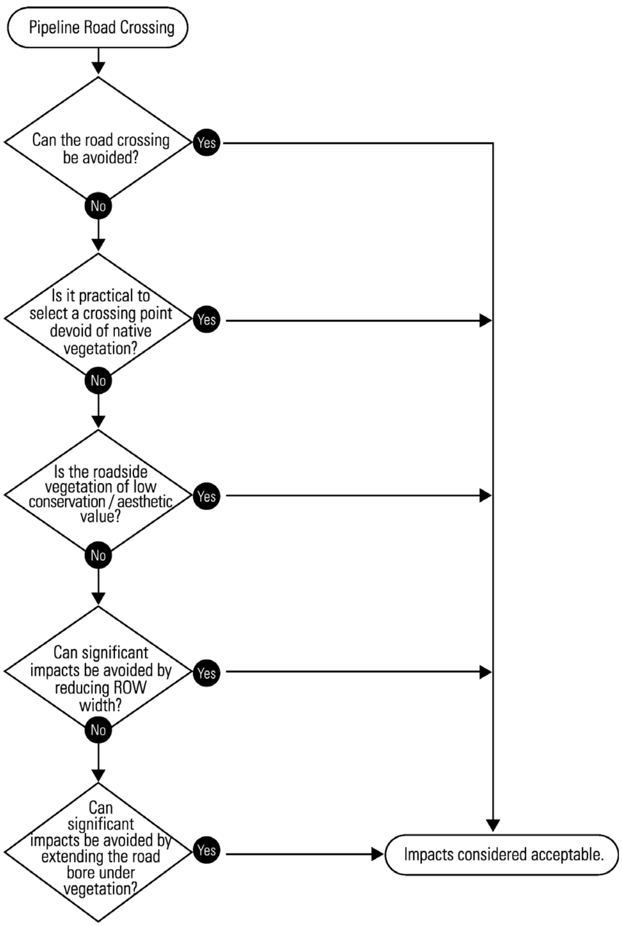

Figure 9-1: Road Crossing Impact Mitigation Decision Tree

- employ specialist fauna monitors to inspect the open trench each morning in areas of ecological sensitivity (animals trapped in the trench will be recovered, recorded and relocated), and
- develop appropriate protocols for dealing with significant fauna populations that may be discovered during construction.

Significant habitats

To mitigate potential impacts, SEA Gas will:

- in areas containing remnant vegetation, select the final alignment with input from suitably qualified ecologists, and in consultation with DNRE or DEH/PIRSA Officers with the aim of minimising and where practicable avoiding destroying significant habitats
- avoid clearing old growth trees, particularly Eucalypts
- avoid communities listed under State and Commonwealth legislation (for example, Plains Grassland)
- select watercourse crossing locations at existing clearances or areas of degraded riparian vegetation, where practicable
- select a watercourse crossing method that minimises impacts to significant in-stream habitats (see Section 7)
- minimise sediment impacts to downstream habitats by incorporating site specific management strategies into the Construction Environmental Management Plan, which may include controls on timing, duration and flow conditions of watercourse crossings and the use of sediment fencing, geotextile fabric and silt curtains, and
- develop and implement site specific rehabilitation procedures to reduce the duration of potential impact that utilise local species where indigenous vegetation is present.

Habitat fragmentation

To mitigate potential impacts, in addition to those actions proposed to minimise vegetation removal above, SEA Gas will:

- select an alignment with input from suitably qualified ecologists, and in consultation with DNRE or DEH officers that:
  - maximises the use of existing gaps in vegetation corridors
  - utilises existing disturbed areas or easements through the vegetation rather than create new fragmentation
  - aims to minimise impacts associated with fragmentation
- reduce right-of-way width to 15m through sensitive areas (for example, native grassland)
- where practicable, drill or bore under significant vegetation corridors, and
- significant trees (for example hollow bearing or old growth Eucalypts) will be flagged for avoidance.

Critical fauna lifecycle stages

To mitigate potential impacts, SEA Gas will:

- where practicable, in areas of higher ecological significance avoid construction during breeding periods for significant species
- where threatened bird species have been identified in roadside locations, vegetation will be cleared outside of breeding periods
- where the above is not practicable, in key areas construction will be organised to:
  - minimise the duration of activities
  - minimise the size of the workforce
  - utilise the minimum amount of construction equipment, and
  - select the most appropriate construction equipment

Biodiversity

Biodiversity issues are covered by those actions proposed to minimise loss of vegetation and disturbance to fauna habitats and lifecycles.

Spread of ecological weeds

To mitigate potential impacts, SEA Gas will:

- conduct a pre-construction survey of weed species
- develop a comprehensive weed management procedure, detailing site specific requirements for:
  - pre-construction controls (such as spraying)
  - quarantine requirements
  - machinery, vehicle and personnel hygiene measures
  - wash down of construction machinery at appropriate frequency
  - records management
  - monitoring
  - post-construction control, and
- incorporate the weed management procedures into the Construction Environmental Management Plan.

Spread of pathogens

To mitigate potential impacts, SEA Gas will:

- conduct a pre-construction survey for *Phytophthora* and symptoms of Mundulla Yellows in high risk areas
- develop a comprehensive pathogen management procedure, that details site specific requirements for:
  - quarantine requirements
  - machinery, vehicle and personnel hygiene measures
  - records management
  - monitoring
  - post-construction control, and

- incorporate the pathogen management procedures into the Construction Environmental Management Plan.

9.5 Conclusion

The vast majority of the proposed pipeline corridor passes through cleared land. It avoids large remnants of native vegetation and areas proclaimed for flora and fauna conservation. A number of key ecological sensitivities and potential impacts have been identified in each of the bioregions crossed by the pipeline corridor. Regional-specific goals for impact mitigation have been developed to address these issues, and strategies for mitigation outlined. The adoption of these mitigation strategies will reduce potential adverse impacts on flora and fauna to an acceptable level.

10 Cultural Heritage

SEA Gas acknowledges the importance of the cultural heritage values of the Project area to the community and is committed to their protection. It recognises that appropriate management of the Project is required to avoid or mitigate a range of impacts to indigenous and historical cultural heritage. Such impacts may include:

- damage to surface artefact scatters
- damage to subsurface cultural material, and
- damage to culturally significant vegetation.

However, SEA Gas is confident that by working closely with regulatory agencies and community representatives and with the application of appropriate impact avoidance and mitigation strategies, all potential adverse effects to the cultural heritage of the Project area can be reduced to an acceptable level.

This Chapter broadly describes the indigenous and historical heritage setting of the Project area, identifies potential impacts and outlines proposed avoidance and mitigation strategies.

10.1 Indigenous Heritage

10.1.1 Existing Environment

The SEA Gas Project area has been divided into eight bioregions. These are based on landforms encompassing a combination of environmental parameters that were likely to have influenced particular Aboriginal economies and settlement patterns (such as vegetation, habitat, topography and the nature of surface water). The bioregions are described in Section 5.1.

The indigenous cultural heritage setting of the Project area is broadly discussed in the following sections. The information is based on a combination of available literature, the results of Project specific consultation, predictive modelling and field survey as described below.

Consultation

Consultation associated with the Aboriginal archaeological and anthropological assessment of the SEA Gas Project was undertaken with State Government authorities, including Aboriginal Affairs Victoria and Department of State Aboriginal Affairs, South Australia, and local Aboriginal organisations.

The SEA Gas Project proposes to traverse two Victorian and five South Australian Aboriginal communities identified under the Commonwealth *Aboriginal and Torres Strait Islander Heritage Protection Act 1984.* Victorian communities consulted include Framlingham Aboriginal Trust and the Kerrup-Jmara Elders Aboriginal Corporation. South Australian communities consulted include Kaurna Meyunna Inc, Kungari Aboriginal Cultural Heritage Association, Mannum Aboriginal Community Association, Ngarrindjeri Heritage Committee and Tattyara Aboriginal Heritage.

Three native title claims are intersected by the Project. The native title claimants are the Gournditch-Mara (Victoria) the Ngarrindjeri and others (South Australia), and the Kaurna Peoples (South Australia).

At the time of writing, the Project was under discussion within the Ngarrindjeri Heritage Committee (associated with the Culburra to Murray River region). A Memorandum of Understanding exists with the Ngarrindjeri and Others Native Title Claim, and it is likely that future surveys will be undertaken jointly. Additional consultation and fieldwork is also required with the Kaurna Meyunna community.

Consultation with all these groups will be a comprehensive and ongoing process. Copies of all archaeological reports and findings have been sent to the relevant groups for their records.

Literature Review and Field Survey

The pipeline corridor traverses a number of regions that have been the subject of detailed research. Investigations undertaken for various development projects also provide information on the archaeology of some areas. A compilation of these sources, together with unpublished literature, provides a comprehensive background for the Project area.

A preliminary survey (Wood, 2001) was also undertaken for the SEA Gas Project to consolidate background and desktop research, with particular reference to key areas of archaeological sensitivity. The field survey was carried out with representatives from local Aboriginal community organisations, and covered approximately 9% of the pipeline route. The survey strategy was developed based on a number of factors, including the availability of representatives from appropriate Aboriginal heritage groups, land access, and the timing of the survey in relation to the "firmness" of the alignment within the corridor. (Section 5.2.2 outlines the iterative nature by which the pipeline alignment is selected. The cultural heritage survey is a key factor in influencing the alignment.)

Further consultation and survey work will be carried out prior to construction and at sensitive sites during construction, as discussed in Section 10.1.3.

Predictive Modelling

The current aim of this assessment is to present a predictive model, which indicates the likely distribution of sites within regions. The model is based on landform units, with each unit defined by a suite of environmental parameters. Such parameters are likely to have influenced the types, distribution and utilisation of resources, including the availability of water, shelter, raw materials and suitable camping locations. This model has been developed by previous research and is tested by the results of the current survey.

The reliability of such a model varies according to the degree of current archaeological knowledge or sampling potential. In areas that have been subjected to detailed studies (such as Condah Swamp and Murray River), there can be a high degree of confidence in the accuracy of the predictions of site distribution. In contrast, for areas such as the Southern Mallee, where previous studies are few, there is insufficient site data to discern patterns in the archaeological record. Sites not necessarily homogeneous with subsistence (for example ceremonial grounds) may lie outside this model as they cannot always be predicted with any degree of accuracy, particularly as they may be located in areas selected to fulfil requirements other than conventional physiographic or environmental settings.

In addition, present day patterns of site distribution may not accurately reflect the full range or location of Aboriginal archaeological sites due to the differential destruction of archaeological remains resulting through landscape processes or modification (Byrne, 1983).

The reliability of any model is also tested and improved by the survey of areas perceived to have low archaeological sensitivity. This ensures that the assumptions used to construct the predictive model are correct. As part of the SEA Gas Project, field-testing was undertaken in such areas and throughout the range of landforms within any given region.

Summary of Existing Conditions

Indigenous archaeological sites within the Project area are likely to have been impacted through widespread land clearance, a prolonged history of agricultural land practices and rural and urban development. Despite this, a broad range and a large number of sites have been recorded throughout the pipeline corridor. Site types most likely to be encountered, in association with likely landforms (predictive model), are presented in Table 10-1 and include:

- earthen mound sites
- quarries
- scarred trees
- burials
- isolated artefacts
- stone fish traps
- stone artefact scatters and campsites
- stone arrangements – domestic
- middens, and
- art sites

Survey Results

Numerous areas within the Project area are considered to be of high archaeological sensitivity. In addition to a number of previously recorded sites, three new sites have been recorded within the current corridor. These sites are shown in Maps 4-11. The following discussion includes general introduction to indigenous ethnographic and historical background of each region, in addition to findings of preliminary survey results.

Coastal Southwestern Victoria

Early observations of the land and its people depict abundant game, fish and bird life, exploited by Aboriginal groups through broad ranging and integrated economies. The diversity and reliability of resources provided for a degree of sedentism and the maintenance of semi-permanent "villages". Swamp habitats, in particular, were recognised as foci for Aboriginal exploitation and settlement (Hugh Donnelly, in Cusack, 1999b, p7). It is evident that the region supported Aboriginal populations approaching those of the most densely populated parts of Australia (Lourandos, 1977, p219).

A number of sites proximate to the existing Iona – Portland pipeline have previously been located (Wood and Lance, 1990) and can be used to complement the current survey. Wood and Lance (1990) recorded no sites along this length of corridor.

No sites were recorded during the preliminary survey (Wood, 2001). However, several locations are considered

Table 10-1: Common Site Types

Site Type	Description	Landform
Earthen mound sites	Characterised by a mounded accumulation of dark, charcoal rich sediment often containing artefactual and faunal material and occasionally human burials. Circular to oval in plan with typical diameters of between 5 and 15m and less than 1m in height. Often dispersed through ploughing and erosion and occur singularly, paired and clustered.	Invariably occupy elevated ground on the edges of flood plains, lakes and swamp margins. Associated with poorly drained soils inherent in these environments.
Scarred trees	Most commonly River Red Gums though also Black and Grey Box. Typically exhibit a symmetrical shape, usually oval or cigar shape. The scar will generally not continue to the ground and the tree will be mature, a minimum age of approximately 100 years.	The distribution of these items has been heavily influenced by land clearing. Can be found in most landforms though probably in association with habitation areas. Presumably canoes were confined to the proximity of larger swamps and watercourses though there is some evidence in the Lower Murray that bark canoes were transported considerable distance to be used along the Murray River.
Isolated artefacts	Any artefact located more than 50m from the next closest artefact.	Occurring within all landforms.
Stone artefact scatters and campsites	May comprise a small number of closely located artefacts or large sprawling complexes containing numerous artefacts, reduction floors, hearths, faunal remains.	Well drained locations most notably dune surfaces. Larger sites tend to be located adjacent to resource areas while smaller sites may have been chosen simply for convenience.
Middens	Accumulations of faunal material. Most commonly recognised as shell middens. Vary in scale and depth from discrete thin heaps to open sprawling complexes. Often poorly preserved through the action of chemical weathering.	Well drained locations most notably dune surfaces. Occur in coastal and inland settings.
Quarries	Identified by the presence of large quantities of primary flakes and unmodified stone debris. Common materials include flint, silcrete, quartzite, chert, greenstone. Excavated pits may be present or evidence of flaked surfaces.	Bedrock geology determines the location and type of stone materials present. For instance flint outcrops along the southern coastline as both in situ nodules within limestone cliffs and as cobble beach deposits, silcrete outcrops in Geriwerd, chert is obtainable from the Murray Basin. Sources such as creekbeds were probably significant sources of material, most notably quartz and quartzite.
Burials	Isolated bone fragments to broad cemeteries containing numerous individuals.	These sites generally occur in areas of loose soil, especially dunes or lunettes. Burials are relatively common within mound sites. May be located within small caves and crevices as found along the Murray River.
Stone fish traps	Often linear to curved stone walls and may have obvious sluices, weirs and gates. May have been supported by timber sections with woven traps placed across weirs and gates.	Typically found along major river systems, coastal and lagoonal settings.
Stone arrangements – domestic	Semi-circular stone walls measuring 3-5m in diameter and 40cm in height. Presumably capped with covered bough structure forming shelter. Occur in clusters, individually or in extensive complexes.	Found within the volcanic plains of south western Victoria and occasionally in close association with fish traps.
Art sites	Painted ochre motifs or engraved surfaces. Stylistic differences are noted between regions.	Painted art invariably occurs in shelters or caves where preservation in enhanced. Engravings occur on covered and exposed rock faces.

to have potentially high sensitivity, most notably the Curdies and Hopkins river crossings. Port Campbell Creek has also been identified as having potentially high sensitivity (Ecos, 1998). Based on the results of the current survey, as well as previous findings, the remaining sections of corridor in this landform are deemed to be of generally low sensitivity.

Volcanic Plains

The record of Aboriginal occupation within this region is defined largely by two site types: mounds, and stone houses or hut bases. These sites not only represent significant levels of occupation, but an adaptive technology aimed at exploiting the highly productive wetland habitats that proliferate throughout the volcanic plains. Access to these habitats is believed to have supported increased sedentism.

During the preliminary survey, 43 sample areas were investigated, with more detailed survey conducted at eight of these (where survey was not hampered by limited ground surface exposure). Various locations throughout this region are of extremely high archaeological sensitivity. Such areas include:

- Merri River crossing (though the previously recorded site on the eastern bank of the Merri River lies outside the proposed corridor)
- Lake Cartcarrong
- Moyne River crossing
- the southern edge of Wild Dog Swamp
- an area of swampy basins (stony rises), between Back Creek and the Shaw River
- a large site complex located along the Eumeralla River course, immediately southeast of Macarthur. (This group of sites is particularly significant, as it is representative of the ethno-historically recorded "villages"), and
- Louth/Weerangourt/Scott Creek swamps (a major branch of the Condah Swamp), where literally hundreds of sites have been previously recorded (the proposed corridor travels north of the swamp and has the potential to incidentally disturb, damage or in some other way affect, a number of unrecorded sites in this location during pipeline construction).

The corridor has been aligned to avoid known sites in the Louth/Weerangourt/Scott Creek swamp area (such as the Macarthur Area sites which are listed on the Register of the National Estate). Further survey and consultation will be carried out to determine an acceptable final alignment.

Immediately west of Branxholme to the Hamilton-Dartmoor Road, the corridor parallels an abandoned rail line reserve. It has been assumed that although the landforms are sensitive, levels of disturbance are likely to have impacted on the preservation of any materials.

No new sites were recorded during the preliminary survey (Wood, 2001).

Dundas Tablelands

This region incorporates the traditional lands of the northwestern clans of the *Dhauwurd*, the western clans of the *Jardwadjali* and the eastern *Buandig* (Clarke, 1990). The corridor north of Casterton approximates the boundaries of these last two groups.

A preliminary pedestrian survey was undertaken in 10 sample areas within this unit. Thick pasture cover limited visibility for much of this distance and no Aboriginal sites were located (Wood, 2001).

However, the corridor traverses several moderate to highly sensitive areas, most notably the courses of several substantial creeklines. Elsewhere, the corridor traverses a dissected tableland setting of high ridges and steep slopes, which is generally considered of low archaeological sensitivity. There was no evidence of Aboriginal scarring associated with large (old) gums within the survey areas.

Wimmera Plains

A preliminary pedestrian survey was undertaken of 19 sample areas between Casterton and Dergholm and, similar to other regions, ground surface visibility was limited by dense vegetation (Wood, 2001).

Elsewhere in this region, archaeological sensitivity remains significantly high in a number of locations, particularly:

- near the southern boundary of the Wannon River valley. (The sensitivity of this area is highlighted by a group of scarred trees, mound sites and artefact scatters. The use of an existing rail reserve does, however, reduce the integrity and sensitivity of this section to some degree.)
- at Deep Creek and Red Cap Creek crossings, and
- parallel to Salt Creek, where shallow granite outcrops over a low hill and is likely to collect water within the course of Salt Creek.

One Aboriginal site was recorded during the survey, Bangallah Road Site 1. This comprises a scatter of stone artefacts together with fragments of freshwater mussel shell immediately adjacent the Glenelg River. The extent of the site warrants further work and the final alignment within this section of the corridor will need to consider the site (Wood, 2001).

The eastern portion of the bioregion was inhabited by the *Jardwadjali* and the ethnography between Dergholm and Poolaijelo is largely similar to Dundas Tablelands. A preliminary pedestrian survey was undertaken at seven locations. A small number of moderately to highly sensitive areas were identified. Of particular interest are the margins of several swampy basins and the courses of Mosquito Creek and a small tributary (lunette feature) (Wood, 2001).

Between Poolaijelo and Naracoorte, six of the 10 sampled areas were deemed to be of low archaeological sensitivity and the remaining four, low to moderate sensitivity. No Aboriginal sites were recorded during the survey (Wood, 2001).

Southern Mallee

The pipeline corridor will traverse the traditional territories of three groups within this region, the *Marditjali*, *Potaruwutj* and *Ngarkat* (Tindale, 1974). The *Marditjali* inhabited the western Wimmera Plains, the *Potaruwutj*[1], the open plains and ridge country between Naracoorte and Keith, and the *Ngarkat* occupied the mallee scrublands belt east of the Murray River to the Victorian border and as far south as Keith.

The area occupied by the *Ngarkat* appears waterless with only a few native wells and soaks. The *Ngarkat* relied heavily on the water they obtained from the roots of the red mallee (*Eucalyptus oleosa*) and the needlebush (*Hakea leucoptera*) (Gara, 1985, p1-2). According to Tindale (1974, p215), *Ngarkat* bands were widely dispersed across their "tribal" territory, constantly shifting camp from one grove of mallee trees to the next and hunting kangaroos, wombats, emus and other animals in the scrub. It was only during very dry or drought conditions that the Ngarkat were driven to the big rivers such as the Murray (Tindale 1974, p62). It is likely that the *Potaruwutji* lead a similar nomadic lifestyle to that of the *Ngarkat*.

Limited survey work was conducted between Naracoorte and north of Willalooka, with only 12 areas surveyed, due to land access constraints. No Aboriginal sites were recorded. Areas of high sensitivity include Morambro Creek and the edges of permanent lagoons and swamps. Areas of moderate archaeological sensitivity include several locations near the eastern edge of the Naracoorte Range (Wood, 2001).

No Aboriginal sites were recorded during the brief survey from Willalooka to south of Tailem Bend, including a survey undertaken north of Culburra. Archaeological sensitivity in this landform unit is generally low but increases markedly around a number of waterholes and skirts the margins of the interdunal swamps (Wood, 2001).

Murraylands

The fertile habitats of the Lower Murray, Lakes District and Coorong are thought to have supported one of Australia's largest temperate semi-sedentary populations. The study area extends through the traditional territories of what is now known as the *Ngarrindjeri*. The term *Ngarrindjeri* incorporates six groups, including the *Nganguruki*, *Ngaralta*, *Warki*, *Portaulun*, *Jarildekald* and the *Ramindjeri*, who inhabited the Lower Murray region. The proposed corridor passes through the territory of the *Ngaralta*.

Settlement patterns reflected the seasonal availability of food resources. In spring and summer, Aboriginal people occupied semi-permanent settlements near the river and the availability of water allowed the *Ngarrindjeri* to venture inland from permanent water sources. However, winter conditions encouraged semi-sedentism in areas near the lakes at the mouth of the Murray River. Fire-softened river red gum bark was commonly used for canoes, and many trees exhibit scars (Berndt, 1941; Boehm, 1948).

The archaeological sensitivity of the Murray River is considered to be extremely high. A survey will be undertaken east of the Murray River, but had not been carried out at the time of writing. Based on extrapolation of previous studies (Wood, 2000), archaeological sensitivity of the western region is generally low. The predominant land use is dairy farming and the irrigated land is highly disturbed. A number of previously recorded sites are located immediately within the vicinity of the pipeline. These sites are concentrated on the river bank and become less dense further from the river. The location of an appropriate horizontal directional drill crossing site will be selected in consultation with the *Ngarrindjeri* and will avoid impact to any heritage sites.

Five areas were surveyed in the northern alluvial plains. No Aboriginal sites were recorded during the survey. Archaeological sensitivity is generally low but increases adjacent to Reedy Creek, despite the lack of cultural material (Wood, 2001).

1 *Potaruwutj* translates to 'wandering' or 'travelling men' (Tindale 1974, p218).

Mount Lofty Ranges
The *Peramangk* group are thought to have occupied the eastern Mount Lofty Ranges to approximately Strathalbyn and Kanmantoo (Tindale, 1974, p217). Tindale (1974, p61) noted that the group kept to elevations below about 365m in winter to avoid the cold and wet conditions common at this time of year. Their territory was well-watered and fertile resulting in little movement to the mallee-covered limestone flatlands east of the Ranges. There was some trade between the *Ngarrindjeri* and the *Peramangk*, trading items such as red gum bark (canoe-making) and whip-stick mallee spears (Tindale, 1974, p60).

Eight areas were closely inspected in this bioregion. Archaeological sensitivity is moderate to high in the vicinity of springs and watercourses and particularly South Para River, Torrens River and Millendella Creek. Sensitivity reduces markedly in areas of steep terrain (Wood, 2001).

Northern Adelaide Plains
At the time of European settlement, the Aborigines of the *Kaurna* language group inhabited the Adelaide area, comprising the coastal plains from Port Wakefield to Cape Jervis and to the western edge of the Mount Lofty Ranges (Gill 1909; Tindale 1974; but see Lucas 1989, p19 for alternative boundaries).

The territory of the *Kaurna* comprised estuarine wetlands, beach fronts, plains and ranges, all of which provided a variety of environments and resources. While there is conflicting evidence regarding seasonal movement through the country, many early historical accounts suggest that the Kaurna occupied the coastal areas in summer and retreated to the inland during winter (Ellis, 1976, p116; Edwards 1966, p239).

The alluvial plains, coastal fringe and estuary zones of this bioregion, like the Murray River and coastal areas of the South East, is a resource-rich ecological zone thought to have supported large numbers of Aboriginal people. The general region is archaeologically sensitive with numerous recorded Aboriginal sites. Sites common to this area include earthen mounds, stone artefact scatters/campsites, isolated artefacts and burials. The distribution of these sites suggests a concentration of settlement along the coastal fringes and about the major watercourses traversing the plains, as well as ephemeral swamps and drainage lines.

A survey has not been undertaken for this section of the route. The area is of high archaeological sensitivity. Subsequently further work will be undertaken and incorporated into the detailed planning phase.

10.1.2 Potential Impacts

The following activities have the potential to affect the cultural heritage values of the Project area:
- creation of construction access
- clear-and-grade operations
- trenching, and
- horizontal directional drilling.

Provisions under the Commonwealth *Aboriginal and Torres Strait Islander Heritage Protection Act 1984* Part 2A, the Victorian *Archaeological and Aboriginal Relics Preservation Act 1972* and South Australian *Aboriginal Heritage Act 1988* make it an offence to disturb, deface or damage an Aboriginal object or site without the prior approval of the relevant State regulatory authority, local Aboriginal community or relevant Federal Minister. The following sections of legislation outline the penalties for damage to or disturbance of an Aboriginal heritage area or object:
- Section 2IU(1) of the *Aboriginal and Torres Strait Islander Heritage Protection Act 1984*
- Section 28 of the *Archaeological and Aboriginal Relics Preservation Act 1972*
- Section 44 of the *Aboriginal Heritage Act 1988*.

Appropriate management of the Project will prevent or successfully mitigate potential adverse impacts to the cultural heritage values of the region. Such impacts include:
- damage to shallow artefact scatters
- damage to subsurface material, and
- damage to significant vegetation (for example scarred trees).

Damage to Shallow Artefact Scatters
Earthworks associated with construction activities have the potential to disturb or damage shallow artefact scatters. These earthworks may be associated with either the mainline pipeline construction or with incidental or related activities such as topsoil removal, trenching, the creation of access tracks, work areas, stockpiles, drill pads and installation of pipeline infrastructure (for example cathodic protection equipment).

Damage to Subsurface Material
Trenching operations have the potential to damage previously unrecorded sites.

Damage to Significant Vegetation

Clearing operations, particularly associated with watercourse crossings, have the potential to damage significant vegetation, such as scarred trees.

10.1.3 Impact Mitigation

Objective

The principal management objective is to minimise adverse impacts to the indigenous cultural heritage of the Project area.

Project Phase	Objectives*
Construction	8.a To minimise and manage adverse impacts to the Cultural heritage values of the Project area
Operation	25.a To appropriately minimise and manage adverse impacts to identified Cultural heritage sites
**Note: Objectives have been numbered to enable cross-referencing in the South Australian SEO.*	

Goals

The principal management goals are:

Project Phase	Goal*
Construction	8.1 To protect surface and shallow artefact scatters from damage 8.2 To minimise damage to subsurface material 8.3 To avoid damage to culturally significant vegetation 8.4 To avoid damage to built heritage 8.5 To obtain all necessary approvals for unavoidable site disturbance 8.6 To implement appropriate protocols for dealing with cultural heritage material discovered during construction
Operation	24.1 To protect surface and shallow artefact scatters from damage 24.2 To avoid damage to culturally significant vegetation 24.3 To implement appropriate protocols for dealing with cultural heritage material discovered during operations
**Note: Goals have been numbered to enable cross-referencing in the South Australian SEO.*	

Mitigation Measures

To mitigate potential impacts to indigenous cultural heritage, SEA Gas will implement the following measures.

General

- consult with local Aboriginal communities throughout pre-construction and construction works
- adopt the principles and practices outlined in the APIA Code
- integrate site specific management strategies into the Construction Environmental Management Plan, and
- work in close liaison with Aboriginal Affairs Victoria, Department of State Aboriginal Affairs, local Aboriginal community organisations and native title claimants regarding the management of cultural heritage issues.

Pre-construction Survey

- conduct survey work in areas not inspected during the preliminary survey
- conduct further analysis of areas of lower sensitivity to ensure accuracy of the predictive model
- include heritage sites identified in preliminary or further survey work as "no-go" areas on the Alignment Sheets

- conduct further assessment of the Louth – Condah swamp areas
- consider archaeological test excavations to determine the presence of sub-surface deposits, at the following locations:
  - Curdies River
  - Glenelg River
  - Hopkins River
  - lunette in the Poolaijelo area
  - Merri River
  - Mosquito Creek
  - Eumerella River
  - South Para River
  - Crawford River
  - coastal dunes on Torrens Island, and
  - Dwyer Creek.

Prevent Damage or Disturbance to Sites of Cultural Heritage Significance

- where practicable, select a final alignment within the proposed corridor that avoids cultural heritage sites
- where lateral alignment changes may not avoid impact, consider boring beneath sites
- select locations of associated site works (for example the horizontal directional drill site at the Murray River) that avoid impacts to sites
- install flagging, protective fencing or erosion control measures to protect sites near the easement, which will not be directly affected by construction
- obtain appropriate authorisation for unavoidable site disturbances necessary to permit the construction of the pipeline
- develop appropriate construction management protocols during the detailed design phase, in consultation with affected Aboriginal communities, which may include:
  - on-site monitoring by representatives from the relevant Aboriginal community in areas of high sensitivity during clear-and-grade and / or trenching
  - strategies for assessment of artefact occurrences identified during construction by experienced / qualified archaeologist
  - site specific management measures
  - strategies for salvage of artefact sites identified during construction, and
- ensure all personnel are adequately aware of the required cultural heritage management procedures.

10.2 Historical Heritage

10.2.1 Existing Environment

Prior to the project commencing Heritage Victoria was notified of survey activities. However, South Australia does not require prior notification. Heritage Victoria and Heritage South Australia maintain non-indigenous heritage registers, which were reviewed as part of the desktop study. The Register of the National Estate was also reviewed.

Overview

Small rural townships have represented the focus of early non-indigenous land use and history, and many can be considered historical precincts. Whereas landscapes can be seen as being historical artefacts (that is representative of pastoralism, agriculture and mining etc), the majority of recorded historical sites lie within township boundaries, and subsequently will be avoided.

Early colonial settlement was largely governed by the basic needs of food, water and shelter. Other stimuli such as discoveries of gold, improvements in transport, mapping of soils (for example, in the wine producing districts) and the re-settlement of refugees and soldiers, has also greatly influenced the pattern and style of settlement. The pipeline corridor has been divided into five regions in which common historical themes can be identified.

Survey Results

The assessment identified three previously recorded sites and seven new sites within the immediate area of the pipeline corridor (Wood, 2001). The following discussion includes a general introduction to the post-indigenous history of each region, in addition to the survey findings.

Victoria

Historical sites recorded in the region cover central themes of early coastal settlement, pastoral expansion, road and rail, gold, timber and soldier settlement. The Project is unlikely to disturb historically significant sites recorded in the general area. However, potential impacts may occur to peripheral infrastructure such as road and rail linkages, particularly as the corridor traverses several former rail easements (for example, Branxholme-Casterton trunklines).

A total of seven new non-indigenous sites were recorded during the survey to occur within the corridor. Six sites are associated with a railway, while the seventh is a road bridge.

Wimmera Plains and Southern Mallee

Pastoralists occupied the southeast border districts as early as the 1830s. Tatiara to the north formed part of an integral transport and communication route and towns were generally established as staging points and stopovers along the overland and gold routes to the Victorian gold fields (Walker, 1986, p133). In the south, thousands of Chinese immigrants arrived at the coastal ports of Robe and Kingston and travelled eastward through the Penola – Naracoorte region.

The centralisation and mechanisation of agriculture in the 1950s resulted in the decline of many smaller townships. Smaller grain yards, schools, shops and post offices closed and towns disappeared, albeit for the churches, district halls and sports facilities evident throughout districts today (Dallwitz and Marsden, 1983, p85). By contrast highway and railway towns flourished.

Previously recorded historical sites within the general Project area include Tintinara and Hynam Homesteads, Hynam shearing shed, William Harding's Grave and a Limestone Well. However, no sites will be impacted. One new site was recorded and comprises the Hynam Cemetery established in 1846. The cemetery is located 400m east of the proposed corridor and will not be impacted.

Murraylands

The Murray River has always provided a common link between districts and towns (Dallwitz and Marsden, 1985, p16). European heritage broadly covers a range of settlement activities such as overlanders, pastoralists, mission settlements, riverboat trade, early irrigation schemes, the various village settlement schemes and other agricultural and horticultural developments. In addition to pastoralism, the riverboat trade and irrigation strongly influenced regional history.

The overwhelming majority of recorded sites are located adjacent the Murray River, often within township boundaries (such as Cooke Plains and Reedy Creek) and it appears that the SEA Gas Project may impact upon these sites to some degree. No new sites were recorded during the historic assessment in this region.

Mount Lofty Ranges

The development of cropping and the influx of German settlers occurred from the mid-1840s to the 1850s. The levels of wheat production and pastoral expansion resulted in increased populations and role of service centres. Flour mills were established in various towns, such as Mount Pleasant (1865) and Eden Valley (1860s), and schools, hotels, police and other community facilities followed.

Mining activities have a long history in the Mount Lofty Ranges, where silver was extracted. The quarry site north of Mount Pleasant is located within the archaeologically-sensitive Barossa gold fields. In addition, the forestry industry existed in the region since early settlement, establishing as early as the 1840s in the Barossa area, with timber utilised for mining, rail and telegraph industries (Lester *et al.*, 1981, p26).

Of particular note is the location of disused rail reserves within the current Project area, which often contains historic artefacts. It is considered that a 25m wide construction zone will impact the physical aspect of the reserves as well as the visual aspect.

There are a number of previously recorded sites in this region, some of which are in close proximity to the corridor. These include the Rosebank Shearing Shed, Mount Crawford Cemetery, Glen Gillan Road Bridge, Whispering Wall and various residences. However, only one site (a quarry) is located immediate to the current corridor. No new sites were recorded during the survey.

Northern Adelaide Plains

Subsequent to initial establishment of colonial South Australia, settlement occurred within high rainfall areas south of Adelaide which displayed familiar climatic conditions for European settlers. Gawler was one of the first country towns established in South Australia (1839) and is considered one of the most significant heritage towns (Walker, 1986, p97). Widespread settlement resulted in large-scale clearing and replacement of native vegetation with crops such as wheat and corn.

Much of the intensive development is relatively recent, post-dating the Second World War and the expansion of industry in the Salisbury-Elizabeth district. Rapid urbanisation resulted in the extensive modification of the landscape, consolidated by the long fringes of the northern Adelaide suburban sprawl.

A number of previously recorded sites are in the general vicinity of the corridor and relate to early regional pastoral and agricultural settlement. Sites in close proximity to the proposed corridor include residences, Dry Creek Railway and Torrens Island Quarantine Station. The Edinburgh Airforce Base is located immediately adjacent the route and will be avoided. No new sites were recorded during the survey.

10.2.2 Potential Impacts

The following activities have the potential to affect the cultural heritage values of the Project area:
- creation of construction access
- clear-and-grade operations
- trenching, and
- horizontal directional drilling.

Items of historical heritage significance are protected under the Victorian *Heritage Act 1995* and the South Australian *Heritage Act 1993*. The majority of items of historical heritage significance are readily identifiable; sites such as buildings, structures and cemeteries. As such, unintentional damage is less likely than for indigenous heritage items.

The main potential impacts are associated with the disturbance to smaller scattered items occurring on or immediately below the land surface as a result of earthworks.

10.2.3 Impact Mitigation

Objective

The principal objective is to avoid adverse impacts to the historical heritage within the Project area.

Project Phase	Objectives*
Construction	9.a To appropriately minimise and manage adverse impacts and long term environmental risk to Historical heritage of the project area
Operation	26.a To appropriately minimise and manage adverse impacts to identified historical heritage sites
**Note: Objectives have been numbered to enable cross-referencing in the South Australian SEO.*	

Goals

The principal management goals are:

Project Phase	Goal*
Construction	9.1 To avoid damage to built heritage 9.2 To implement appropriate protocols for dealing with historical heritage material that may be discovered during construction
Operation	26.1 To avoid damage to built heritage 26.2 To implement appropriate protocols for dealing with historical heritage material discovered during operations
**Note: Goals have been numbered to enable cross-referencing in the South Australian SEO.*	

Mitigation Measures

To avoid impacts to historical heritage SEA Gas will implement the following measures.

General
- adopt the principles and practices outlined in the APIA Code
- integrate site specific management strategies into the Construction Environmental Management Plan, and
- work in close liaison with Heritage Victoria, Heritage SA and local historical societies regarding the management of historical heritage issues.

Preconstruction Survey
- conduct a heritage survey of the final alignment during the detailed design phase to identify all known heritage sites
- conduct further field assessment of historical structures such as railway infrastructure and bridges, and
- include site locations as "no-go" areas on the Alignment Sheets.

Prevent Damage or Disturbance to Sites of Historical Heritage Significance
- where practicable, select a final alignment within the proposed corridor that avoids historical heritage sites

- select locations of associated site works that avoid impacts to sites
- avoid impact to all standing buildings and structures
- where stone walls are unavoidable consent from Heritage Victoria may be required and stones replaced after pipeline construction is complete
- install flagging, protective fencing or erosion control measures to protect sites near the easement, which will not be directly affected by construction, and
- ensure all personnel are adequately aware of the required historical heritage management procedures.

10.3 Conclusion

An assessment of potential impacts to the cultural heritage of the Project area has been carried out based on a combination of available literature, the results of Project specific consultation, predictive modelling and field survey. A range of potential impacts to the indigenous and historical cultural heritage of the project area have been identified, including damage to surface artefact scatters, damage to subsurface cultural material, and damage to culturally significant vegetation. A number of areas of high archaeological sensitivity within the Project area have been identified, and further work will be undertaken in these areas and incorporated into the detailed planning phase. SEA Gas is confident that by working closely with regulatory agencies and community representatives, and with the application of existing protocols and appropriate impact avoidance and mitigation strategies, all potential adverse effects to the cultural heritage of the Project area can be reduced to an acceptable level.

11 Socio-Economic Issues

This chapter assesses the potential social and economic implications of the proposed SEA Gas Project. These include benefits, such as increased regional expenditure and development. In addition the chapter identifies the need to protect:

- existing land use activities
- third party infrastructure, and
- visual amenity.

SEA Gas is confident that with the application of appropriate management strategies, regional communities will receive significant economic benefits and any negative socio-economic impacts can be avoided or reduced to an acceptable level.

11.1 Regional Economic Issues

The benefits to Victoria and South Australia, at the state level, are dealt with in Section 1.1. In addition, the Project will generate significant benefits for regional communities in the Project area.

Regional socio-economic analysis is traditionally based upon Statistical Sub-Divisions (SSD) which group Local Government Areas with similar broad characteristics to allow data to be presented in a concise manner. Other sections of this document have divided the Project area into bioregions, due to the nature of the available economic data these bioregions are not considered appropriate for regional economic analysis. The Statistical Sub-Divisions used are outlined in Table 11-1.

Estimates of the regional economic implications of the Project were determined by identifying significant regional expenditures (in particular wages and salaries) and local purchases of goods and services (for example, food, accommodation, mechanical and earthmoving services and compensation payments). The approximate value of these purchases was determined by reference to previous gas pipeline projects and allocated on a pro-rata basis, reflecting the distance of pipe through each sub-division.

Direct expenditure is likely to lead to subsequent expenditures in regional economies. It was estimated that subsequent expenditures would typically add no less than a further 50% (multiplier of 1.5) to the local region.

Regional benefits will not be distributed evenly throughout the Project area, and are largely dependent on the construction program (that is, the location of construction bases). These details will be finalised during the detailed design and early construction phase of the Project (see Section 5.2).

Regional profiles are based upon the published literature, with additional information gained from interviews with local government authorities. Details of organisations consulted are outlined in Section 12.

11.1.1 Existing Socio-Economic Environment

Hopkins SSD

At the time of the 1996 Census, 59,606 persons lived in the region, where 23.5% were children aged 0-14 years. The SSD had an average household income of approximately $34,515 per annum compared to the Victorian average of $41,599.

Although the region had a relatively low unemployment rate of 4.9% (DEWRSB, 2001), unemployment was concentrated in the major urban centre of Warrnambool (7.0%). The actual region through which the pipeline passes has an unemployment rate of less than 3.0%. Agriculture, forestry and fishing was the major employing industry (25.2%), followed by retail (14.7%) (Australian Bureau of Statistics, 1996).

As expected in an area dominated by agricultural employment, local people are mostly employed as managers or administrators (23.6%, of which 19.9% are farmers). Tradespeople account for 12.4% of local employment, predominantly in the food (1.8%), automotive (1.7%), engineering (1.5%) and construction trades (1.3%). The area has also experienced strong growth in the dairy industry in recent years and much of this growth is attributed contributed to small boutique businesses.

Glenelg SSD

Some 37,064 persons were recorded as living in these regions in the 1996 Census. The area has a relatively high proportion of residents aged between 0-14 years and over 65 years. The average income of the region at that time was approximately $33,508. Currently, unemployment in the

Table 11-1: Statistical Sub-Divisions

State	Statistical Sub-Division	Local Government Areas (LGA)	Pipeline passes through the LGA	Main population centres or locations
Victoria	Hopkins	Corangamite Moyne Warrnambool	Yes Yes No	Camperdown Port Fairy Warrnambool
	Glenelg	Glenelg Southern Grampians	Yes Yes	Portland Casterton Hamilton
	West Wimmera	West Wimmera Horsham Northern Grampians	Yes (minor) No No	Edenhope
South Australia	Upper South East	Naracoorte and Lucindale Tatiara Lacepede Robe	Yes Yes No No	Naracoorte Bordertown Padthaway Cape Jaffa Robe
	Murray Mallee	The Coorong Murray Bridge Mid Murray	Yes Yes Yes	Tailem Bend Meningie Murray Bridge Mannum
	Barossa	Barossa Light Mallala	Yes No No	Angaston Tanunda Mt Pleasant Kapunda Mallala
	Northern Adelaide	Gawler	Yes	Gawler
		Playford	Yes	Elizabeth Salisbury
		Port Adelaide Enfield (East & Inner)	No	
	Western Adelaide	Port Adelaide Enfield (Coast & Port)	Yes	
		Charles Sturt	No	
		West Torrens	No	

regions averages 5.9%, well below the Victorian average of 6.5%. Most locals are employed in the agricultural, forestry and fishing sectors (21.7%), followed by manufacturing (13.7%). Almost half of the employment in manufacturing is in the metal products sector, reflecting the presence of the Alcoa aluminium smelter in Portland. Similar to the Coastal South-west Victoria bioregion, there is a high proportion of local residents employed as managers and administrators (20.2%) and in the trades and related jobs (13.5%). Over recent years, agricultural practices in the Glenelg Shire have changed substantially from pastoral land to plantation forestry.

The local economy of the region is currently exhibiting strong economic growth, reflecting the expansion of the forestry sector and strong farm commodity prices. Accommodation in Hamilton is currently under-supplied with housing prices rising. There are a number of undeveloped projects in the general area including wood product processing proposals in association with the Glenelg Shire. The mineral sand project located near Balmoral may also be developed within the next few years.

The Project traverses the north and western sectors of the Glenelg Shire, past Casterton to the South Australian border. The pipeline also makes a slight incursion through the southern boundaries of the West Wimmera Shire municipality. The Shire estimated unemployment rates of 2.0% in March 2001, mainly attributed to the limitation of "workforce entry" jobs.

Upper South East SSD

The largely agricultural SSD, is home to 17,986 persons, 23.6% of whom were aged between 0-14 years. The average household income was an estimated $36,413, compared to the State average of $36,808. The unemployment rate recorded in March 2001 was estimated at 3.4%. The agriculture, forestry and fishing sector dominated local employment (some 36.9%), while 11.8% were employed in manufacturing (predominantly food processing – 8.6%). Construction employment accounted for a relatively low proportion of the total industries (3.9%). As expected in an economy with an agricultural based industry structure, most were employed as managers and administrators (26.5%) and farmers (22.9%), while tradespeople accounted for only 11.5% of employment.

The region is experiencing a strong economic growth phase, indicted by almost no local unemployment. Industries contributing to current strength include viticulture (Coonawarra/Padthaway), abattoir and associated meat production (Naracoorte) and other primary service industries.

Specific to Tatiara, strong growth has occurred in the local dairy and viticultural industries. In addition, Tatiara Meats, an export abattoir, currently employs some 480 people and is also a signatory to the Greenhouse Challenge.

Murray Mallee SSD

The population of the SSD was 31,342 at the time of the 1996 Census. The region has a relatively older age profile with some 30.5% of residents over the age of 65 years. It is a predominantly agricultural and manufacturing with these industries employing 29.3% and 13.8% of local residents, respectively. Manufacturing is dominated by the food processing sector (7.5%) and machinery manufacture (3.8%). Some 23.9% of locally employed persons are managers and administrators – mostly farmers (20.5%), while 13.0% of residents are employed as tradespeople.

The average weekly household income recorded at the 1996 Census was a relatively low $29,937. The local unemployment rate was estimated at 7.1% compared to the South Australian average of 7.4%. Unemployment was highest in the urban areas of Mannum (8.6%) and Murray Bridge (8.5%).

Murray Bridge is growing rapidly, partly in response to the opening of the Adelaide Hills tunnel, but also by strong industrial growth in town and at Monarto where BigW has centred its distribution operations for southern Australia.

Barossa SSD

The pipeline traverses only a small area in the southern section of the Barossa SSD, which had a population of 17,692 with a slightly higher proportion of young children aged 0-14 years (24.1%) and a lower than average share of older residents over 65 (11.3%). To be expected for Australia's primary wine producing centre, the manufacturing industry dominates (21.4%) with over half of this represented by the food-processing sector. The occupational structure of the SSD is less skewed towards management and administrative employment (15.0%) than other rural areas, with professional (13.7%) and trade related jobs (14.3%) being closer to the State average. The average household income in the area was $34,602, and unemployment was a low 3.9%.

Northern Adelaide SSD

This area is best described as the outer northern suburbs of Adelaide. The 1996 Census identified some 325,132 persons living in this area. The age profile is relatively young with 37.7% of residents less than 24 years old compared to 34.4% for the State. Most local residents are employed in the manufacturing industry (19.8%), predominantly in machinery and equipment manufacturing (7.4%). The predominant local employer is the General Motors Holden plant at Elizabeth. The retail trade is considered a secondary industry providing 15.5% of employment. The most significant occupational category is the intermediate, clerical sales and services, employing 18.7% of employed residents.

The Northern Adelaide region had an average annual household income of $36,101, compared to the State average of $36,808. However, unemployment remains relatively high at 9.4%. Within the region, disparities in unemployment rates are marked, ranging from 21.4% at Elizabeth in the central area of the SSD to 8.6% at Gawler in the north and down to 4.7% at Tree Gully in the south east of the SSD.

Western Adelaide SSD

The area had a population of 201,801 persons, with a relatively high number of people aged 65 and over (18.6%), possibly reflecting eastern coastal gulf locations such as

Glenelg. Manufacturing was the largest employment generator (17.9%), with machinery and equipment manufacturing contributing slightly over a third of this employment. Subsequent employment industries include retail trades (14.4%) and transport and storage, providing 5% of jobs compared with a State average of only 3.8%. Most residents were employed as intermediate clerical, sales and service workers (19.1%), while 15.8% are employed as professionals. The average income within the SSD was a relatively low $33,656, reflecting the age profile of the region. As of March 2001, the average unemployment rate for the SSD was 8.5%. However, there were strong regional disparities, with the Enfield area having an unemployment rate of 17.6% and Port Adelaide 8.7%.

11.1.2 Regional Benefits

The socio-economic assessment estimated the expected total direct and indirect regional expenditure during the construction phase of the Project. The assessment identified a range of additional regional benefits associated with employment, increased gas supply and stimulus for other sectors. Table 11-2 summarises the findings.

The regional benefits reflect the direct impacts of pipeline construction pipeline through the regions estimated on a pro rata basis reflecting the historical share of local expenditures on similar projects. The benefits incorporate a flow on (or multiplier) effect based on a multiplier of 1.5. This incorporates the impact of subsequent expenditures in the regions, which will be stimulated by the initial pipeline based spending. The multiplier of 1.5 is a conservative estimate of the likely flow on impacts reflecting the different characteristics of potential support industries in the affected regions[1].

The estimated benefits are specifically related to the construction of the pipeline and do not include the impacts of projects, which may be facilitated by the successful completion of the SEA Gas Project. Thus while this project may lead to the commissioning of the Minerva Gas Project, any benefits associated with that project have been excluded from this analysis.

11.2 Land Use

Minimising disruptions to the wide ranging land use activities occurring within the Project area is an important objective of the SEA Gas Project. It is recognised that appropriate management will mitigate:

- any adverse effects to agricultural productivity or other primary production activities in both short term and long term
- disruption to important land use periods (that is, calving, lambing, breeding, sowing, harvesting or recreation)

Table 11-2: Summary of Regional Benefits

SSD	Project Implications	
	Regional Expenditure	Other Issues
Hopkins	$7.6 million	• Stimulus for Minerva development (the economic implications of which have not been considered here). • Four direct long term employment positions.
Glenelg	$8.1 million	• Likely accommodation base during construction. • Opportunities for supply of gas to timber and minerals processing sectors.
West Wimmera	$0.6 million	• Limited benefits due to short distance of SSD traversed. • Some scope for supply of gas to proposed olive processing facility in north of Shire.
Upper South East	$9.2 million	• Local contract employment associated with compressor station. • Opportunities for supply of gas to wine and meat processing industries (eg. Naracoorte abattoirs and Tatiara Meats).
Murray Mallee	$10.4 million	• Opportunities for increased gas reticulation and domestic supply. • Opportunities for supply of gas to the dairy industry.
Barossa	$2.3 million	• Opportunities for supply of natural gas to the wine and food processing industries.
Northern Adelaide	$3.3 million	• Construction employment opportunities particularly related to supply of earthmoving and mechanical services
Western Adelaide	$0.6 million	• Opportunities for supply of natural gas for power generation.

1 There were no published statistics on regional multipliers for the construction regions.

- spread of noxious weeds, pests and diseases, and
- disruption to conservation, recreational, industrial or other third party land use activities.

SEA Gas is confident that all impacts to current land use activities within the Project area can be reduced to an acceptable level.

11.2.1 Existing Land Use

The Project predominantly traverses pastoral and agricultural properties. Land uses within the pipeline corridor include:

- agriculture (including irrigated pasture/cropping, dairy, dryland cropping, stock grazing, other livestock and viticulture)
- conservation (including forestry reserves)
- mining and light industry
- recreational, and
- residential.

A range of additional land-uses are present in the Project area but will not be directly impacted by the Project. These include nature conservation, mining and water storage and treatment.

Table 11-3 illustrates broad land uses representative of each bioregion.

The following description of current land uses within the proposed SEA Gas Project area outlines key livestock, cropping periods and other important times, activities and requirements.

Agriculture

The south-west of Victoria is considered the third largest agricultural production region in Australia (ABARE, 2000a). Victoria contributed 22% of the total gross value of agricultural production, 16% of total rural exports and supported 25% of the total number of establishments with agricultural activity in Australia. High average rainfall and access to major sources of water for irrigation have enabled the State to support a broad range of agricultural activities including milk cattle, sheep and beef cattle farming, cereal grain, and fruit and vegetable production, all of which are represented in the south-west region.

South Australia's agricultural industry is dominated by the broadacre industries including grain growing, sheep and beef farming and grape growing (ABARE, 2000a). Broadacre industries represent 65% of all agricultural

Table 11-3: Representative Land Uses Within Each Bioregion

Bioregion	Representative Land uses
Coastal Southwest Victoria	• Irrigation Dairy • Minor grazing cattle and sheep farming, and some cereal cropping
Volcanic Plains	• Irrigation Dairy • Minor grazing cattle and sheep farming, and some cereal cropping
Dundas Tablelands	• Wheat and barley, with secondary crops comprising turnips and peas
Wimmera	• Wheat and barley, with secondary crops comprising turnips and peas • Forestry (Dergholm) • Plantations • Viticulture
Southern Mallee	• Cattle and sheep farming, and cereal cropping • Plantations • Viticulture
Murraylands	• Sheep grazing • Recreational (associated with Murray River) • Irrigation Dairy
Mt Lofty Ranges	• Prime sheep grazing – Mt Crawford • Olive Plantations • Viticulture • Hobby farming • Forestry (Mt Crawford)
Northern Adelaide Plains	• Industrial/Commercial • Horticulture • Hobby farming

industries in South Australia. Similar to Victoria, the extent of the pipeline route traverses most agricultural practices and land uses within the State.

Dairy Farming

Victoria's temperate climate and natural resources enable year round grazing of quality pastures grown using rainfall or relatively low cost irrigation water. Victoria's agricultural land use sector is dominated by the milk, beef cattle and sheep industries. In 1999, the total number of milk cattle in Victoria was 1.9 million, representing 60% of all milk cattle in Australia. Milk production in this time has increased by 56%, totaling 1.6 billion litres. The Victorian industry is focussed on milk production for manufacturing purposes, whereas other States generally cater for the fresh milk market.

Dairy farming is the most predominant agricultural and land use practice in the Victorian sector of the pipeline corridor, extending from Port Campbell to Branxholme. Dairying in the west Moyne region is in the form of "irrigated rotation paddocks", where the use of paddocks are alternated throughout the year to maximise milk quality. Paddock rotation is particularly concentrated during peak milking season. The prime milking period for dairy farmers in this region is summer, with calving occurring during June and August. Milk from this region is processed at the Devondale facility or regional cheese factories, with product distributed to both regional and state retail outlets.

Representative of the boutique dairy industry is the Timboon Farmhouse Cheese Factory located in Timboon, some 8 km from the corridor. The Timboon Farmhouse Cheese Factory produces an organic product based on biodynamic farming, which is practiced at the site and by contributing farmers. Organic initiatives that have been introduced into the pastoral regions are an important developing regional "boutique" industry. One criteria for organic certification is verification that products are free from chemical contamination.

In addition to organic certification, several Victorian properties are Quality Assurance certified. To gain certification, farmers must implement specific and auditable management controls, which primarily record the process and details of farming management (for example, cattle dip dates and washes, and other vaccinations, inoculations and worming treatments).

Landholders in the south-west of Victoria commonly construct "mole drains" to facilitate drainage of the pasture paddocks during the wetter winter periods. Mole drains consist of small subsurface channels, commonly at depths of 30cm.

Intensive dairy farming along the Project route in South Australia is limited to a 1.5km strip of the Murray River flood plain near Jervois.

Cattle and in particular sheep stock are susceptible to respective "footrot" bovine and ovine disease (*Dichelobacter nodosus).* Footrot is primarily passed from foot to foot via pasture or mud. Consequently, moist pastures, laneways and muddy yards are main areas where footrot may be spread. Goats, cattle and possibly vehicles can act as carriers. Footrot is spread most rapidly when it is warm and moist, as in spring and some autumns. One property in Victoria's south-west dairy region and one in Padthaway, South Australia (approximately 5km from the alignment) have been identified to potentially support the footrot disease. Footrot control and management is administered by DNRE's Animal Health Officers in Victoria and by PIRSA in South Australia.

Other Livestock

Improved pastures provide the feed-base for 90% of beef cattle and sheep on 16 000 farms. However, in recent years beef feedlots have expanded in Victoria. Although dairy farming is the most significant land use extending to Branxholme, north of Warrnambool, land uses also include grazing cattle and sheep farming, and some cereal cropping.

Numbers of sheep and lambs in South Australia totals 13.1 million and represents 11% of the total number of sheep and lambs in Australia. Beef cattle number approximately 1 million and represented 4% of Australia's beef cattle herd. Cattle and sheep farming and cereal cropping extends from the South Australian border, passing near Keith, Coonalpyn, Cooke Plains to Tailem Bend. Sheep grazing predominantly occurs from Murray Flats to Palmer. Of significant note is prime sheep grazing land near Mount Pleasant, South Australia.

Sheep and cattle are primarily farmed for human meat consumption. Paddocks are used on a rotational basis, not to the intensity of dairy farming. A secondary source of income is sheep shearing for wool production.

The calving season extends through autumn/winter. In areas of summer rainfall or on properties with irrigation, the spring growing period is extended and spring-born calves may grow as well as autumn-born calves. The peak lambing period occurs during June and August. The first two weeks of lambing is considered the most critical to the success of the lambing season, as ewes must bond with newborn lambs.

Alternate livestock activities, including pig farming, occur within close proximity to the proposed route. The corridor abuts a property near Kiki, South Australia though does not encroach operational activities.

Agriculture

Wheat and barley are the main crops grown in Victoria and South Australia. In Victoria, wheat crops produced 1.5 million tonnes of grain from an area of 949 000 hectares and barley crops produced 0.9 million tonnes of grain from 568 000 hectares. The combined grain value is estimated at $400 million. South Australia's barley crop is generally the largest in Australia with 2 million tonnes of grain harvested from 1 million hectares of plantings.

Grain legume or pulse production is increasing in both States. Pulses are grown in rotation with cereal crops to improve soil fertility and assist with the control of cereal diseases. Fallowing typically occurs in July/August and crops are sown in the following autumn/winter.

Within Victoria, cropping occurs east of Macarthur and predominantly includes cereals such as wheat and barley, with secondary crops comprising turnips and peas. The sandy soils near the South Australian border and limestone soils near Cooke Plains also support cereal cropping pastures. Cereals are sown from mid-April to June, often later in the south. Crops ripen from mid-November (inland) to mid-January (near the coast) and are generally harvested in mid-summer.

Olive plantations are a relatively new agriculture industry in the southern states of Australia. Olive trees have recently been planted north of the corridor in the west Wimmera region, Victoria and in the Mount Lofty Ranges and Direk area, South Australia. It is anticipated that most olive groves will be avoided during construction, but some minor tree removal is anticipated at Direk.

Viticulture

South Australia dominates Australia's grape growing industry, producing an estimated 39% of the national grape crop (ABARE, 2000b). Viticulture is an important land use in the North Mount Lofty Ranges and Padthaway region (Northern Hills Soil Conservation Board, 1996), and is increasing in importance in the Wrattonbully region, south and east of Naracoorte.

A pest of concern to the grape growing industry is the insect phylloxera. It attacks grapevine roots, causing a decline in health and ultimate death of vines. It can be spread between vineyards in a range of ways, including movement of soil and machinery. South Australia is currently free of phylloxera, and is designated a Phylloxera Exclusion Zone. While phylloxera is not known to be present in southwestern Victoria, the region is designated as Phylloxera Risk Zone. PIRSA administers regulations to control the movement of vineyard machinery into Phylloxera Exclusion Zones from Phylloxera Risk Zones (that is, into South Australia), and protocols exist to prevent the spread of phylloxera (Phylloxera and Grape Industry Board of South Australia, 2000).

Forestry

Within the broad Project area, three main types of forestry are present:

- blue gum plantation
- native forest, and
- pine plantation.

Blue gum (*Eucalyptus globulus*), a tall (30m) fast growing species (from 7 years and up to 20 years), typically prefers heavy loam-clay but can grow on a range of sites. The species is not considered drought or salt tolerant, although is moderately frost tolerant. Blue gum timber is used for superior pulp and general building purposes, with harvest time depending on local markets and climatic conditions. Blue gums require a minimum 700mm annual rainfall, and areas with more rainfall are considered higher quality, faster producing sites (Measki, 2000). The Victorian blue gum pulpwood industry has rapidly expanded in recent years, primarily dominated by plantation investment and forestry companies.

The area north of Branxholme, through Casterton and Dergholm contains extensive areas of blue gum plantation. However, none are crossed by the pipeline corridor.

The Roseneath Sate Forest south of Dergholm contains large areas of native woodland, which historically has been used for timber harvesting. The pipeline traverses approximately 3km of native forest in this area using an electricity easement (see Map 6).

The Mount Lofty Ranges contains approximately 9639ha of plantation and 4400ha of native forests. These areas are used for a combination of forestry, recreation and conservation purposes. The corridor traverses two sections of pine plantation in the Mt Crawford Forest area utilising existing firebreaks and tracks.

Conservation Areas

Seventeen areas of designated conservation importance are located within 5km of the corridor (see Table 11-4).

Parks

The pipeline corridor avoids all national, state, regional and conservation parks in Victoria and South Australia.

National Estate Areas

Two areas listed on the Register of the National Estate are traversed by the pipeline corridor:

- The Reedy Creek area, and
- The Macarthur area.

The Reedy Creek area (reference number 007895) is listed for its geological representation of the relationship between the metamorphics of the Kanmantoo Group and the intrusive Reedy Creek granodiorite. Caloote Swamp is located in the eastern portion of the area and is recognised as an important water bird habitat. The area contains waterfalls, rockpools and areas of remnant vegetation and is of recreational importance, with developed bushwalking and picnic facilities.

The corridor crosses Reedy Creek some 1.5km upstream of the principal values associated with the listing through an area used for grazing and cropping.

The Macarthur area (reference number 003728), located near a major branch of the Condah Swamp, is listed for its indigenous heritage values. The pipeline corridor avoids all sites that were identified in this area during initial consultation with the Kerrup-Jmara Elders Aboriginal Coporation and government authorities or during the heritage survey (see Chapter 11). Further consultation will be carried out to ensure the project does not adversely impact the heritage values of the area.

World Heritage

The Naracoorte Caves are included on the World Heritage List and contain one of the world's richest deposits Pleistocene vertebrate fossil deposits (Wells *et al.*, 1984, Wells, 1975). In addition to its World Heritage listing, the Naracoorte Caves are proclaimed under the South Australia *National Parks and Wildlife Act 1972*. The caves are located some 8km from the corridor.

Table 11-4: Conservation Areas Within Five Kilometres of the Pipeline Corridor

State	Park Name	Distance from Corridor	Map Reference
Victoria	Port Campbell National Park	3km	Map 4
	Macarthur National Estate Area	Traversed	Map 5
	Mocambro Bushland Reserve	1km	Map 5
	Dergholm State Park	500m	Map 6
	Beniagh Swamp Wildlife Reserve	2km	Map6
	Mageppa Bushland Reserve	4km	Map 6
	Meereek Bushland Reserve	3km	Map 6
South Australia	Grass Tree Conservation Park	2km	Map 7
	Padthaway Conservation Park	500m	Map 8
	Desert Camp Conservation Park	3km	Map 8
	Reedy Creek National Estate Area	Traversed	Map 11
	Palmer Granite Boulders National Estate Areas	500m	Map 11
	Hale Conservation Park	2km	Map 11
	Warren Conservation Park	4km	Map 11
	Sandy Creek Conservation Park	2km	Map 11
	Para Wirra Recreation Park	3km	Map 11
	Torrens Island Conservation Park	1km	Map 11

Recreation

The pipeline corridor has been selected to avoid most recreational areas. Key areas in close proximity to the corridor include:

- the Reedy Creek National Estate area, and
- The Heysen Trail, near Mount Crawford

Mining and Other Industry

A number of mining operations are located in the vicinity of the corridor particularly in the area south of Gawler, however, there are no operational mines within the pipeline corridor. One private sand-mining operation south of Palmer may impact the corridor prior to construction

The Northern Adelaide Plains region contains a range of light and heavy industries, dominated by manufacturing, assembly and storage industries. Of particular note are cement, battery and salt production, power generation and vehicle maintenance and wrecking.

Rural Living

The corridor avoids all areas of closely settled residential development, but does traverse areas of rural properties and medium sized rural living areas on town fringes, in the Adelaide Hills and on the Northern Adelaide Plains.

11.2.2 Potential Impacts

The following Project activities have the potential to affect the land use activities within the Project area:

- construction access
- earthworks
- materials transport and storage, and
- the storage and handling of small quantities of fuel and chemicals

However, application of appropriate management strategies will mitigate:

- any adverse effects to agricultural productivity or other primary production activities in both short term and long term
- disruption to important land use periods (that is, calving, lambing, breeding, sowing, harvesting or recreation)
- spread of noxious weeds, pests and diseases, and
- disruption to conservation, recreational, industrial or other third party land use activities.

Dairy

Construction of the SEA Gas Project may temporarily restrict stock access to paddocks where the easement occurs and may potentially disturb access tracks used by diary herds. However, significant disturbance to dairy production is unlikely due to mitigation measures described in the following Section, "Impact Mitigation".

Summer is the most important period for dairy production (that is, for milk quality and quantity) in the southwest of Victoria. During this time, dairy farmers heavily rotate stock to capitalise on high quality pasture paddocks.

In addition to the restriction of certain paddocks, Victoria's southwest dairy pastures are commonly irrigated using a "travelling irrigator". There is a potential that the irrigator will not be able to function at full capacity when the trench is open. An inherent and common problem associated with this irrigation system is the "burrowing" of the equipment into the ground during the cycle. Potential consequences of the irrigation infrastructure intercepting the pipeline depth may cause direct damage to the integrity of the pipeline.

"Mole" drains may also be affected by trenching activities.

Other Livestock

The lambing period occurs from June to August. The first two weeks of this period is considered critical to the success of breeding programs. The construction period may potentially impact on the lambing period, but prior planning aims to ensure that such impacts are unlikely. However, restrictions to general sheep grazing activities during the construction phase may occur.

The construction and operation of the SEA Gas Project is highly unlikely to contribute to the spread of ovine and bovine diseases such as Johnes and Footrot due to strict quarantine and construction management protocols. Footrot can cause severe economic loss, animal suffering due to lameness and disruption to normal farm operations. The economic loss to landholders is directly related to reduced body weight and growth, decreased wool production and restricted marketing opportunities.

Agriculture

Impacts to agriculture primarily relate to loss of productivity associated with construction activities. Post construction impact can be a result of two primary factors – inadequate reinstatement of surface drainage and easement (that is, compaction) conditions, and soil inversion. Provided appropriate management strategies are implemented, the SEA Gas Project should not unduly contribute to losses of productivity post construction.

SEA Gas have an obligation of duty of care to minimise the spread of weeds, particularly those weeds which cause significant economic damage. Of particular note is the weed species branched broomrape (*Orobanche* spp) which is a parasitic weed of broadleaf crop species such as oilseeds, field peas, vegetables and lupins. Each broomrape plant is capable of producing up to 500,000 dust-sized seeds, which can remain dormant for up to 10 years. A broomrape quarantine area is located east of Murray Bridge, and the pipeline route has been chosen to avoid this area.

The avoidance of known broomrape areas, and the development and implementation of strict weed management protocols during all phases of Project development (that is, planning, construction, restoration and operations) will ensure that the spread of broomrape and other weeds to uninfested areas is very unlikely. These protocols will be developed in consultation with PIRSA, and will include specifications for washdown, decontamination and inspection of vehicles and machinery where necessary.

Viticulture

There are no anticipated impacts to viticulture in the Barossa and Padthaway region as the corridor has selectively avoided all producing viticulture properties and operations. Minor impacts may occur to a small area of vines (approximately 100m) in the Macdonald Park area on the Northern Adelaide Plains.

Impacts on future vineyard development (for example in the Hynam region) are likely to be limited to minor restrictions on development along the pipeline easement. These may include requirements to use the easement as an access track, rather than for planting of vines.

The construction and operation of the SEA Gas Project is highly unlikely to contribute the spread of phylloxera, as construction management protocols will ensure that machinery operating in wine-growing regions in South Australia complies with the Phylloxera Prevention Protocol (Phylloxera and Grape Industry Board of South Australia, 2000).

Forestry

The SEA Gas Project has been selectively planned to use existing fire access trails and infrastructure easements where possible. Construction through the short sections of forestry areas will not require the creation of new access tracks.

In some forestry areas near Dergholm construction may require the power easement to be widened by up to 5m to allow for safe construction conditions. This incremental increase will not significantly affect the forestry values or activities.

Conservation Areas

Conservation Parks

The project will not impact any proclaimed parks or reserves.

National Estate Areas

The National Estate values of the Reedy Creek will not be directly impacted by the Project. Control of sedimentation and erosion will protect the area from indirect impacts.

The National Estate values of the Macarthur area will not be significantly impacted by the Project. The pipeline corridor avoids the National Estate sites (and other indigenous heritage sites) that were identified in this area during the consultation and survey process, and further survey and consultation will ensure that significant impacts to this area are avoided.

World Heritage

The Project will have no effect on the World Heritage values of the Naracoorte Caves.

Mining and Other Light Industries

The SEA Gas Project will not directly impact mining activities or light industry located within the pipeline corridor. However, potential indirect disturbances may include short-term disruptions to local traffic conditions.

Private sand mining operations north of Palmer will not be impacted as a result of pipeline construction, as the landholder has indicated an intention to extract the resource prior to commencement of the Project.

Recreation

The pipeline corridor avoids most areas of recreational activity. Potential impacts to areas of recreational activities (that is, Mount Crawford, Mount Lofty Ranges, Reedy Creek and Murray Bridge sections of the route) include temporary restriction of public access during construction to ensure protect public safety. The SEA Gas Project may temporarily affect the recreational experience in some areas associated with a loss of visual amenity (see Section 11.3).

In general, such impacts will be of a temporary nature and will not exclude the public from undertaking recreational based activities away from the immediate construction area.

11.2.3 Impact Mitigation

Objective

The principal management objective is to minimise adverse impacts to land use activities.

Project Phase	Objectives*
Construction	10.a To appropriately minimise and manage adverse impacts and long term environmental risk to current land use activities 10.b To appropriately reinstate and rehabilitate easement to allow continuation of current land use activities
Operation	27.a To appropriately minimise and manage adverse impacts to land use activities during operations 27.b To appropriately monitor land use productivity post construction
**Note: Objectives have been numbered to enable cross-referencing in the South Australian SEO.*	

Goals

The principal management goals are:

Project Phase	Goal*
Construction	10.1 To prevent adverse effects on stock during construction 10.2 To avoid unacceptable disturbances to landowner assets and infrastructure 10.3 To adequately protect conservation or recreational values and activities 10.4 To prevent the spread of, and to take practicable measures to control, weeds and animal and plant pests and diseases (such as branched broomrape, phylloxera and footrot), and to take appropriate remediation measures where required 10.5 To avoid adverse effects to residential and industrial activities
Operation	27.1 To prevent adverse effects on stock during operations 27.2 To adequately monitor agricultural productivity post construction 27.3 To avoid unacceptable disturbances to landowner assets and infrastructure 27.4 To adequately protect conservation or recreational values and activities 27.5 To avoid the spread of agricultural weeds and diseases (such as branched broomrape phylloxera and footrot) and to take appropriate remediation measures where required 27.6 To avoid adverse effects to residential and industrial activities
**Note: Goals have been numbered to enable cross-referencing in the South Australian SEO.*	

Mitigation Measures

To mitigate potential impacts to land use, SEA Gas will:

- consider current land use practices and future infrastructure extensions, and to design the pipeline accordingly
- work closely with landowners and managers to minimise conflict with existing land use activities
- enter into formal easement agreements outlining the legal responsibilities of both SEA Gas and the landowner
- where possible, avoid construction activities during peak lambing periods or, if not practicable, consult with landholders to coordinate lambing beyond proposed construction paddocks
- implement appropriate quarantine measures and weed, pest and disease control and management protocols during construction and operations, in consultation with relevant management authorities
- rehabilitate the construction right-of-way in consultation with landholders
- consult with relevant management authorities (that is, Forestry SA and Department of Natural Resources and Environment) to develop and implement strategies to control inappropriate public access
- implement appropriate erosion and sediment control measures upstream of Reedy Creek

- develop and implement appropriate traffic management procedures to minimise impacts in residential areas
- consult Country Fire Authority/Service and other emergency service agencies to develop alternative summer fire access response plans to be applied when existing fire access trails in forestry areas are being used, and
- monitor activities in close proximity to the easement to ensure the integrity of the pipeline is maintained and that no potential land use conflicts arise.

11.3 Visual Amenity

Pipelines, by their very nature, have a low level of impact on visual amenity. Generally this is restricted to short term disturbances associated with construction earthworks and localised impacts associated with the presence of above ground facilities. SEA Gas is confident that with the application of appropriate design and mitigation strategies, there will be no significant long term impacts to the visual amenity of the Project area.

This section deals with the existing visual sensitivities, potential impacts and mitigation strategies. Other potential impacts to the local amenity are associated with dust and noise. These issues are dealt with in Chapter 8.

11.3.1 Existing Environment

Visual assessment involves the evaluation of the visual effects of development in relation to the landscape and particular areas of visual sensitivity.

The "visual effect" of the SEA Gas Project is the expression of the interaction between the development and the existing landscape setting along the pipeline corridor. For example, a high visual effect will result in the pipeline contrasting strongly with the landscape and being therefore obvious (for example tree clearing through forested area). The "visual sensitivity" of the Project principally depends on land use, the distance of the development from the viewer and general visibility of the Project from critical view areas.

The majority of the pipeline corridor is considered to have low visual sensitivity as it is removed from general viewing, or already has been significantly modified by development (such as vegetation clearing, rural housing and infrastructure and roads). Agricultural activities dominate the pipeline corridor from Port Campbell to Mount Pleasant, with forestry prevalent in the Mount Lofty Ranges and industry and residential development occurring on the Northern Adelaide Plains.

Key areas where visual amenity is considered an important aspect of the Project are broadly outlined in Table 11-5. Visually sensitive locations principally correlate to important tourist, recreation, forest and conservation areas.

11.3.2 Potential Impacts

Potential impacts to visual amenity are generally described as a visual or aesthetic disturbance to landholders, residents and tourists, where the Project may be perceived to contrast significantly with existing landscape settings and aesthetic values.

The following Project activities have the potential to affect the visual attributes of the Project area:

- vegetation clearing and earthworks during construction
- the success of easement reinstatement and rehabilitation works, and
- the presence of above ground facilitates.

The construction of the pipeline will result in short term disturbance to the visual amenity of the local environment. Key issues include the potential to create new breaks in vegetation corridors, line-of-sight along the linear easement and the presence of construction vehicles, equipment and stockpiles. As outlined below, all such issues can be avoided or successfully mitigated.

The bare appearance of the easement after construction and prior to revegetation will create local short term reduction to visual amenity in areas accessible to the public. However, due to the nature of the pipeline development such reductions are temporary and considered to be of low potential impact. There will be no substantial, significant or long-term change to the aesthetic appearance of the natural environs associated with the pipeline route due to rehabilitation measures post construction.

During operations, any cleared gap in trees and shrubs will be maintained to allow access for pipeline inspection and maintenance. As the corridor has been selected to minimise vegetation and fragmentation of vegetation corridors, such impacts will be few.

Table 11-5: Visually Sensitive Locations

Bioregion	Location	Reference Township	Visual Sensitivity	Visual Effect	Rationale
Coastal Southwestern Victoria	Great Ocean Road	Port Campbell to Warrnambool	High	Low	• Areas important for tourism
West Wimmera	Dergholm State Forests	Dergholm	Medium	Low	• Native forest
Southern Mallee	Compressor Station Site	Padthaway	Low	High	• Distant from areas of tourism • Distant from vineyards • Visually contrasting Compressor Station
	Road reserves (various)	Padthaway to Murray Bridge	Medium	Low	• Remnant vegetation • Feasible opportunities to mitigate impacts
Murraylands	Murray River crossing	Tailem Bend	Medium	Medium	• Some recreation use • High volume general public motorists • Significant watercrossing
	Reedy Creek area	Palmer	Medium	Low	• Register of the National Estate • Crossing point removed from sensitive area • Conservation areas
Mt Lofty Ranges	Mt Lofty Ranges	Mt Pleasant	High	Medium	• Tourist precinct • Recreation areas • Forest areas • High volume general public motorists
Northern Adelaide Plains	Port River Torrens Island	Port Adelaide Torrens Island	Medium	Low	• Commercial / industrial setting • High public use • Conservation area removed from public view

Above ground facilities such as the compressor station, meter stations and marker signs will impact local amenity in a more permanent manner. Mitigation measures, associated with site selection and screening (see below) are expected to reduce impacts to acceptable levels. Pipeline markers, which are designed to be seen, will not result in a significant visual impact.

11.3.3 Impact Mitigation

Objective

The principal management objective is to minimise impacts on visual amenity.

Project Phase	Objectives*
Construction	11.a To appropriately manage adverse long term impacts to visual amenity 11.b To appropriately rehabilitate the easement to minimise visual amenity
Operation	28.a To appropriately minimise and manage adverse impacts on visual amenity 28.b To appropriately monitor easement rehabilitation to minimise long term visual amenity impacts
**Note: Objectives have been numbered to enable cross-referencing in the South Australian SEO.*	

Goals

The principal management goal is to have a limited effect on the landscape values of the local area.

Project Phase	Goal*
Construction	11.1 To have a limited effect on the landscape values of the local area
Operation	28.c To have a limited long term effect on the landscape values of the local area.
**Note: Goals have been numbered to enable cross-referencing in the South Australian SEO.*	

Mitigation Measures

Mitigation measures recommended to reduce the effects of visual amenity include:

- selecting an alignment that:
  - avoids areas of high visual impact, except where an alternative alignment is unavailable or impractical
  - reduces the line of sight clearances along the easement in areas of high sensitivity
  - minimises the extent of vegetation clearing
- stockpiling material and equipment in areas of away from general public view, where practicable
- maintaining all working areas in a neat and orderly manner
- adopting appropriate waste management practices
- restoring, reinstating and rehabilitating the easement as soon as practicable following backfill
- selecting locations for above ground infrastructure in areas of low visual sensitivity, where practicable
- planting screening vegetation around above ground infrastructure, where necessary, and
- using suitable paint colours where appropriate.

11.4 Third Party Infrastructure

Impacts to third party infrastructure can be easily mitigated by careful pre-construction planning and appropriate consultation with relevant regulatory authorities, public utility service companies and landholders. With adequate management, the Project can prevent impacts such as:

- disruption or damage to road and other transport infrastructure or networks
- disruption or damage to utility services, and
- disruption or damage to private third party property.

11.4.1 Existing Environment

Transport Network

The existing road network will be used wherever practicable as access to the easement and associated pipeline construction sites and for moving equipment and personnel in the local area. In addition, the corridor crosses numerous roads. Primary roads, such as highways and dual carriageways are outlined in the following table.

Table 11-6: SEA Gas Project Roadcrossings

State	Status	Road Name	Reference township
Victoria	Primary	Princes Highway	Allansford
		Hopkins Highway	Warrnambool
		Henty Highway	Branxholme
		Glenelg Highway	Casterton
South Australia	Primary	Riddoch Highway	Willalooka
		South Eastern Freeway	Murray Bridge
		Sturt Highway (Main North Road)	Gawler/Elizabeth
		Port Wakefield Road	Burton
		Proposed Gillman Highway	Ottoway

All key highways are bitumen and sealed. It is anticipated that all main highways will be crossed by boring.

A series of secondary, minor and local roads, and farm access tracks will also be used by vehicles associated with pipeline construction activities or transected by the pipeline alignment. Dependant on usage and other considerations such as environmental, geological or safety, unsealed secondary roads are typically crossed using standard open cut construction techniques.

The corridor crosses four railroads:
- Melbourne/Warnambool Rail, at Allansford
- Portland Hamilton Railroad (heavy freight), west of Branxholme
- Adelaide – Melbourne Railway, west of Murray Bridge, and
- Port Pirie Salisbury Railway, at Direk.

Victrack, a private organisation, manages both Victorian railways, whereas Australian Rail Track Corporation is the responsible authority for the Adelaide-Melbourne Railway and the Port Pirie Salisbury Railway. In addition to the two rail networks in the south-west of Victoria, several disused rail reserves may be used for the pipeline. The pipeline will be installed to a depth of 2m below the natural land surface level by boring.

Public Utilities

Gas Pipelines

The pipeline will parallel the existing GPU GasNet Pty Ltd Warrnambool Sales Gas Pipeline easement for approximately 40km (15% of the Victoria sector). The pipeline will be located between 5m and 30m from the GPU GasNet pipeline. The separation distance will be varied to reduce environmental impacts and manage safety related issues.

In addition, the pipeline will cross three other transmission pipelines:
- the Hamilton Lateral Pipeline (GPU GasNet) south of Byaduk
- the Angaston – Murray Bridge Pipeline (Envestra) at Palmer, and
- the Moomba – Adelaide Pipeline (including the Wasleys Loop) (Epic Energy) approaching Torrens Island.

Telecommunications

The installation of telecommunication cables and associated infrastructure has increased dramatically over the preceding five-year period, primarily due to the increase in demand for improved and expanded communication capacity and coverage to regional and isolated centres. This expansion has occurred over a large scale across Australia, and as a result, any new linear project is likely to cross or to be within close proximity to a number of telecommunication cables.

Aside from regular private residential housing cables and infrastructure, the SEA Gas Project route will be within close proximity to six major fibre optic telecommunication cables, and is likely to cross these cables at one or more points.

Water Utilities

The SEA Gas Project will be required to cross numerous industrial and residential water pipes adjoining the properties to mains supply. However, of particular importance to the construction phase is the identification of important mains and township supply pipes and irrigation systems.

The Project route intersects the Murray Bridge – Onkaparinga water pipeline north of Murray Bridge.

In addition, the alignment will intersect the above ground Barossa – Adelaide water pipeline east of Gawler and will subsequently run parallel to the easement to Evanston South (approximately 8km).

Power
The pipeline corridor will cross three major high-voltage powerlines varying in capacity from 175kilovolts to 375kilovolts. The pipeline will also be constructed parallel to two standard powerlines in the Dergholm region.

Private Property
A variety of private infrastructure is present within the pipeline corridor. Common types include gates and fences.

11.4.2 Potential Impacts

With adequate management the following potential impacts to private infrastructure can be avoided or appropriately mitigated:

- disruption or damage to roads and other transport infrastructure or networks
- disruption or damage to utility services, and
- disruption or damage to private infrastructure.

Transport Networks

The following Project activities may disrupt or damage transport networks:

- use of roads during construction by extendable semi-trailers delivering stockpiles of pipe to worksites
- use of roads by low loaders mobilising construction equipment between worksites
- transporting of construction personnel to worksites
- open cut crossings of unsealed roads, and
- pipeline surveillance and maintenance activities.

With adequate management the following potential impacts to the transport network can be avoided or adequately managed:

- loss of road integrity, and
- localised traffic congestion or disruptions.

Construction Activities
During construction it is estimated that up to 2800 pipe sections will be delivered to various locations along the easement. Based on this requirement, it has been estimated that approximately 100 deliveries will be required for the SEA Gas Project, transported by extendable semi trailers. Impacts of pipe and equipment transportation during the construction period include slow moving traffic on roads and subsequent disturbance to local traffic and motorists. Levels of disturbance are anticipated to be greater in small rural communities and associated local roads where the entire road breadth may be needed by the semi trailers. Similar disturbance to traffic may be expected during the slow passage through the Mount Lofty Ranges or through the Adelaide Plains (that is, steep inclines and/or high density traffic conditions resulting in "intermittent" movement). However, this is generally a "once-off" occurrence during the early construction phase of the Project and therefore such impacts are not considered significant.

It is anticipated that there will be localised traffic disruptions associated with road crossings as typically standard open cut road-crossings can take up to six hours.

Heavy vehicle and equipment movement may result in localised damage to the integrity of the road pavement or surface (that is through wear-and-tear). Boring beneath sealed roads will not cause damage to road integrity.

Operation
Inspection of the easement will be required during operations. However, it is expected that inspections will be undertaken by four wheel drive vehicles and by aerial inspection. Impacts to roads or traffic conditions are considered negligible as the frequency of vehicle use of the pipeline would normally be no more than once each six months.

Public Utilities

The SEA Gas Project will not result in significant impacts to public utility services. Utilities will be identified prior to construction and incorporated into construction line lists and appropriately flagged, earthed, protected and avoided during construction. Should the construction of the SEA Gas Project perforate, rupture or incise cables, pipes or other utility infrastructure, short term disruptions to services such as electricity, water and telecommunication networks may occur.

Utility infrastructure may also pose safety risks to personnel during construction, in particular induced current and direct contact with 'live' wires arising from placement and movement of construction equipment and large metal objects in parallel and close proximity to power lines. Arching between transmission lines and construction plant equipment and vehicles may also occur if required separation distances are violated.

Private Property

Impacts to private property will be necessary as part of the normal construction process, but will occur with the prior knowledge and approval of the landholder. Such impacts include cutting fences and installing temporary gates, and modifications to existing gates or driveways. Inadvertent damage will be avoided where practicable.

11.4.3 Impact Mitigation

Objective

The principal management objective of the SEA Gas Project with respect to third party infrastructure is to minimise and where practicable avoid impacts to transport networks, private property and to public utilities.

Project Phase	Objectives*
Construction	12.a To minimise and where practicable avoid impacts to transport networks, private property and to public utilities 12.b To appropriate reinstate disturbed third party infrastructure as a result of construction activities
Operation	29.a To minimise and where practicable avoid impacts to transport networks, private property and to public utilities 29.b To appropriately monitor reinstated third party infrastructure
**Note: Objectives have been numbered to enable cross-referencing in the South Australian SEO.*	

Goals

The principal management goals are to:

Project Phase	Goal*
Construction	12.1 Minimise damage to road integrity 12.2 Avoid unacceptable disturbance to local traffic conditions and access 12.3 Prevent damage to public utilities 12.4 Protect construction personnel safety 12.5 Contain any damage to private property to agreed levels
Operation	29.1 Minimise damage to road integrity 29.2 Avoid unacceptable disturbance to local traffic conditions and access 29.3 Prevent damage to public utilities 29.4 Protect construction personnel safety 29.5 Contain any damage to private property to agreed levels.
**Note: Goals have been numbered to enable cross-referencing in the South Australian SEO.*	

Mitigation Measures

Transport

Mitigation measures recommended to reduce the effects of transport network disturbances include:

- Equipment and material transport routes and storage areas will be planned in consultation with local and state authorities to minimise disruption to residents and industry.
- Delivery of project related equipment will be planned to occur during daylight hours, where practicable.
- A traffic safety management plan will be implemented that addresses the use of safety vehicles signs and flagmen.
- Project related equipment will be stockpiled in close proximity to main roads to reduce impacts to unmade roads.
- Where practicable, sealed road crossings will be bored to minimise disruptions.
- Road crossings will be planned to take place outside peak periods and in one continuous construction cycle, where practicable.
- Open cut roads will be reinstated to the satisfaction of the local authorities.
- Where practicable, shuttle buses will be used to transport personnel to worksites.
- Project related traffic will drive at slow speeds near residences.
- Temporary gates will be erected across easements at all roads to reduce illegal entry.
- Where practical project equipment will be stockpiled close to main roads.

Public Utilities

Mitigation measures recommended to reduce the effects of public utilities disturbances include:

- close liaison with utility companies to identify existing overhead and buried cables, lines, pipes, water mains
- obtain standard clearance from services from various authorities
- incorporating services onto "line lists" (see Section 5.2)
- preventative flagging to mark the location of services and infrastructure
- appropriate earthing of equipment and pipe at established intervals, and
- where possible, transmission easements will be crossed at or near 90 degrees and well away from structures.

Private Property

Mitigation measures recommended to reduce impacts to private property include:

- close liaison with all affected landowners
- pre-construction agreement of the type and extent of impact to occur
- appropriate notation on the line list of agreed impacts or modifications, and
- pre-construction agreement regarding strategies, and responsibilities for rectification of, or compensation for, damage.

11.5 Public Safety and Risk

Pipelines are recognised as a safe and efficient means of transporting natural gas. However, all developments present some level of risk. As part of the preliminary engineering, a preliminary pipeline risk assessment and has been completed by the Project's engineering consultants, Brown and Root. Summary details of the assessment are presented in this section and a copy of the assessment is included in Appendix 4. A detailed risk assessment will be carried out before construction in accordance with AS 2885.1 – 1997.

In accordance with AS 2885, a combination of physical and procedural measures will be applied to ensure the pipeline design and management meet appropriate safety standards.

Objectives

The preliminary risk assessment and the subsequent development of procedures are in accordance with AS 2885.1-1997 (Pipelines – Gas and Liquid Petroleum, Part 1: Design and Construction). The risk assessment is based on the pipeline design parameters as outlined in Chapter 3, in addition to potential risk locations and processes identified for the SEA Gas Project.

The principle objectives of the risk assessment are:

- to identify the threats to the pipeline and associated facilities and evaluate the consequence of loss of integrity (considering the location of each threat)
- to incorporate design, operational and maintenance requirements in line with AS 2885.1 to ensure risk level associated with threats is sufficiently dealt with (incorporating use of procedures)
- to determine remaining unmitigated threats which may result in pipeline integrity loss and an associated hazardous event
- to determine the frequency and consequence of a hazardous event, and
- to implement necessary measures and/or procedures which will reduce the risk ranking to low or negligible and ensure that a risk level As Low As Reasonably Practicable (ALARP) is achieved.

Project Phase	Objectives*
Construction	15.a To incorporate design, operational and maintenance requirements in line with AS 2885.1 to ensure risk level associated with threats is sufficiently dealt, that is, As Low As Reasonably Practicable
Operation	32.a To incorporate operational and maintenance requirements in line with AS 2885.1 to ensure risk level associated with threats is sufficiently dealt, that is, As Low As Reasonably Practicable 34.a To minimise and manage the occurrence of third party damage to the pipeline, risks to public health and safety 34.c To adequately ensure the security of production or supply of natural gas 35.a To ensure that all emergency responses are immediate, to reduce the severity of any emergency gas release and to follow existing procedures whilst maintaining public and personnel safety as a priority

**Note: Objectives have been numbered to enable cross-referencing in the South Australian SEO.*

Goals

The principal management goals are to:

Project Phase	Goal*
Construction	15.1 To satisfactorily mitigate all risks through the adoption of the requirements under AS2885.1
Operation	32.1 To satisfactorily mitigate all risks through the adoption of the requirements under AS2885.1 34.1 To effectively manage third party operations in close proximity to the easement in accordance with AS 2885.1 34.2 To effectively maintain pipeline markers and safety signage during operations 34.3 To adequately protect public safety during uncontrolled releases and other unplanned incidents 34.4 To adequately reduce the likelihood of fire associated with uncontrolled releases and other unplanned incidents 35.1 To adequately respond to unplanned emergency incidents 35.2 To adequately protect public safety during emergency responses, uncontrolled releases and other unplanned incidents 29.5 To adequately reduce the likelihood of fire associated with uncontrolled releases and other unplanned incidents
**Note: Goals have been numbered to enable cross-referencing in the South Australian SEO.*	

11.5.1 Risk Methodology

Preliminary risk assessment was undertaken in accordance with AS 2885.1, where the process is summarised as follows:

- location analysis
- threat identification
- threat analysis and mitigation
- failure analysis and risk evaluation, and
- risk management.

Threat Identification

The threat identification process identifies all threats to the pipeline at all locations along its length. A threat to the pipeline can be assumed to include any element which can potentially cause pipeline failure, including threats due to location (including crossing and land use segments) and general threats common to the entire system (for example, corrosion).

The location analysis considered land use related activities (for example, irrigated grazing, forestry, heavy industrial, vineyards, recreation) and crossing segments (for example, main sealed roads, rail crossings, utilities and waterways).

Threat Analysis and Mitigation

All identified threats will be mitigated through the adoption of the requirements under AS2885.1. Mitigation considers threats due to external interference (deliberate and accidental) as well as threats due to unsatisfactory design, construction, materials and operations. Threats due to natural events such as erosion and lightning are also considered.

The protection methods available to SEA Gas are broadly described in Table 11-7.

11.5.2 Results

The preliminary risk assessment identified a number of threats, which can only be reviewed in the final risk assessment, as they must be assessed with respect to location. This final risk assessment will be carried out in accordance with AS 2885.1 – 1997, and will result in the application of physical and procedural measures to ensure that the pipeline design, construction, operation and maintenance meet appropriate safety standards.

11.6 Waste Management

Relatively small amounts of domestic and industrial wastes will be generated during construction and operation.

11.6.1 Impact Mitigation

Objective

The principal management objective of the SEA Gas Project with respect to waste management is to minimise impacts of waste management to the environment and third parties.

Project Phase	Objectives*
Construction	14.a To effectively minimise and manage all waste generated during construction 14.b To dispose of all waste in an appropriate manner
Operation	30.a To effectively minimise and manage all waste generated during operations and to dispose of all waste in an appropriate manner
**Note: Objectives have been numbered to enable cross-referencing in the South Australian SEO.*	

Goals

The principal management goals are to:

Project Phase	Goal*
Construction	14.1 To have a limited effect on the environment of the local area. 14.2 To ensure all personnel are aware of appropriate waste minimisation and management protocols
Operation	32.1 To have a limited effect on the environment of the local area. 34.1 To ensure all personnel are aware of appropriate waste minimisation and management protocols.
**Note: Goals have been numbered to enable cross-referencing in the South Australian SEO.*	

Table 11-7: Pipeline Protection Safety Measures

Methods	Measures	Description
Physical Measure	Burial	The entire pipeline will be buried at depth in accordance with AS2885.1.
	Barrier/Slab	Crash barriers and concrete slabs will be adopted where risks are not sufficiently mitigated (for example, within railway easements).
	Exclusion	Fences will be installed where necessary to limit access by unauthorised personnel.
	Wall thickness	Wall thickness is increased where higher levels of risk to pipeline integrity exists or the consequences of rupture is considered unacceptable (for example, populous centres)
	Barrier to Penetration	Other physical barriers may be used to protect the pipeline such as coating or encasing.
Procedural Measure	Liaison – Contractors	Organisations, such as councils, utility or major agriculture/community groups that may present a threat to the pipeline will be contacted.
	Marker Signs	Pipeline signs will be posted in accordance with AS 2885.1 (Clause 4.2.5.4. (a)(ii)
	Marker Tape	Marking tape will be used for the entire length of the pipeline.
	Liaison – Landholders	Landowners will be contacted on an ongoing basis throughout Project development, construction and operation.
	One-call	Project incorporated in a one call network for efficient processing of public inquiries and enabling an effective pipeline reporting mechanism.
	Patrolling	Quarterly patrolling of the entire route throughout the life of the pipeline.

Mitigation Measures

Specific mitigation and procedural measures to achieve the objectives and goals include:

- prior to the commencement of any waste producing activities, specific waste management strategies will be developed for each waste stream based on the principles of "Reduce, Reuse, Recycle" and appropriate disposal
- the workforce induction program will inform site personnel of the required waste management procedures
- hazardous wastes, such as solvents, rust proofing agents and primer, will be managed in accordance with the requirements of relevant legislation and industry standards
- all personnel will be instructed in project waste management practices as a component of the environmental induction process
- all hydrotest water will be disposed of in accordance with the Construction EMP
- contractors will place a high emphasis on housekeeping and cleanliness at the site. All work areas will be maintained in a neat and orderly manner
- hydrocarbon wastes, including lube oils, will be collected for safe transport off-site for reuse, recycling, treatment or disposal at approved locations, and
- storage and handling of chemicals will be conducted in accordance with Section 11.7, and
- on completion of each section of the pipeline, all waste material will be removed from the worksite.

11.7 Hazardous Storage, Spill and Emergency Response Management

A variety of chemicals may be required on-site for the construction of the SEA Gas Project. These include fuel, lube oils, solvents, rust proofing agents and primer. Potential impacts include contamination to soils and water resources and other environmentally sensitive values. Such impacts have been detailed in Sections 6, 7 and 9 respectively.

11.7.1 Impact Mitigation

Objective

The principal management objective of the SEA Gas Project with respect to hazardous storage and spill response is to minimise impacts of accidental exposure to the environment and third parties.

Project Phase	Objectives*
Construction	13.a To appropriately prevent, minimise and manage adverse impacts and long term environmental risk as a result of spill events 13.b In the event of a spill, to appropriately remediate site location
Operation	31.a To prevent, minimise and manage spills occurring and during operations. 31.b To appropriately monitor remediated spill locations (where applicable)
**Note: Objectives have been numbered to enable cross-referencing in the South Australian SEO.*	

Goals

The principal management goals are to:

Project Phase	Goal*
Construction	13.1 To ensure the storage and distribution of hazardous materials and fuels during construction, so as to prevent spillage and contamination 13.2 To ensure personnel are trained in spill prevention and response procedures 13.3 To liaise with relevant emergency services
Operation	32.1 To ensure the storage and distribution of hazardous materials and fuels during operation, preventing spillage and contamination 34.1 To ensure personnel are trained in spill prevention and response procedures
**Note: Goals have been numbered to enable cross-referencing in the South Australian SEO.*	

Mitigation Measures

Mitigation measures recommended to reduce the effects of hazardous substances and spill events to the environment and third parties include:

- hazardous material will not be stored or drained onto the ground or onto watercourses or floodplains
- all fuels and hazardous materials used on-site will be appropriately stored (bunding as per regulatory guidelines)
- vehicles and machinery will not be refuelled within 50m of a floodplain or watercourse
- materials and equipment required to respond to a hazardous spill will be readily available
- appropriate implementation of cleanup/spill response procedures in the event of a spill
- material Safety Data Sheets to be kept for each chemical used on-site and at a location that is easily accessible 24 hrs per day, and
- all personnel will be instructed in Project prevention, safety and response practices as a component of the environmental induction process.

11.8 Conclusion

The assessment of the potential social and economic implications of the SEA Gas Project has identified a range of additional regional benefits associated with employment, increased gas supply and stimulus for other sectors. The need to protect existing land use activities, third party infrastructure, and visual amenity has been identified. SEA Gas is confident that with the application of appropriate management strategies, regional communities will receive significant economic benefits and any negative socio-economic impacts can be avoided or reduced to an acceptable level.