## Beverley Four Mile Project Public Environment Report and Mining Lease Proposal

<table>
<thead>
<tr>
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<th>Quasar Resources Pty Ltd and Alliance Craton Explorer Pty Ltd Joint Venture</th>
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### Tenement details
- EL 3666

### Name of mining operation
- Beverley Mine Four Mile Project

### Commodity to be mined
- Uranium

### MLA application date
- 16th May 2008

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**Prepared for**

**Heathgate Resources Pty Ltd**

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7th January 2009  
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Acronyms and Abbreviations

AGSO  Australian Geological Survey Organisation
AHD  Australian Height Datum
Alliance  Alliance Craton Explorer Pty Ltd
ANZECC  Australian and New Zealand Environment and Conservation Council
ARI  Annual Rainfall Index
ARMCANZ  Agriculture and Resource Management Council of Australia and New Zealand
ARPANSA  Australian Radiation Protection and Nuclear Safety Agency
BGL  Below Ground Level
CASA  Civil Aviation Safety Authority
CSIRO  Commonwealth Scientific and Industrial Research Organisation
DEST  Department of Education, Science and Training
DEWHA  Department of Environment, Water, Heritage and the Arts
DITR  Department of Information, Tourism & Resources
DWLBC  Department of Water, Land, Biodiversity and Conservation
ECP  Environmental Clearance Permit
## Figures, Tables, Plates, Abbreviations

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<td>National Occupational Health and Safety Commission</td>
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<td>NPWA</td>
<td>National Parks and Wildlife Act</td>
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<td>NVC</td>
<td>Native Vegetation Council</td>
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<td>PER</td>
<td>Public Environment Report</td>
</tr>
<tr>
<td>PFN</td>
<td>Prompt Fission Neutron</td>
</tr>
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<td>PIRSA</td>
<td>Primary Industry and Resources of South Australia</td>
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Figures, Tables, Plates, Abbreviations

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<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tr>
<td>Quasar</td>
<td>Quasar Resources Pty Ltd</td>
</tr>
<tr>
<td>RPC</td>
<td>Radiation Protection and Control</td>
</tr>
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<td>RPD</td>
<td>Radiation Protection Division</td>
</tr>
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<td>RL</td>
<td>Retention Lease</td>
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<td>RMP</td>
<td>Radiation Management Plan</td>
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<tr>
<td>RWMP</td>
<td>Radioactive Waste Management Plan</td>
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<td>SEB</td>
<td>Significant Environmental Benefit</td>
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<tr>
<td>SO$_4$</td>
<td>Sulphate</td>
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<td>TALR</td>
<td>Target Action Leakage Rate</td>
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<tr>
<td>UNSCEAR</td>
<td>United Nations Scientific Committee on the Effects of Atomic Radiation</td>
</tr>
<tr>
<td>UOC</td>
<td>Uranium Oxide Concentrate</td>
</tr>
<tr>
<td>4WD</td>
<td>Four-wheel-drive</td>
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Executive Summary

This document has been prepared by Heathgate Resources Pty Ltd (Heathgate) in accordance with Guidelines dated 17 September 2008 prepared by the South Australian Department of Primary Industries and Resources SA (PIRSA) and the Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA) (DEWHA, PIRSA 2008), for construction and operation of the Beverley Four Mile Project.

The purpose of the document is to satisfy the requirements of the South Australian Government for a Mining Lease Proposal to support an application for a Mining Lease under the SA Mining Act 1971, and the Commonwealth Government’s requirements for a Public Environment Report (PER) under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

The intention of the PER and Mining Lease Proposal (hereafter referred to as the PER / Proposal) is to develop the Four Mile uranium deposits using in-situ recovery (ISR) methodology to provide uranium-bearing resin as part of the feedstock requirements for the Beverley Uranium Mine.

The Four Mile deposits lie within the boundaries of the Exploration Lease EL 3666. A Mining Lease application covering part of EL 3666 was lodged on 16th May 2008. This MLA is the Project Area for this PER / Proposal.

By a Joint Venture Agreement between the companies, Quasar Resources Pty Ltd (Quasar) holds a 75% beneficial interest and Alliance Craton Explorer Pty Ltd (Alliance) holds a 25% beneficial interest in EL 3666. Heathgate Resources Pty Ltd (Heathgate) have been appointed as the mining operator for the project, and are hence the proponents of the PER / Proposal.

The Beverley Four Mile Project entails construction of a satellite facility on Heathgate’s existing Beverley mining lease, close to the Four Mile deposits, and construction of in-site recovery (ISR) wellfields of the same design as currently used on the Beverley mining lease. This satellite facility would remove the uranium from the ISR liquor by physical means, producing uranium bearing resin, which would be trucked to the Beverley processing plant. The resin would then be stripped of uranium, and trucked back to the satellite facility.

Minor modifications would be required at the Beverley processing plant to accept the uranium-bearing resin, however there would be no net increase in uranium processing capacity. The uranium stripped from the resin would be processed at Beverley, and the small quantity of liquid waste arising would be disposed of at Beverley.

There would be no change to the existing Beverley camps, airstrip and camp water supply bore. An unsealed access road would be constructed between the processing plant and the satellite facility. Some additional internal roads would be necessary within the Four Mile lease to access the wellfields. There would also be some additional fencing along the western boundary of the Four Mile deposits for security purposes, and a minor change to the alignment of the 4WD track from Paralana Springs to Hidden Valley, which runs near this boundary, to divert around the Four Mile West deposit.

It is noted that this PER / Proposal relates only to those activities associated with the Four Mile Project. The Beverley project has recently completed a comprehensive approval process for extension of the Beverley mine, which involved a PER, Mining Proposal and Mining and Rehabilitation Plan (MARP). Those aspects which are unchanged as a result of the proposed Four Mile Project are addressed in the Beverley MARP.

This PER / Proposal demonstrates that the proposed Beverley Four Mile Project can be developed to meet applicable South Australian and Commonwealth requirements, and with no significant impact on the environment.
Introduction

1.1 General Description and Objective

This document has been prepared by Heathgate Resources Pty Ltd (Heathgate) in accordance with Guidelines dated 17 September 2008 prepared by the South Australian Department of Primary Industries and Resources SA (PIRSA) and the Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA) (DEWHA, PIRSA 2008), for construction and operation of the Beverley Four Mile Project (refer Appendix A).

The purpose of the document is to satisfy the requirements of the South Australian Government for a Mining Lease Proposal to support an application for a Mining Lease under the SA Mining Act 1971, and the Commonwealth Government’s requirements for a Public Environment Report (PER) under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act).

The intention of the PER and Mining Lease Proposal (hereafter referred to as the PER / Proposal) is to develop the Four Mile uranium deposits using in-situ recovery (ISR) methodology to provide uranium-bearing resin as part of the feedstock requirements for the Beverley Uranium Mine. The Four Mile deposits lie within the boundaries of the Exploration Lease EL 3666.

By a Joint Venture Agreement between the companies, Quasar Resources Pty Ltd (Quasar) holds a 75% beneficial interest and Alliance Craton Resources Pty Ltd (Alliance) holds a 25% beneficial interest in EL 3666. Heathgate has been appointed as the mining operator for the project, and are hence the proponents of this PER / Proposal. Figure 1-1 shows the general location of the Beverley Four Mile Project.

This PER / Proposal demonstrates that the proposed Beverley Four Mile Project can be developed to meet applicable South Australian and Commonwealth requirements, and with no significant environmental impact.

1.2 Background

An Environmental Impact Statement (EIS) was prepared in 1998 (Heathgate 1998a,b) to satisfy both Commonwealth and South Australian Government requirements, resulting in approval of the Beverley project, an Export Permit and other related requirements. In 2008, Heathgate was granted approval for an extension of the previously approved mining area. The approval resulted in replacement of the previous ML 6036 with the larger ML 6321, comprising part of the previous Exploration Lease EL 3251, and which subsumed the former ML 6036 and three Miscellaneous Purposes Licences (MPLs 57, 58 and 59).

The extended ML 6321 includes the pre-existing camps, airstrip, Four Mile Bore for water supply, and associated internal access roads as well as the pre-existing Beverley processing plant and wellfields on former ML 6036. There were no changes to the operations at the Beverley processing plant and no increased production as a result of the extension of the mining area.

This document has been prepared by Heathgate Resources Pty Ltd (Heathgate) in accordance with Guidelines dated 17 September 2008 prepared by the South Australian Department of Primary Industries and Resources SA (PIRSA) and the Commonwealth Department of Environment, Water, Heritage and the Arts (DEWHA) (DEWHA, PIRSA 2008), for construction and operation of the Beverley Four Mile Project.

The purpose of the document is to satisfy the requirements of the South Australian Government for a Mining Lease Proposal to support an application for a Mining Lease at Four Mile under the SA Mining Act 1971, and the Commonwealth Government’s requirements for a Public Environment Report (PER) under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act). As noted above it is proposed to develop the Four Mile uranium deposits using ISR methodology to provide uranium-bearing resin as part of the feedstock requirements for the Beverley Uranium Mine.
Section 1

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Figure 1-1  Four Mile / Beverley Uranium Mine - Location
It is noted that this PER / Proposal relates only to those activities associated with the Four Mile Project. The Beverley project has recently completed a comprehensive approval process for extension of the Beverley mine, which involved a PER, Mining Proposal and Mining and Rehabilitation Plan (MARP). Those aspects which are unchanged as a result of the proposed Four Mile Project are addressed in the Beverley MARP (Heathgate 2008c). A copy of the main text of the current Beverley MARP is available on the PIRSA website. Specifically, descriptions and ongoing activities at Beverley due to mining at Four Mile (not assessed in this document) are given in Table 1-1 below.

**Table 1-1 Cross References to Beverley Documentation for Ongoing Activities Not Addressed Elsewhere in this Document**

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Reference in Beverley MARP (Heathgate 2008c)</th>
<th>Notes</th>
</tr>
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<tbody>
<tr>
<td>Description of the environment of Beverley ML 6321</td>
<td>3 Description of the Environment</td>
<td>Other than sightly lower elevation and rainfall and details of hydrogeology, the environment is very similar to that at Four Mile</td>
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<tr>
<td>Beverley accommodation camp, airstrip and utilities</td>
<td>4.5 Supporting Infrastructure</td>
<td>This infrastructure will be used for the Four Mile project</td>
</tr>
<tr>
<td>Description of Beverley extraction plant</td>
<td>Section 4.3.5 Processing</td>
<td>This plant will be modified for the Four Mile project – see also Section 4.5 of this document</td>
</tr>
<tr>
<td>Waste disposal arrangements</td>
<td>Section 4.4 Wastes</td>
<td>The liquid and solid waste disposal facilities at Beverley will be used for wastes arising from Four Mile. This includes the approved procedure for underground liquid waste disposal (Appendix C of the MARP). Section 4.6.2 of this document discusses the capacity of the Beverley liquid waste disposal arrangements to cater for mining from Four Mile.</td>
</tr>
<tr>
<td>Resource inputs</td>
<td>Section 4.6 Resource Inputs</td>
<td>Similar quantities of water, natural gas, sulphuric acid, sodium hydroxide, hydrogen peroxide, fuel and lubricants will be used during mining from Four Mile.</td>
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<td>Environmental, Social and</td>
<td>Section 6 Environmental,</td>
<td>This considers context and stakeholder views, potential impacts,</td>
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</table>
Section 1  

Introduction

<table>
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<tr>
<th>Economic aspects</th>
<th>Social and Economic aspects</th>
<th>control and management strategies, risks and consequences, specific outcomes, outcome measurement criteria, leading indicator criteria and company compliance monitoring plans for:</th>
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<tbody>
<tr>
<td>Soil, vegetation, surface water, hydrogeology, fauna, air quality and heritage</td>
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Mine closure and rehabilitation  
Section 7 Mine Closure and Rehabilitation Plan  
This gives a timeframe for the closure, decommissioning and rehabilitation of all surface facilities at Beverley. Some facilities at Beverley will be progressively rehabilitated as mining areas are exhausted there, but those facilities used for Four Mile would be retained at least until the end of mining at Four Mile.  
The Beverley closure plan includes general and specific outcomes and a residual risk assessment

1.3 Summary of the Land and Environment Description

The Four Mile deposits and the Beverley Mine are located in an arid region of South Australia, on the western boundary of a broad, almost featureless plain approximately 45 km wide lying between the eastern margin of the Flinders Ranges and Lake Frome. The area is characterised by low average, but highly variable rainfall. A series of water courses, rising in the Flinders Ranges, flow in a generally easterly direction (including across the Heathgate site), eventually discharging into Lake Frome.

Between the Ranges and the Lake, many small flow channels are cut into the topography, rising in the low foothills of the area, at about elevation 100 m Australian Height Datum (AHD), and which also flow in an easterly direction toward Lake Frome.

*Swainsona oligophylla*, which is listed as rare under the National Parks and Wildlife Act, 1972 (NPWA), is known to occur at Beverley. Two previously reported species, *Frankenia subteres* and *Swainsona murrayana*, are now considered to be based on misidentifications. Most of the threatened species that are known to occur in the general area are restricted to the Flinders Ranges and are not known to exist on the plains.

One proclaimed plant, *Tribulus terrestris*, has been recorded at Beverley. It is fairly common in the general area but is not recorded in all years. Twenty alien plant species have been recorded at Beverley and a further 10 are known to occur in the general area. None of these occurrences can be directly attributed to exploration or mining activities.
Introduction

The dominant habitat types within the project area are a mixture of gibber plains, very open eucalyptus woodland, tall shrubland and tall shrubland over chenopods. Fauna surveys conducted as part of the Beverley Mine EIS in 1998 and baseline surveys for Beverley Four Mile identified no species of state or national conservation significance. Since then, at Beverley, one notable capture was a *Pseudomys hermannsburgensis* (Sandy Inland Mouse), which is listed as rare in the NPWA. This represented a range extension for this species of over 80 km.

The annual fauna monitoring survey that occurs at the Beverley Mine site has recorded an additional two bird and three reptile species, none which are considered to be of conservation significance. In 2007, the first recording of the Dusky Hopping Mouse, *Notomys fuscus*, was made during the routine annual fauna survey (Waudby & Howe 2008). This native mouse has a national and state conservation rating of Vulnerable. It was not found at Four Mile but may occur in the area in favourable years.

In terms of its hydrogeology, the formations in the Four Mile area are part of the Frome Embayment, but are mostly separated from those in the Beverley area (refer Section 3.10), and the hydrogeological regime is quite different. The Four Mile uranium deposits are located in the Eyre Formation, rather than in the overlying Namba Formation (as at Beverley). At Four Mile, aquifer lenses have been found in the Namba Formation, however, unlike at Beverley no groundwater has been found in the overlying Willaworta Formation. The Great Artesian Basin (GAB) does not extend into the Four Mile area.

In the Beverley area groundwater from the Namba Formation aquifer within the Beverley mineralised zone is saline, with Total Dissolved Solids up to 15,000 mg/L, and contains naturally occurring radioactive uranium and radium at many times drinking water limits. It is therefore entirely unsuitable as potable water, and the radioactivity renders it unsuitable, now and in the future, for agriculture or stock watering purposes. Higher quality groundwater is found in both the underlying GAB and in part of the overlying Willaworta Formation, which is and will remain both suitable and available for stock and other uses.

Water use for the Beverley mine comes from two sources: groundwater from the Namba Formation aquifer in the area of the Beverley mine, which is largely recycled throughout the ISR process; and groundwater from the GAB, which is utilised for potable, plant and camp use.

1.4 Summary of Existing Operations

The Beverley Uranium Mine is capable of producing about 1,500 t/a uranium as uranium oxide concentrate (UOC) by the ISR method, although the current production is approximately 800 t/a. The current production target for Heathgate is 600-1000 t/a UOC (approximately 1.3 – 2.4 million pounds of uranium per annum). The export licence is for 1,500 t/a (as U₃O₈) and it is possible that the production may be increased to that in the future.

ISR is a mining method that is applicable to uranium ore-bodies that present in aquifers and have suitable geological and other conditions. ISR mining removes uranium from the host ore without the physical removal of ore and covering soils and rocks. It requires installation of multiple close-spaced wells into the aquifer, pipelines to and from the wells and a surface treatment plant and does not require either underground mine workings or open cut pits.

In the ISR process, natural groundwater from the mineralised zone of the aquifer is conditioned by adding an oxidant (hydrogen peroxide at Beverley) and dilute sulphuric acid, which after conditioning is called mining solution. This mining solution is then pumped via multiple injection wells back into the aquifer, where it dissolves the uranium contained in the aquifer. The resulting uranium-rich solution is pumped back to the surface via multiple extraction wells, to a uranium recovery plant.

7/01/2009
Prepared for Heathgate Resources Pty Ltd, 7th January 2009
Figure 1-2 shows the general arrangement of the Beverley operations, and Figure 1-3 shows the existing Beverley mining lease ML 6321, including locations of the processing plant, camp, airstrip and main infrastructure.

At the processing plant, uranium is stripped from the uranium-rich mining solution using ion exchange resin beads and held for later precipitation, drying and packaging. The barren solution is reconditioned (back to mining solution specification) and recycled back to the injection wells. Within any given area, this cycle continues until the uranium remaining in the aquifer is depleted to uneconomic levels. At Beverley, mining solution is typically circulated between 50 and 100 times through a specific mined area.

A group of multiple injection and extraction wells is called a wellfield. Control of the flow of mining solution through the aquifer is maintained through careful design and operation of the wellfield, adjusting the pressures in each extraction well to direct the fluid to required areas. This ensures continuous recycling within the active mining area and minimises the potential for leakage of mining solutions outside the active mining area (excursions).

A small amount of liquid waste is produced through this process which is reinjected in unused or mined out sections of the Namba Formation aquifer. A small amount of solid waste (radioactive and non-radioactive) is also produced and is buried in purpose-built near surface facilities that meet the requirements of the Radiation Protection and Control Act 1982 (SA), in particular as set out in the ARPANSA Code of Practice and Safety Guide, and Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (ARPANSA 2005). Other relevant legislation and Codes of Practice are listed in Table 7-1.
Extraction of uranium may be conducted over a number of phases to maximise the total amount extracted (only about 70% is extracted in the first phase). After the final phase has been completed, the wellfield will be closed and rehabilitated.

ISR mining is a relatively low impact mining method, since ore is not mined in the conventional sense. There is minimal surface disturbance, no overburden removal, no ore treatment facility, no tailings generation nor any disposal requirements. It requires a simple processing plant that can be removed on completion of mining and simple surface rehabilitation once a wellfield has completed its final operational phase.

No rehabilitation of wellfields had been undertaken to mid 2008, as further ISR mining may be undertaken in future phases, subject to the price of uranium and also to meet operational needs of desired minimum average uranium grade in process liquors. However, owing to the low disturbance impact of ISR mining, the final rehabilitation of wellfields is not a major exercise, in comparison to other forms of mining.
Section 1

Introduction

The existing mine is operated 24 hours per day, 365 days per year on a fly in-fly out basis. The Beverley operations on ML 6321 comprise the processing plant, a camp that accommodates about 180 people, an airstrip and other associated infrastructure. The current Beverley operations include:

- Work area clearance surveys (Aboriginal heritage surveys)
- Drilling and logging
- Well installation, and wellhouse construction
- Installation of power communications and pipe work to wells and wellhouses
- Rehabilitation of delineation holes
- Ancillary related activities
- Accommodation camp
- Airstrip operations
- Water supply
- Processing and packing of UOC
- Office support
- Workshop support.
1.5 Summary of Proposed Operations

The Beverley Four Mile Project entails construction of a satellite facility close to the Four Mile deposits, and construction of ISR wellfields of the same design as currently used on the Beverley mining lease. The Four Mile satellite facility would remove the uranium from the ISR liquor by physical means, producing uranium bearing resin, which would be trucked to the Beverley processing plant. The resin would then be stripped of uranium, and trucked back to the satellite facility.

Minor modifications would be required at the Beverley processing plant to accept the uranium-bearing resin, however there would be no net increase in uranium processing capacity. The uranium stripped from the resin would be processed at Beverley, and the small quantity of liquid waste arising would be disposed of at Beverley.

There would be no change to the existing Beverley camps, airstrip and camp water supply bore. An unsealed access road would be constructed between the Beverley processing plant and the Four Mile satellite facility. Some additional internal roads would be necessary within the proposed Four Mile mining lease to access the wellfields.

Some additional fencing may be installed along the western boundary of the Four Mile deposits for security purposes. There is also a 4WD track to Hidden Valley, which runs north-east from Paralana Springs approximately along the Wooltana / Arkaroola pastoral lease boundary; and presently cuts across the Four Mile West deposit. This track would be re-aligned around the Four Mile West deposit.

Figure 1-4 shows the location of the Four Mile deposits and a possible location for the satellite plant and the access road.

1.6 Key Environmental Impacts and Management Strategies

The following environmental topics have been identified as requiring consideration with respect to the proposed Beverley Four Mile project:

1) Surface hydrology
2) Hydrogeology
3) Landscape (soil and vegetation)
4) Landscape (amenity)
5) Flora, including weeds and plant pathogens
6) Fauna
7) Radiation management
8) Non-radioactive waste
9) Chemical Management
10) Heritage management and community liaison
11) Rehabilitation
12) Air quality.
Section 1  Introduction

Figure 1-4  Key Elements of the Beverley Four Mile Project

The risk assessment criteria outlined in the Guidelines for the Preparation of a MARP document (PIRSA 2007a) and the project-specific Guidelines for Preparation of a Public Environment Report (DEWHA/PIRSA 2007 - refer Appendix A) have been applied to these activities.

A description of this risk assessment methodology and the proposed control and management strategies to reduce the potential identified environmental impact events, has been set out in Section 7. The strategies for managing issues involve the implementation of technically and economically achievable best practice mining and environmental management techniques, including progressive rehabilitation where applicable and practicable.

The control and management strategies detail one or more of the following:

- A change in design or procedures to avoid or reduce the likelihood of the impact occurring
- A change in design or procedure(s) to avoid or reduce the consequences of an environmental impact event, should such an event happen.

1.7  Proposed Post Mine Land Use

The long-term objective for rehabilitation of the proposed Four Mile Project mining lease is the return of the landscape to pastoral activity.
1.8 Mine Closure and Rehabilitation Strategies

The long-term objective for closure and rehabilitation of the Four Mile Project mining lease is the return of the landscape to a moderately stable soil surface carrying a self-maintaining set of plant communities dominated by grasslands/chenopods, with no major surface hydrological alterations and minimal acceleration of natural erosion processes and which is suitable for pastoral activity. As discussed in Section 7, it is possible that some facilities, primarily internal access roads, may be handed over for other activities on the cessation of mining, subject to appropriate approvals and handover arrangements.

The primary activities for the closure and rehabilitation of the proposed Four Mile Project mining lease under current assumptions are:

- the closure of wells
- the removal/disposal of trunklines and associated pipelines and supporting infrastructure such as fences and tracks
- the removal/disposal of the satellite plant and associated ponds and facilities
- the return of the landscape as described above.

Heathgate intends to undertake the decommissioning and rehabilitation of the proposed Four Mile Project mining lease. As surety, a bond that is adequate to cover the cost of decommissioning and rehabilitation will be provided to the South Australian government, and this bond will be maintained in accordance with PIRSA requirements.

The extraction of uranium at Four Mile may be conducted over a number of ISR phases to maximise the total amount extracted. After the final phase has been completed, each wellfield will be closed and rehabilitated. The timing of future phases is subject to the price of uranium and also to meet operational needs.

At the conclusion of mining operations, any remaining ponded process solutions at the satellite plant would be treated and disposed of in accordance with the relevant regulations. Once this is accomplished, all remaining wells (not required for environmental monitoring purposes) and the satellite plant will be decommissioned. It is possible, subject to appropriate approvals and handover arrangements, that some general infrastructure such as some internal access roads may be retained long-term.

Heathgate proposes an initial period of five years from the conclusion of commercial operations to complete the decommissioning of facilities. A monitoring and maintenance program is proposed to run for a further two years, for a total of seven years from the final conclusion of mining activities. The total monitoring period will be reviewed with the regulatory authorities and may be extended.

Facilities will therefore be fully decommissioned within seven years from the conclusion of the commercial operation. This period includes a post-completion monitoring period for vegetation maintenance, groundwater sampling, drainage repairs and other activities to ensure the long-term permanent rehabilitation of the site.

Rehabilitation of temporary access tracks and other temporary infrastructure will be completed as soon as possible after the conclusion of mining operations. Details of the rehabilitation requirements in these instances are included as part of the environmental clearance permits issued prior to commencement of activities in undisturbed areas or areas under rehabilitation.
2.1 Tenement Information

The Four Mile Project uranium deposits are located on exploration lease EL 3666. Sixty three (63) Mineral Claim applications were lodged with PIRSA on 9 May 2008 and subsequently granted on 3 June 2008, numbered 3955 to 4017 inclusively. A Mining Lease application for part of EL 3666 (for the MLA area shown in Figure 1-3) was lodged on 16th May 2008. This MLA is the Project Area for this PER / Proposal.

The proposed satellite plant would be located close to the Four Mile deposits (Figure 1-4).

Heathgate will keep accurate records of the quantity, value and manner of disposition of all minerals mined and, whenever required to do so by the Director of Mines or a delegate authorised by the Director of Mines, will submit the records for inspection by the person so authorised.

2.2 Name of the Mining Operation

The name of the mining operation is the Beverley Four Mile Project.

2.3 Location of the Operation

The Beverley Four Mile Project is located between the Northern Flinders Ranges and Lake Frome, approximately 550 km north of Adelaide and 300 km north-east of Port Augusta. The closest communities include the tourist resort at Arkaroola (some 25 km to the south-west) and the Aboriginal community at Nepabunna (approximately 75 km south-west) (Figure 1-1).

2.4 Land Tenure

Most of the proposed Four Mile Project (including the deposits) is on the Wooltana pastoral lease, however much of the western part of the Four Mile West deposit is on the Arkaroola pastoral lease (Figure 2-1). Arkaroola Station is a declared Sanctuary under the SA National Parks and Wildlife Act 1972, and is referred to as the Arkaroola Wilderness Sanctuary.

The Wooltana pastoral lease is owned by Heathgate, the owners and operators of the Beverley Uranium Mine. The Arkaroola Wilderness Sanctuary is owned by the Sprigg family. The title details are:

- Wooltana Pastoral Lease Parcel/Plan D42204/A34 Pastoral Lease No 2293 Crown Leasehold Volume 1289 Folio 38; and
- Arkaroola Pastoral Lease Hundred 833900 Pastoral Block 1108 Pastoral Lease No 2240, Crown Leasehold Volume 1278 Folio 43.

In regard to Native Title, the surveys of cultural heritage matters pertaining to the Beverley and Four Mile project areas are undertaken by Adnyamathanha representatives who have been selected by named Native Title applicants. The applicants are generally considered by their peers to be most closely associated with the Beverley and Four Mile project areas, and knowledgeable about its cultural amenity. This is the preferred approach of the body representing the Native Title claimants for the area.
2.5 Mine Owner and Operator

The owners of EL 3666 are Quasar Resources Pty Ltd (Quasar) and Alliance Craton Explorer Pty Ltd (Alliance). By a Joint Venture agreement between Quasar and Alliance, Quasar has a 75% ownership and Alliance has a 25% ownership of EL 3666.

By agreement between Quasar and Alliance Joint Venture and Heathgate, Heathgate is the operator (and proponent) for the Beverley Four Mile Project, and Heathgate retain ownership of all facilities installed on EL 3666. The contact details are shown on the cover page of this report.

2.6 District Council or Corporation

The Woollana and Arkaroola pastoral leases are out of Hundreds, and are not within a District Council or Corporation area. The land is within the Development Plan ‘Land not within a Council Area (Flinders) (Consolidated 25 September 2003)’.

The land on which the mining is proposed is zoned EnA (Environmental Class A). The land on which the proposed satellite plant is located, and the Beverley plant, is zoned PaLa (Pastoral Landscape) (Figure 2-2).
The Outback Areas Community Development Trust provides many of the services to the region that may otherwise be undertaken by a Council.
3.1 Local Community

The closest communities include the tourist resort at Arkaroola and the Aboriginal community at Nepabunna (Figure 3-1). A total of some 50 permanent residents live within a 50 km radius of the Beverley Four Mile Project site. This figure includes staff at the Arkaroola tourist facilities and Wooltana Station, each some 25 to 30 km distant. The population at Arkaroola varies with tourist demand. The North Mulga outstation of Wooltana Station is located 10 km east of Beverley and is only occupied for approximately 6 months per year.

Small numbers of people reside at the former homestead of Balcanoona, which is now the Vulkathunha-Gammon Ranges National Park headquarters (45 km south-west).

The Aboriginal communities of Nepabunna and Iga Warta are approximately 75 km from the Beverley Four Mile Project site, on the western side of the Gammon Ranges (Figure 3-1). These communities are within Aboriginal Lands and operate as self-contained settlements. The population is currently estimated to be about 120 persons but it fluctuates with the movement of residents to and from the townships. Leigh Creek, some 150 km to the west, is the nearest significant township and service centre.
Section 3  Description of the Natural, Social and Economic Environment

Beverley employees are flown to and from the mine site out of Adelaide and Port Augusta on a regular roster. All employees are housed at the camp on the Beverley site. This would continue unchanged with the implementation of the Beverley Four Mile Project. Emphasis is placed on hiring local personnel, with most operational staff coming from Nepabunna, Iga Warta, Leigh Creek, the Iron Triangle region and Adelaide.

Beverley contributes over $1.5 million/year in Aboriginal royalties, administration and community payments, $2.2 million/year in State royalties, taxes, fees and licenses and about $25 million/year to regional and state businesses/suppliers.

Heathgate strives to achieve 20% Aboriginal employment at the mine site by providing employment opportunities for Aboriginal people from the Flinders Ranges. At the end of December 2006, the percentage of local area Aboriginal employment was at 22.2% (with respect to non-professional site-based positions), although this figure may vary from month to month.

3.2 Land use

The majority of the proposed Four Mile Project (including the deposits) is on the Wooltana pastoral lease (Figure 2-1), however much of the Four Mile West deposit (the western part) is on the Arkaroola pastoral lease.

The primary land use of the Wooltana lease is pastoral, currently cattle grazing for beef production but previously sheep grazing for wool production. The Wooltana pastoral lease has been used for pastoral purposes continuously since the 1870s.

Key areas of the existing Beverley operations have been fenced to prevent access by stock to mining and accommodation areas, and the same approach would be used for the Beverley Four Mile Project. Wooltana lease areas that are not involved with mining are sub-leased to another party for pastoral use. Issues related to water supply, fencing, stock control and roads are discussed with the sublessees on a co-operative and ongoing basis.

As noted above the western part of the Four Mile West deposit is on the Arkaroola pastoral lease (Figure 1.4). Arkaroola Station is a declared Sanctuary under the SA National Parks and Wildlife Act 1972 (the Arkaroola Wilderness Sanctuary).

The primary use of the Arkaroola Wilderness Sanctuary is as a wildlife sanctuary and for tourism. Arkaroola has been destocked for more than 35 years, and has been managed as a controlled tourism and conservation enterprise for 40 years. Originally called the Arkaroola Mt Painter Sanctuary, the name Arkaroola Wilderness Sanctuary was adopted in 1995 (Arkaroola Wilderness Sanctuary 2008).

Adjoining the south-western boundary of the Arkaroola Wilderness Sanctuary is the Vulkathunha - Gammon Ranges National Park (Figure 3-1). The Department of Environment and Heritage website describes the Park as comprising arid wilderness with rugged, spectacular scenery, interesting wildlife and a wealth of Adnyamathanha Aboriginal culture and European heritage, with challenging bushwalking experiences and cottage accommodation (http://www.environment.sa.gov.au/cgi-bin/parks.pl?Vulkathunha-GammonRangesNP).

The Flinders and Outback Region is a key tourist area within South Australia with potential to expand its tourism industry. A significant element in tourist attraction to the Flinders Region is the sense of wilderness conveyed by open and largely uninhabited spaces. The Beverley Four Mile Project operations will have negligible impact on tourism. The proposed operations are similar to those being undertaken at present.

In regard to tourism activities, there would also be some additional fencing along the western boundary of the Four Mile deposits for security purposes, and a consequential minor change to the alignment of the 4WD track.
from Paralana Springs to Hidden Valley, which runs near this boundary. Overall, the proposed ISR operations at Four Mile West, which are on the plains area abutting the Flinders Range, would not affect the wildlife sanctuary and tourism activities at the Arkaroola Wilderness Sanctuary.

Over the life of the Beverley Four Mile Project, the modest size of the overall project (for instance compared with the Leigh Creek coalfields, located at a similar latitude but on the western side of the Flinders Ranges) plus the modest scale of the satellite plant, wellfields and wellhouses, and the small numbers of traffic movements associated with it, will produce a very minor overall surface impact.

It is anticipated that the future land use (post-rehabilitation) of the proposed Four Mile Project Mine Lease will be for pastoral activity, in particular cattle grazing on Woolltana Station and on-going conservation activities on Arkaroola Wilderness Sanctuary.

3.3 Proximity to Infrastructure and Housing

The area is remote and sparsely populated. Section 3.1 describes the nearest communities, and Figure 3-1 shows the principal access routes to the area. The Epic Energy gas pipeline runs nearby, and a 15 km long spur line provides gas to Beverley for power generation.

Due to the nature of ISR mining, it is anticipated that ongoing ISR mining at the Beverley Four Mile Project will have negligible social impact in terms of dust and noise or damage to infrastructure of other parties.

3.4 Amenity

The main opportunities for viewing the Beverley mine site by tourists and visitors to the region arises when travelling the Balcanoona-Moolawatana Road, which is some 5 km distant at the closest point (Figure 3-1).

The main opportunity to viewing the proposed Beverley Four Mile Project facilities will be from the Paralana Springs to Hidden Valley 4WD track, which runs north-east along the base of the Flinders Ranges (Figure 3-1). As noted in Section 3.2, there would be a minor change to the alignment of this 4WD track, around the proposed wellfields at Four Mile West. The re-aligned track would be close to the wellfields in this area, however the track would be some 3 km distant from the satellite plant at its closest point.

Despite the small probability of adverse visual impact, the existing Beverley buildings and infrastructure are designed to blend in with the surrounding landscape. From the Flinders Ranges (Sillers Lookout), the mine is barely detectable to the naked eye (Plate 3-1). From the north, some roads are visible depending on the angle of the view. This situation will be little changed with the Beverley Four Mile Project, with the proposed satellite plant being much smaller than the Beverley processing plant, and some 15 km away from Siller’s Lookout.

At night, at present the Beverley processing plant lights can be seen from both the Balcanoona-Moolawatana Road and Sillers Lookout. The proposed satellite plant would be an additional lit-up area. Given that the beauty of the Flinders Ranges is appreciated during daylight hours, the use of lights at night at the satellite plant is not regarded as a significant negative impact. In any event, the overall visual impact would be no more significant than structures normally associated with a pastoral station. It is anticipated that the proposed Beverley Four Mile Project will have negligible additional impact on the visual aesthetics of the area.
3.5 Noise, Dust and Air Quality

No specific noise monitoring has been collected for the Beverley Four Mile Project area other than that required for occupational health and safety purposes. The nearest sensitive noise receptor to the mining operation is North Mulga outstation which is located some 15 km east of the project area. This outstation is occupied approximately six months per year.

Particulate matter (dust), as the result of wind is likely to be the most significant natural impact on air quality. For example, Oodnadatta, an arid site north-west of Beverley, experiences on average five dust storms annually (Arid Areas Catchment Water Management Board 2006). This frequency is related to the lack of ground cover and major dust storms have been recorded after periods of drought. High wind levels are likely to exacerbate dust generation and lead to an increase in the concentration of airborne dust. An example of a dust storm at Beverley is shown in Plate 3-2.
Dust deposition has been measured at four compass points near the boundary of the previous ML 6036 since 2005. Similar results would be expected for the adjacent Four Mile area. The average, maximum and minimum daily dust deposition rates (from quarterly composites) are 118, 319 and 22 mg/m²/d respectively. These compare to rates of 49 mg/m²/d and 46 mg/m²/d attributed to background measurements near Olympic Dam during the 1 January to 31 December 2004 reporting period by Termite Resources (2007).

Vehicles and the existing Beverley operations are the only anthropological sources of other existing emissions to air in the area. There would be some minor additional emissions of nitrogen oxides, carbon monoxide and particulates associated with vehicle movements to and from the proposed satellite plant. However as the overall Beverley production would remain the same, there would be little change to emissions from the power station at Beverley, which burns natural gas.

3.6 Topography and Landscape

The Beverley Four Mile Project area is on the western boundary of a broad, almost featureless plain approximately 45 km wide lying between the eastern margin of the Northern Flinders Ranges and Lake Frome. The Ranges rise abruptly on the western margin of the plain to about 600 m above sea level, falling to between 100 m to 60 m over the Beverley Mining Lease, then to the lowest elevation of +0.5 to -3.0 m above sea level at Lake Frome some 35 km south east. The terrain consists of four main landforms:

- level to moderately steeply sloping stream channels rising on the High Plain and discharging on to the Low Plain
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- flat to very gently sloping slightly elevated areas adjacent to drainage
- gently to steeply sloping dissection slopes of the High Plain
- gently sloping, broadly rounded foot slopes and interfluves of the second-order and streams forming the lower margins of the High Plain.

Additional information on topography and landscape is provided in Appendix B (soils baseline report) and Appendix C (hydrology baseline report) and the Beverley EIS (Heathgate 1998a).

3.7 Climate

3.7.1 Regional Recording Stations

Beverley is located in an arid region of South Australia, adjacent to the Northern Flinders Ranges and in their rain shadow. The area is characterised by low but highly variable, average rainfall. Meteorological data has been collected continuously at the Beverley weather tower since December 1999 and from Four Mile since April 2007.

Wind speed and wind direction are collected at the height of 3 m and are recorded every 10 minutes using a continuous data logging system. Data from the weather station at Beverley shows the most common winds in the area are from the south-south west and the south. These two directions account for nearly 31% of wind direction time. The predominance of southerly and south westerly winds persist throughout the year, regardless of season.

Wooltana Station homestead and Arkaroola are the closest Bureau of Meteorology rainfall recording stations to the Beverley site (Figure 3-1). The mean annual rainfall at Wooltana at the foot of the Ranges is 192 mm (median 164 mm) and at Arkaroola within the Ranges the mean and median rainfall are 251 mm and 212 mm respectively (www.bom.gov.au accessed 2007). There is a one-year-in-ten expectation of an annual total less than 80 mm.

Weather monitoring data are available for Four Mile from April 2007 to October 2008. A longer period of meteorological data is available for Beverley, a distance of only some 10-15 km, and so a summary of the Beverley data is provided below, as well as the available Four Mile data. Overall the Four Mile data are consistent with the longer climatic records at Beverley and elsewhere in the district.

3.7.2 Beverley Data

Rainfall data is collected using a tipping bucket and recorded every hour. The Beverley average of the six years 2002 – 2007 is 109 mm; however, the length of record is not sufficient to consider this the average rainfall of the site. Based on its location in the rain shadow of the Ranges the average rainfall of the Beverley – Four Mile area is estimated at approximately 150 – 200 mm/yr.

Average annual pan evaporation for the region ranges from around 2,500 mm near Yunta to the south, to over 3,700 mm to the north-east at Moomba. Evaporation is measured at Beverley using a standard above-ground Class A evaporation pan located adjacent to the weather tower, with a precision level meter linked to the weather station that logs every 24 hours. The six-year average (2002-2007) is 3,433 mm/yr but this has occurred during below-average rainfall. The estimated long-term average pan evaporation for the Beverley – Four Mile area, based on regional trends, is likely to be between 3,000 and 3,500 mm.

The available annual evaporation and rainfall data for Beverley is shown in Figure 3-2.
For November to March, mean maximum temperatures exceed 30°C and daily temperatures may exceed 40°C. Summer mean minima are around 20°C. Mean maximum temperatures are lowest for June and July, around 15°C. Mean minimum temperatures are <10°C, with <0°C daily minima recorded. Frosts are frequent, although actual white frosts appear less frequently because of the dryness of the air.

The mean and maximum temperatures on a quarterly basis for Beverley are shown in Figure 3-3.

### 3.7.3 Four Mile Data

The available meteorological data for Four Mile (April 2007 to October 2008) are shown in Figures 3.4 to 3.7.

The maximum temperature recorded during this period is 43.1 °C and the minimum was 0.4 °C. These are consistent with the longer climatic records at Beverley and elsewhere in the district. The average humidity...
during this period was 38% and the maximum wind speed recorded was 22.6 m/s. The recorded data shows that the rainfall in the Four Mile east and west areas differs considerably. The highest monthly rainfall at Four Mile East was 91.8 mm, and that for Four Mile West was 33 mm. The total rainfall received at Four Mile East during the monitoring period was 239 mm, and at Four Mile West was 82.6 mm. These records are consistent with the longer climatic records at Beverley and elsewhere in the district, where for short-term records rainfall can vary considerably over relatively short distances.

![Four Mile East Temperature Graph](image)

![Four Mile West Temperature Graph](image)

**Figure 3-4 Four Mile Temperature Data**
Figure 3-5 Four Mile Humidity Data
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Figure 3-6  Four Mile Wind Speed Data
3.8 Geohazards

URS undertook a study of earthquake ground motion parameters for use in any design aspects of the Four Mile operations. A full copy of the report is provided at Appendix D.

The Four Mile site is located close to active faults of the Northern Flinders Ranges. Two categories of earthquake sources were used to represent the seismic hazard in the region. The first consists of active faults, and uses estimates of fault slip rate to quantify the seismic activity rate on the faults. The second earthquake source category consists of distributed seismicity.
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URS commissioned a review by Professor Mike Sandiford of active faults in the northeastern corner of the Northern Flinders Ranges. He identified a system of four faults, shown in Figure 3-8, which include (clockwise from west) the Buxton, Paralana, Four Mile, Adams, Parabarana, Poontana, Wooltana, and Wooltana Range Front faults. The Four Mile West and East sites are located at the heads of the two black arrows just east of the Four Mile Fault in Figure 3-8.

![Figure 3-8 Faults in the Northern Flinders Ranges Near Four Mile](image)

The fault segments, clockwise from the west, are: B: Buxton; Pa: Paralana; 4M: Four Mile; A: Adams; Pb: Parabarana; Po: Poontana; W: Wooltana; and WRF: Wooltana Range Front. The Four Mile West and East sites are located at the heads of the two black arrows just east of the Four Mile Fault. Source: Sandiford (2008).

These faults are all west-dipping reverse faults, and earthquakes on them cause the Flinders Ranges to rise in elevation above the adjacent Paralana High Plains. The Pontoona – Parabarana fault dips down to the west and underlies the Four Mile site. The Four Mile site is 1.3 km east of the Paralana fault, but on the foot wall side...
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because the Paralana fault also dips down to the west. Although the Four Mile mine site is located close to active faults, there is no indication that active faults intersect the Four Mile mine site.

Two alternative spatially distributed earthquake source models were used in this study. Both the AUS5 source model and the Risk Frontiers source model assume a maximum earthquake magnitude of Mw 7.5 throughout Australia. We consider that these models are equally viable alternative models of spatially distributed earthquake activity, so we use both of them in order to represent uncertainty in earthquake occurrence in the site region.

The Four Mile site is located within the tectonically active Flinders Ranges. We expect the ground motion characteristics at the site are intermediate between those for stable tectonic regions and those for more tectonically active regions. Accordingly, we have given equal weight to ground motion models that represent each of those two conditions.

As described by Heathgate (2008c), the ground surface at the Four Mile site consists of about 15 m of gravels of the Tertiary Willawortina formation, overlying the sands of the Tertiary Upper Eyre Formation. The mineralization occurs within the Tertiary Lower Eyre Formation at a depth ranging from 150 – 200 m and averaging 180 m.

In this report, we provide estimates of the ground motions at the surface and at 180 m depth, the average depth to mineralisation. In the ground motion models that we use, ground motion amplification in the near surfaces is estimated based on the average shear wave velocity in the top 30 m of the soil profile (Vs30). We estimate that the Vs30 at the site is 400 m/sec.

Several effects cause the ground motions at depth to be generally lower than those at the ground surface. URS used data from down-hole ground motion recordings at other locations to make very conservative estimates of the reduction factors at a depth of 180 m. The surface ground motion levels were multiplied by a period dependent scaling factor ranging from 0.6 for peak acceleration and short periods to 0.9 for a period of 2 seconds.

The ground motion parameters are provided in the form of uniform hazard response spectra for a series of return periods ranging from 475 years to 10,000 years. The response spectra for the ground surface and for a depth of 180 m below the ground surface at Four Mile West are shown in Figures 3.9 and 3.10. The ground motions at Four Mile East are slightly lower than those at Four Mile West.

The estimated peak acceleration values at the ground surface are listed in Table 3-1 for both Four Mile West and Four Mile East, for both ground surface level and a depth of 180 m below the ground surface. The peak acceleration values for return periods of 475, 1,000 and 10,000 years at the ground surface at Four Mile West, listed in Table 3-1, are 0.044g, 0.073g, and 0.374g respectively. The corresponding values at a depth of 180 m below the ground surface, listed in Table 3-1, are 0.026g, 0.044g, and 0.224g respectively.
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Figure 3-9  Probabilistic Ground Motion Response Spectra at Surface at Four Mile West
Figure 3-10  Probabilistic Ground Motion Response Spectra at 180 m Depth at Four Mile West
3.9 Hydrology

URS undertook a study of the hydrology of Four Mile Creek, in the vicinity of the proposed Beverley Four-Mile Project. The report is provided in full at Appendix C1. This study supplements that of the hydrology of the Paralana and Mulga Creeks, which was considered in detail in the approval process for the Heathgate Mining Lease extension project. The Paralana and Mulga Creeks study was presented as Supporting Report B of URS (2007) and is reproduced as Appendix C2. A summary of these studies and their findings is presented below.

3.9.1 Context

Early mining of the Four Mile East and West deposits are in the catchment of Four Mile Creek. The Four Mile Creek catchment lies primarily north-west of the Beverley Uranium Mine, with an upstream catchment area of approximately 100 km$^2$. Paralana Creek is the next catchment south, with a catchment of approximately 208 km$^2$. The upper reaches of these creeks’ catchments drain the north-eastern slopes of the Flinders Ranges, whilst the smaller Mulga Creek arises on the High Plains and has a catchment of 47 km$^2$. All three creeks flow in a generally easterly direction, eventually discharging to Lake Frome, to the east of Beverley.

Whilst the creeks on the Beverley Four Mile project area consists of dry creek beds for most of the year, they are subject to occasional flood flows. The extent of this flooding can be quite significant in the lower reaches of the catchment, as the creek topography is characterised by gentle slopes and shallow braided creek beds, in many places extending hundreds of metres in width.

The upper reaches of the Four Mile and Paralana catchments are quite steep, while the reaches of these creeks and all of Mulga Creek lying to the east of the Flinders Ranges are much gentler in grade, with slopes typically of the order of 0.5%-1%. Correspondingly, flow decreases in velocity away from the Ranges, but increases in depth and extent of flood flow.

Vegetation in the Four Mile East zone is generally sparse and low, with tree growth concentrated along watercourse routes. The creek beds in the lower reaches of Four Mile and Paralana Creeks are typically highly braided, characterised by multiple channels, and lined with small rocks or cobbles (see Plate 3-3). Mulga Creek reproduces these characteristics on a smaller scale.
Creeks in the Beverley Four Mile Project area are located in an arid region of South Australia, in and adjacent to the north-eastern Flinders Ranges. The area is characterised by low, but highly variable, average rainfall. Rainfall recording stations are widely scattered and the length of record is relatively short. Though further information has been gathered in the time since previous studies, Australian Rainfall and Runoff (ARR) (Institution of Engineers Australia 1987) still defines the manner in which rainfall is estimated across Australia, based on analysis from these stations.

As a result of the mine’s establishment, weather stations have been installed at Beverley and more recently at Four Mile (refer Section 3.7), however, the short length of these records, and the highly variable nature of rainfall events in the region, means that deriving meaningful data for event prediction is likely to be subject to significant uncertainty. Previous studies by Tonkin (1998) and URS (2006) utilised ARR rainfall estimation techniques, and this was still considered appropriate for the Four Mile Creek study.

### 3.9.2 Hydrology Assessment Methodology

#### Spatial Data

Early mining of the Four Mile East and West deposits are in the catchment of Four Mile Creek, and all the infrastructure proposed here is in this catchment. The remainder of the hydrology discussion regards Four Mile Creek based on the detailed study given in Appendix C1. In the future, an equivalent discussion based on the studies of Paralana Creek (and, if relevant, Mulga Creek) given in Appendix C2 would be prepared for any
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mining or infrastructure that may be later proposed for the southern portion of the Beverley Four Mile project area.

Catchment areas and creek alignments in the areas of interest east of the ranges were determined by analysis of satellite ortho-imagery of the Four Mile Creek region. This information extended as far as the proposed Beverley MLA boundary and provided contour resolution of 0.5 m. In order to determine the extent of the upper catchment in the ranges beyond the lease boundary, it was necessary to use a lower resolution scale plan, with contour intervals of 50 m, and to confirm assumptions by comparison with satellite imagery.

Streamflow Estimates

The annual exceedance probability (AEP) is defined as the probability that a given rainfall total accumulated over a given duration will be exceeded in any one year. Three different methods were employed in the hydrology study for streamflow estimation:

- The Rational Method described in ARR for the northern and western regions of South Australia (Institution of Engineers Australia 1987);
- A RORB model was developed to estimate flows in major channels in Four Mile Creek; and
- The Gerny Method (Gerny 1962) was used for hydraulic modelling of minor channels.

Table 3-2 lists the streamflow methods used and the estimated flows for the 10 year ARI (9.5% AEP) and 100 year ARI (1% AEP) flood events.

<table>
<thead>
<tr>
<th>Method Used</th>
<th>9.5% AEP flow (m³/s)</th>
<th>1% AEP flow (m³/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gerny (1962)</td>
<td>153</td>
<td>275</td>
</tr>
<tr>
<td>Rational</td>
<td>165</td>
<td>295</td>
</tr>
<tr>
<td>RORB</td>
<td>179</td>
<td>398</td>
</tr>
</tbody>
</table>

Flood Plain Extent

A first-order estimation of the flood plain extent within the Four Mile Creek catchment was undertaken using HEC-RAS, an industry standard, one-dimensional, backwater curve analysis package.

Floodplain maps, indicating approximate flooding extents of 9.5% and 1% AEP events respectively, were prepared using HEC-RAS data output, and are shown in Figures 3-11 and 3-12.

For the analysis undertaken for the Four Mile Creek catchment, events of duration 10 minutes to 72 hours were simulated, allowing the peak flow event to be identified. The RORB output summary files for the 10 year ARI (9.5% AEP) and 100 year ARI (1% AEP) flood events are presented in the hydrology report at Appendix C.
3.9.3 Discussion of Hydrology Modelling Results

It has been noted that there is some uncertainty in the prediction of both flow rates used in the HEC-RAS modelling, as well as in the determination of cross-sectional information along flow paths.

In assessing the impact of predicted flood risk on potential operations within the floodplain, recognition must be made of the likelihood of a flood event occurring. For example, if activities are to be located within a floodplain for a short period, such as for an ISR wellfield, a lower flood standard may be appropriate. Over a 12-month period, the probability of operations within the 100 year floodplain being inundated is 1%, while within a 1 in 10 year ARI floodplain it is 10%.

However operational facilities that are to remain in one place for a much longer period, for example 15 years, would be exposed to a greater probability of inundation if located within a floodplain. Within a 1% AEP floodplain, a facility with a 15 year life would have a probability of 14% of being inundated, which although still unlikely, is clearly higher.

The results show that the 12 hour duration event is critical for determination of the 9.5% AEP (10 year) flood event, while 1 hour and 2 hour duration events are critical in the Four Mile Creek catchment for the 1% AEP (100 year) flood event.

However, it is also apparent from comparison of the predicted water surfaces for both the 9.5% AEP and the 1% AEP events, that a significant increase in flow (more than 100%) results in only a small increase in predicted inundation area. This is shown in Figures 3.11 and 3.12 – it is evident that there is little difference in the extent of inundation for these events, although the depth of inundation is higher for the 1% AEP event.

Consideration of risk should also be tempered with consequence of inundation. Flow velocities within the floodplain, be it either the 9.5% or 1% AEP floodplain, are relatively low; generally 1 m/s or less. Provided that the design of infrastructure is able to sustain flow of such a velocity, the location of certain facilities or equipment within the 9.5% AEP (10 year) floodplain for 12 month periods could be considered appropriate, with more long-term equipment or facilities located beyond the 9.5% AEP floodplain.
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Figure 3-11  10 Year Return Event Flood Extent – Four Mile Creek
3.10 Groundwater

This section describes the hydrogeological aspects of the Beverley Four Mile development. The information presented aims to provide an appropriate level of information to allow a meaningful assessment of the possible impacts on the local and regional groundwater system that may arise from mining and to provide the framework for planning the management of those impacts.

3.10.1 Context

This information is presented in a broad regional context that considers the current conceptual understanding of the surface and groundwater system that summarizes the aspects of groundwater movement, interactions between aquifer systems and groundwater quality.

The information provided includes a detailed description on a smaller scale, focused on all aquifers that may be affected by mining operations at the Beverley Four Mile East ore zone, which is proposed to be mined initially. As was the case at Beverley, additional studies will be performed, and further specific approvals sought, before moving into the Beverley Four Mile West ore zone or other yet-to-be discovered ore zones.

This section also presents the current understanding of the aquifer recharge and discharge mechanisms, the potential for connectivity between aquifer systems, and presents an assessment of current and potential third party groundwater users including the environment. The long term potential impacts of mining are examined.
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through numerical flow modelling and hydrogeochemical reactive transport modelling of the fate of chemical constituents of concern.

3.10.2 Regional Hydrogeology

Overview

The regional hydrogeological setting is important in understanding the potential downstream impacts of mining on the groundwater system over the longer term. This sub-section presents the current conceptual understanding of the surface and groundwater systems that summarizes the aspects of groundwater movement, interactions between aquifer systems and groundwater quality. Further detail on the regional hydrogeological setting is presented in Appendix H.

The regional setting information draws on a wide range of available data sources including:

- Geological information from over 1000 exploration drillholes, drilled by Quasar and Heathgate.
- Geological drillhole data sourced from PIRSA's SARIG Database.
- Airborne and surface acquired geophysical data sets sourced from Quasar Resources and PIRSA.
- Aquifer pressure and water quality data from over 60 observation wells installed by Quasar and Heathgate.
- Well information sourced from DWLBC's Drillhole Enquiry System.
- Heathgate survey of over 50 pastoral wells recorded in the DWLBC's Drillhole Enquiry System.
- Published hydrogeological reports including PIRSA reports (Kerr, 1965; Draper and Jensen, 1974), BRS reports (Radke, et al 2000); Heathgate hydrogeological reports associated with the Beverley Mine (HGR, 1998 and URS 2008); and published geological papers (e.g. Callen and Tedford, 1976).

The Beverley Four Mile East orebody is hosted in the Eyre Formation aquifer. The ore zone is located in a sedimentary embayment denoted here as the Four Mile Embayment. This embayment lies between the Northern Flinders Ranges and the Woolltana and Poontana Fault Zones. It forms part of the larger sedimentary Lake Frome Basin (Figure 3-13), which is part of the very extensive Eromanga Basin that extends across three states and the Northern Territory.

Recharge and Discharge Zones

Regional recharge is considered to occur mainly via direct infiltration into the fractured rock aquifers of the Northern Flinders Ranges and through streambed infiltration in ephemeral streams of the Flinders Ranges and on the plains of the Lake Frome Basin. This is consistent with the general understanding of recharge mechanisms in arid zones (Gee and Hillel, 1988). In the deeper GAB aquifer, which is present only to the east of the Poontana Fault Zone, groundwater inflow to the region occurs through lateral flow from the north and north east (Radke, et al 2000), and also via inferred leakage from basement.

In general terms, groundwater flows towards the regional groundwater sink of Lake Frome (Kerr, 1965; Draper and Jensen, 1974). The lake surface exhibits an elevation that ranges from -2 to 4 mAHD and is the lowest point in the Lake Frome Basin. Discharge is via diffuse upward vertical leakage, and also via upward flow along more conductive pathways associated with faulting.
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Figure 3-13 Beverley Four Mile East Ore Zone Location and Main Hydrogeological Structures
Structural Controls

Structural features associated with faulting have a significant impact on groundwater flow paths within the Four Mile Embayment.

The Beverley Four Mile East ore body is hosted in the Eyre Formation within the Four Mile Embayment. This embayment is formed between the Paralana Fault, which defines basement uplift to the surface along the eastern edge of the Northern Flinders Ranges, and the Poontana and Wooltana Fault Zone where basement is uplifted (though not to the surface) in a Horst structure forming a hydraulic barrier.

The embayment becomes deeper to the north east, parallel to the range front. This structure is shown in cross sections presented as Figures 3-14 and 3-15. This basement structure has resulted in the situation where older sediments within the Four Mile Embayment are uplifted and positioned at a higher elevation than younger sediments east of the Wooltana Poontana Fault Zone in the main part of the Lake Frome Basin.
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Details of Aquifers

Willawortina Formation

The Willawortina Formation comprises Quaternary age sediments derived from weathering of the Northern Flinders Ranges. The formation is an alluvial deposit of poorly sorted gravels, sands, and clays (Callen and Tedford, 1976).

The Formation is unsaturated in areas to the west of the Poontana Fault Zone (including the BFME ore zone), where uplift of sediments has placed the Willawortina Formation above the regional water table.

To the East of the Poontana Fault Zone, in the Frome Basin, the Willawortina Formation is saturated and comprises the only sedimentary aquifer exploited for pastoral use within 30km of the BFME ore zone. Recharge of this aquifer is thought to occur mainly through streambed infiltration. Discharge is via lateral flow and eventual evaporation from Lake Frome.

Water quality

Figure 3-15  Inferred Regional Cross Section South-West to North-East

(Long section south west - north east along the Four Mile Embayment and the Lake Frome Basin (from SKM 2008). Cross section is based on stratigraphic interpretation of 16 drillholes from Heathgate, Quasar and PIRSA datasets. Drillhole locations are shown in SKM (2008, Figure 3.1). Fault locations are based on PIRSA datasets. Cross section is to scale; vertical exaggeration is approximately 100:1.)
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Groundwater quality in the Willawortina Formation aquifer is highly variable. In general, salinity is lower near ephemeral streams and stream flood outs. Measured salinity ranges from 1000 to 9000 mg/L TDS.

Pressure

Aquifer pressure ranges from approximately 20 mAHD to 5 mAHD

Gradient

The hydraulic gradient is approximately 0.0005 from west to east towards Lake Frome.

Namba Formation

The Namba Formation comprises Tertiary age fluvial and lacustrine sediments. The formation consists of mainly low permeability mudstones and siltstone, deposited in a low energy lacustrine environment. (Callen and Tedford, 1976).

West of the Poontana Fault Zone, in the Four Mile Embayment, the Namba Formation is elevated through tectonic uplift. The formation is oxidized, possibly due to the formation being elevated relative to the water table. At this location, some thin saturated sand units are observed. Well yields from these sand units are very low.

East of the Poontana Fault zone, the formation is reduced and mudstones are dark grey and black in color. Some reduced sand units are observed, particularly at the Beverley Uranium mine where they host mineralisation. These sand units are thought to represent remnant shoreline and deltaic meandering stream features and are generally discontinuous and limited in extent.

Water quality

Salinity in the Namba Formation is variable and generally quite poor, averaging around 6000 mg/L TDS.

West of the Poontana Fault Zone, within the Four Mile Embayment measured salinity in the Namba Formation ranges from 1700 mg/L to 7000 mg/L TDS. Natural radionuclide concentrations are moderately high with measured uranium concentrations ranging from 0.05 to 0.1 mg/L and radium 226 concentrations ranging from 2.5 to 3.1 Bq/L.

East of the Poontana Fault Zone, at the Beverley Mine, salinity is higher, ranging from approximately 2500 mg/L to 13,500 mg/L TDS. Naturally occurring radionuclide concentrations at the Beverley mine are very high with measured concentrations of radium 226 averaging approximately 1000 Bq/L.

Pressure

West of the Poontana Fault Zone, in the Four Mile Embayment, aquifer pressure in the Namba Formation ranges from approximately 78mAHD at the BFME ore zone to 61 mAHD at the BFMW ore zone.

East of the Poontana Fault, within the Beverley Uranium mine lease the aquifer pressure is much lower, ranging from approximately 16 to 14 mAHD.

Gradient

West of the Poontana Fault Zone, in the Four Mile Embayment there are currently insufficient data points to accurately determine a hydraulic gradient. Additional data will be available shortly, but this data will not have a material impact on the environmental assessment.
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East of the Poontana Fault Zone groundwater elevation data in the vicinity of the Beverley deposit suggests an easterly trending pressure gradient. The vertical and lateral boundaries that confine the Beverley Aquifer and render it a stagnant system have been extensively tested and documented as part of the Beverley EIS and ongoing approvals (HGR, 1998, Lisdon, 1999, HGR 2007, HGR 2008). The observed slight pressure gradient is consistent with the overlying Willawortina Formation and is considered to be due to long term steady-state pressure equilibrium between the two aquifers.

Eyre Formation

The Tertiary age Eyre Formation (host of the Four Mile deposit) is widespread throughout the Lake Eyre Basin (Callen et al 1995). The Eyre Formation commonly consists of mature, carbonaceous, pyritic sand, with grain size varying from silt to gravel. The depositional environment of the Eyre Formation is believed to be one of braided streams originating in the uplifted Olary, Barrier and Northern Flinders Ranges flowing into the subsided Lake Eyre Basin. The permeability of this unit is quite high. The measured permeability of this unit was 5 m/day at the BFME ore zone.

Water quality

Measured water quality in the Eyre Formation is variable, reflecting the significant extent of the formation and the available data. Close to recharge sources, salinity is low ranging around 2000 mg/L TDS. Further along flow paths salinity increases to a measured maximum of approximately 4000 mg/L. Radionuclide concentrations are similarly variable with uranium concentrations in ore zones ranging up to 0.1 mg/L and as low as below detection limits in the Lake Frome Basin east of the Poontana Fault Zone. Radium concentrations are similarly high in ore zones (up to 90 Bq/L) but maximum concentrations east of the Poontana Fault Zone, in the main part of the Lake Frome Basin are lower at approximately 5.8 Bq/L.

Pressure

Measured aquifer pressure in the Eyre Formation exhibits a maximum of approximately 100 mAHD at the top (south western extent) of the Four Mile Embayment. Further down the embayment, to the north east, at the Four Mile East ore zone, aquifer pressure is lower at approximately 55 mAHD. Aquifer pressure undergoes a significant pressure drop across the Poontana Fault Zone at the north eastern extent of the Four Mile Embayment from approximately 45 mAHD to 20 mAHD. Aquifer pressure reduces further along the flow path towards Lake Frome.

Gradient

The measured gradient in the Eyre Formation ranges from 0.01 at the top of the embayment, reducing to 0.0025 across the BFME ore zone, and reducing even further east of the Poontana Fault Zone in the broader Lake Frome Basin, to 0.0007. Discharge at Lake Frome, with a ground surface of 0 mAHD indicates that the gradient from the easternmost monitoring point (pressure approximately 15 mAHD), to the discharge area reduces further to 0.0004.

Cadna-Owie

The Cretaceous age Cadna-Owie Formation is host to the high pressure Great Artesian Basin (GAB) aquifers in the Lake Frome Basin proper.

The GAB aquifer is not present within the Four Mile Embayment. The aquifer is present approximately 5 km east of the BFME Ore zone, on the eastern side of the Poontana Fault. Here the Cadna-Owie Formation is at a substantial depth of approximately 450m, deepening further towards the east into the Lake Frome Basin.

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Cadna-Owie Formation is a thin, mainly fine grained unit that extends throughout the Eromanga Basin (of which the Frome Basin is part) (Radke et al 2000). The formation represents a transition from terrestrial freshwater to marine conditions and consists of a pale grey siltstone to a fine grained sandstone, with locally developed medium to coarse grained sandstone interbeds.

Pressure in the GAB aquifer is confined by the overlying Cretaceous age Bulldog Shale, a low permeability dark grey marine shaley mudstone.

Water quality

Water quality in the GAB aquifer is reasonably good. Salinity, measured at production wells at the Beverley Mine, ranges from 2000 to 3000 mg/L TDS. Radionuclide concentrations are low with Ra226 concentrations averaging 0.15 Bq/L and uranium concentrations averaging less than 0.001 mg/L.

Pressure

Aquifer pressure in the GAB aquifer is very high. A pressure of approximately 90 to 95 mAHĐ is measured at the Beverley Mine.

Gradient

Aquifer pressure data indicates that, to the west of Lake Frome, the GAB exhibits a decreasing pressure gradient from west to east, toward Lake Frome. A pressure gradient is also evident from the north and north east of Lake Frome converging towards Lake Frome.

Fractured Rock

The hard rock of the Proterozoic age Mt Painter Group comprises a fractured rock aquifer. This formation is the receptor of recharge within the Northern Flinders Ranges. Flow from the fractured rock aquifer is inferred to be the source of much of the groundwater flowing into the sedimentary aquifers of the Four Mile Embayment and the Lake Frome Basin. The measured permeability of this unit was 0.05 m/day beneath the BFME ore zone.

Water quality

Water quality in the Fractured Rock aquifer is highly variable, reflecting the wide spatial distribution of the data, the variety of host rocks, and the variable recharge locations. Measured groundwater salinity ranges from approximately 500 to 5,500 mg/L TDS.

Pressure

Measured aquifer pressure in the Fractured Rock aquifers ranges from a maximum of approximately 550 mAHĐ in midst of the northern Flinders Ranges recharge zone, to a minimum of approximately 60 mAHĐ beneath the Four Mile Embayment which is inferred to be a discharge zone where groundwater leaks from the fractured rock aquifers into the overlying Eyre Formation aquifer.

Gradient

The inferred hydraulic gradient in the Fractured Rock aquifer is relatively high at 0.02, from west to east. The high gradient reflects possibly relatively high recharge rates, coupled with low bulk permeability of the host rock.
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Potential for Connectivity

Understanding the potential for connectivity between aquifer units is important in understanding the potential movement of groundwater between aquifer units, and hence, in understanding the possible down-gradient receptors of groundwater impacted by ISR mining activities at the Beverley Four Mile East ore zone.

Lateral Connectivity

The Eyre Formation aquifer at the BFME ore zone is not bounded laterally. Under natural conditions groundwater will migrate slowly down the natural hydraulic gradient (refer Figure 3-20). The rate of this migration is very slow at approximately 15 m/year towards the north east in the BFME ore zone, and is slower again to the east in the broader Lake Frome Basin where the hydraulic gradient is reduced.

Overlying Connectivity

The Eyre Formation is bounded above by the low permeability Namba Formation. There is little potential for significant connectivity between the Eyre Formation and permeable horizons in the Namba Formation because these units are hydraulically separate. This separation is demonstrated by the following:

- The measured aquifer pressure in the permeable units of the Namba Formation is approximately 20 mH2O higher than in the Eyre Formation at the BFME ore zone (water level in wells screened in the Namba Formation are 20m higher than in wells screened in the Eyre Formation ).
- A pumping test at the BFME ore zone showed no pressure response in the Namba Formation in response to pumping from the Eyre Formation (Appendix I).
- A significant difference in groundwater chemical composition is observed between water sourced from the two formations.

Underlying Connectivity

The Eyre Formation is bounded below by the Basal Diamictite unit. This low permeability unit provides a hydraulic separation between the Eyre Formation aquifer and the deeper fractured rock aquifer (FRA). It is possible that this confining bed does not provide complete hydraulic isolation between the two aquifers. This is indicated by the fairly similar aquifer pressure and similar groundwater quality exhibited by the two aquifers.

If a hydraulic connection exists, groundwater moves from the FRA to discharge into the sedimentary Eyre Formation which hosts mineralisation at Four Mile East. The key point here is that natural flow is from the FRA into the Eyre Formation aquifer, not the other way around. This means that for mining solution to impact upon the FRA it would have to move against the direction of natural flow. This is not a credible scenario under natural pressure conditions.

The evidence for this natural flow regime is as follows:

- The measured aquifer pressure in the FRA at the BFME ore zone is higher than the pressure in the Eyre Formation aquifer.
- The hydraulic gradient in the FRA, on a regional scale, is shown in SKM (2008 Fig 3.16 pp 28). This data shows that the pressure measured in the FRA at the BFME ore zone is consistent with the regional gradient and that groundwater flow in the FRA moves toward the east to discharge into the sedimentary aquifers of the Lake Frome Basin.
Conceptually, the Eyre Formation is the most permeable pathway for groundwater to move from areas of recharge (The Flinders Ranges) to areas of discharge (Lake Frome). This is supported by aquifer tests at the BFME ore zone which show that the Eyre Formation is approximately 100 times more permeable than the FRA (Eyre Formation permeability is 5 m/day compared to 0.05 m/day for FRA). This means that the Eyre Formation will act as a “drain” to conduct water to discharge zones, and hence the potential for flow is from the FRA to the Eyre Formation aquifer.

Hydrogeochemical data indicate that groundwater hosted in the FRA at the BFME ore zone is closer to recharge sources, than groundwater in the Eyre Formation aquifer. The plot of HCO₃ (SKM, 2008, Fig. 3.22) shows that groundwater within the FRA has lower salinity and slightly lower HCO₃ relative to chloride compared to groundwater in the Eyre Formation. Since HCO₃, is generally depleted, relative to chloride, along a flow path, this data indicates that the Eyre Formation aquifer is further down the flow path than the FRA.

**Conceptual Hydrogeological Model**

The conceptual hydrogeological model for the Four Mile Region and western Lake Frome Basin is presented as a cross section in Figure 3-16.

On a broad scale, recharge occurs mainly through infiltration into the fractured rock aquifers of the Flinders Ranges, and via streambed infiltration into the water table aquifer on the sedimentary plains.

This groundwater then flows laterally eastwards towards the regional discharge zone of Lake Frome. Groundwater generally moves preferentially via the most conductive pathway from recharge areas to discharge areas. This means that the fractured rock aquifers discharge into the more conductive Eyre Formation sedimentary aquifer, and elsewhere into the deeper GAB aquifer where these sedimentary aquifers on-lap or abut the fractured rock aquifer and hydraulic connection exists.

This groundwater flows via the sedimentary aquifers to Lake Frome in the east where the discharge pathway is via diffuse upward leakage, and focused upward leakage (springs) through more conductive pathways associated with faulting and eventual evaporation. Significant discharge from the GAB aquifer also occurs through discharge from pastoral wells east of Lake Frome (Draper and Jensen, 1974).

The Willawortina Formation, which comprises the water table aquifer east of the Poontana Fault Zone, receives recharge via streambed infiltration. This surficial aquifer is isolated from the underlying aquifers by the low permeability of the underlying Beverley Clay. Groundwater in this aquifer flows eastwards to discharge to Lake Frome via upward leakage and subsequent evaporation.

There are significant confining units separating aquifers within this groundwater system. Within the Frome Basin, the Bulldog Shale forms a confining bed which overlies the Cadna Owie Formation GAB aquifer forming a hydraulic seal between the GAB and Eyre Formation aquifers. This is an extremely competent confining unit and is responsible for maintaining the high artesian pressure in the GAB aquifer. The Eyre Formation is, in turn confined by the predominately low permeability Namba Formation.

Whilst the Namba Formation does host some permeable sand units including the Beverley mineralised sand units, in the Western Frome Basin the formation is comprised mainly of lacustrine, low permeability, siltstones and mudstones. As mentioned above, the Willawortina Formation is isolated from the underlying Namba and Eyre Formations by the low permeability of the Beverley Clay unit of the Namba Formation.
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Figure 3-16  Conceptual Hydrogeological Model – Cross Section
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3.10.3 Four Mile East Ore Zone Hydrogeology

Overview
This section describes, in detail, the current understanding of the hydrogeological structure and properties of the Beverley Four Mile East (BFME) ore zone. A strong understanding of the hydrogeological structure on this small scale is important to enable planning of ISR mining strategies, and to allow an assessment of the potential impacts of mining this ore zone.

The source of this information is primarily derived from extensive geological drilling, monitoring well installation, and aquifer testing.

- High density drilling data provides very good geological control over the deposit and the overlying and underlying formations. Heathgate has drilled in excess of 450 exploration holes across the BFME ore zone using mud rotary and coring methods. Drill hole locations are shown in Figure 3-17.

- Aquifer pressure and groundwater quality data has been obtained from 16 observation wells completed in the Eyre Formation and in the overlying and underlying formations within the ore zone extent. Well Locations are shown in Figure 3-18. Groundwater samples were analyzed for a full suite of chemical parameters by Western Radiation Services. Groundwater chemical data is presented in Appendix J.

- Aquifer properties of the Eyre Formation, and underlying and overlying formations were determined through aquifer tests (pumping tests) undertaken in the BFME ore zone. Aquifer testing is reported in detail in Appendix I.

Hydrostratigraphy
Mineralisation at the Beverley Four Mile East ore zone is hosted within the permeable unconsolidated sandstone sediments of the Tertiary age Eyre Formation at a depth of around 200m. This formation comprises a relatively thick aquifer of approximately 70m thickness. The Eyre formation is overlain by the low permeability, predominately mudstone and siltstone of the Tertiary Namba Formation which forms an effective upper hydraulic confining bed.

The Eyre Formation is deposited unconformably on a diamictite unit which is comprises a lower hydraulic confining unit. This confining unit, in turn, overlies the Proterozoic basement rocks which comprise a moderately low permeability fractured rock aquifer. The hydrostratigraphic sequence observed at Beverley Four Mile East is presented in Figure 3-19.

Each hydrostratigraphic unit is described in detail below.

Willawortina Formation
The Quaternary age Willawortina Formation is present from surface to a depth of approximately 30 m. The unit comprises two main fining upwards sedimentary packages, possibly remnant stream beds. These permeable units are almost certainly above the water table and unsaturated. The presence of old hand dug wells with derelict windmills, in Four Mile creek, approximately 1 km south of the Beverley Four Mile East ore zone, indicate that this Quaternary unit may comprise a perched aquifer, in proximity to creek beds, after significant creek flows, however, these wells are currently observed to be dry.
Figure 3-17  Geological Drill Hole Locations, 500m Grid

Contours show grade x thickness (% x m) of the orebody. Contour intervals are 0.05, 0.15 and 1.
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Figure 3-18  Monitoring Well Locations

Main Map – 500m grid. Inset – 20m Grid.
Figure 3-19  Hydrostratigraphic Section
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Namba Formation

The Namba Formation is present from approximately 30m to 150 m depth. The formation comprises mainly low permeability siltstones and mudstones, with some thin sand units. The formation acts mainly as an aquitard and a hydraulic confining layer to the Eyre Formation, however, the thin sand units may host marginal recoverable water supplies. Yields of wells completed in this formation in the Four Mile area have been very low at less than 0.1 L/s.

Water quality

The salinity recorded for wells completed in this formation ranges from 1700 to 7000 mg/L TDS. Natural uranium concentrations are relatively high, ranging from 0.05 to 0.10 mg/L. Radium concentrations are also relatively high ranging from 2.5 to 3.1 Bq/L.

Pressure

Aquifer pressure in the Namba Formation at Beverley Four Mile East is approximately 78 mAHD.

Hydraulic Gradient

Insufficient data is available to define a gradient in the Namba Formation at BFME. This information will be available for the PER response document but is not material to an environmental assessment of mining in the underlying Eyre Formation.

Eyre Formation

The Eyre Formation, which is host to mineralisation at BFME, is present from approximately 150 m to 220 m depth. The formation comprises fine to coarse unconsolidated sand. Mineralisation is hosted from approximately 190 to 210m depth. Aquifer testing of this unit at the BFME ore zone indicates a transmissivity of 350 m²/day, which equates to a bulk permeability of 5 m/day at the test site.

Water quality

The salinity of this aquifer ranges from 2400 to 3600 mg/L. Natural uranium concentrations are relatively high, ranging from 0.005 to 0.09. Radium concentrations can be very high ranging from 1.5 to 90.4 Bq/L. Natural fluoride concentrations are also high ranging from 2 to 6 mg/L.

Pressure

Aquifer pressure in the Eyre Formation at the BFME ore zone ranges from 54 to 60 mAHD.

Hydraulic Gradient

Eyre Formation aquifer pressure exhibits a low gradient of 0.0025 from west to east across the Ore Zone. Aquifer pressure data is presented in Figure 3-20.

Basal Diamictite

The diamictite unit underlying the Eyre Formation serves as a lower hydraulic confining unit. The unit comprises cobbles cemented in an indurated clay matrix. Permeability of this unit is very low.
Mt Painter Group Fractured Rock

The Proterozoic basement rocks of the Mount Painter Group underlie the sedimentary package in the BFME ore zone. These rocks comprise a fractured rock aquifer where groundwater is hosted mainly in fractures in the hard rock. The bulk permeability calculated from aquifer testing of this formation is low at 0.05 m/day.

Water quality

The salinity of this aquifer is 2450 mg/L TDS, whilst radionuclide concentrations are moderate at 0.015 mg/L uranium and 1.5 Bq/L radium 226. Fluoride concentration is high at 4 mg/L.

Pressure

Aquifer pressure measured in the Fractured Rock aquifer is approximately 59 mAHĐ at the BFME ore zone.

Hydraulic Gradient

There are at insufficient data points to infer hydraulic gradient in the fractured rock aquifer across the BFME ore zone.
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Aquifer Structure

The aquifer structure for the BFME ore zone is presented in Figure 3-21. The Eyre Formation comprises the most permeable aquifer unit in this system. It exhibits an aquifer pressure which is lower than both the overlying Namba Formation and the underlying Mt Painter Group Fractured Rock aquifer indicating that the potential for natural vertical groundwater flow converges towards the Eyre Formation aquifer. Aquifer testing indicates that the Eyre Formation is effectively, vertically, confined by the low permeability of the overlying Namba Formation and the underlying basal Diamictite unit.

![Figure 3-21 Conceptual Hydrogeological Model of the BFME Ore Zone](image)

The elevation of the interpreted top and base of the aquifer are shown in Figure 3-22 and 3-23 respectively. This data is based on geological logs from approximately 450 drillholes. Interpreted cross sections are presented in Figures 3-24, 3-25 and 3-26. These figures show that the formation dips to the east at approximately 2 degrees. The aquifer thins slightly to the south, whilst aquifer thickness remains constant to the east.

A lateral aquifer pressure gradient across the ore zone indicates that lateral groundwater migration in the Eyre Formation aquifer is from the west to the east (Figure 3-23). Lateral groundwater migration is estimated as relatively slow at approximately 15 m/year.
Figure 3-22  Inferred Top of Eyre Formation Aquifer

(10 mAHD contour interval)
Figure 3-23  Inferred Base of Eyre Formation Aquifer

(10 mAHD contour interval)
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Figure 3-24  Cross Section Locations
Aquifer pressure in the overlying Namba Formation and underlying Mount Painter fractured rock aquifer is greater than in the Eyre Formation, indicating that the potential for natural groundwater flow converges towards the Eyre Formation (Table 3-3).

Table 3-3 Vertical Aquifer Pressure Survey Data

<table>
<thead>
<tr>
<th>Aquifer Unit</th>
<th>Well_ID</th>
<th>Aquifer pressure (mAHD)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Namba Formation</td>
<td>4M0002</td>
<td>77.93</td>
</tr>
<tr>
<td>Eyre Formation S-1c Mineralised</td>
<td>4M0008</td>
<td>56.29</td>
</tr>
<tr>
<td>Fractured Rock Basement</td>
<td>4M0012</td>
<td>59.10</td>
</tr>
</tbody>
</table>
Key Values for Each Aquifer

The key values for each aquifer are defined by the current and potential use by third parties. These third parties include pastoralists, other mining companies, the government, and the environment.

Assessment of current or potential third party use

Current Third Party Use

Pastoral Use

A field survey was undertaken of all the water bores within the sedimentary Frome embayment within 30 km of the Four Mile East orebody recorded in the South Australian Government DWLBC Drillhole Enquiry system database. The full report is presented as Appendix K.

This survey showed that, of the 57 bores recorded in the database, 22 bores are in use by third party groundwater users for stock and domestic use. The remainder are either non-existent, in disrepair, or are used by the Beverly Mine.

There are no bores that use groundwater from the Eyre Formation aquifer within 30 km of the BFME ore zone. All third party bores access the Willawortina Formation aquifer. Salinity ranges from 1500 mg/L to 10,000 mg/L.

The closest third party well to the Four Mile East ore zone is Pepegoona Bore, located approximately 15 km east of the proposed mining zone. This well accesses the Willawortina formation aquifer and is used for stock water supplies.

Springs and Groundwater Dependant Ecosystems

There are no springs recorded within 30 km down-gradient of the BFME ore zone. The closest down-gradient springs are on Lake Frome some 60 km to the east. Research into these springs concluded that the springs are fed by groundwater discharge from the deeper GAB aquifer (Draper and Jensen, 1974). There is no credible potential for impact on these springs.

There are four springs recorded within 30 km of the BFME ore zone (Figure 3-27) (PIRSA 2008). Three springs; Mount Fitton, Radium Camp and Bolla Bollana Springs are all located within the Northern Flinders Ranges and are fed via groundwater flow from local fractured rock aquifers. These springs are located more than 10 km up gradient from the Four Mile Embayment hence no adverse impact on these springs is possible as a result of the proposed mining at BFME ore zone.

Paralana Hot Springs (PHS) is located approximately 10 km south west of the BFME ore zone. A detailed study of the hydrogeochemistry of these springs (Brugger et al, 2005), concluded that the water source of these springs is the fractured rock aquifers of the Mt Painter Inlier, not the sedimentary aquifers of the Four Mile Embayment which are the target for mining. This indicates that any impact on PHS from mining is unlikely.

Further, aquifer pressure in the mining target aquifer is approximately 60 mAH.D. This aquifer pressure is much lower than the ground surface at PHS which is approximately 190 mAH.D. Hence the aquifer feeding PHS exhibits at least 130 mH2O higher pressure than the target mining aquifer and, even if a hydraulic connection were to exist, there is no potential for adverse impacts on these springs due to flow from the mining zone to PHS as this flow would have to be against a significant pressure gradient.
Groundwater abstraction due to mining will not impact on spring flows through de-pressurising of source aquifers. This is because mining will have a negligible effect on the aquifer water balance. Mining operates at a near neutral water balance. At most, a 0.5% bleed at a mining flow rate of 450 L/s equates to a net groundwater abstraction of 2.25 L/s.

To test the impact that 2.25 L/s of groundwater abstraction would have on aquifer pressure in the Eyre Formation, 10 km distant from the mining zone (PHS are located approximately 10 km from the orebody and Four Mile East) predicted pressure drawdown was calculated using the Theis equation. This methodology is extremely conservative in that, no recharge to the system or induced leakage is considered. In reality, both recharge and induced leakage would occur and drawdown would be less. The following parameters were derived from aquifer testing at Four Mile East and are used in calculating drawdown:

\[
\text{Transmissivity} = 350 \text{ m}^2/\text{day}
\]
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**Storage Coefficient** = 8 e^{-6}

**Aquifer Thickness** = 70 m

**Pumping Rate** = 200 m³/day (2.25 L/s)

**Duration of pumping** = 3650 days (10 years)

Calculated drawdown in a confined aquifer 10,000m distant from the pumping centre is 0.18 m (Figure 3-28). For an unconfined aquifer (Paralana Hot Springs discharges to the surface and is thus unconfined) with specific yield of 0.02 (typical of a fractured rock aquifer) drawdown would be many orders of magnitude smaller at around $7.2 \times 10^{-5}$ m.

#### Calculate Drawdown (s) for known Discharge (Q)

**THEIS Analytical Solution (Theis, 1935)**

- **Storage coefficient (s) of aquifer:** 0.00056
- **Transmissivity (m²/day):** 350
- **Time since pumping started (c):**
- **Distance (m):**

<table>
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<tr>
<th>Distance (m)</th>
<th>( u )</th>
<th>( W(u) )</th>
<th>Drawdown (m)</th>
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</table>

#### Distance Versus Drawdown

(Drawdown in a confined aquifer resulting from pumping at 2.25 L/s for 10 years)

**Potential Third Party Use**

There are a number of factors which impact upon potential third party groundwater use, including the location/remoteness of the water source, the suitability of the environment for alternative land use, the availability of other services and the groundwater quality.

This assessment of potential third party use will focus only on groundwater quality since the other factors are beyond the scope of this assessment. It is noteworthy that the other factors, such as remoteness, adverse climate and environment, and a lack of services, will all act to constrain other potential groundwater use in this area.

Prepared for Heathgate Resources Pty Ltd, 7th January 2009
The assessment compares the measured groundwater quality of samples taken from monitoring bores against the ANZECC water quality guidelines for potable, irrigation and stock water use. Appendix J presents the full groundwater chemical dataset.

Table 3-4 summarizes the water quality constraints for third party use of groundwater from the different aquifer systems in the Four Mile area. All groundwater is of poor quality and is unsuitable for potable or irrigation use without treatment. The water table aquifers (Namba Formation west of the Poontana Fault Zone, and the Willawortina Formation east of the Poontana Fault Zone) are sometimes suitable for use as stock water supplies. The GAB aquifer is also suitable for use as a stock water supply.

### Table 3-4 Potential Groundwater Use Water Quality Constraints

<table>
<thead>
<tr>
<th>Aquifer</th>
<th>Location</th>
<th>Potable Constraints</th>
<th>Irrigation Constraints</th>
<th>Stock Water Constraints</th>
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<tbody>
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<td>Willawortina Formation</td>
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<td>Salinity, U, Ra</td>
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<td>Eyre Formation</td>
<td>Four Mile Embayment</td>
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<td>U, Ra, F</td>
<td>Ra, F</td>
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<td></td>
<td>Lake Frome Basin</td>
<td>Salinity, U, Ra, F</td>
<td>U, Ra, F</td>
<td>F</td>
</tr>
<tr>
<td>Fractured Rock</td>
<td>Four Mile Embayment</td>
<td>Salinity, Ra, F</td>
<td>U, F</td>
<td>F</td>
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<td>Great Artesian Basin</td>
<td>Lake Frome Basin</td>
<td>Salinity</td>
<td>Salinity</td>
<td>none</td>
</tr>
</tbody>
</table>

Notes: U: Uranium; Ra: Radium 226; F: Flouride

### Water Protection Area

**Prescribed Water Resources Under NRM act**

The Beverley Four Mile Project is located within the Far Northern Prescribed wells area. Because the GAB in the Beverley Four Mile area is a prescribed water resource under the *Natural Resources Management Act 2004* (SA), a water allocation and license will be required. This license is currently being prepared by the State government for the existing Beverly Mine. When the license is issued Heathgate will abide by its conditions.

No additional GAB water supply will be needed for Beverley operations to extend to BFME as the BFME ore bodies will take the place of mined out Beverley ore bodies.
3.10.4 Hydrogeochemical Modelling

Overview

In the context of ISR mining the Beverley Four Mile ore body, an understanding of the hydrogeochemical fate of mining lixiviant is a key component of predicting the impacts of mining upon the aquifer system. This is particularly important in the BFME ore zone since this ore zone is hosted within an aquifer which does not exhibit lateral boundaries. After mine closure, remnant mining solution is expected to migrate very slowly down the natural hydraulic gradient.

It is expected that this remnant mining solution will be modified during its travel through the aquifer material due to chemical reactions and physical mixing and dilution of the lixiviant with natural groundwater.

The process where groundwater, which has been altered through the addition of leach solution or liquid waste, reverts through reaction to its surrounding aquifer matrix and pre-existing groundwater over a period of time to or towards its pre-contaminated state, without additional attenuating treatment is termed natural attenuation.

Data from overseas operation indicates that natural attenuation does occur over time. At Beverley there is emerging evidence based on available data that natural attenuation has indeed reduced the impact from acid ISL on groundwater and limited the movement of leach liquor from the well-fields, and that eventual return approaching pre-mining conditions is likely.

(from “Review of environmental impacts of the acid in-situ leach uranium mining process”, CSIRO, 2004).

Natural attenuation is acknowledged as an appropriate control measure for ISR mines to avoid impact on aquifer environmental values.

A comprehensive work program has been undertaken by Heathgate to demonstrate that this will occur in the BFME ore zone aquifer with some certainty and in an appropriate timeframe. This work program includes:

- groundwater flow modelling,
- laboratory geochemical test work
- geochemical modelling, and
- ongoing, iterative natural attenuation modelling validation and assessment.

This chapter outlines the methodology and outcomes of this work. Full detail of the groundwater flow modelling and the geochemical modelling is provided in Appendices L and M.

Groundwater Flow Modelling.

The aim of this work is to develop a model that can predict the expected down-gradient flow paths and flow velocity of groundwater and mining fluids which flow through the Beverley Four Mile East orebody.

The modelling approach is to develop a simple, two dimensional model of the regional groundwater system which hosts the BFME deposit using known aquifer properties and boundary conditions. The intention is that the model be fit for purpose, and reflect the currently available information with minimal uncertainty, or non-
uniqueness. To this end, the model set-up comprises very simple boundary conditions which reflect measured data, and a simple, two dimensional, transmissivity-based, approach to aquifer property setup and calibration.

Model setup, calibration and reporting have been undertaken in accordance with the current industry standard guidelines for numerical groundwater modelling (MDBC, 2000). The modelling serves three purposes:

- Firstly, to confirm that the conceptual model is hydraulically feasible. I.e. that the model can be calibrated to measured water levels using realistic aquifer properties and boundary conditions that are supported by real data.
- Secondly, to predict flow paths and flow velocities which can be used as inputs into geochemical modelling of natural attenuation. The geochemical modelling will consider water–rock reactions in two dimensions along these flow paths.
- Thirdly, to estimate long term three dimensional mixing and dispersion of mining lixiviants down-gradient of the ore zone.

The steady-state flow model was well calibrated with a RMS error of 3.3%; well within industry guidelines. This indicates that the conceptual hydrogeological model is a plausible, simplification of the real system.

The flow model was used to predict flow paths and flow velocities for a range of aquifer porosity values. Predicted flow paths are shown in Figure 3-29. This modelling showed that the flow paths could be categorized into three main flow domains based on fluid velocity:

- Four Mile East ore zone 15 m/year
- Four Mile Embayment down gradient of ore zone 20 m/year
- Lake Frome Embayment 6 m/year.
This simplified flow line conceptual model (shown in Figure 3-30) was used for the geochemical transport modelling.

Figure 3-30 Flow Path Conceptual Model

Three dimensional solute transport modelling demonstrated that dilution of mining lixiviant is anticipated down gradient of the mining zone due to dispersion of the mining solution plume. This mechanism results in a more extensive and less concentrated plume as it moves down gradient.

**Laboratory Test Work**

Laboratory Test work was undertaken by the Commonwealth Government Australian Nuclear Science and Technology Organisation (ANSTO). The laboratory test work comprised:

- column studies, where synthetic mining lixiviant was passed through aquifer material packed into columns to examine the change in lixiviant composition following transport through the aquifer, and
- batch tests, where synthetic mining lixiviant was added to aquifer material and allowed to reach chemical equilibrium.

The aim of the test work was to provide a geochemical data set to develop and calibrate the geochemical reactive transport model which could be used to predict the fate of mine lixiviant.

The laboratory test results are presented in detail in Appendices N and O.

**Geochemical Modelling**

Geochemical modelling was undertaken by UIT in Dresden, Germany. UIT are specialists in uranium mine rehabilitation. The geochemical modelling is reported in detail in Appendix M.

The geochemical modelling within Heathgate’s Natural Attenuation Project consists of two parts:

- **Part I**: Interpretation of Column and Batch Tests
- **Part II**: Reactive Transport Simulations in BFME aquifer

Part I lays the foundations for subsequent aquifer studies in Part II. The main goal is to understand the principal geochemical processes that determine the fate of uranium and other lixiviant constituents.

A reactive transport model (TRN) was provided by UIT to describe the column tests and the geochemistry in the BFME aquifer. It combines transport (advection & dispersion) with geochemistry (thermodynamics & kinetics).
The chemical equilibrium module is based on PHREEQC. PHREEQC is an industry standard geochemical modelling package.

PART I Lab Test Simulations

The results of batch and column tests are complementary. The large residence time (contact time with core material) during the batch tests allows an equilibrium approach using PHREEQC. On the other hand, the column tests, with a small residence time, are modeled with the reactive transport model TRN. All batch and column simulations are based on the same fundamental assumptions and model parameters.

The model simulations for both batch and columns are in good agreement with the observations. They are based on a dataset with minimum assumptions and parameters. This makes the approach straightforward and transparent. The obtained dataset provide a firm platform for the prediction of geochemical processes in the BFME aquifer.

The main geochemical transformations within the columns can be summarized as follows (Figure 3-31): The lixiviant enters the stagnant water zone and dissolves the reductive minerals pyrite and coffinite. Due to the contact with the O₂-rich mobile phase the released Fe(II) and U(IV) species oxidize and precipitate as Fe(III) and U(VI) minerals. As a result Fe and U are immobilized. The immobilization occurs as far as pH > 3 - 4. If the pH drops below 3 (due to the ongoing lixiviant inflow), the precipitation stops and all accumulated Fe(III) and U(VI) minerals re-dissolve. The greater the pH buffer the more the peaks are retarded. The pH buffer is determined by both ion exchange and the amount of dissolved calcite (and clay minerals).

![Figure 3-31 Main Geochemical Processes Within the Dual Porosity Approach](image)

(Double arrows symbolize reversible processes)
The laboratory tests show explicitly a retardation of pH and uranium. Uranium retardation / immobilization is caused by:

- precipitation of U(VI) minerals
- uranyl ion exchange at clay minerals
- a combination of both processes

**PART 2 Beverly Four Mile East Aquifer Simulation**

The geochemical modelling framework developed and calibrated using laboratory test data was utilized to simulate the fate of mining lixiviant over a longer time frame and at a field scale. The aquifer simulations rest on two pillars:

(i) the hydraulic parameters taken from the hydrogeological model, and  
(ii) the geochemical data taken from the column and batch tests.

The up scaling procedure is described in detail in Section 4.3, Appendix M. The up scaling from columns to the aquifer is characterized by a significant changeover:

- **Length:** 1 m → 7 000 m
- **Time:** 60 h → 800 years
- **PHREEQC calls:** 12 000 → 5 Million
- **Runtime:** 160 sec → 14 hours

The study of post-mining scenarios represents the central part of the natural attenuation studies. The model configuration is as follows: After mining/leaching, groundwater flows into the ore zone and pushes the dissolved lixiviant from the ore zone into the down gradient Eyre Formation aquifer within the Four Mile Embayment. At the beginning (initial state t = 0), mobile and stagnant pores of the ore zone are filled either with:

- aggressive lixiviant (pH = 1.7, U = 50 ppm) ‘Worst Case’ or
- diluted lixiviant (pH = 2.0, U = 25 ppm) ‘Real Case’

In addition, there is an ongoing dilution along the flow path caused by transversal dispersion. Based on these assumptions four calculations are performed:

- **W_noDILU** Worst Case without Dilution
- **W_DILU** Worst Case with Dilution
- **R_noDILU** Real Case without Dilution
- **R_DILU** Real Case with Dilution

Thereby, **W_noDILU** represent the most improbable and **R_DILU** the most probable case. The results are discussed in detail in Section 4.5, Appendix M.

Plots of predicted pH, and uranium concentration profiles along the flow path for time steps up to 800 years are presented in Figures 3-32 and 3-33. In all cases, the acid front (with pH < 5) as well as uranium never leaves the FM Embayment; their influence is confined within a maximum range of 3 to 5 km away from the ore zone.
The uranium geochemistry strongly depends on ORP. In contrast to the lab tests, which have been performed under non-reducing conditions (pe = 5), reducing conditions definitely exist in the aquifer (pe < 1). Thus, the aquifer simulations are performed at lower pe values. In particular, due to the dissolution of reducing minerals (pyrite and coffinite) pe drops below zero.

Figure 3-32  Predicted pH Profiles Along BFME Aquifer Flow Path
(For time steps up to 800 years)
The impact of an uncontrolled flow through fractured rocks is discussed in Appendix M. This impact is small and does not comprise a significant potential pathway for impact.

The United States Geological Survey (U.S.G.S.) performed a similar study (Davis and Curtis, 2007) for groundwater restoration after uranium leaching. The current study is based on this reported methodology; the current study refines the USGS model and applies it to a real case. A comparison of both approaches is given in Table 3-5.
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Table 3-5  Model Comparison with the U.S.G.S Study from Davis and Curtis, (2007)

<table>
<thead>
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<th></th>
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<th>BFME report</th>
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</tr>
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</tr>
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</table>

The geochemical model and methodology developed in this study enables us to describe geochemical processes in the Four Mile Eyre Formation aquifer. On this foundation in combination with extended knowledge about the real aquifer conditions (observations, experimental data) new investigations can be done easily and the forecast can be refined as described below.

Ongoing Natural Attenuation Modelling Validation and Assessment.

The geochemical modelling predictions will be assessed and refined following commencement of mining. This is an important step which will allow validation of the modelled outcomes, and further refinement of the modelling methodology. This iterative approach to the prediction of mining solution evolution in the Four Mile aquifer comprises 3 steps (Figure 3-34):

1) Calibration of a geochemical model using laboratory data (Current step)
2) Validation / recalibration of geochemical model using mining data.
3) Validation / recalibration of geochemical model using post-mining data.

This iterative approach to understanding and predicting impacts on the aquifer is essential to provide confidence in the predicted outcomes, and to allow accurate and appropriate planning of mine closure strategies.
Figure 3-34 Iterative Approach to Prediction of Chemical Evolution of Mining Solutions

The methodology for natural attenuation modelling validation and assessment will be to model real-world mining and post-mining scenarios, and compare the modelled outcomes with measured outcomes. Three examples of this approach are:

- To examine chemical breakthrough data from active well fields. This will entail collecting samples immediately following the start up of new wellfield patterns and comparing the measured chemical composition of lixiviant that has travelled 30m through the aquifer, to the predicted chemical composition of lixiviant in this scenario.

- To examine chemical breakthrough data from observation wells placed within the zone of “flare” of an active wellfield. In this scenario, lixiviant will travel some 20 m through the aquifer at a lower velocity than the scenario above.

- To examine the chemical evolution of groundwater in inactive well fields following the completion of mining, and comparing modelled against actual results.

The refined and validated geochemical model will be used to confirm, or refine the predicted impacts of mining, and this information will be used to inform mine closure planning.

3.11 Vegetation/Weeds/Plant Pathogens

A baseline survey of the flora of the Four Mile area, concentrating on the area around the Four Mile East and West deposits, was conducted in May 2007 (Badman 2007a). This report is provided at Appendix E.

An annual flora survey of the same area was undertaken later in 2007 (Badman 2007b), and this report is provided at Appendix F.
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The flora of the entire Beverley Four Mile project area has been inferred by air photograph interpretation (see below). In the future, an equivalent study would be prepared for any mining or infrastructure that may be later proposed for the southern portion of the Beverley Four Mile project area at least one year in advance of a proposed start of mining in those areas, to confirm the air-photograph interpretation.

There are three principal vegetation associations on the Beverley Four Mile mining lease application (as in the Beverley ML 6321) (Badman 2007a,b):

- Mitchell Grass plains
- Major drainage lines
- Minor drainage lines.

Plates 3-4 to 3-6 illustrate the vegetation associations of the area. A vegetation map for the site is given as Figure 3-35, based on air photograph interpretation and the studies by Badman.

The main land cover (Mitchell Grass plains) is perennial Mitchell Grass grassland (*Astrebla pectinata*) with a very high component of Bassias and *Sclerolaena* species. Slopes and shallow drainage lines (the minor drainage line association) have a tall shrubland cover of mainly *Eremophila* or *Acacia* species.

It should be noted that the series of dry years experienced at Beverley leading to 2008 have lead to the natural demise of much of the Mitchell Grass on the plains, as described in the surveys given in Badman (2006; Supporting Report D of URS 2007 and Heathgate Resources Pty Ltd 2008c). *Astrebla pectinata* cover values reached a maximum of 13.2% cover in 2000 declining to 1.8% in 2005 (see Table 3 of Badman (2006) for historic monitoring at the existing Beverley operations). Small chenopods such as *Sclerolaena* are currently the most common plants on the plains.
Figure 3-35  Vegetation Associations
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Plate 3-4  Mitchell Grass Plains at Beverley Four Mile

Plate 3-5  Major Drainage Line Vegetation at Beverley Four Mile
Four Mile Creek is an example of the major drainage line association with a fringing woodland of Red Gum *Eucalyptus camaldulensis* and Teatree *Melaleuca sp.* along major channels. A very open tall shrubland of *Acacia victoriae* is present on the lower levels of floodplains. Higher levels of floodplains, as well as outwash areas, have a very open shrubland of cottonbush *Maireana aphylla* or other similar chenopod shrubs, interspersed with Mitchell grass.

One threatened species, *Swainsona oligophylla*, which is listed as rare under the National Parks and Wildlife Act, is known to occur at Beverley ML 6321, but has not been found at Four Mile.

Two previously reported plant species at Beverley, *Frankenia subteres* and *Swainsona murrayana*, are now considered to be based on misidentifications. Most of the threatened species that are known to occur in the general area are restricted to the Flinders Ranges and are not known to exist on the plains.

One proclaimed plant, *Tribulus terrestris* (Caltrop), has been recorded at Beverley, together with the native *Tribulus minitus* with which it can easily be confused. *T. terrestris* is fairly common in the general area and is not recorded in all years, and has not been recorded at Four Mile to date.

Twenty alien plant species have been recorded at Beverley and a further ten are known to occur in the general area. None of these occurrences can be directly attributed to exploration or mining activities. Existing procedures at Beverley will be extended to the proposed additional mining areas at Four Mile to prevent any adverse vegetation impacts from new wellfield development.
3.12 Fauna

3.12.1 Habitats

Beverley is located in the Flinders and Olary subregions of the Flinders Lofty Block Bioregion (Neagle 2003) in the South Australian rangelands on the North Olary Plains. These subregions are characterised by a chain of mountains and hills extending into arid gibber plains in the north (where the Beverley Uranium Mine is located). Characteristic habitat types of this region have been described by Neagle (2003) and Brandle (2001) and those present at Beverley Four Mile are:

- Tall Shrubland adjacent a minor creekline with Dead Finish (*Acacia tetragonophylla*), Elegant Wattle (*A. victoriae*), Emu-bush (*Eremophila* spp.), and Senna (*Senna* spp).
- Major Ephemeral Creek Line (Four Mile Creek) associated with Inland Paper-bark (*Melaleuca glomerata*) thickets and River Red Gum (*Eucalyptus camaldulensis*) Woodlands.
- Gibber Plain with Saltbush (*Atriplex* spp.), Bindyi (*Scleroleana* spp.) and Bluebush (*Maireana* spp.) herbland and shrublands. Mitchell Grass (*Astrebla pectinata*) would be a dominant species in this habitat when climatic conditions are suitable.

3.12.2 Fauna Surveys

A number of fauna surveys have been undertaken within the Beverley area as part of the existing Beverley Uranium Mine and the Beverley Uranium Mine Expansion. The initial baseline survey for the Beverley Mine was undertaken in 1996 whilst ongoing annual fauna monitoring has been undertaken since 2000 (Gunninah 1997; Fatchen 2000, 2001, 2002; Tattersall 2003; Carter 2004, 2005; EBS 2006, 2007). The baseline fauna survey for the Beverley Mine Expansion was undertaken in 2006 (EBS 2006) with the first monitoring event undertaken in spring 2007 (EBS 2007).

As a result of the amount of survey effort, there are extensive datasets of fauna species known to occur in different habitats within the area. Therefore, detailed knowledge of the species likely to occur within the Four Mile Prospect are known and can be utilised when assessing possible impacts on fauna species, particularly those of conservation significance.

The baseline fauna survey for the Four Mile East and West deposits of the Beverley Four Mile project area was undertaken over an eight day period from 22 – 29 October 2007. A number of survey techniques were used to ensure a comprehensive coverage of species that occur in the survey area (detailed in EBS 2008 – Appendix G. Eight trapping sites were installed during the survey. Two pitfall lines (line A and line B) were installed at each site, along with 30 Elliott traps and four cage traps. Traps were checked for fauna and bait replaced (if necessary) each day in the morning and the late afternoon. Each site was opened for four nights.

Air photograph interpretation of the entire Beverley Four Mile project area (Figure 3-XXX above) indicates no significant differences in the flora, and by implication, fauna, for the southern part of the Beverley Four Mile project area that was not covered by the EBS (2008) study. In the future, an equivalent study would be prepared for any mining or infrastructure that may be later proposed for the southern portion of the Beverley Four Mile project area at least one year in advance of a proposed start of mining in those areas. The discussion below refers to the EBS (2008) study area for the Four Mile East and West deposits, but is likely to be relevant for the southern part of the project area also.

The trapping and fauna detection methods used were based on the standard biological survey methodology developed by the South Australian Department for Environment and Heritage (refer to Owens 2000). Pitfall,
Elliot, and cage traps were used at the trapping sites; harp traps and mist nets were used at suitable selected sites within the monitoring area. Active searching, spotlighting and AnaBat detectors were also used to detect fauna. Bird surveys were undertaken by an ornithologist at each site. Any opportunistic sightings of fauna and their locations were also noted.

The annual monitoring was conducted under the following licences and permits:

- Scientific Research Permit No. M25542 -1 (Department for Environment and Heritage)
- Wildlife Ethics Committee Permit No. 5/2006 (Wildlife Ethics Committee)

**Mammals**

Nine mammal species and 56 individuals were captured or directly observed at the Four Mile Prospect survey sites (Table 7 in Appendix G). A further eight bat species were detected at the survey sites using the AnaBat detectors, however, the number of individuals cannot be quantified using this survey method. Three species and four individuals were detected opportunistically. No conservation significant species were observed.

The annual monitoring was conducted under the following licences and permits:

- Scientific Research Permit No. M25542 -1 (Department for Environment and Heritage)
- Wildlife Ethics Committee Permit No. 5/2006 (Wildlife Ethics Committee)

The most commonly recorded species was the Fat-tailed Dunnart (*Sminthopsis crassicaudata*) with 23 individuals detected (Plate 2 of Appendix G). The least commonly detected species, with each only being detected once, were the Dingo (*Canis lupus dingo*), Euro (*Macropus robustus*) and Echidna (*Tachyglossus aculeatus*).

The diversity of mammal species did not vary between the three different broad habitat groups. The minor drainage lines had a slightly higher diversity compared to other habitat groups, but the differences are seen as minor (e.g. minor drainage lines had 2-3 more species than other sites). Interestingly, the sites within Four Mile Creek did not have a higher diversity of mammal species, particularly bat species, as expected.

The reason for this is likely to be the location of the survey sites and the low frequency of River Red Gums (*Eucalyptus camaldulensis*). The majority of the River Red Gums within the surveyed section of Four Mile Creek did not contain hollows. This would therefore reduce the diversity of species, particularly bats, that utilise the area. The bats recorded at other sites are likely to have flown in from further down Four Mile Creek which contains larger River Red Gums with numerous hollows.

Mammals previously recorded or known to occur in the vicinity of the project area but were not recorded during the current baseline survey include the Sandy Inland Mouse (*Pseudomys hermannsburgensis*) and the nationally vulnerable Dusky Hopping-mouse (*Notomys fuscus*) (EBS 2007). The Western Grey Kangaroo (*Macropus fuliginosus*) and Feral Cat (*Felis catus*) were also not recorded during the current survey.

**Reptiles and Amphibians**

Fifteen species and 46 individuals were detected at the monitoring sites (Table 9 of Appendix G). Four species and five individuals were noted opportunistically (Table 10 of Appendix G). Sixteen species were detected overall during the survey period. No conservation significant species were observed.

The most commonly observed species were the Eyrean Earless Dragon (*Tympanocryptis tetraporophora*) with 14 individuals detected and Tree Dtellas (*Gehyra variegata*) with six individuals detected. Several species were only detected once, including the Desert Wall Skink (*Cryptoblepharus plagioccephalus*), Mueller’s Lerista (*Lerista muelleri*), Common Snake-eye (*Morethia boulengeri*) and Smooth Knob-tailed Gecko (*Nephrurus levis*).
The diversity of reptiles was generally lower at the gibber sites compared to the minor and major drainage line sites. The diversity of habitat within the gibber sites is generally lower with very little cover present. This reduces the available refuges and promotes the species more adapted to living within relatively bare gibber plain areas. Additionally, some habitat features, such as leaf litter, are not present within the gibber plain areas, therefore reducing the number of species likely to be recorded at the gibber sites.

An additional seventeen species have been previously recorded within close proximity to the Beverley Four Mile area (in the previous surveys for the Beverley Mine and Mine Extension areas), which were not recorded in the current survey (Table 11 of Appendix G). These species include large elapids (Western Brown Snake and Mulga Snake) as well four gecko species. Suitable habitat occurs within the Beverley Four Mile Project area for these species to occur, however, it is likely that either weather conditions did not promote activity in some species (e.g. large elapids and geckos) or the species occur at low densities in the area and therefore were not detected.

In addition to the species recorded or likely to occur on site, a Common Bandy-bandy (Vermicella annulata) was recorded, after the current survey was completed, within the Four Mile project area (Hunt, D. pers. comm.). The Common Bandy-bandy is listed as being rare at the state level and has not been previously recorded within close proximity to the project site.

**Birds**

Thirty-seven species and 456 individuals were observed or detected at the monitoring sites (Table 12 of Appendix G. In addition twenty species and 77 individuals were observed or detected opportunistically (Table 13 of Appendix G. Overall, 38 species and 533 individuals were observed. No birds of conservation significant species were detected, however the Rainbow Bee-eater (Merops ornatus), an EPBC-listed Migratory species, was detected at FOU008.

The most commonly observed species were Galahs (Cacatua roseicapilla) with 98 individuals observed and Little Corellas (Cacatua sanguinea) with 70 individuals detected. The least observed species, with each only being detected once, were the Inland Thornbill (Acanthiza apicalis), Grey Shrike-thrush (Colluricincla harmonica), White-winged Triller (Lalage tricolor) and Common Bronzewing (Phaps chalcoptera).

Generally, the gibber plains sites had a lower diversity of bird species compared to the minor and major drainage lines. The minor and major drainage line sites have comparable bird species diversity, except for one major drainage line site which had more than double the number of bird species compared to any other survey site. It is likely that the increased bird species in the minor and major drainage lines is due to the diversity of habitat offered within these different areas.

Nesting and roosting sites are available for a broader range of bird species due to the presence of tree and shrub species and better protection from predators is offered when compared to the gibber plain sites. The gibber plain sites are generally more favourable for species which are either predominantly ground dwelling or spend time on the ground feeding.

A total of 16 additional bird species were recorded within the Beverley Mine and Mine Extension areas during the annual fauna monitoring surveys which were undertaken directly after the current Four Mile Prospect baseline survey (Table 14 of Appendix G). This is likely to be partly due to the increased survey effort during the Beverley Mine and Mine Extension monitoring program (12 sites surveyed versus 8 in the Four Mile Prospect baseline survey).
Four species recorded during the 2006 annual monitoring for the Beverley Mine were not recorded during the current baseline survey. It is likely that several of these species (e.g. Zebra Finch) were not present due to environmental conditions or specific habitat required for a species was not within the Four Mile project area (e.g. Little Grassbird and Clamourous Reedwarbler previously recorded within the reedbeds area near the Beverley camp).

3.12.3 Discussion

The presence of fauna species (particularly that of birds) will vary seasonally and in response to environmental conditions, consequently not all species that utilise the project area would have been detected during the baseline survey. However, the number of sites and the survey effort has resulted in a thorough fauna survey of the area. Additionally, previous surveys undertaken within the Beverley Mine and Mine Extensions areas also have provided extensive survey effort for the general region and provide valuable data on the species likely to occur within the current project area.

Weather conditions during the 2007 baseline fauna survey were not necessarily optimal for some survey techniques. For example, during most spotlighting nights, the conditions were very windy and relatively cool, which would have reduced the activity and possibly visibility of fauna. Windy conditions are also not optimal for mist netting or harp trapping because movement of the traps (as experienced in windy conditions), make the traps more visible to bats and consequently easier for them to avoid.

Comparisons of changes in faunal abundance and species diversity in the Beverley Four Mile Project area cannot be made at this stage, since the 2007 baseline survey was the first year fauna surveys have been undertaken in that area.

3.13 Topsoil and Subsoil

URS undertook a soil survey of the Four Mile East and West deposit part of the project area in the period July to November 2008. A full copy of the soil survey report is provided at Appendix B. Examination of regional soil maps and air photography suggests the findings of the soil survey can be expected to be reproduced in the southern part of the Beverley Four Mile project area. In the future, an equivalent study would be prepared for any mining or infrastructure that may be later proposed for the southern portion of the Beverley Four Mile project area at least one year in advance of a proposed start of mining in those areas. The discussion below refers to the URS study area for the Four Mile East and West deposits, but is likely to be relevant for the southern part of the project area also.

The objectives of the soil survey were to summarise the available descriptive information on soils with reference to the landforms, provide indicative baseline chemical and physical data of soil across various landforms, and to provide recommendations for management of the soils across the general landforms to minimise degradation of soil structure and erosion. The soil survey did not map the distribution of the main soil types across the study area but was designed to describe the physical and chemical nature of soils likely to be present across the proposed Beverley Four Mile Project area.

The scope of works included review of available published material and aerial photographs to determine the major landform and soil types in the vicinity of the site, excavation of test pits across the site and testing of soil samples for analysis for soil physical and chemical characterisation, reporting on observed soils and discussion of soil analytical results with reference to the soil properties.
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The investigation test pit locations were designed to assess variation in soil parent materials and soil physical properties in the vicinity of likely development areas within the proposed mining lease (e.g. trunklines, wellfields, roads) and across landform types (low and high elevation gibber plains, minor and major floodplains).

Soils on the Four Mile lease area can be classified as brown sandy clay profiles on the more elevated and better drained areas and brown sandy clay underlain by clayey gravel profiles on the floodplain zone of the lower plains. The sub-surface soil conditions are summarised in Table 3-6.

### Table 3-6  Generalised Sub Surface Soil Conditions

<table>
<thead>
<tr>
<th>Depth</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0 - 0.1</td>
<td>Silty Sandy CLAY; low to medium plasticity, brown to orange brown, fine sand, minor quartz gravels, occasional minor gibber gravel and cobbles at surface</td>
</tr>
<tr>
<td>0.1 – 1.0</td>
<td>Silty Sandy CLAY; medium to high plasticity, brown, fine sand, inferred calcareous, blocky</td>
</tr>
<tr>
<td>1.0 – 2.0</td>
<td>Silty Clayey GRAVEL; fine to coarse, brown with occasional white staining, calcareous silt, with some mixed cobbles, gravels and cobbles comprising mix of one or more of schist, quartzite, gneiss, pegmatite and granite.</td>
</tr>
</tbody>
</table>

The differences in soil morphology were associated with variation in physiography as follows:

- major ephemeral creekline (Four Mile Creek) dissecting the landscape - layers of sands and gravels were encountered to depth
- floodplain areas or surface gibber in the vicinity of minor or major creeklines - a subsurface layer of gravel was encountered in the majority of test pits
- higher elevation surface consisting of gibber plains distant from ephemeral drainage or creeklines - encountered only clay throughout the profile.

The surface soils are saline (low to moderately low salinity) and non-sodic while subsoils are saline (high salinity) and sodic. Variations in this pattern were associated with enhanced leaching along major creek lines.

Soils across the site have low wet strength, slaking when wet. This limits their traffickability when wet.

The baseline data also established background soil chemical conditions (primarily pH, electrical conductivity and major ion chemistry) in the event of an unexpected chemical release such as saline extraction solutions from the trunkline.

The topography of the majority of site is relatively flat or gently sloping and as such the risk of significant rill erosion and runoff is likely to be low where the natural soil surface is protected from channelled overland flow. Gibbers are present at the surface of much of the plains of the site; the resulting surface has a low permeability but is generally considered quite resistant to water erosion.

Management strategies are presented in the Soil Survey report (Appendix B to minimise soil degradation and erosion from activities such as excavation, handling and stockpiling of materials including topsoils during development of roads, tracks, structures such as wellhouses, and mud pits for drilling. It is noted that it is not the disturbance of soil per se that has the potential to cause environmental impacts at the site; rather it is the potential for soil disturbance to lead to problems such as enhanced erosion and sedimentation.
3.14 Heritage

3.14.1 Aboriginal Heritage

As part of the 1998 Beverley EIS process, anthropological and archaeological investigations in conjunction with the Native Title claimants were undertaken in 1997 within the original Mining Lease and Miscellaneous Purpose Lease areas. No sites were identified as requiring entry on the South Australia Register of Aboriginal Sites.

Since that time, numerous heritage surveys (Work Area Clearance inspections) have been conducted over both the Four Mile MLA area and the extended Beverley ML (ML 6321). Maps have been produced in association with the researchers, which detail areas where approval has been granted for exploration, mining and related activities.

The Work Area Clearance methodology adopted by the company in association with the Native Title applicants, has been developed to minimise potential deleterious impact upon Aboriginal cultural values at all stages of exploration and development within the area (refer Section 7.10.9).

3.14.2 European Heritage

The Flinders Ranges is of significance to European heritage. From the start of European use of the Flinders Ranges and immediate surrounds in the 1850s, the historical land use of the region has been primarily pastoral. Mining has been historically a secondary land use. Apart from coal mining post-World War 2 at Leigh Creek, other minerals have been successfully mined, particularly copper, gold, talc, and barite.

The Four Mile MLA itself contains no artefacts of European occupation of historical value. The operation of the existing Beverley mine and its associated facilities has had no impact upon the European heritage of the area, and an extension of the area on which wellfields could be developed would also have no impact.

3.14.3 Heritage Management

Inspections have been conducted using the Heathgate Work Area Clearance methodology, adopted by the company in association with the Native Title applicants, to minimise potential deleterious impact upon Aboriginal cultural values at all stages of exploration and development within the mining leases and licences held. This methodology and the inspections it has generated have resulted in detailed and in most cases, on-foot investigation, of areas covered by the Four Mile MLA.

The Work Area Clearance methodology was developed in the Northern Territory to permit Aboriginal traditional owners, in company with cultural heritage professionals or advisors, (but not those professionals or advisors alone), to assess activities proposed on Aboriginal land, without the necessity for them to divulge information on the cultural amenity of the area within which work is proposed.

The Native Title applicants are generally considered by their peers to be most closely associated with the Wooltana Pastoral Lease and surrounding areas, and are knowledgeable about its cultural amenity. This is the preferred approach of the body representing the Native Title claimants for the area under review and the one that most closely replicates the traditional decision-making responsibilities that previously applied in this area.

Such an approach is recommended as one most likely to ensure continuing protection for the cultural heritage values and places associated with the areas under consideration. It is also considered to have the benefit of promising opportunity for Heathgate and Quasar to negotiate reasonable and speedy resolution of matters essential for future mine development within such tenements as they may be granted in this location.
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3.14.4 National Estate Listings

The Four Mile MLA is not subject to any National Estate or similar listings.

3.14.5 Development Act Listing

The Beverley Four Mile mine is located in the Land not within a Council Area (Flinders) Development Plan, consolidated 25th September 2003. This Plan was current (according to the Planning SA website) on 6th December 2008: http://www.planning.sa.gov.au/go/development-plans/development-plans-online/country-plans.

The zone boundaries in the Beverley Four Mile Project area are shown in Figure 2-2. The satellite plant and access road from the Beverley plant is in the PaLa (Pastoral Landscape) zone, but most of the deposit areas, and thus most of the wellfields and associated wellhouses, would be in Environment Zone A.

The Development Plan objective in relation to mining is:

Objective 16: The protection of the landscape from undue damage from prospecting, mining, quarrying, and similar extractive and associated manufacturing industries.

In relation to this objective, the Plan states that:

The permanent effect of mining operations on the appearance of the landscape should be considered before operations begin. It is important that prospecting, and mining and quarrying operations, be carefully planned to avoid unnecessary impairment of the landscape. Structures should be removed and the natural cover of land restored so far as possible after workings are finished.

At Leigh Creek the massive disturbance of the earth by open-cut mining will preclude the restoration of the land to its original state when mining operations are completed. However an attractive artificial landscape should be created using the cuts and dumps in conjunction with the diversion of streams and planting of vegetation to the best advantage.

In relation to this objective, the nature of the ISR mining undertaken at Four Mile means its surface impact is small during operations and, unlike Leigh Creek, when structures are removed the natural cover of land will be able to be restored to very close to original. Exceptions may be if parts of the infrastructure, such as some roads, are retained long term. However, any of the infrastructure that might be retained is typical of a pastoral landscape (although on a larger scale) and is not considered to detract from the landscape.

The Development Plan also includes additional objectives for the zones within the Plan. These are listed below:

Pastoral Zone (PaLa)

Objective 1: The preservation of the environmental and scenic qualities of the foreground of the most prominent ranges.

Environment Zone A (EnA)

Objective 1: The conservation of the natural character and environment of the area.

Objective 2: The protection of the landscape from damage by mining operations and exploring for new resources.

Objective 3: Roads which do not unduly disturb the natural character and beauty of the area.

In relation to Objective 2 for Environment Zone A, the Development Plan states that:
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*Mining operations should not take place in the Environmental Class A Zone unless the deposits are of such paramount importance and their exploitation is in the highest national or State interest that all other environment, heritage or conservation considerations may be overridden. Deposits which may potentially have the required degree of significance have been identified in the following localities only: the western face of the Heysen Ranges; portion of the Moralana Valley; portion of the Mount Hack and Mount Uro areas; portion of the Stirrup Iron Range; portion of the east Gammons and the Mount Painter-Freering Heights area.*

In addition, in relation to mining the Principles of Development Control for Environment Zone A state:

4. No mining operations should take place in the Environmental Class A Zone except where:

   (a) the deposits are of such paramount significance that all other environment, heritage or conservation considerations may be overridden;

   (b) the exploitation of the deposits is in the National or State interest;

   (c) investigations have shown that alternative deposits are not available on other land in the locality outside the zone; and

   (d) the operations are subject to stringent safeguards to protect the landscape and natural environment.

Mining is a permitted use in both the PaLa and EnA zones, subject to the considerations above. It is considered that the development of Beverley Four Mile Project is in conformance with the objectives; in particular the Four Mile development conforms to item 4 of the principles of development for the EnA zone.

### 3.15 Proximity to Conservation Areas

The nearest conservation areas are the Vulkathunha-Gammon Ranges National Park and the Arkaroola Wilderness Sanctuary (a declared Sanctuary under the SA National Parks and Wildlife Act 1972) (Figure 3-1). The Vulkathunha–Gammon Ranges National Park includes a section of plain between the Northern Flinders Ranges and Lake Frome of similar character to the proposed mining lease. Refer also to Section 3.2.

Paralana Hot Springs (Figure 3-1) is simultaneously of major significance to Aboriginal people, a tourist attraction, a site of particular geological interest and, albeit radioactive, the closest permanent natural surface water to the site. The springs are located on Wooltana Station adjacent to the Arkaroola Wilderness Sanctuary. The proposed Beverley Four Mile Project will not impinge on the springs.

Lake Frome was proclaimed a Regional Reserve on 19 December 1991 and comprises 259,615 ha. The reserve was proclaimed to extend the conservation management of the adjoining Vulkathunha-Gammon Ranges National Park. It conserves a large arid salt lake system that is of regional geological significance. The dominant land use of the reserve is biological and cultural conservation. It is located south-east of the proposed Beverley Four Mile Project Beverley, and at its closest is some 40 km distant.

There are some areas within the proposed Beverley Four Mile Project MLA that are considered environmentally sensitive for reasons such as unusual vegetation, good faunal habitat, gibber/gilgai landforms posing erosion hazards or because they are flood prone areas thus care and environmental sensitivity is taken in surface activities throughout the mining process. The clearance of native vegetation is subject to the issuing of individual clearance permits under Heathgate’s Environment Management System (see Section 7.5.3).
Pre-existing Site Contamination and Disturbance

No mining-related site disturbance or pre-existing contamination is known to exist on the proposed Beverley Four Mile Project MLA.

The Lake Frome Plains area has, however, been subject to some mining and pastoral activity since European settlement. This is evident by ruins in the vicinity of the ML, such as the old Paralana Homestead and a number of small mines and associated structures. Pastoral activity in the region since the late 1850’s has also resulted in substantial modification to natural vegetation.

Natural Radioactivity

3.17.1 Context

Radiation is a part of universe and our life and was present on earth even before the evolution of human kind. The radiation that we receive from nature is called natural radiation or natural background radiation. The sources of natural background radiation are cosmic radiation and terrestrial radiation. Radiation that has enough energy to cause ionisation of molecules or atoms that it collides with is called ionising radiation. Lower energy radiation such as infra-red or microwaves do not cause ionisation of molecules or atoms but can have effects on living tissue by other means.

Radioactivity is the term used to describe the breakdown of unstable atoms and the associated release of energy, which is in the form of subatomic particles or electromagnetic waves. Over time radioactive material is completely broken down (this is called radioactive decay), stable atoms are formed and there is no further release of energy or radiation. Intermediate atoms that decay further and stable atoms resulting from the decay of the initial atom are called decay (or daughter) products. In natural settings uranium is accompanied by 13 radioactive decay products as well as the ultimate stable decay product the lead isotope Pb-206.

During the decay process radioactive atoms mainly emit three different types of ionising radiation, alpha, beta and gamma. Radiation when it passes through matter dissipates its energy, and the released energy is absorbed in the medium; this is termed as Radiation Dose. The unit that quantifies radiation dose is Sievert (Sv). Sievert is a large unit and so the millisievert or microsievert is usually used to describe occupational radiation dose.

Different types of radiation have different energies and hence varying penetrating powers in human tissue. The radiation dose absorbed in tissue depends on the type of radiation and its penetrating power. The sensitivity of different types of tissues or organs to radiation in human body is different, and hence some organs are more susceptible to the effects of ionising radiation.

Radiation exposure to human body can take place either from external exposure to radiation sources or through inhalation and ingestion of radioactive materials. The biological effects of exposure to ionising radiation depend on the amount of radiation received and the rate at which it is received.

When people are exposed to very low levels of ionising radiation the damage that it causes to the body is practically negligible, because of the ability of living cells to repair any minor damage that it may sustain from the exposure. Serious damage to the body or future generations is possible only when people are exposed to high amounts of radiation dose.

Uranium is an unstable atom that emits radiation during its decay process. As a result occupational exposure to very low levels of radiation is expected during mining operations. Radiation exposure to employees and members of public are minimised using various engineering and administrative controls. Details of this are
available in Heathgate’s Radiation Management Plan (RMP) and Radioactive Waste Management Plan (RWMP), which are approved by the South Australian Environment Protection Authority (SA EPA), Radiation Protection Branch.


For workers who are occupationally exposed to radiation, the dose limit is 20 mSv per annum averaged over a five year period. For members of the public the dose limit set in this national standard is an annual effective dose of 1 mSv above the ambient background dose rate, excluding exposure from medical procedures.

The ISR process to recover uranium from its ore significantly reduces the occupational exposure to workers. Table 3-7 gives the average and maximum radiation doses received by the employees during the operation of Beverley Uranium Mine over the past seven years. The occupational radiation dose received by the workers of Heathgate Resources is much lower than the annual limit set in the national standard.

Table 3-7  Occupational Dose Received at Beverley

<table>
<thead>
<tr>
<th>Year</th>
<th>Occupational Dose (mSv)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Avg</td>
</tr>
<tr>
<td>2001</td>
<td>0.63</td>
</tr>
<tr>
<td>2002</td>
<td>0.74</td>
</tr>
<tr>
<td>2003</td>
<td>0.68</td>
</tr>
<tr>
<td>2004</td>
<td>0.89</td>
</tr>
<tr>
<td>2005</td>
<td>0.48</td>
</tr>
<tr>
<td>2006</td>
<td>0.45</td>
</tr>
<tr>
<td>2007</td>
<td>0.28</td>
</tr>
</tbody>
</table>

3.17.2  Four Mile Background Radiation Levels

The average dose from natural background ionising radiation, from radionuclides in the soil, radon in air, cosmic rays, and radionuclides in food, received by everyone in the world is generally between 2 mSv and 3 mSv per year.

The Paralana Creek near to the project area is a historically identified source of radon because of the elevated radium content in the water. Both of these are decay products of uranium.

Gamma radiation levels from the natural background in some of the creeks in the Beverley Four Mile area are slightly elevated than the rest of the area. This is mainly due to the erosion of some of the rocks of the northern Flinders Ranges, which have naturally above-background concentrations of radionuclides, particularly uranium and thorium and their decay products.
Gamma surveys undertaken in the Beverley Four Mile Project area prior to the commencement of drilling operations show that the average gamma radiation field at approximately 1 m above the ground is 0.11 µSv/h, with maximum reading measured up to 0.18 µSv/h (Figure 3-36).

The background gamma radiation levels are much higher in several of the creek beds than the plains. A recently conducted survey shows that the radiation field in the Four Mile creek beds varies in the range 0.6 to 1.4 µSv/h (Table 3-8).

**Table 3-8 Background Gamma Radiation in Four Mile Creek Beds**

<table>
<thead>
<tr>
<th>Location</th>
<th>Gamma Field (µSv/h)</th>
<th>Location</th>
<th>Gamma Field (µSv/h)</th>
<th>Location</th>
<th>Gamma Field (µSv/h)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.7</td>
<td>8</td>
<td>1.1</td>
<td>15</td>
<td>0.7</td>
</tr>
<tr>
<td>2</td>
<td>0.8</td>
<td>9</td>
<td>0.6</td>
<td>16</td>
<td>1.4</td>
</tr>
<tr>
<td>3</td>
<td>0.9</td>
<td>10</td>
<td>0.6</td>
<td>17</td>
<td>1.4</td>
</tr>
<tr>
<td>4</td>
<td>1.2</td>
<td>11</td>
<td>0.7</td>
<td>18</td>
<td>1.0</td>
</tr>
<tr>
<td>5</td>
<td>0.7</td>
<td>12</td>
<td>0.6</td>
<td>19</td>
<td>1.2</td>
</tr>
<tr>
<td>6</td>
<td>0.8</td>
<td>13</td>
<td>0.7</td>
<td>20</td>
<td>1.0</td>
</tr>
<tr>
<td>7</td>
<td>1.1</td>
<td>14</td>
<td>0.7</td>
<td>21</td>
<td>1.0</td>
</tr>
</tbody>
</table>
A low level airborne radiometric survey done in May 2008 by UTS Geophysics using an Exploranium GR-820 gamma ray spectrometer mapped the natural background dose rate as well as the ground concentrations of uranium, thorium and potassium in the project area. (Whilst all uranium and thorium atoms are radioactive, most potassium is not. However, potassium-40 (K-40) is a naturally occurring isotope of potassium that contributes to natural radiation doses and can be measured by sensitive instruments. Because the ratio of radioactive to total potassium atoms is constant, measurements of K-40 can be used to estimate total potassium content of materials such as soil and rock).

Figures 3-37 to 3-40 show the results of this survey as the finely detailed information over most of the Beverley Four Mile Mine Lease Application area, supplemented by publicly available data for the Flinders Ranges in the west (courtesy PIRSA).

Uranium concentrations at the soil surface determined by the airborne spectrophotometry in the Beverley Four Mile Project area vary from 0.6 to 6.5 ppm. Elevated concentrations up to 12.3 ppm are measured in some of the creek beds and in the nearby Flinders Ranges (the source).

Thorium concentrations at the soil surface in the project area vary from 15 to 60 ppm whereas in some of the creek beds and the nearby Ranges the levels reach up to 73.5 ppm. The patterns of uranium and thorium concentration are generally similar in both the Flinders Ranges (the source) and the creek beds.

Potassium concentrations are also shown but relate to total potassium, not the radionuclide K-40. The pattern is different to both uranium and thorium both in the Flinders Ranges and the creek beds.

The dose rate from the natural background terrestrial radiation in the project area varies from 60 to 200 nGy/h. In many of the creek beds it is in the range 220 to 260nGy/h, and in the Paralana Creek bed and in the nearby Ranges it reaches up to 300 nGy/h. It most closely matches the pattern of uranium and thorium, suggesting the contribution by K-40 to the total natural dose rate is small.

Radiation (and weather) monitoring stations have been operating in Beverley Four Mile East and West areas since February 2007. Each of these monitoring stations have devices to measure long-lived alpha (LLA) dust concentration in air, radon decay products concentration in air, temperature, wind speed and direction, humidity and rainfall. The summary meteorological data are presented in Section 3.7.

The measured Natural Radon (Rn) and Radon Daughter Products (RnD) concentration in air is highly variable, showing a strong diurnal cycle and is also influenced by the day by day weather pattern. Seasonal and year to year variations are also noticeable depending on long term weather patterns.
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Figure 3-37  Four Mile Uranium Concentrations
Figure 3-38  Four Mile Thorium Concentrations
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Figure 3-39 Four Mile Potassium Concentrations
Figure 3-40  Four Mile Background Dose Rate
Continuous RnD monitoring at Four Mile is carried out using Environmental Radon Daughter Monitors (ERDM). The average RnD concentration measured in the area is 0.05 µJ/m$^3$ and the maximum reaches up to 0.99 µJ/m$^3$ (Table 3-9). A graphical representation of the RnD concentrations is shown in Figures 3.41 and 3.42.

### Table 3-9 Four Mile Radon Daughter Concentrations

<table>
<thead>
<tr>
<th>Month &amp; Year</th>
<th>RnD Concentration (µJ/m$^3$)</th>
<th>East</th>
<th>West</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Avg</td>
<td>Max</td>
</tr>
<tr>
<td>Feb-07</td>
<td></td>
<td>0.03</td>
<td>0.25</td>
</tr>
<tr>
<td>Mar-07</td>
<td></td>
<td>0.03</td>
<td>0.2</td>
</tr>
<tr>
<td>Apr-07</td>
<td></td>
<td>0.03</td>
<td>0.3</td>
</tr>
<tr>
<td>May-07</td>
<td></td>
<td>0.05</td>
<td>0.18</td>
</tr>
<tr>
<td>Jun-07</td>
<td></td>
<td>0.03</td>
<td>0.19</td>
</tr>
<tr>
<td>Jul-07</td>
<td></td>
<td>0.05</td>
<td>0.28</td>
</tr>
<tr>
<td>Aug-07</td>
<td></td>
<td>0.04</td>
<td>0.31</td>
</tr>
<tr>
<td>Sep-07</td>
<td></td>
<td>0.03</td>
<td>0.25</td>
</tr>
<tr>
<td>Oct-07</td>
<td></td>
<td>0.03</td>
<td>0.19</td>
</tr>
<tr>
<td>Nov-07</td>
<td></td>
<td>0.03</td>
<td>0.19</td>
</tr>
<tr>
<td>Dec-07</td>
<td></td>
<td>0.03</td>
<td>0.18</td>
</tr>
<tr>
<td>Jan-08</td>
<td></td>
<td>0.02</td>
<td>0.54</td>
</tr>
<tr>
<td>Feb-08</td>
<td></td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Mar-08</td>
<td></td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Apr-08</td>
<td></td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>May-08</td>
<td></td>
<td>0.06</td>
<td>0.26</td>
</tr>
<tr>
<td>Jun-08</td>
<td></td>
<td>0.1</td>
<td>0.89</td>
</tr>
<tr>
<td>Jul-08</td>
<td></td>
<td>0.06</td>
<td>0.36</td>
</tr>
<tr>
<td>Aug-08</td>
<td></td>
<td>0.06</td>
<td>0.34</td>
</tr>
<tr>
<td>Sep-08</td>
<td></td>
<td>0.08</td>
<td>0.62</td>
</tr>
<tr>
<td>Oct-08</td>
<td></td>
<td>0.06</td>
<td>0.35</td>
</tr>
</tbody>
</table>
The monitoring of LLA dust is carried out using Ecotech Microvol samplers. Dust from the sampled air is collected in filters and then analysed using an alpha counter for gross alpha activity. The average measured LLA dust concentration is 0.36 mBq/m³ and the maximum value is 1.81 mBq/m³ (Table 3-10). Figure 3-43 shows the LLA data graphically. Note that there is insufficient data for Four Mile West for a graph to be presented (refer Table 3.10).
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Table 3-10 Long Lived Alpha Dust Concentrations

<table>
<thead>
<tr>
<th>Month &amp; Year</th>
<th>LLA Dust (mBq/m³)</th>
<th>East</th>
<th>West</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dec-06</td>
<td>0.74</td>
<td>0.55</td>
<td></td>
</tr>
<tr>
<td>Jan-07</td>
<td>1.10</td>
<td>1.30</td>
<td></td>
</tr>
<tr>
<td>Feb-07</td>
<td>0.00</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Mar-07</td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Apr-07</td>
<td>0.09</td>
<td>0.19</td>
<td></td>
</tr>
<tr>
<td>May-07</td>
<td>0.37</td>
<td>0.81</td>
<td></td>
</tr>
<tr>
<td>Jun-07</td>
<td>0.27</td>
<td>0.41</td>
<td></td>
</tr>
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<td>NA</td>
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</tr>
<tr>
<td>Nov-07</td>
<td>0.03</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Dec-07</td>
<td>1.51</td>
<td>NA</td>
<td></td>
</tr>
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<td>Jan-08</td>
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</tr>
<tr>
<td>Feb-08</td>
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</tr>
<tr>
<td>Mar-08</td>
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</tr>
<tr>
<td>Apr-08</td>
<td>0.41</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>May-08</td>
<td>0.39</td>
<td>NA</td>
<td></td>
</tr>
<tr>
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<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Jul-08</td>
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<td></td>
</tr>
<tr>
<td>Aug-08</td>
<td>0.00</td>
<td>NA</td>
<td></td>
</tr>
<tr>
<td>Sep-08</td>
<td>0.64</td>
<td>0.15</td>
<td></td>
</tr>
</tbody>
</table>
Description of the Natural, Social and Economic Environment

Figure 3-43  Four Mile Long Lived Alpha Concentrations
4.1 General Description

4.1.1 Background and Relation to Other Actions

As described in Section 1.5, the Beverley Four Mile Project entails construction of a satellite facility close to the Four Mile deposits, and construction of ISR wellfields of the same design as currently used on the Beverley mining lease. The Four Mile satellite facility would remove the uranium from the ISR liquor by physical means, producing uranium bearing resin, which would be trucked to the Beverley processing plant. The resin would then be stripped of uranium, and trucked back to the satellite facility.

Minor modifications would be required at the Beverley processing plant to accept the uranium-bearing resin, however there would be no net increase in uranium processing capacity. The uranium stripped from the resin would be processed at Beverley, and the small quantity of liquid waste arising would be disposed of at Beverley.

There would be no change to the existing Beverley camps, airstrip and camp water supply bore. An unsealed access road would be constructed between the Beverley processing plant and the Four Mile satellite facility. Some additional internal roads would be necessary within the proposed Four Mile mining lease to access the wellfields.

Some additional fencing may be installed along the western boundary of the Four Mile deposits for security purposes. There is also a 4WD track to Hidden Valley, which runs north-east from Paralana Springs approximately along the Wooltana / ArKaroola pastoral lease boundary; and presently cuts across the Four Mile West deposit. This track would be re-aligned around the Four Mile West deposit.

Figure 1-4 shows the location of the Four Mile deposits and a possible location for the satellite plant and the access road.

4.1.2 Location and Distance to Nearest Town

The project location and distance to closest communities is described in Section 3-1, and Figure 3-1 shows the locations of these communities.

As described in this section, the nearest communities include the tourist resort at ArKaroola and the Aboriginal community at Nepabunna. A total of some 50 permanent residents live within a 50 km radius of the Beverley Four Mile Project site. This figure includes staff at the ArKaroola tourist facilities and Woolltana Station, each some 25 to 30 km distant. The population at ArKaroola varies with tourist demand.

The North Mulga outstation of Wolltana Station is located 10 km east of Beverley and is only occupied for approximately 6 months per year. Small numbers of people reside at the former homestead of Balcanoona, which is now the Vulkathunha-Gammon Ranges National Park headquarters (45 km south-west).

The Aboriginal communities of Nepabunna and Iga Warta are approximately 75 km from the Beverley Four Mile Project site, on the western side of the Gammon Ranges (Figure 3-1). These communities are within Aboriginal Lands and operate as self-contained settlements. The population is currently estimated to be about 120 persons but it fluctuates with the movement of residents to and from the townships. Leigh Creek, some 150 km to the west, is the nearest significant township and service centre.
4.1.3 Current Status of Action

The current status of the action is described in Section 1.1. As stated in that section, this document has been prepared in accordance with Guidelines dated 17 September 2008 prepared by PIRSA and DEWHA (DEWHA, PIRSA 2008), for construction and operation of the Beverley Four Mile Project (refer Appendix A).

As well as approval of the SA Minister for Mineral Resources Development (and various other approvals under various Acts [refer Section 4.1.4]), the proposed action is a “controlled action” under the Commonwealth Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act) (because of the Sections 21 and 22A - nuclear actions). Thus approval is required from the Australian Government Minister for the Environment and Water Resources.

The purpose of the document is to satisfy the requirements of the South Australian Government for a Mining Lease Proposal to support an application for a Mining Lease under the SA Mining Act 1971, and the Commonwealth Government’s requirements for a Public Environment Report (PER) under the EPBC Act.

In terms of status of activities on site, the Four Mile deposits lie within the boundaries of the Exploration Lease EL 3666. Extensive exploration of the Four Mile deposits has been undertaken; the extent of the exploration drilling and the resource estimate is described in Section 4.2.2.

4.1.4 Other Approval Requirements

The key items of legislation relevant to the Beverley Four Mile Project are listed in Table 7-1.

There are three principal further State approvals; these are:

1) Following approval of this PER / MLA Proposal, a Mining and Rehabilitation Plan (MARP) would be submitted to PIRSA, to gain operational approval of the proposed mining activities. The MARP would be based broadly on this PER / MLA Proposal document, but would include some additional detail as set out in Section 3 of the Guidelines (refer Appendix A). It is noted that Heathgate is the operator at Beverley, and would also be the operator of the Beverley Four Mile Project. Thus a single consolidated MARP covering both the Beverley and Beverley Four Mile Project may be prepared, using as a basis the existing Beverley MARP (Heathgate Resources Pty Ltd 2008c). This is for PIRSA to determine.

2) Licensing under the Radiation Protection and Control Act 1982 (SA), referred to generally as a Radiation Licence. As above, it is noted that Heathgate would be the operator of both the Beverley and the Beverley Four Mile Project operations. Thus the RPC Act licensing for the Beverley Four Mile Project may be consolidated into the existing Beverley licence. This is for the SA EPA to determine.

3) Licensing under the Environment Protection Act 1993 (SA). In particular, as a stand alone operation, the satellite plant would be a prescribed activity under the EP Act. However the satellite plant would be integral to the Beverley operations, and Heathgate would be the operator of both the Beverley and the Beverley Four Mile Project operations. Thus the Four Mile satellite plant could be treated as a process change to the existing activities at Beverley. This is a matter for the SA EPA to determine. In any event, the supporting information required for the applications would be similar, although the forms are different.

There are two particular other Commonwealth approvals that may be required. These are:

1) A permit and approval for possession of nuclear material (including uranium) (Australian Safeguards and Non-Proliferation Office (ASNO), under the Nuclear Non-Proliferation (Safeguards) Act 1987). It is noted that the existing Beverley permit may cover the Beverley Four Mile Project; this is a matter for the Commonwealth authorities to determine.
2) An export licence for the export of radioactive material (Dept of Industry, Tourism and Resources, under the *Customs (Prohibited Exports) Regulations* 1958 and amendments 2000, under the *Customs Act* 1901). Again it is noted that the existing Beverley export licence may cover the Beverley Four Mile Project; this is a matter for the Commonwealth authorities to determine.

As listed in Table 7-1, there are certain Commonwealth standards or guidelines that are applicable, and which are used as reference by State authorities. The key ones are:

- Protection of environment and human health from impact from radioactive materials, e.g. *Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing* (ARPANSA 2005)

### 4.1.5 Feasible Alternatives

There are two identified alternatives to the Beverley Four Mile ISR Project described in this document. These are described below.

**Open Cut Mining**

The structural strength of the overburden material of the Four Mile deposits is low to very low, which would require pit slopes of about 35 degrees for an open cut operation. Thus the footprint and site disturbance that would result from open pit mining would be much greater than that for an ISR project.

In addition the open cut option would require a complete new processing plant, as the uranium concentration in leached liquor from a metallurgical plant would be unsuitable as a feedstock for processing at Beverley. Thus an open cut mining operation would be a high capital project. It has thus been decided to proceed with the ISR option at this time.

**Not Proceeding with the Beverley Four Mile Project**

If the Beverley Four Mile Project was not proceeded with, the existing Beverley Mine would run out of mineable uranium resources within two years, and be financially unviable, and would close.

The State and Traditional owners would thus not gain the economic benefits of the Beverley Mine operations, including royalties, taxes and employment, and the nationally there would be a loss of export income.

As noted in Section 3.1, Beverley contributes over $1.5 million/year in Aboriginal royalties, administration and community payments, $2.2 million/year in State royalties, taxes, fees and licenses and pays about $25 million/year to regional and state businesses and suppliers.

Heathgate also strives to achieve 20% Aboriginal employment at the mine site by providing employment to Traditional owners; these jobs would be lost, in addition to loss of royalties and other payments.

Beverley's annual export income is currently a positive contributor to the national balance of payments; the current operations at Beverley are a $120 million investment, with an export income of about $100 million per annum.
Section 4  

Description of the Operations

4.2 Ore Reserves and Market

4.2.1 Geological Environment

The Four Mile uranium deposit was discovered in a drilling program in 2005, and is located in the Paralana High Plains west of the Beverley uranium mine, close to the eastern margin of the Flinders Ranges, in north east South Australia. A stratigraphic cross-section of the region, showing known and potential uranium deposits, is shown in Figure 4-1.

The geologic setting of the Four Mile deposit is in Tertiary sediments of the Callabonna sub-basin of the Lake Eyre Basin. These sediments cover an area of approximately 25,000 square kilometres between the Mt. Painter Inlier in the NW, the Olary block to the south and Broken Hill block to the east. Basement to this sub basin may be variably Cretaceous Palaeozoic, Adelaidian or Mid to Lower Proterozoic, generally following that progression from NW to SE. The sub basin comprises an almost flat lying sequence reaching 300 m maximum thickness.

In its southern part, Lower Tertiary (Eocene) Eyre formation sediments are restricted to incised palaeovalley infill. Overall gentle palaeovalley gradients are towards to north where skeletal valley fill sediments grade into widespread blanket sands overlying the Cretaceous Frome Embayment. Mesoproterozoic, uranium rich granites within infringing or underlying terranes are considered the source for the uranium mineralisation.

Other palaeo channel uranium deposits occur within the Tertiary units of the Callabonna and Birdsville Basins of the Frome Region. This uranium province was recognised some years ago as having the potential for additional discoveries of uranium resources. The Four Mile deposit, as with the Beverley deposit is hosted by valley fill fluviatile sands in Eocene to Miocene palaeo channels concealed beneath later lacustrine and fluviatile deposits.

The host sediments are predominately sands intercalated with clay beds, generally in upward fining sequences. The basal Palaeo Channel mineralogy reflects nearby basement providences. The Four Mile deposit is in an inferred NE trending half graben within the Paralana-Wertalonna structural zone.

Interpretation of seismic data has previously identified the major faults as west-dipping structures that extend well down into Proterozoic basement rocks and show west over east compression. The structural regime was established in the early Palaeozoic and has periodically re-activated (Heathgate Resources, 2006b). The faults generally extend steeply to within 100m of surface.

Following an assessment of a high resolution gravity survey for the region, the tectonics and stratigraphy in the Four Mile region have been reassessed. It is now believed that fault locations are known with improved precision.

The region between the Poontana and Paralana faults is interpreted as a complex of fault-bounded blocks that are progressively higher to the west or north-west. The major basement relief on the cross-section is caused by faulting but displacement magnitudes are difficult to establish.
Figure 4-1  Regional Stratigraphic Cross-Section
4.2.2 Reserves and Resources

The resource estimates for the Four Mile first stage mining area (FMSA) are based on 109 core drill holes and 678 rotary mud drillholes, giving a total of 787 drill holes. The resource calculations for the FMSA were undertaken utilising two methods, the Inverse Distance (ID) and Ordinary Kriged (OK) 3D block models. It should be noted that the FMSA represents a fraction of the total Four Mile resource region.

Results from these two methods were within 4% of each other for pounds of $\text{U}_3\text{O}_8$ contained. The results are based on a block cut off grade of 0.05% $\text{U}_3\text{O}_8$. It was recommended by the resource analyst that the figures estimated using Ordinary Kriging be used, which give slightly higher grades with lower volumes than the Inverse Distance estimates. The estimate would be classified as Inferred Resource under the JORC code if confirmed by a JORC Competent Person. A summary of the resource estimate by the two methods is provided in Table 4.1.

<table>
<thead>
<tr>
<th>Resource Calculation Method</th>
<th>Cutoff $\text{U}_3\text{O}_8$ %</th>
<th>$\text{U}_3\text{O}_8$ % (average)</th>
<th>Volume ($\text{m}^3$)</th>
<th>$\text{U}_3\text{O}_8$ lbs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ordinary Kriged</td>
<td>0.05</td>
<td>0.16</td>
<td>1,360,000</td>
<td>10,200,000</td>
</tr>
<tr>
<td>Inverse Distance</td>
<td>0.05</td>
<td>0.14</td>
<td>1,540,000</td>
<td>9,830,000</td>
</tr>
</tbody>
</table>

FSMA = first stage mining area

The resource study identified that the Four Mile mineralization occurs in three main seams. In many locations mineralization is present in all the seams, which means that the ISR mining process will require several re-screens of the production wells to fully exploit the deposits.

4.2.3 Market

Global population is predicted to double from 5 billion between early and the middle of the 21st century and consumer demand for electricity (particularly in eastern Europe and Asia) is set to more than double. The world population (http://www.census.gov/ipc/www/popclockworld.html) at July 2008 is estimated to be 6.7 billion. This will lead to increasing dependence on electricity and thus nuclear power stations. About 17% of the world’s electrical energy is currently generated by nuclear power.

The Uranium Institute in London says uranium production in 2006 was insufficient to meet demand, a condition that has persisted for over a decade. Australian exports are now approaching 9000 tonnes per year of uranium oxide concentrate - about 25% of world uranium supply.

Uranium prices vary as the balance between supply and demand fluctuates. Over the past couple of years, prices have increased 10 times or more from historic lows. Most recent prices have retreated from a peak in mid 2007 but are still well above those of three years ago (http://www.uxc.com/).

All Beverley contracts are subject to Australian Government safeguards requirements. The main customers are in:

- Japan
- Europe (presently only France)
- United States.
Description of the Operations

All ongoing sales from the Beverley Four Mile Project, as part of the production from the Beverley Uranium Mine processing plant, will continue to be subject to the safeguard requirements. Sales may be made to other approved countries in the future.

4.2.4 Radioactive Substances and Ores

Where radioactive ores are to be mined, preoperational monitoring is required to determine background radiation levels in the environment. These measurements are required to ensure that the mining operation does not significantly increase exposure of the environment to radiation as a result of mining activities.

Heathgate will prepare a RMP and a RWMP to satisfy the monitoring and reporting requirements under relevant regulations and Codes of Practice (particularly the ARPANSA Code *Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing* (2005)).

These plans will be submitted to, and approved, by the SA EPA RPD prior to construction and operation, and adapted from those recently updated for Beverley ML 6321 operations. It is likely that consolidated documents would be submitted for approval for combined Beverley ML 6321 and Beverley Four Mile operations. This is to be discussed with the SA EPA RPD.

Heathgate conducts all operations in a safe and responsible manner, and places the safety of workforce (employees and contractors) and protection of the environment ahead of commercial considerations. The RMP and the RWMP are designed to enable Heathgate to critically review the radiological impact of the Beverley ML 6321 processing plant, the Beverley Four Mile satellite plant and associated wellfields. The RMP and RWMP give details of the issues related to the occupational and environmental radiation at the Beverley operations respectively.

ISR mining is a relatively low impact mining method for extraction of uranium, since ore is not mined in the conventional sense. There is minimal surface disturbance, no overburden removal, no ore treatment facility, no tailings generation or disposal requirements, and rehabilitation is relatively simple. Section 4.6 provides further information on the wastes generated, and Section 4.3 provides information on the mining operations.

4.3 Mining Operations

4.3.1 Type of Mining Operations

The Beverley Four Mile Project would undertake mining by the In Situ Recovery (ISR) process. ISR mines have many advantages when compared with traditional uranium mines since they have:

- minimal surface disturbance
- no ore surface exposure, waste rock dumps or tailings dams
- greatly reduced radiation exposure to workers and the community at large.

ISR mining removes economic mineralisation from the host ore without the physical removal of ore and overburden. It requires multiple close-spaced wells into the ore, pipelines to and from the wells and a surface processing plant but does not require either underground mine workings or open cut pits, or waste rock dumps and tailings management facilities. The general arrangement of the ISR mining at Beverley is shown in Figure 1-2.
Section 4

Description of the Operations

The operations for the Beverley Four Mile Project would be very similar to those at Beverley, other than utilisation of a satellite plant at Four Mile, where uranium would be adsorbed onto resin, for trucking to the Beverley plant for processing. These operations are described in Section 4.1.1.

In the ISR process, natural groundwater from the mineralised zone requires the addition of oxidising and complexing reagents. Oxidising reagents are commonly oxygen or hydrogen peroxide, though other alternatives may be used. Complexing reagents may be acidic or alkaline. The present operation is an acidic leach, using dilute sulphuric acid with added hydrogen peroxide.

The mining solution (lixiviant) is pumped via multiple injection wells into a permeable orebody where it mobilises the uranium contained in the ore. In this process, some of the reagents are consumed. The resulting uranium-rich solution is pumped back to the surface via multiple extraction wells to a uranium processing plant.

At the processing plant, uranium is stripped from the solution and held for later precipitation, drying and packaging. The barren solution is refortified to replace used reagents and recycled back to the injection wells. Within any given area, this cycle continues until the uranium remaining in the ore is depleted to uneconomic levels. Typically mining solution is circulated 50 - 100 times through a given patch of mined ore.

ISR mining is feasible where the geological and hydrological characteristics of the orebody are favourable. This is the case with the Beverley uranium deposit, where the uranium is easily mobilised. The mineralised zone occurs in highly permeable sediments that are confined by largely impermeable strata above and below the ore body and the mineralised zone is saturated with groundwater.

The design and operation of the wellfield controls the flow of mining solution through the mineralisation. Operations are generally limited to only parts of wellfields at any one time, although the whole of each wellfield will eventually be mined during the life of the mine.

Injection and extraction wells are closely spaced, at present between 12 m to 40 m apart. Within the active mining area, the volume of solutions extracted is slightly more than the volume injected. This ensures a slight continuous inflow from the surrounding formation into the active mining area and minimises leakage of mining solutions away from the active mining area (excursions).

4.3.2 Sequence of Operation

Heathgate anticipate commencing operations as soon as possible after the proposed development is approved. The main development would be construction of the satellite plant at Four Mile (refer Section 4.1.1), and construction of wellfields, associated wellhouses and access tracks, as occurs currently at Beverley. As is current practice, when a wellfield is no longer viable, its wellhouse is relocated elsewhere within the ML for further use.

As described in Section 4.1.1, only minor modifications are required at the Beverley plant to elute the Four Mile resin. Beverley currently has three ion exchange ‘trains’ of five vessels. One of these trains will be converted from ion exchange to elution, where the uranium is stripped from the resin. The other operations at the Beverley processing plant would remain unchanged.

4.3.3 Modes and Hours of Operation

The Beverley Four Mile Project operating ours would be the same as for the Beverley operations, namely 24 hours a day, 365 days a year, on a fly-in fly-out basis.
4.3.4 Type of Field Equipment

The field activities at Beverley Four Mile would be the same as undertaken at Beverley. These activities would comprise wellfield construction, operation, maintenance, monitoring and rehabilitation following closure. All drilling is undertaken using wet mud-rotary techniques.

The same field equipment used at Beverley would also be used at Beverley Four Mile. No additional field equipment is expected to be required.

The current list of field equipment in use at Beverley ML 6321, which would be progressively moved over to work on the Beverley Four Mile, is given below. Some of this equipment would remain based at the Beverley processing plant and office complex:

- up to six drill rigs and support vehicles including water tankers
- two to four geophysical logging vans
- one airlift truck
- one water recovery truck
- one water sampling truck
- two backhoes
- one low-loader and prime mover
- one crane
- one grader
- five forklift trucks
- two water trucks
- 4WD ambulance
- one fire truck
- assorted light vehicles (4WD utilities and wagons).

4.3.5 Well Construction

Delineation drilling and geophysical logging results are used to design the wellfield layouts. Typically, 7 spot patterns (i.e. each extractor well is surrounded by 6 injector wells) are used, although other patterns are used to optimise environment protection around creeks and drainage lines. Injection and extraction wells are typically spaced between 25 m to 40 m apart.

Well construction methods at Beverley Four Mile are designed to achieve minimal surface impact, and to maintain the integrity of aquifer-confining layers. Plate 4-1 shows a typical wellfield at Beverley.
Section 4  Description of the Operations

Wellfield construction outcomes are achieved through the following measures:

- **Surface Impacts:**
  - Mud pits are excavated in such a way that surface soil is stockpiled and re-used to rehabilitate the site.
  - Drill cuttings are stored in the mud pit and are buried by at least 1m of soil during rehabilitation.

- **Maintain the integrity of aquifer confining layers:**
  - Wells are constructed in accordance with the *Minimum Construction Requirements for Water Bores in Australia Edition 2*, Land and Water Biodiversity Committee 2003.
  - Wells are cased with appropriately pressure rated PVC and the annulus is pressure grouted with sulphate resistant cement to the surface.
  - Well casing is integrity tested to 1000 kPa after installation.
  - Wells which fail integrity test are abandoned by pressure grouting with sulphate resistant cement to the surface.
  - Exploration drillholes are pressure grouted with sulphate resistant cement to the surface after the drillhole is logged.

### 4.3.6 Wellhouses

Operations are generally limited to only parts of any particular wellfield at any one time, although the whole of each wellfield will eventually be mined during the life of the mine. Wellhouses are small sheds of about the same size as a domestic single garage, which contain all the plumbing and control devices to facilitate the movement of fluids from the trunklines to and from the wellfields. Plate 4-2 shows the internals of a wellhouse at Beverley; the same controls would be used for the wellhouses at Four Mile.
Description of the Operations

At Four Mile, each wellhouse would connect to up to 11 extractor wells (each containing larger capacity pumps than at Beverley where the maximum is 13 extractors) and typically 30 to 35 injectors.

Wellhouses are moved and reused throughout the life of the mine as the resource in wellfields become exhausted.

Plate 4-2 Flow Monitoring and Control in a Wellhouse at Beverley

4.3.7 Pipelines

The use of the satellite plant would avoid the need for major trunk lines from the Four Mile area to the Beverley process plant.

The Four Mile wellfields would be connected to the satellite plant by a series of pipelines of similar design to those used at the Beverley operation. This would comprise larger diameter pipelines to the wellhouses, and smaller diameter pipelines from the wellhouses to the injector and collector wells. The pipelines would be constructed of poly pipe of the appropriate pressure rating for the proposed use, as used at the Beverley operation.

4.4 Haulage

It is noted that there is no rock haulage as such in an ISR project. The only change to the existing Beverley operations in regard to haulage would be trucking of resin between the satellite plant and the Beverley processing plant.
Section 4 Description of the Operations

4.4.1 Modes and Hours of Operation

The satellite plant will operate on a 24-hour 7-days-a-week basis, the same as Beverley, on a fly-in fly-out basis. The truck used for transport of resin to and from the satellite plant to Beverley would run approximately every six hours, depending on operational requirements.

4.4.2 Types of Equipment

The resin would be transported in a purpose-built tanker truck, of similar design to a cement tanker truck. Only one truck would be required.

4.5 Processing

4.5.1 Processing Equipment

The Beverley Four Mile project would comprise two processing facilities, a new ‘satellite’ processing plant adjacent to the Four Mile wellfields, and some minor modifications to the existing Beverley plant for processing and packaging. The satellite plant would be an ion exchange operation where uranium is adsorbed onto resin. Once fully loaded with uranium, resin would be transported in a purpose built tanker back to the Beverley plant. The uranium would then be stripped from the resin and the regenerated resin transported back to the Four Mile satellite plant.

The overall processing arrangements are shown in Figure 4-2. The proposed operations on the Four Mile MLA area are shown on light blue background. The existing Beverley operations are shown on white background. The proposed changes to the Beverley plant are shown on grey background. The operations in pale yellow are the existing product area, no changes would be required for this area. An accounting procedure based on uranium concentration monitoring information would be used to identify the production from Four Mile. Four Mile product would be separately identified from Beverley product.

The Four Mile satellite plant and wellfields would be essentially identical to the existing Beverley operation. Mining solution would be injected into the permeable mineralized regions of the Four Mile orebody for dissolution of deposited uranium. The solution would be extracted through a series of down-hole pumps and transferred into a storage pond (pregnant liquor pond). The pregnant liquor would be then pumped into the bottom of five ion exchange vessels containing approximately 80 m$^3$ of resin.

‘Barren’ solution then overflows from the top of the ion exchange (IX) column and flows into a barren lixiviant tank. The barren solution would be then re-dosed with sulphuric acid and hydrogen peroxide (as is currently done at Beverley) and reinjected into the wellfields.

Some 20 m$^3$ of loaded resin would be pumped into the purpose built tanker approximately every 6 hours (depending on process requirements) and transported to Beverley. The construction of an unsealed access road approximately 8 km long between Beverley and Four Mile will be constructed as part of the project (refer Figure 1-4).

It would be necessary to ‘bleed’ a small amount of barren liquor from the mining circuit to ensure control of solution in the aquifer. This bleed solution would be transported back to Beverley in water tankers, and would be used in the elution process, reducing the water consumption at Beverley. The updated water balance for the revised operations is shown in Figure 4-3.
Description of the Operations

Figure 4-2 Overall Processing Arrangement
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Description of the Operations

Only minor modifications would be required at the Beverley plant to elute the Four Mile resin. Beverley currently has three ion exchange ‘trains’ of five vessels. One of these trains (Train A) would be converted from ion exchange to elution, where the Four Mile uranium would be stripped from the resin. Uranium would be stripped from the resin to create a concentrated uranium solution called pregnant eluant.

Trains B and C would continue to process liquor from the Beverley wellfields on ML 6321, as at present, producing pregnant eluant from the Beverley wellfields. Pregnant eluant from Beverley and Four Mile would be mixed together and the uranium would be then precipitated, dewatered and dried as currently done at Beverley, to produce the UOC product (Figure 4-2).

4.5.2 Modes and Hours of Operation

Beverley Four Mile would operate on a 24 hour 7 days a week basis, the same as Beverley.

4.5.3 Types of Field Equipment

The principal proposed equipment for the Beverley Four Mile Project comprises:

- At the satellite plant (refer to conceptual plant layout in Figure 4-4):
  - A bunded processing area.
Description of the Operations

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- Five ion exchange (IX) vessels, to contain approximately 80 m$^3$ of resin.
- A truck loading / unloading bay for resin, and a truck unloading / loading area for reagents and for liquid wastes (refer Section 4.6.2).
- A ‘pregnant’ liquor storage pond, i.e. for liquor prior to removal of uranium into resin.
- A ‘barren’ liquor storage pond, i.e. for liquor following removal of uranium into resin.
- A wellfield injection dosing system and associated storage tanks for sulphuric acid and hydrogen peroxide (as is currently done at Beverley).
- Associated pumps, pipes and control systems.

- At the Beverley plant:
  - The existing main equipment components would remain (columns, eluant tanks).
  - New holding tanks would be provided to receive loaded resin from Four Mile, and for stripped resin ready for transport back to the satellite plant.
  - Minor pipework changes and an update of the process control system would be provided to accommodate the process change in Train A.
  - A truck loading / unloading bay would be provided within the existing Beverley bunded area.

The conceptual layout provided in Figure 4-4 would be finalised, and design information included, in the MARP, which is the next stage of the approval process (refer Appendix A).

4.6 Wastes

4.6.1 Drilling Wastes

Mud pits are excavated adjacent to the rig at each drill hole collar, to allow the circulation of drilling fluid and for capture of drill cuttings. At the completion of the drill hole or well development, the mud pits are rehabilitated as follows:

- The mud pit is allowed to dry out
- Drill cuttings are returned to the pit after which the pit is in-filled with the excavated material
- The surface is compacted to ensure that the surface of the capping is levelled with the surrounding terrain.

Radiation monitoring and modelling of the above procedure has been undertaken and has demonstrated that the method conforms with best practice and ensure that radiation doses to employees and members of the public are below applicable limits and as low as reasonably achievable.

4.6.2 Liquid Processing Wastes

No liquid waste will be generated at the Beverley Four Mile wellfields, and minimal quantities at the Beverley Four Mile satellite plant. Any liquid waste from the satellite plant will be transported to the main Beverley plant on ML 6321, either specifically or as part of the bleed water stream that will be regularly transported by tanker.
Section 4

Description of the Operations

Figure 4-4  Satellite Plant Conceptual Layout
Description of the Operations

Modification to the main Beverley plant to elute uranium from transported resin from Beverley Four Mile will mean that the volume of liquid waste at Beverley will be reduced compared to current Beverley operations. With the inclusion of maximised recycling of water, approximately 2.5 L/s (averaged over a year) of liquid waste will be generated once the Beverley extraction circuits are decommissioned. This will be disposed of at Beverley ML 6321 in the hydraulically isolated formerly mined Beverley Sands aquifers in the North, Central and South wellfields.

It is noted that initially the Beverley Four Mile resin elution circuit and Beverley ML 6321 capture and elution circuits will operate in parallel. During this time the combined volume of liquid waste will remain within an annualised average rate of 5 L/s.

At the indicated rate there is enough disposal volume in those three wellfields to accommodate up to 16 years of liquid waste. Additional volume exists in Beverley North East, East and Deep South wellfields. Any extension of liquid waste disposal in these areas would be subject to a successful application to the regulatory authorities using the Beverley Mine Procedure for Management of Liquid Waste Disposal (Appendix C of the MARP, Heathgate 2008c) or its approved successor.

4.6.3 Low-level Radioactive (LLR) Solid Wastes

Small amounts of low level radioactive waste will be generated from the proposed Beverley Four Mile Project, largely in the form of filter bags but including miscellaneous equipment and piping that cannot be efficiently cleaned to below the appropriate standards. The appropriately designed and approved disposal method and facilities at Beverley ML 6321 will be used and are described in detail in Section 4.4.3 of the Beverley MARP (Heathgate 2008c) and the RWMP.

4.6.4 Industrial and Domestic Wastes

The Beverley Four Mile project will produce a certain amount of non-radioactive solid waste associated with both its mining operation and accommodation facilities, including:

- ‘Household’ type wastes (food scraps, plastic wrapping, etc)
- Packaging and containers (cans, bottles, etc)
- Commercial wastes (papers, documents, etc)
- Industrial wastes (oils, chemicals, etc).

All wastes that are deemed to have no further use are disposed of in an approved landfill facility at the Beverley ML 6321 site. The objectives for managing the landfill comprise:

- Minimising waste requiring disposal in approved refuse facility
- Maximising recycling and reuse
- Minimising the impact on the environment by waste handling and disposal methods
- Ensuring that the integrity of the waste management facilities is maintained.

The strategies for managing the landfill operations are:

- Identification of waste streams
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- Segregation of radioactive wastes from the general waste stream (see Section 4.4.3 of the Beverley MARP (Heathgate 2008c))

- Implementation of management systems to minimise waste generation, including:
  - Recycling and re-use
  - Shredding
  - Baling or other form of compaction.

- Periodic review of waste management technology with a view to adoption of cost-effective waste management methods

- Fencing and locking of refuse facilities to prevent inappropriate use (and potential access by large animals)

- Waste facilities are constructed according to engineering specifications.

The location of the landfill on Beverley ML 6321 is shown in Figure 4-4 in Section 4.5 of the Beverley MARP (Heathgate 2008c).

4.6.5  Silt Control and Drainage

Operations in drainage channels and creeks are avoided wherever possible. However, some silt control measures would be employed on roads, particularly creek crossings, as is presently done at Beverley.

4.7  Supporting surface infrastructure

4.7.1  Access

There would be no change to the external access requirements to service the Beverley Four Mile Project.

Within the operational area, an unsealed access road would be constructed between the processing plant and the satellite facility. Some additional internal roads would be necessary within the Four Mile lease to access the wellfields. There would be some additional fencing along the western boundary of the Four Mile deposits for security purposes, and a minor change to the alignment of the 4WD track from Paralana Springs to Hidden Valley, which runs near this boundary, to divert around the Four Mile West deposit.

4.7.2  Accommodation and Offices

It is anticipated that 12 full time new positions will be required to service the satellite plant (Section 4.8.1). A small site office, sufficient for up to six operating and other personnel would be constructed at the satellite plant. All employees would be accommodated in the Beverley camp. There is sufficient accommodation at the Beverley camp for the additional operational personnel.

A temporary construction camp would be provided between the existing camp and the existing Beverley plant, to accommodate 100-120 construction personnel. Utilities would be provided from the Beverley plant.

4.7.3  Public Roads, Services and Utilities

There would be no change to use of public roads, services and utilities from that at present for the Beverley operations.
4.7.4 Visual Screening and Site Security

**Visual Screening**

As described in Section 3.4, the main opportunity to viewing the proposed Beverley Four Mile Project facilities will be from the Paralana Springs to Hidden Valley 4WD track, which runs north-east along the base of the Flinders Ranges (Figure 3-1). There would be a minor change to the alignment of this 4WD track, around the proposed wellfields at Four Mile West. The re-aligned track would be close to the wellfields in this area, however the track would be some 3 km distant from the satellite plant at its closest point.

The nearest viewing point for Four Mile and the Beverley operations from the Flinders Ranges is Sillers Lookout, from which Beverley is barely detectable to the naked eye (Plate 3-1). This situation will be little changed with the Beverley Four Mile Project, with the proposed satellite plant being much smaller than the Beverley processing plant, and some 15 km away from Siller’s Lookout.

At night, at present the Beverley processing plant lights can be seen from both the Balcanoona-Moolawatana Road and Sillers Lookout. The proposed satellite plant would be an additional lit-up area. Given that the beauty of the Flinders Ranges is appreciated during daylight hours, the use of lights at night at the satellite plant is not regarded as a significant negative impact. In any event, the overall visual impact would be no more significant than structures normally associated with a pastoral station.

**Site Security**

The main access to the Beverley Four Mile Project area would continue to be through the existing Beverley main gate, which has an electronic pass system. As noted in Section 1.5, there would be some additional fencing along the western boundary of the Four Mile deposits for security purposes,

4.8 Resource inputs

4.8.1 Workforce

The satellite ion exchange plant and wellfields will be manned at all times with a minimum of two people. Given the 24 hour operation of the mine, it is anticipated that 12 full time new positions will be required to service the satellite plant. These comprise of plant operator and water truck driver roles. Extra positions required to run the satellite plant such as wellfield staff, maintenance and ESH will be made up of existing Beverley employees. All employees will be based in the Beverley camp.

4.8.2 Energy Sources

Power will be supplied to the Four Mile satellite plant and wellfields from the existing gas fired Beverley power station via overhead power lines. The power lines will follow the road between the Beverley and Four Mile. Transformers located at Four Mile would distribute power as required to the wellfields and satellite plant.

4.8.3 Water Sources

The current GAB water source to the Beverley camp and extraction plant will remain.

The Four Mile plant will contain a reverse osmosis unit to treat groundwater to supply potable and safety shower water to the plant. Two alternatives are under consideration for a water supply to the Four Mile satellite plant:

- GAB water may be pumped to the Four Mile plant from the existing Beverley camp bore. However, it is noted that the additional GAB usage at Four Mile is expected to be minimal.
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- Local ground water from non-mineralised parts of the Eyre formation may supply any necessary process water for the satellite plant.
5.1 Social

In association with labour hire companies in Port Augusta and Port Pirie, and in line with commitments made in the mining agreement with Adnyamathanha and Kuyani Native Title claimants, Heathgate strives to achieve 20 percent Aboriginal employment at the Beverley site (with respect to non-professional site-based positions).

Significant non-economic benefits can be expected to flow from increased employment, particularly in the Iron Triangle (Pt Pirie – Pt Augusta – Whyalla region), from which a major portion of direct employment is drawn. Heathgate have a pro-active employment policy directed to the Aboriginal community, and compensation flows to Native Title claimants.

The social benefits include:

- Increased social wellbeing in the region as a flow-on from direct and indirect employment;
- Increased opportunity and independence in the Aboriginal community as a flow-on from influence of mining development and operation via advisory committees, and from royalties;
- From employment opportunities as well as associated skills training; and
- Proactive assistance for Aboriginal businesses.

5.2 Economic

Without the Four Mile deposits, the Beverley Mine would run out of ore within two years, and its significant contribution to the economy (particularly in the Pt Augusta region) would cease. The development of the Four Mile deposits means that the economic benefits described below can continue for many more years.

Beverley is a significant contributor to the South Australian economy through a number of avenues, including:

- Employment;
- Royalties; and
- Construction contracts.

Accepting mining industry multipliers, it is estimated that Beverley has created up to 450 permanent jobs off site. This has led to additional wage income in the vicinity of $6 million a year, with associated payroll tax revenue to the State Government. Employees are drawn from the northern South Australia regional areas whenever possible.

Further, with the approval of the proposed development, the Government will benefit through continuing annual royalty payments. Beverley’s annual export income is currently a positive contributor to the national balance of payments.

The current operations at Beverley are a $120 million investment, with an export income of about $100 million per annum. Royalties to the state and Aboriginal communities are in the order of $6 million per annum.

5.3 Environmental

There are a number of environmental benefits associated with development of Four Mile, including:
Section 5

Description of Potential Benefits

- Removing introduced grazing animals from the active mining areas of the ML, on the Wooltana pastoral lease. The granting of the Four Mile ML would result in the removal of livestock from the active mining areas of the ML, allowing regeneration of vegetation in these areas.

- Heathgate operates a program of feral species management on the mine site. This would be extended to Four Mile.

- Heathgate has been responsible for closing off free flowing bores in the area of the Beverley Mine Site. This work would continue with respect to Four Mile.

- High net energy yields and low greenhouse gases using uranium in nuclear power plants, compared with other methods of electricity generation. Using Life Cycle Analysis, nuclear power shows up very well as a net provider of energy and as an emitter of greenhouse gases (UIC 2006).

In regard to the final point above, the Standing Committee on Industry and Resources, in the Inquiry on use of Australia’s uranium (Parliament of the Commonwealth of Australia 2006), made the following comments in the Foreword of their Report:

‘There is now a growing recognition that nuclear power makes a significant contribution to the mitigation of greenhouse gas emissions. Worldwide, nuclear power plants currently save some 10 per cent of total carbon dioxide (CO\textsubscript{2}) emissions from world energy use. This represents an immense saving of greenhouse gas emissions that would otherwise be contributing to global warming. If the world were not using nuclear power, emissions of CO\textsubscript{2} would be some 2.5 billion tonnes higher per year.

Nuclear power plants emit no greenhouse gas emissions at point of generation and very small quantities over the whole nuclear fuel cycle, from uranium mining through to waste disposal. Indeed, the Committee reports that nuclear power emits only 2 to 6 grams of carbon per kilowatt hour of electricity produced. This is two orders of magnitude less than coal, oil and natural gas, and is comparable to emissions from wind and solar power.

A single nuclear power plant of one gigawatt capacity offsets the emission of some 7–8 million tonnes of CO\textsubscript{2} each year, if it displaces use of coal. Nuclear power also avoids the emission of sulphur dioxide, nitrous oxide and particulates, thereby significantly contributing to air quality.

Australia’s uranium exports displace some 395 million tonnes of CO\textsubscript{2} each year, relative to black coal electricity generation, and this represents some 70 per cent of Australia’s total greenhouse gas emissions for 2003.’

The Committee’s report quoted a comparison of greenhouse gas emissions, based on a study by Spadaro et al (2000); also reported by McDonald and Rogner (IAEA, 2002). This comparison is provided in Figure 5-1.

The data from these various studies indicates that clear cash terms nuclear energy incurs about one tenth of the costs of coal. Also, the external costs for coal-fired power are a very high proportion (50-70%) of the internal costs, while the external costs for nuclear energy are a very small proportion of internal costs, even after factoring in hypothetical nuclear catastrophes. It is noted that all of the waste management costs in the nuclear fuel cycle are already internalised.

The external costs of nuclear energy averages 0.4 euro cents/kWh, much the same as hydro, whereas coal is over 4.0 cents (4.1 - 7.3 cent averages in different countries), gas ranges from 1.3-2.3 cents and only wind shows up better than nuclear, at 0.1-0.2 cents/kWh average (UIC 2006). However wind (and also solar) provide
Description of Potential Benefits

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intermittent inputs of primary energy, with inevitably low capacity utilisation and relatively high energy costs in the plant (for silicon manufacture in the case of solar cells, or steel & concrete for wind turbines) (UIC 2006).

In terms of greenhouse gas emissions, nuclear compares favourably with hydro, solar and wind (Spadaro 2002), as reported in McDonald and Rogner (IAEA, 2002) and the Parliament of the Commonwealth of Australia (2006) (Figure 5-1).

Figure 5-1  Greenhouse Gas Emissions from Electricity Generation

![Greenhouse Gas Emissions from Electricity Generation Diagram](image_url)

Source: Spadaro et al (2000); also reported by McDonald and Rogner (IAEA, 2002), and Parliament of the Commonwealth of Australia 2006.
6.1 Identification of Stakeholders and their Views

The Four Mile Project is located well away from any populated centre, too far for noise, dust or any nuisance created at the site to affect a community. In the context of the Mining Proposal/PER Guidelines, unlike projects such as Kanmantoo copper project or the Angas lead-zinc project in the Adelaide Hills, where thriving communities are located within a few kilometres of the site, there is no local community for Four Mile.

There is potential, however, for some regional communities to be impacted by the project, such as by disruptions to families because of fly-in, fly-out employment, or Aboriginal cultural disruptions. In light of this, the key stakeholders were identified as follows:

- The Adnyamathanha community – the mine is located on their claim, production payments are received, some members are employed at Beverley;
- The Port Augusta region – most employees live in either Adelaide or the Port Augusta region;
- Arkarooa – a wilderness sanctuary and tourist venture (Four Mile will be visible from some lookouts at Arkarooa);
- The regulators – who represent the whole community.

In addition to numerous consultation meetings with the Commonwealth and SA regulators, public consultation sessions were planned for Port Augusta on 1 December 2008, and Hawker and Arkarooa on 2 December 2008. Notifications for the Port Augusta and Hawker sessions were placed in:

- The Recorder, Port Pirie (Tuesday 20/11/08);
- The Transcontinental, Port Augusta (Thursday 22/11/08); and
- The Flinders News, (Wednesday 21/11/08);

and were sent via email to the Southern Flinders Ranges Development Board and the Port Augusta City Council on 19 November 2008. Hawker was chosen because it is a regular meeting place for Adnyamathanha people who may want to receive information on the project directly from the company rather than through their representatives who participate in the Native Title Mining Agreement information and negotiation sessions.

A flyer advertising the Arkarooa session was provided to that facility by email on 26/11/08 and faxed to Vulkathunha/Gammon Ranges National Park headquarters at Balcanoona on 28/11/08.

6.2 Stakeholder Consultation Process and Results

It is recognised that different mechanisms are required for effective consultation with various stakeholder groups, and that the level and type of consultation varies between these groups.

For the Adnyamathanha community, a specific information session was held on 30 October 2008 to introduce the project. This will be followed by further sessions over the next six months to ensure that the project is fully understood, and to negotiate a mining agreement that will allow the ML to be granted.

Adnyamathanha people could also attend any of the public sessions in Port Augusta, Hawker or Arkarooa. In fact, the Hawker session was planned specifically to provide more options for Adnyamathanha people to receive...
Section 6 Stakeholder Consultation

The information. In addition to the above, a meeting of the Beverley Advisory Committee was held on 8 December 2008, at which Four Mile was discussed.

The Pt Augusta, Hawker and Arkaroola sessions were held in public meeting places using a slide presentation. Questions were invited at any time during the presentations, and discussions continued until all questions had been addresses satisfactorily. It is noted that although this style of presentation was planned for Hawker but as only one person attended, who had already attended the Pt Augusta session on the previous night, the presentation at Hawker was not required.

A list of the attendees at the consultation sessions, and their affiliation, is provided in Table 6-1.

Table 6-1 Consultation Sessions Attendees

<table>
<thead>
<tr>
<th>Pt Augusta</th>
<th>Hawker</th>
<th>Arkaroola</th>
</tr>
</thead>
<tbody>
<tr>
<td>Annette Morse - Office Manager, Lester Franks</td>
<td>Gordon Coulthard</td>
<td>Marg Sprigg – Director, Arkaroola Resort</td>
</tr>
<tr>
<td>Dan van Holst Pellekaan - Liberal member for Port Augusta</td>
<td></td>
<td>Arthur Coulthard – Senior Ranger, Vulkathunha-Gammon Ranges National Park</td>
</tr>
<tr>
<td>Lynn Wallace - Development Manager, Global Maintenance</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Christine Arnold - Wildlife Officer, DEH</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gordon Coulthard - Adnyamathanha senior man</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jessica Balasso - Skilled Group</td>
<td></td>
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</tbody>
</table>

Numerous meetings have been held with Commonwealth and SA regulators over the second half of 2008. The key areas discussed were hydrogeology and the risk assessment.

Nearby pastoralists are also consulted on a regular basis.

6.3 Details of Consultation

The stakeholder groups, type, issues raised and responses are provided in Table 6-2.
## Stakeholder Consultation

### Table 6-2  Results of Stakeholder Consultation

<table>
<thead>
<tr>
<th>Stakeholder group</th>
<th>Type of stakeholder</th>
<th>Issues raised</th>
<th>Response</th>
</tr>
</thead>
</table>
| Adnyamathanha communities                  | Regional Aboriginal Communities | Aboriginal employment  
Investment fund  
Environmental performance  
Community benefits  
Continuity of benefits | There is preliminary agreement by the Adnyamathanha governing committee that the project should proceed.  
More emphasis is needed on employment and business opportunities, issues that have been addressed in the new draft agreement.  
Environmental performance is considered satisfactory.  
The investment fund needs to be improved and more cultural funding is required.  
The new agreement has not yet been considered by a full community meeting. |
| Beverley Advisory Committee                | Regional Aboriginal Communities | Environmental performance  
Aboriginal employment  
Cross cultural matters  
Coming events | The Beverley advisory committee meets quarterly. In addition to providing a forum for dissemination of information, the advisory committee presents an opportunity for the Aboriginal community of the Northern Flinders Ranges to raise any issues of concern it may have.  
Meetings are held in Adelaide, Port Augusta and at the Beverley site. The most recent was held in Pt Augusta on 8 December 2008.  
The minutes of the meetings over the last few years show that the Adnyamathanha community is satisfied with Heathgate’s employment and environmental performance. |
| Adnyamathanha Heritage Survey teams        | Regional Aboriginal Communities | Protection of Aboriginal heritage  
Environmental performance | During the last 8 years, Heathgate and Quasar have conducted a number of Work Area Clearances with Native Title Claimants as part of their extensive Exploration program. These clearances ensure that future activities will not interfere with Aboriginal heritage, and that past activities have been conducted in accordance with previous clearance reports. They also provide further consultation and ensure the local Aboriginal people are up to date with any mine developments.  
The survey reports show that Heathgate and Quasar take their responsibilities seriously and have performed well in this area. |
| DEH                                        | Wildlife Officer          | What tonnage would be going through the plant once Four Mile is up and operating? | 1,500 tonnes per year - the same as the current licence maximum. |
## Stakeholder Consultation

<table>
<thead>
<tr>
<th>Stakeholder group</th>
<th>Type of stakeholder</th>
<th>Issues raised</th>
<th>Response</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Is Wooltana still stocked and can wildlife get access to any liquids e.g. ponds etc and how do we keep them out.</td>
<td>Wooltana is destocked at the moment due to the drought. All pits, wellfields and ponds are either bunded or fenced off so the larger wildlife animals cannot enter.</td>
</tr>
<tr>
<td></td>
<td>General Public</td>
<td>When do you expect to commence production from Four Mile</td>
<td>Between December 2009 and February 2010.</td>
</tr>
<tr>
<td>Arkaroola Resort</td>
<td>Neighbour and owner of Arkaroola lease onto which part of Four Mile West deposit extends</td>
<td>Avoiding disturbance of hills. More information on groundwater aspects. Possible co-operation with a conservation project to provide Significant Environmental Benefit for Beverley operations</td>
<td>MLA has avoided hills other than a small buffer at the edge of the plains which would be used for monitoring purposes only. Groundwater aspects will be an emphasis of the PER including rehabilitation aspects. Quasar will provide a paper copy of the PER to Arkaroola. Heathgate and Quasar are pursuing co-operation with an SEB conservation project with Arkaroola (and probably Vulkathunha-Gammon Ranges National Park also)</td>
</tr>
<tr>
<td>Vulkathunha-Gammon Ranges National Park</td>
<td>Neighbour</td>
<td>Being keep fully informed. Co-operation in search-and-rescue and medical emergencies</td>
<td>Quasar will provide a paper copy of the PER to the Park Office. Heathgate will look for opportunities to undertake joint emergency response training and provide resources on request where appropriate.</td>
</tr>
</tbody>
</table>
## Stakeholder Consultation

<table>
<thead>
<tr>
<th>Stakeholder group</th>
<th>Type of stakeholder</th>
<th>Issues raised</th>
<th>Response</th>
</tr>
</thead>
</table>
| Pastoralists                      | Farming communities          | Fencing and access to stock water at Wooltana      | Heathgate is committed to maintaining a good working relationship with pastoralists. An active program of consultation is in place. This includes:  
- Regular telephone contact and visits to various pastoral properties in the area – in particular Wooltana and Wertaloona to the south and Moolawatana and Murnpeowie to the north.  
- Further, other pastoral properties ranging further north, south and east are recipients of the regular project newsletter, In Situ.  
- Significant developments within the area are brought to the attention of the surrounding pastoral leaseholders or managers, by way of written and verbal communications, as required.  
Fencing changes at Wooltana will be discussed fully before implementation and that restrictions to access to water will be minimised. |
| Government regulatory bodies      | Regulatory agencies          | Environmental and safety issues                    | Throughout the past 6 months Heathgate and Quasar have attended formal meetings with various government regulatory bodies including the ISR Radiation Review Committee and the Beverley Environment Consultative Committee (BECC). The most recent ISR Radiation Review Committee meeting was held at the SA EPA on 11 December 2008, and BECC last met on 14 November 2008, both in Adelaide.  
The record shows that regulatory agencies are satisfied with the performance at Beverley, and these agencies are aware that Four Mile will be operated by the same staff using the same procedures. |
| Heathgate workforce               | Employees                    | Continuity of employment                            | The workforce clearly supports the Four Mile project and the continuation of employment. |
Environmental, Social and Economic Aspects

Section 7

7.1 Context and Stakeholder Views

The Beverley Four Mile Project and the Beverley Mine are located in a remote part of the State, between the eastern edge of the Northern Flinders Ranges and Lake Frome. There are few communities within proximity of the mine, notably (Figure 3-1):

- Arkaroola
- Nepabunna
- Iga Warta.

Heathgate recognises the importance of information regarding the environment, heritage management and Aboriginal issues in the region. In order to aid in community liaison a Visitor and Heritage Centre has been constructed at the mine site. The mine furthermore has an extensive OH&S system and risk assessment process which addresses the risks associated with environment and heritage issues.

Different community groups require different specific mechanisms for consultation. The level and type of consultation varies between these groups, as described in Section 6 and later discussed in Section 7.10.

7.2 Applicable Legislation and Standards

A listing of the principle legislation and standards relevant to the Beverley mine is provided in Table 7-1.

7.3 Impact Event Analysis

7.3.1 Potential Impact Events

A listing of all credible potential impact events associated with activities relating to the proposed project, including construction and operational activities, has been developed. This includes any potential impacts relating to the following:

- natural environment (including air quality, surface and underground water supplies, flora, fauna, landform stability, etc.)
- social environment (including public health, amenity, nuisance, fires, heritage, use of public resources, etc.)
- economic environment (including regional economy, individual landholder incomes, land values, etc.).

The basis for identifying these issues involves application of a risk assessment methodology, which is set out in Section 7.3.5, and in Tables 7-2 to 7-5. The potential impact events include any major negative public perceptions (even if not technically justified). Such events will be considered as a social impact event and appropriately managed.

A discussion of potential impact events is provided in Section 7.3.5. In particular, Table 7-6 in this section includes a reference, aspects, the assigned inherent risk level, the control and management strategies leading to a revised risk level, outcomes to be achieved and outcome measurement criteria. More details are given below.
Table 7-1 Principle Relevant State and Commonwealth Legislation and Codes of Practice

<table>
<thead>
<tr>
<th>State Legislation</th>
<th>Commonwealth Legislation</th>
<th>Commonwealth Codes of Practice</th>
<th>SA State Codes of Practice</th>
</tr>
</thead>
<tbody>
<tr>
<td>National Parks and Wildlife Act 1972</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Native Vegetation Act 1991</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Natural Resources Management Act 2004</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Occupational Health Safety and Welfare Act 1986 and Regulations</td>
<td></td>
<td></td>
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</tbody>
</table>
### Environmental, Social and Economic Aspects

<table>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Waste tracking form (EPA Guidelines, 2003)</td>
</tr>
</tbody>
</table>
Section 7 Environmental, Social and Economic Aspects

7.3.2 Likelihood and Severity of Consequence and Risks

The risk assessment has been carried out based on Heathgate’s Risk Management System, which in turn is based on Australian Standard AS/NZS 4360:2004 Risk Management. The methodology conforms generally with the criteria outlined in the Guidelines for the Beverley Four Mile Project (Appendix A). The assessment was been prepared by taking into account the history of environmental management, regulation and reporting undertaken including during and since the production of the Beverley EIS in 1998.

The Heathgate Risk Management System differs slightly from the Australian Standard in that it applies risk classifications that are more in keeping with the common-use meaning of terms such as “low” “medium” and “high”. This difference in terminology does not have any impact on the management of risks. The Heathgate Risk Management System also covers risks outside the traditional health, safety and environment fields.

For clarification, the definitions and risk assessment matrix as used in the risk assessment are outlined in Tables 7-2 to 7-5.

7.3.3 Control and Management Strategies

Table 7-6 includes a brief description of proposed control and management strategies to reduce the environmental impacts associated with mining at Beverley. These strategies are set out opposite the corresponding potential impact event, with some repetition as a strategy may be relevant to more than one impact event. The strategies for managing issues involve the implementation of technically and economically achievable best practice mining and environmental management techniques, including progressive rehabilitation where applicable and practicable.

In general, the hierarchy of controls are applied:

1) Elimination – if possible a procedure will be modified to eliminate the need for exposure to the risk;
2) Substitution – if possible a procedure will be modified to substitute a less hazardous alternative;
3) Engineering controls – engineering barriers to reduce risk;
4) Administrative controls – operating procedures that reduce likelihood or consequences;
5) Personal Protective Equipment – hard hats etc that reduce consequences;
6) Transfer – suitable mainly for business risks (eg insurance).

Specifically, the control and management strategies detail one or more of the following:

- A change in design or procedures to avoid or reduce the likelihood of the impact occurring
- A change in design or procedures to avoid or reduce the consequences of an event, should it happen.
### Table 7-2 Definitions of Severity and Consequence

<table>
<thead>
<tr>
<th>S</th>
<th>A</th>
<th>F</th>
<th>E</th>
<th>R</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Safety &amp; Health</strong></td>
<td><strong>Assets: Plant/Equipment Damage</strong></td>
<td><strong>Finance: Business Interruption and Corrective costs</strong></td>
<td><strong>Environment: Land, Air, Flora, Fauna and Authorisations</strong></td>
<td><strong>Reputation: Media, Community</strong></td>
</tr>
<tr>
<td><strong>Catastrophic</strong></td>
<td>Life threatening or disabling illness e.g: cancer (quartz, radon, ionising radiation) reproductive hazards</td>
<td>Ongoing production operations severely compromised. Immediate corrective action required. Loss of production &gt; 6 months. &gt;$10M remediation costs.</td>
<td>Widespread severe and permanent Environmental damage. Could lead to closure. Prosecution very likely.</td>
<td>Severe national public and media negative opinion. National denouncement of operations by key stakeholders. Prosecution very likely.</td>
</tr>
<tr>
<td><strong>Major</strong></td>
<td>Irreversible health effects resulting in extended lost time and admission to medical facilities for corrective procedures. Rehabilitation required to effect full recovery.</td>
<td>Major impact on production. Significant action required to correct situation. Loss of Production 1 week to 6 months. $1M-$10M remediation costs.</td>
<td>Substantial or permanent damage, prosecution likely. Major stakeholder concerns</td>
<td>Widespread national public attention and media scrutiny. Serious key stakeholder concern. Damage to HGR’s corporate image.</td>
</tr>
<tr>
<td><strong>Moderate</strong></td>
<td>Severe reversible health effects of concern e.g: breathing SO2, solvents, musculoskeletal</td>
<td>Moderate impact to operations. Loss of production &lt;1 week. Corrective actions require immediate planning. $100,000 - $1M remediation costs.</td>
<td>Substantial temporary or permanent minor damage. Possible breach of authorization and prosecution. Stakeholder enquires.</td>
<td>Attention from SA public and media services. Public complaints from key stakeholders.</td>
</tr>
<tr>
<td><strong>Minor</strong></td>
<td>Reversible health effects of concern e.g: jetlag, stress, sunstroke</td>
<td>Minor damage that requires no resulting production loss. Corrective action requires short plan time. $10,000 - $100,000 remediation costs.</td>
<td>Temporary impact – minor effect. No publicity likely and with no stakeholder concerns.</td>
<td>Minor localised public scrutiny and minimal media attention.</td>
</tr>
<tr>
<td><strong>Insignificant</strong></td>
<td>Reversible health effects of little concern e.g: offensive odours, minor throat irritation</td>
<td>Insignificant damage to operation resulting in low level planned action to rectify. &lt;$10,000 remediation costs</td>
<td>No measurable impact on the environment. Non-reportable with no publicity.</td>
<td>No public interest in incident.</td>
</tr>
</tbody>
</table>
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Table 7-3  Probability Chart
(The probability that the consequence will occur again if no additional controls are put in place)

<table>
<thead>
<tr>
<th>Probability</th>
<th>Almost Certain</th>
<th>Likely</th>
<th>Possible</th>
<th>Unlikely</th>
<th>Rare</th>
</tr>
</thead>
<tbody>
<tr>
<td>Common or repeating occurrence (weekly).</td>
<td>Known to occur (it has happened several times a year).</td>
<td>Could occur or have heard of it happening.</td>
<td>Not likely to occur (once in 20 years).</td>
<td>Practically impossible (once in 200 years).</td>
<td></td>
</tr>
</tbody>
</table>

Table 7-4  Risk Assessment Matrix

<table>
<thead>
<tr>
<th>Probability</th>
<th>Insignificant</th>
<th>Minor</th>
<th>Intermediate</th>
<th>Major</th>
<th>Catastrophic</th>
</tr>
</thead>
<tbody>
<tr>
<td>Almost Certain</td>
<td>M</td>
<td>H</td>
<td>H</td>
<td>C</td>
<td>C</td>
</tr>
<tr>
<td>Likely</td>
<td>L</td>
<td>M</td>
<td>H</td>
<td>H</td>
<td>C</td>
</tr>
<tr>
<td>Possible</td>
<td>L</td>
<td>L</td>
<td>M</td>
<td>H</td>
<td>H</td>
</tr>
<tr>
<td>Unlikely</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>M</td>
<td>H</td>
</tr>
<tr>
<td>Rare</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>L</td>
<td>M</td>
</tr>
</tbody>
</table>
Table 7-5  Risk Classification

<table>
<thead>
<tr>
<th>Level</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>C: Critical risk</td>
<td>Requires immediate senior management intervention to reduce risk to a lower level.</td>
</tr>
<tr>
<td>H: High risk</td>
<td>Requires senior management intervention to reduce risk to a lower level.</td>
</tr>
<tr>
<td>M: Moderate risk</td>
<td>Requires corrective action or continuous monitoring to reduce risk. Management accountability must be specified.</td>
</tr>
<tr>
<td>L: Low risk</td>
<td>Routine operations will generally control the risk. No specific management attention required unless a reality check determines that such attention is advisable.</td>
</tr>
</tbody>
</table>

7.3.4  Outcome Overview

The desired overall environmental outcome for the establishment of additional wellfields and infrastructure at Four Mile is expressed in the Heathgate Environment Policy (which will apply to Four Mile), and which states that integral to the policy are goals focused on:

- Waste minimisation
- Zero pollution events
- Compliance with all applicable laws and regulations concerning the environment
- Environmental awareness training
- Minimum site disturbance.

Detailed outcomes were developed during the Beverley PER/MARP process (refer URS 2007 and Heathgate Resources Pty Ltd 2008c) and have been formalised via the Mine Lease conditions and the EPBC approval. Further details are given below.

7.3.5  Risks to Achieving Outcomes

The main risks associated with potentially not meeting the desired outcomes are discussed below and are later summarised in Table 7-6 and discussed further in Sections 7.4 to 7.11. The identified eight key risk areas are:

1) Soils
2) Vegetation
3) Surface water
4) Hydrogeology
5) Fauna
6) Air quality
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7) Heritage

8) Radiological aspects.

Identifiers corresponding to these numbers have been assigned to allow easy identification of these aspects in Table 7-6.

The control and management strategies are devised to ensure that the risks (after control measures have been implemented) are managed to "As Low As Reasonably Achievable" (ALARA) levels. In accordance with the Guidelines (Appendix A), the discussion for each of the key risk areas includes consideration of:

- Risk acceptance
- Outcomes
- Outcome measurement criteria
- Leading indicator criteria
- Compliance monitoring plan.

There are instances where control and management strategies, outcomes and outcome measurement criteria for an event are not set out in this chapter where:

- The risk level for an event is deemed so low, that further specific control measures are not warranted. If this is case, no outcome, criteria or further monitoring may be warranted;
- The risk is considered acceptable in context of the mining industry and surrounding environment such that there are no control measures available;
- The cost of implementing further control measures is grossly excessive compared to the benefit obtained; or
- The risk is acceptable, given the other benefits that will arise from the mining operation, which will outweigh the impact that will or may arise.

It is noted that radiological issues relevant to the various categories of aspect (surface water, air quality etc) are covered in Table 7-6 within the key risk area where radiological issues are considered.

It is noted also that the risks addressed in Table 7-6 are those relevant to the Beverley Four Mile Project only; the risks specific to the Beverley operations only are addressed in the approved MARP (Heathgate Resources Pty Ltd 2008c).

It is noted also that the risks addressed in this document apply to the whole of the Beverley Four Mile Project Area. However, as noted in Section 3-10, additional hydrogeology study work will be undertaken prior to any mining activity in the Four Mile West area, and in any further yet-to-be discovered ore zones.
### Table 7-6  Potential Impact Events, Risks, Management, Outcomes and Measurement

<table>
<thead>
<tr>
<th>ID</th>
<th>Potential Impact Event</th>
<th>Inherent Risk Level</th>
<th>Design Control Measure(s)</th>
<th>Operational Management Measure(s)</th>
<th>Residual Risk Level</th>
<th>Outcome(s)</th>
<th>Outcome Measurement Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>SOILS</td>
<td>1.1 Chemical and radiological contamination of soil and watercourse sediments that would prevent its return to pastoral use arising from: a. Seepage from water management ponds through construction defects, wear and tear and accidental damage. b. Pond overflows of mining solutions and waste disposal solution from high rainfall events or control system failure. c. Escape of mining solution due to accidental breakages of piping from poor welds, vehicle damage or pipe defects.</td>
<td>Likelihood: Possible Consequence: Intermediate Risk: MODERATE</td>
<td>Pressure testing of all pipework prior to commissioning. Ponds lined with plastic or clay. Leak detection system beneath ponds. Wellhead drip trays. Bunds around processing plant and operational mining areas. Protection of piping from traffic in key areas. Refer RWMP.</td>
<td>Wellfields are continually checked by Wellfield Operators and Maintenance personnel. Soils that are radiologically affected above the operational contamination criteria will be buried according to the RWMP. Leaks in double-lined ponds above the target action leakage rate (TALR) will be repaired. Leaks in ponds 1-4 will be repaired based on visual observations. Continuous pressure monitoring of trunklines. Continuous flow monitoring of wellhouses. Monitoring of wellhead drip trays.</td>
<td>Likelihood: Unlikely Consequence: Minor Risk: LOW</td>
<td>Soil affected by mining activities is suitable for return to pastoral use.</td>
<td>For: a: Only rehabilitation criteria apply (See Section 8.6). b, c: All sites subject to spills meet radiological criteria as defined in the RWMP.</td>
</tr>
</tbody>
</table>

1 Chemical and radiological contamination is intrinsically linked and radiological is the primary indicator.

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</thead>
</table>
| 1.2 | Spillage of hazardous substances during transport, storage and handling resulting in contamination of soil that would prevent its return to pastoral use. | Likelihood: Possible Consequence: Minor Risk: LOW | Hazardous materials and fuel stored in bunded areas. | Undertake routine inspection of tanks and equipment used to store and transfer chemicals and process materials. Any deficiencies in the integrity of any equipment discovered by the inspection will be brought to the attention of senior site management for appropriate corrective action. Implement and regularly update spill and emergency response procedures, maintain spill kits and train Emergency Response Team (ERT) personnel. Implement and regularly update standard operating procedures for handling of chemicals. Fuel-affected soil removed for landfarming and later disposal (if required). Acid or alkali spills remediated (if required). | Likelihood: Rare Consequence: Minor Risk: LOW | Soil affected by mining activities is suitable for return to pastoral use. | Spills of hazardous materials are assessed and if so determined cleaned up:  
  a) Diesel spills to site-specific criteria to be established using National Environmental Protection Measure (NEPM) Risk Assessment methodology as recommended by the SA EPA.  
  b) Acid or alkali spill sites returned to within local background range of pH. |
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</table>
| 1.3 | Soil disturbance due to excessive off-road vehicle movement which may compromise rehabilitation for later pastoral use resulting from:  
- compaction of soil  
- exacerbated erosion. | Likelihood: Possible  
Consequence: Minor  
Risk: LOW | Provide stabilised tracks or roads for areas with frequent traffic.  
Provide fencing in key areas to keep vehicles on tracks. | Educate all site employees and contractors on the importance of remaining on existing tracks.  
Personnel to drive only on existing tracks, unless permitted otherwise via Environmental Clearance Permit.  
Additional fencing in areas with repeated unauthorised off-road tracks.  
Progressive closure and rehabilitation of obsolete formed tracks and unauthorised off-road tracks.  
Ripping of compacted areas and soil when replaced. | Likelihood: Unlikely  
Consequence: Minor  
Risk: LOW | Soil affected by mining activities is suitable for return to pastoral use. | Off-road vehicle movements not approved via an Heathgate’s Environmental Clearance Permit (ECP) are investigated, reported and one of the following actions are taken:  
- fenced off to prevent reuse,  
- rehabilitated, or  
- converted to an authorised road subject to Significant Environmental Benefit (SEB). |
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</thead>
<tbody>
<tr>
<td>1.4</td>
<td>Spillage of resin during transport, storage and handling resulting in contamination of soil that would prevent its return to pastoral use.</td>
<td>Likelihood: Possible Consequence: Insignificant Risk: LOW</td>
<td>Resin stored in bunded areas. Resin transported in suitably designed containers, to withstand spillage in event of an incident.</td>
<td>Transportation across Four Mile Creek will cease if flood risk is present. Resin spills are cleaned up within 24 hours. Undertake routine inspection of tanks and equipment used to store and transfer resin. Any deficiencies in the integrity of any equipment discovered by the inspection will be brought to the attention of senior site management for appropriate corrective action. Implement and regularly update spill and emergency response procedures, maintain spill kits and train ERT personnel. Implement and regularly update standard operating procedures for handling resin. Resin spills recovered should they occur.</td>
<td>Likelihood: Rare Consequence: Insignificant Risk: LOW</td>
<td>Soil affected by mining activities is suitable for return to pastoral use.</td>
<td>All sites subject to spills meet radiological criteria as defined in the RWMP.</td>
</tr>
</tbody>
</table>
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<th>Outcome Measurement Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>VEGETATION</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.1</td>
<td>Reduction in regional native vegetation species density and diversity due to mining operations.</td>
<td>Unlikely</td>
<td>Minimise perennial vegetation clearing by design:</td>
<td>Enforcement of Environmental Clearance Permit system. Establishment of approved SEB compensation where due. Weed control.</td>
<td>Rare</td>
<td>No loss of abundance or diversity on or off the Beverley mining lease to native vegetation through clearance or any other damage unless prior approval under the relevant legislation is obtained.</td>
<td>Demonstrate that all clearing undertaken is approved in accordance with the MARP.</td>
</tr>
<tr>
<td>2.2</td>
<td>Loss of local native vegetation (habitat) due to clearance for mining operations.</td>
<td>Almost Certain</td>
<td>Minimise perennial vegetation clearing by wellfield layout design.</td>
<td>Enforcement of Heathgate's ECP system. Establishment of approved SEB compensation where due. Progressive and final revegetation.</td>
<td>Rare</td>
<td>No loss of abundance or diversity on or off the Beverley mining lease to native vegetation through clearance or any other damage unless prior approval under the relevant legislation is obtained.</td>
<td>Demonstrate that all clearing undertaken is approved in accordance with the MARP.</td>
</tr>
</tbody>
</table>
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<th>Outcome Measurement Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.3</td>
<td>Introduction of new or increase in abundance of existing weeds and pests (feral animals)(^2)</td>
<td>Likelihood: Possible Consequence: Minor Risk: LOW</td>
<td>Flora and fauna surveys to identify trends. Weed control. No pets on Mine Lease. Feral animal control.</td>
<td>Likelihood: Unlikely Consequence: Minor Risk: LOW</td>
<td>No introduction of new weeds, plant pathogens or pests (including feral animals), nor increase in abundance of existing weed or pest species in the lease area compared to adjoining pastoral areas.</td>
<td>Flora and fauna surveys demonstrate no new weeds or feral animals (due to mining activities) nor statistically significant increase in abundance of existing weed or pest species in the lease area compared to adjoining pastoral areas.</td>
<td></td>
</tr>
<tr>
<td>2.4</td>
<td>Loss of local native vegetation (habitat) due to mining-related fires.</td>
<td>Likelihood: Possible Consequence: Minor Risk: LOW</td>
<td>Fire fighting equipment. Roads/tracks act as fire breaks. Design control measures to be implemented should fuel loads become significant.</td>
<td>Fire-fighting exercises undertaken.</td>
<td>Likelihood: Unlikely Consequence: Minor Risk: LOW</td>
<td>No uncontrolled fires caused by mining operations.</td>
<td>Any fires caused by mining operations are controlled within the ML boundary.</td>
</tr>
</tbody>
</table>

\(^2\) Feral animals and fauna surveys are included here to match condition 5 of Schedule 2 of the lease conditions (Section 7.8). They influence vegetation outcomes.

\(^3\) Control sites are chosen by qualified and experienced specialists (see text).

\(^4\) Where such statistical measures are valid. Qualitative assessment by independent specialists is considered more appropriate in some cases. See Section 7.5.8.
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#### SURFACE WATER

<table>
<thead>
<tr>
<th>ID</th>
<th>Potential Impact Event</th>
<th>Inherent Risk Level</th>
<th>Design Control Measure(s)</th>
<th>Operational Management Measure(s)</th>
<th>Residual Risk Level</th>
<th>Outcome(s)</th>
<th>Outcome Measurement Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>Watercourse contamination (including radiological) arising from release of mining solution due to flood damage to pipes, ponds and infrastructure, or from high rainfall causing overflow of ponds.</td>
<td>Likelihood: Unlikely Consequence: Minor Risk: <strong>LOW</strong></td>
<td>Engineered creek crossings where high opportunity for flood damage is present. Ponds, wellhouses and processing plant located on high ground above 1-in-100 year Annual Rainfall Index (ARI) flood level. Use of 1-in-100 year ARI flood level map in design of pipe routes and flood protection to minimise creek crossings. Minimise production well installation in flood-prone areas.</td>
<td>Visual Inspection around site and review of Flood Management Plan as appropriate. Visual assessment of infrastructure as part of routine maintenance and following all major rainfall events of greater than 1-in-10 year ARI. Sufficient freeboard in ponds to ensure that a high rainfall event does not result in over-topping.</td>
<td>Likelihood: Rare Consequence: Minor Risk: <strong>LOW</strong></td>
<td>No compromise of pastoral use of downstream surface water bodies.</td>
<td>Water quality in downstream water storages (within 5 km of the site) will be measured as soon as it is safe to do so following surface water flow, if there has been any release of mining solution into a flowing stream. This must show no compromise of pastoral use that it is attributable to mine operations. A mass balance calculation using estimated spill volume and chemical quality and estimated stream flow will be undertaken to ascertain if any compromise is plausibly due to the mine operations. Applicable ANZECC/ARMCANZ stock water guidelines are: • salinity (EC) – 4,000 mg/L (6,000 μS/cm) • sulphate (SO(_4)) – 1,000 mg/L • uranium – 0.2 mg/L.</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th>ID</th>
<th>Potential Impact Event</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Groundwater contamination of upper Eyre FM outside ML preventing stock watering</td>
</tr>
<tr>
<td>4.2</td>
<td>Contamination (including radiological) of the Namba aquifer units overlying the Four Mile East Ore Zone arising from mining activities.</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ID</th>
<th>Potential Impact Event</th>
<th>Inherent Risk Level</th>
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<th>Outcome(s)</th>
<th>Outcome Measurement Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>Groundwater contamination of upper Eyre FM outside ML preventing stock watering</td>
<td>Low</td>
<td>Pumping infrastructure in place to actively control fluids</td>
<td>Monitoring network sampled during operations and fluids actively controlled. Post rehabilitation, natural attenuation studies will have been used to design treatment options if necessary.</td>
<td>Low</td>
<td>No compromise of pastoral use of downstream groundwater.</td>
<td>No migration of mining and disposal solutions outside the ML as demonstrated by Excursion Control Limit (ECL) monitoring and response using the same concepts as at Beverley.</td>
</tr>
<tr>
<td>4.2</td>
<td>Contamination (including radiological) of the Namba aquifer units overlying the Four Mile East Ore Zone arising from mining activities.</td>
<td>Low</td>
<td>Exploration holes cement grouted. Production and monitor wells cement grouted and integrity tested. Wells that do not pass integrity tests are cemented up and abandoned. Refer to RWMP.</td>
<td>Monitor Namba Formation water levels and quality. Adjust injection and extraction balances in mined areas to maintain control of mining solution. Adjust pressure in Eyre Formation aquifer at end of mining to restore pre-mining pressure gradient or a gradient towards mined area. Refer to RWMP.</td>
<td>Low</td>
<td>No compromise of potential pastoral use (should it meet pastoral water quality standards) of the Namba Formation aquifer.</td>
<td>Monitoring of ECL parameters and EC demonstrates that the category of pastoral use of the overlying aquifer does not change adversely in relation to ANZECC/ARMCANZ categories of water use, as a result of mining operations.</td>
</tr>
</tbody>
</table>
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<table>
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<tr>
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<th>Outcome Measurement Criteria</th>
</tr>
</thead>
</table>
| 4.3 | Contamination (including radiological) of the Mt Painter Group Fractured Rock aquifer units underlying the Four Mile East Ore Zone arising from mining activities. | Likelihood: Unlikely  
Consequence: Minor  
Risk: LOW | Exploration holes cement grouted.  
Production and monitor wells cement grouted and integrity tested.  
Wells that do not pass integrity tests are cemented up and abandoned.  
Refer to RWMP. | Monitor Mt Painter Group Fractured Rock aquifer water levels and quality.  
Adjust injection and extraction balances in mined areas to maintain control of mining solution.  
Adjust pressure in Eyre Formation aquifer at end of mining to restore pre-mining pressure gradient or a gradient towards mined area.  
Refer to RWMP. | Likelihood: Rare  
Consequence: Minor  
Risk: LOW | No compromise of potential pastoral use (should it meet pastoral water quality standards) of the Mt Painter Group Fractured Rock aquifer. | Monitoring of ECL parameters and EC demonstrates that the category of pastoral use of the underlying aquifer does not change adversely in relation to ANZECC/ARMCANZ categories of water use, as a result of mining operations. |
| 4.4 | Net groundwater pumping of bleed stream impacts on Paralana Hot Springs (NB - not a credible risk – see Section 6.7.4) | Likelihood: Rare  
Consequence: Insignificant  
Risk: LOW | Monitoring of aquifer pressure between mining zone and springs | Maintain bleed stream at minimal volume. Flow metering. | Likelihood: Rare  
Consequence: insignificant  
Risk: LOW | No reduction in aquifer pressure at springs | No reduction in aquifer pressure due to mining greater than an amount to be determined (in consultation with PIRSA) at monitoring points between the ore zone and springs. |
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</tr>
</thead>
<tbody>
<tr>
<td>FAUNA</td>
<td>Reduction in native vertebrate species density and diversity caused by wellfield development, access road construction and operations.</td>
<td>Likelihood: Possible Consequence: Minor Risk: LOW</td>
<td>Minimise perennial vegetation clearing by design: Fencing patches of vegetation and soaks to protect seed stock and habitat. Run pipeline on surface. Wellfield and projects planning.</td>
<td>Enforcement of Heathgate’s ECP system. Enforce speed limits within Mining Lease. Rapid backfilling and rehabilitation of mud pits. Presence of drilling crews (discouraging fauna near pits and operations). Rescue of trapped fauna. Backfilling of exploration and delineation drill holes. Placing stockpiled vegetation as habitat. Recreational hunting prohibited within the lease area.</td>
<td>Likelihood: Unlikely Consequence: Minor Risk: LOW</td>
<td>No net adverse impacts from the site operations on native fauna abundance or diversity in the lease area and in adjacent areas.⁵</td>
<td>Results of monitoring program show no reduction of native vertebrate density and diversity compared with local area background as per fauna monitoring.</td>
</tr>
</tbody>
</table>

⁵ Control sites are chosen by qualified and experienced specialists (see text)
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<tbody>
<tr>
<td>5.2</td>
<td>Reduction in native vertebrate species density and diversity resulting from an increase in feral animals caused by creation of food sources, modified habitat and waste management operations.</td>
<td>Likelihood: Unlikely Consequence: Minor Risk: LOW</td>
<td>All putrescible waste disposed of at Beverley.</td>
<td>Covering of putrescible waste. Increase personnel awareness via inductions and notices.</td>
<td>Likelihood: Rare Consequence: Minor Risk: LOW</td>
<td>No net adverse impacts from the site operations on native fauna abundance or diversity in the lease area and in adjacent areas.⁶</td>
<td>Results of monitoring program show no reduction of native vertebrate density and diversity compared with local area background as per fauna monitoring. Results of monitoring program show no increase in feral vertebrates, compared with local area background, based on assessment by the appropriately qualified and experienced specialists engaged to undertake and assess the monitoring program.</td>
</tr>
<tr>
<td>5.3</td>
<td>Reduction in adjacent pastoralist viability due to increase in feral animals due to mining operations.</td>
<td>Likelihood: Unlikely Consequence: Minor Risk: LOW</td>
<td>Prohibition on pets within the lease area. Trap and destroy feral species. Recreational hunting prohibited within the lease area.</td>
<td>Likelihood: Rare Consequence: Minor Risk: LOW</td>
<td>No introduction of new weeds, plant pathogens or pests (including feral animals), nor increase in abundance of feral animals in the lease area compared to adjoining pastoral areas.⁷</td>
<td>All complaints from neighbours regarding feral animal control are investigated and are demonstrated to be not due to mining operations.</td>
<td></td>
</tr>
</tbody>
</table>

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⁶ Control sites are chosen by qualified and experienced specialists (see text)

⁷ Whist this outcome includes vegetation it is included here as the Mining Lease condition lists feral animals with weeds

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<th>Inherent Risk Level</th>
<th>Design Control Measure(s)</th>
<th>Operational Management Measure(s)</th>
<th>Residual Risk Level</th>
<th>Outcome(s)</th>
<th>Outcome Measurement Criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td><strong>AIR QUALITY</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6.1</td>
<td>Radon release from water management ponds (and other sources) increasing radiation doses to the environment or the public.</td>
<td>Likelihood: Rare Consequence: Minor Risk: LOW</td>
<td>Ponds located downwind of satellite plant area with respect to prevailing winds. Refer RWMP and RMP.</td>
<td>Radon and radon progeny monitoring and review. Refer RWMP and RMP.</td>
<td>Likelihood: Rare Consequence: Minor Risk: LOW</td>
<td>No adverse impacts to workers, public or the environment due to radon release, nor radiological aspects of seepages and spills.</td>
<td>Estimated radiation doses to the public (and workers) within applicable limits as defined under the Radiation Protection and Control (RPC) Act.</td>
</tr>
<tr>
<td></td>
<td><strong>HERITAGE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7.1</td>
<td>Impacts on Aboriginal heritage as a result of mine activity.</td>
<td>Likelihood: Rare Consequence: Major Risk: HIGH</td>
<td>Maintain and improve the use of Aboriginal Heritage Clearance surveys. Protection of heritage sites in accordance with State and Commonwealth legislation (there are currently no listed heritage sites within the ML). Check flagged areas for disturbance.</td>
<td>Likelihood: Rare Consequence: Intermediate Risk: LOW</td>
<td>No disturbance to Aboriginal artefacts or sites of significance unless prior approval under the relevant legislation is obtained. Commitments to Traditional Owners as set out in agreements are met.</td>
<td>Documented Aboriginal Heritage Clearance surveys of all operational areas. Audits show flagged areas are not disturbed. Commitments to Traditional Owners reviewed and discussed at the Beverley Advisory Committee to the satisfaction of members (as the agreement is confidential the measurement criterion will be the absence of disputes requiring legal action).</td>
<td></td>
</tr>
</tbody>
</table>
7.4 Soil Aspects

7.4.1 Context and Stakeholder Views - Soil

The nature of mining at Four Mile requires some disturbance and in cases removal and stockpiling of soil. It is not the disturbance of soil, *per se*, that could cause environmental impacts at Four Mile; rather, it is the potential for soil disturbance to lead to other problems.

Nevertheless, as the measures to avoid or minimise these effects are to do with soil stabilisation and the like, soil is considered an aspect with risks to be assessed and ameliorated.

The conservation of soil, in the context of its ability to support appropriate vegetation, is of importance to stakeholders in the area. Soil conservation is considered in pastoral leases, conservation interests including Vulkathunha-Gammon Ranges National Park and the private Arkaroola Wilderness Sanctuary and the Traditional Owners. It is of interest to PIRSA principally with respect to potential compromise of rehabilitation.

7.4.2 Potential Impacts - Soil

Mine operations may degrade soil or allow additional erosion that could affect infrastructure (e.g. road washouts), cause vegetation death by exacerbated dust deposition, or delay final revegetation of the site and the return to pastoral use, e.g. by compaction or other degradation including spills of mining solution, fuel or chemicals.

The potential impact events considered in Table 7-6 are:

1.1. Chemical and radiological contamination\(^8\) of soil and watercourse sediments that would prevent its return to pastoral use arising from;
   a. Seepage from water management ponds through construction defects, wear and tear and accidental damage
   b. Pond overflows of mining solutions and waste disposal solution due to high rainfall events or control systems failure
   c. Escape of mining solution due to breakages of piping from poor welds, vehicle damage or pipe defects.

1.2. Spillage of hazardous substances during transport, storage and handling resulting in contamination of soil that would prevent its return to pastoral use.

1.3. Soil disturbance due to excessive off-road vehicle movement which may compromise rehabilitation for later pastoral use resulting from compaction of soil or exacerbated erosion.

1.4. Spillage of resin during transport, storage and handling resulting in contamination of soil that would prevent its return to pastoral use.

Potential Impact Event 1.1 has three parts - parts ‘a’ and ‘b’ apply to pond management while part ‘c’ is mainly relevant across the minesite.

7.4.3 Control and Management Strategies - Soil

The management strategies to minimise the risks of soil degradation and erosion have been used and progressively reviewed and improved at Beverley over the seven years of operations. These strategies will be applied at Four Mile. Those most directly related to the identified potential impact events are given in Table 7-6.

\(^8\) Chemical and radiological contamination are intrinsically linked and radiological is the primary indicator.
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A fuller list is given below, and reference should also be made to the RWMP, which details controls and management strategies related to radiological impacts that will apply at Four Mile:

- **Design Measures**
  - Pressure testing of pipework prior to commissioning
  - Ponds lined with plastic or clay
  - Leak detection beneath processing plant ponds
  - Wellhead drip trays
  - Bunds around plant and operational mining areas
  - Protection of piping from traffic in key areas
  - Hazardous materials and fuel stored in bunded areas
  - Provide stabilised tracks or roads for areas with frequent traffic
  - Provide fencing in key areas to keep vehicles on tracks.
  - Soil and gibber stripped from processing plant, associated ponds and similar areas is stockpiled for later re-spreading.
  - Stockpiles generally less than 2 m high
  - Trunklines, lateral lines and spider lines to be surface run (i.e. not buried)

- **Management Measures**
  - Wellfields are continually checked by Wellfield Operators and maintenance personnel
  - Soils that are radiologically affected above the operational contamination criteria will be buried according to the RWMP
  - Leaks in double-lined ponds above the TALR will be repaired
  - Continuous pressure monitoring of trunklines
  - Continuous flow monitoring of wellhouses
  - Monitoring of drip trays
  - Undertake routine inspection of tanks and equipment used to store and transfer chemicals and process materials. Any deficiency in the integrity of any equipment discovered by the inspection is brought to the attention of the Senior Site Supervisor for appropriate corrective action
  - Implement and regularly update standard operating procedures for handling of chemicals
  - Implement and regularly update spill and emergency response procedures
  - Remove fuel-affected soil for landfarming and later disposal (if required)
  - Acid or alkali soils remediated, if required
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- Regular training of emergency response personnel
- Educate all site employees and contractors on the importance of remaining on existing tracks
- Personnel to drive on existing tracks, unless permitted otherwise via Environmental Clearance Permit
- Additional fencing in areas with repeated unauthorised off-road tracks
- Progressive closure and rehabilitation of obsolete formed tracks and unauthorised off-road tracks.
- Ripping of compacted areas and soil when replaced
- Prior to any planned disturbance issue an Environmental Clearance Permit and document any expected disturbance
- Actively manage activities to minimise disturbance areas
- Measure actual disturbance at completion of planned activity
- Rehabilitate disturbed areas post closure for suitability for later pastoral use
- Maintain stabilised tracks for areas with frequent traffic to reduce potential erosion, runoff and sedimentation issues
- Provide regular stormwater turn-outs along roadways to reduce water velocities
- Use stone (gibber) or environmental matting cover to protect cut slopes from erosion during major rainfall events
- Restrict down slope movement of soil from bared ground by stabilising soil surfaces
- Establish silt fences or similar management tools to minimise the amounts of sediment entering creeks
- Where possible, install processing plant, ponds and wellhouses above the known 1 in 100 year ARI flood level to protect from possible flood damage
- Visual assessment of infrastructure as part of routine maintenance and following all major rainfall events of greater than 1-in-10 year ARI
- Sufficient freeboard in ponds to ensure that a high rainfall event does not result in over-topping
- Protection for piping that crosses creeks where flood damage is credible
- Wellfield and trunkline shut down procedures for significant rainfall events
- No reversing rule in wellfield areas to avoid damage to wellfield infrastructure
- Chemicals storage and processing areas appropriately banded to contain potential spills
- Remove hazardous material-affected soil for burial, neutralisation or dilution
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7.4.4 Likelihood and Severity of Consequence, Risk and Risk Acceptance - Soil

The inherent risks for soil aspect 1.1 were moderate, whilst those for 1.2 to 1.4 were low. However, with the design and operational measures proposed (based on those in use at Beverley in 2008), all residual risks were reduced to low, which are considered acceptable.

7.4.5 Specific Outcome - Soil

The specific outcome to be achieved for soil is that:

- Soil affected by mining activities is suitable for a return to pastoral use.

7.4.6 Outcome Measurement Criteria – Soil

- All sites subject to mining or disposal solution spills meet the radiological criteria as defined in the RWMP.
- Spills of hazardous materials are assessed and if so determined cleaned up:
  - Diesel spills to site specific criteria to be established using NEPM Risk Assessment methodology as recommended by EPA
  - Acid and Alkali: spill sites returned to within local background range of pH.
- Off-road vehicle movements not subject to Heathgate’s Environmental Clearance Permit (ECP) system are investigated, reported and one of the following undertaken:
  - fenced off to prevent re-use
  - rehabilitated
  - converted to an authorised road subject to SEB.

7.4.7 Leading Indicator Criteria – Soil

Leading indicator criteria in relation to the Risks are:

- Leakage from double-lined ponds is compared to the Target Action Leakage Rate (TALR) of 22 mL/m²/day
- Water levels in ponds are checked at least weekly and after >10 mm of rainfall in a day and maintained at least 0.20 m below lowest level of rim
- Any leaks detected by automatic systems or visual observation are logged as events and rectified
- Number and nature of spills and cleanups
- Number of non-compliant ECPs involving off-road incidents.

7.4.8 Company Compliance Monitoring Plan - Soil

Table 7-7 gives the soil monitoring program directly related to soil outcome criteria (even though they may not be soil measurements). Sediment sampling locations will be determined before operations begin and documented in the MARP, which must be approved by the regulating authorities. If mining later extends to the southern part of the project area, additional sites will be established.
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Ecosystem Function Analysis (EFA) monitoring, much of which is related to soil but includes additional vegetation measurements, will also be applied to Four Mile.

### Table 7-7 Company Compliance Monitoring Plan – Soil

<table>
<thead>
<tr>
<th>Location</th>
<th>Method</th>
<th>Parameter</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Double lined Ponds (PLP and Evaporation Pond)</td>
<td>Seepage collected and measured over a known time period</td>
<td>Leakage converted to mL/m²/d</td>
<td>Fortnightly</td>
</tr>
<tr>
<td>Site-wide</td>
<td>Manual area and affected depth or thickness measurements of spills of hazardous substances</td>
<td>Spill dimensions, diesel concentration (if not all removed)</td>
<td>When required</td>
</tr>
<tr>
<td>Site-wide</td>
<td>Surface sediment grab up and downstream of local creeks</td>
<td>Chemical parameters including radionuclides</td>
<td>Following rainfall events of &gt;10 year ARI or at least once per year</td>
</tr>
</tbody>
</table>

### 7.5 Vegetation Aspects

#### 7.5.1 Context and Stakeholder Views – Vegetation

The nature of mining requires some disturbance and removal of vegetation. The vegetation associations affected are widespread in the area and the proportion of vegetation removal is very small compared to the surrounding area, such that no species or vegetation associations are threatened by the Four Mile operations.

The conservation of vegetation and its diversity is of importance to stakeholders in the area. Vegetation conservation is considered in pastoral leases (fodder, shelter, soil conservation) and is intrinsic to the State Government’s Native Vegetation Council (NCV) and Department of Environment and Heritage (DEH) and to local conservation interests including Vulkathunha-Gammon Ranges National Park and the private Arkaroola Wilderness Sanctuary and the Traditional Owners. It is of interest to PIRSA, principally for rehabilitation reasons and the Commonwealth, with respect to the protection of rare or endangered species and biodiversity conservation.

Although vegetation removal at Four Mile is small by mining standards, due to the arid climate, establishment and slow growth of native vegetation after clearing, it is important to minimise the removal of vegetation. This is the aim of the management strategies described below.

A Native Vegetation Management Plan will determine the Significant Environmental Benefit (SEB) ratio for proposed wellfields and infrastructure development areas, and will be incorporated in the MARP.

#### 7.5.2 Potential Impacts - Vegetation

Disturbance and clearing of vegetation closely mirrors that of soil described above. The proportion of vegetation removal is very small compared to the surrounding area, such that no species or vegetation associations are threatened by the Four Mile operations. However, locally the removal or degradation of vegetation has follow-on effects by the local temporary reduction in habitat for fauna and can exacerbate erosion discussed above.

The potential impacts considered in Table 7-6 are:
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2.1. Reduction in regional native vegetation species density and diversity due to mining operations
2.2. Loss of local native vegetation (habitat) due to clearance for mining operations
2.3. Introduction of new or increase in abundance of existing weeds and pests (feral animals)
2.4. Loss of local native vegetation (habitat) due to mining-related fires.

7.5.3 Control and Management Strategies - Vegetation

The management strategies to minimise the risks to vegetation have been used and progressively reviewed and improved at Beverley over the seven years of operations. These strategies will be applied at Four Mile. Those most directly related to the identified potential impact events are given in Table 7-6. A fuller list is given below:

- **Design Measures**
  - Minimise perennial vegetation clearing by design (wellfield and projects planning)
  - Fencing patches of vegetation and soaks to protect seed stock and habitat
  - Run pipelines on the surface
  - Wellfield and projects planning
  - Fire-fighting equipment
  - Road/tracks acts as fire breaks
  - Design control measures to be implemented should fuel loads become significant.

- **Management Measures**
  - Prior to planned vegetation clearance identify and protect any vulnerable vegetation (fencing off) via the Environmental Clearance Permit system.
  - Enforcement of Environmental Clearance Permit system
  - Examine actual vegetation clearance at completion of activity
  - Establishment of approved SEB compensation where due
  - Use of Ecosystem Function Analysis (EFA) on progressive rehabilitation areas to refine techniques
  - Annual flora and fauna surveys to identify trends
  - Aerial Photography – comparisons with previous photographs to assess site wide vegetation cover changes
  - Weed and feral animal control
  - Train personnel to identify and report any alien species
  - Train all site employees and contractors on the importance of remaining on existing tracks
  - Personnel to drive only on existing tracks, unless permitted otherwise via Environmental Clearance Permit

9 Feral animals are included here to match condition 5 of Schedule 2 of the lease conditions. They influence vegetation outcomes.
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7.5.4 Likelihood and Severity of Consequence, Risk and Risk Acceptance - Vegetation

The inherent risk for vegetation aspects 2.1, 2.3 and 2.4 was low, and for 2.2 was high. However, with the design and operational measures proposed (based on those in use at Beverley in 2008), all residual risks were reduced to low, which are considered acceptable.

7.5.5 Specific Outcomes - Vegetation

All of the soil protection management strategies also apply to vegetation. Additional specific outcomes to be achieved by the combined soil and vegetation management measures are:

- No loss of abundance or diversity on or off the Four Mile mining lease to native vegetation through clearance or any other damage unless prior approval under the relevant legislation is obtained.
- No introduction of new weeds, plant pathogens or pests (including feral animals), nor increase in abundance of existing weed or pest species in the lease area compared to adjoining pastoral areas.
- No uncontrolled fires caused by mining operations.

7.5.6 Outcome Measurement Criteria – Vegetation

The specific outcomes to be achieved for vegetation at Four Mile are:

- Demonstrate that all clearing undertaken is approved in accordance with the MARP.
- Flora and fauna surveys demonstrate no new weeds or feral animals (due to mining activities), nor statistically significant increase in abundance of existing weed or pest species in the lease area, compared to adjoining pastoral areas.
- Any fires caused by mining operations are controlled within the ML boundary.

Control sites are chosen by appropriately qualified and experienced specialists. In general terms:

- Control sites are planned approximately 5 km away from planned disturbance areas
- Confirmation is received from Beverley staff of the absence of known mineralisation.

7.5.7 Leading Indicator Criteria – Vegetation

Leading indicator criteria for vegetation are:

- Progressive SEB accounting in the annual Mining and Rehabilitation Compliance Report (MARCR).

Where such statistical measures are valid. Qualitative assessment by independent specialists is considered more appropriate in some cases (see text this section).

7/01/2009
Trends noted in annual vegetation surveys.

### 7.5.8 Company Compliance Monitoring Plan - Vegetation

#### General Vegetation Monitoring

The vegetation monitoring program at Beverley has been developed using the years of experience at the site, and it will be extended to include Four Mile. The program set out below is largely based on that established in the consolidated MARP of 2008 (Heathgate 2008c), taking into account the risk assessment and criteria developed above.

EFA monitoring includes a vegetation component that contributes to the specialised vegetation monitoring described in Table 7-8. The locations of vegetation quadrats are shown in Figure 7-1. These locations will cover mining activities in both Four Mile East and West deposits. In the future, equivalent sites would be prepared for any mining or infrastructure that may be later proposed for the southern portion of the Beverley Four Mile project area at least one year in advance of a proposed start of mining in those areas.

<table>
<thead>
<tr>
<th>Location</th>
<th>Method</th>
<th>Parameter</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>ML and Local Area</td>
<td>Survey 5 m x 2 m vegetation quadrats</td>
<td>Species richness and total cover for all plant species and perennials only</td>
<td>Annually</td>
</tr>
<tr>
<td>ML and Local Area</td>
<td>Survey 4 x 1 ha quadrats for weed abundance</td>
<td>Weed species and cover</td>
<td>Annually</td>
</tr>
<tr>
<td>ML</td>
<td>Opportunistic watch –look for and record any alien species.</td>
<td>Number of species and their density</td>
<td>Following rainfall and during Annual Survey</td>
</tr>
<tr>
<td>ML</td>
<td>Aerial photograph – comparisons with previous photographs to assess site wide vegetation cover changes</td>
<td>Vegetation cover</td>
<td>Biannually (odd-numbered years)</td>
</tr>
<tr>
<td>ML</td>
<td>Prior to any planned disturbance issue Environmental Clearance Permit and document expected disturbance. Measure actual disturbance at completion of year by GPS.</td>
<td>Percent Actual vs Expected Disturbance Area</td>
<td>Annual (December)</td>
</tr>
<tr>
<td>ML</td>
<td>Map extent of any fire should one occur</td>
<td>Area burned and distance from boundary</td>
<td>If required</td>
</tr>
</tbody>
</table>

Reporting of the surveys will include the appropriate statistical comparison of mine-affected and control areas with respect to no statistically significant increase in abundance of existing weed or pest species in the lease area compared to adjoining pastoral areas. Other measures are more appropriately assessed qualitatively by the appropriately qualified and experienced specialists undertaking and interpreting the results of the annual vegetation surveys.

#### Ecosystem Function Analysis

In 2006 Heathgate introduced an integrated monitoring technique in a response to the CSIRO review (CSIRO 2004), the recommendations of which were required to be implemented by the State government (EPA 2007). This ‘Ecosystem Function Analysis’ (EFA) technique (Tongway and Hindley 2003) is primarily a tool for examining surface rehabilitation at the mine, both of progressive and final rehabilitation.
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However, as an integrated technique it includes both soil and vegetation measurements that contribute to the operational monitoring that is required to measure soil and vegetation leading indicators and outcome measurement criteria. In recent decades rangelands monitoring had been based on plant cover and biomass, which are time-consuming and subject to high variation between observers.
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This noisy data have made interpretation difficult and prediction almost impossible. The location of monitoring sites often ignores biophysical landscape function. CSIRO was sponsored by the mining industry to develop a monitoring technique that not only provides a quantitative analysis of a number of indicators to assess the functional status of landscapes but also provides vectors to indicate rehabilitation success (Tongway and Hindley, 1999).

The indices measured as part of EFA are:

- Landscape integrity reflecting overall resource “economy”
- Soil surface considerations, comprising
  - Stability (resistance to erosion)
  - Infiltration (capacity to absorb rain and run-off water)
  - Nutrient cycling (organic matter decomposition and cycling)
- Vegetation dynamics
- Habitat complexity (a measure of development of mammalian habitat niches).

Thus, this system of EFA not only provides a quantitative analysis of the landscape but also provides vectors which indicate whether the landscape is moving to sustainability (Tongway and Hindley 2003). This system of monitoring is particularly useful for assessing the rehabilitation of disturbed areas, but as stated above, contributes to operational monitoring and hence is introduced here.

The vegetation aspects of EFA complement the specialised vegetation monitoring described above. The full EFA monitoring program is set out in Table 7-9.

**Table 7-9  Company Supplementary Monitoring Plan – Ecosystem Function Analysis**

<table>
<thead>
<tr>
<th>Location</th>
<th>Method</th>
<th>Parameter</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ecosystem Function Analysis (EFA) transects at both analogue (control) and disturbed areas Lease and Local Area</td>
<td>Determination of: geographic setting of site; landscape organisation and soil surface assessment (rain splash protection, perennial vegetation cover, litter, cryptogram cover, crust brokenness, soil erosion, deposited materials, surface roughness, surface nature, slake test, texture)</td>
<td>Soil stability, water infiltration and nutrient recycling</td>
<td>Annually</td>
</tr>
<tr>
<td></td>
<td>Point centred quarter – sampling points established on EFA transect at regular intervals – at each point distance to nearest perennial plant in each of four sectors measured.</td>
<td>Plant cover, density and diversity.</td>
<td>Annually</td>
</tr>
<tr>
<td></td>
<td>Wandering Quarter – in areas with plants over 3 m in height - measuring 25 plants over 3 m in height within a 90° arc starting at the 0 m post of EFA transect.</td>
<td>Upper-storey cover and density in areas with plants over 3 m in height.</td>
<td>Annually</td>
</tr>
</tbody>
</table>

The locations of EFA monitoring sites will be shown in the MARP.
7.6 Surface Water Aspects

7.6.1 Context and Stakeholder Views – Surface Water

The nature of mining at Four Mile requires very little disturbance to the hydrology of the area, as there are no creek diversions or significant catchment area reductions or alterations required.

However, roads, tracks and pipelines do cross creeks of various sizes and flow potential and the protection of these creeks and their associated ecology needs to be considered. These have parallels to soil protection discussed above.

The protection of surface water is of importance to stakeholders in the area. Surface water dams are used by pastoralists as (often intermittent) stock water supplies. Protection of surface water and associated ecosystems is intrinsic to conservation interests including Vulkathunha-Gammon Ranges National Park, Lake Frome Regional Reserve and the private Arkaroola Wilderness Sanctuary and the Traditional Owners. Surface water also helps recharge the surficial aquifer (Willawortina Formation) which is used in some areas for stock water.

The ANZECC/ARMCANZ guidelines (2000) give the following advice.

No adverse effects to stock are expected if the concentration of sulphate (SO$_4$) in drinking water does not exceed 1,000 mg/L. Adverse effects may occur at sulphate concentrations between 1,000 and 2,000 mg/L, especially in young or lactating animals or in dry, hot weather when water intake is high. These effects may be temporary and may cease once stock become accustomed to the water. Levels of sulphate greater than 2,000 mg/L may cause chronic or acute health problems in stock.

With respect to salinity, the tolerance of different animals varies. Tolerances of the three possible stock types (beef cattle, sheep and horses) are reproduced below (Table 7-10).

<table>
<thead>
<tr>
<th>Livestock Type</th>
<th>No adverse effects on animals expected</th>
<th>Animals may have initial reluctance to drink or there may be some scouring but stock should adapt without loss of production</th>
<th>Loss of production and a decline in animal condition and health would be expected. Stock may tolerate these levels for short periods if introduced gradually</th>
</tr>
</thead>
<tbody>
<tr>
<td>Beef Cattle</td>
<td>0–4,000</td>
<td>4,000–5,000</td>
<td>5,000–10,000</td>
</tr>
<tr>
<td>Sheep</td>
<td>0–4,000</td>
<td>4,000–10,000</td>
<td>10,000–13,000</td>
</tr>
<tr>
<td>Horses</td>
<td>0–4,000</td>
<td>4,000–6,000</td>
<td>6,000–7,000</td>
</tr>
</tbody>
</table>

(Total Dissolved Solids [Salinity, mg/L] in Drinking Water [ANZECC/ARMCANZ 2000])

Concentrations of uranium less than 0.2 mg/L in livestock drinking water are considered unlikely to be harmful to animal health.
No specific guidelines are given for pH, which is low in mining and disposal solutions. However, as there would be both neutralisation and very significant dilution from natural runoff should mining or disposal solutions enter a flowing creek, pH is not a credible risk to downstream water bodies.

### 7.6.2 Potential Impacts – Surface Water

The potential impact considered in Table 7-6 is:

3.1. Watercourse contamination (including radiological) arising from release of mining solution due to flood damage to pipes, ponds and infrastructure, or from high rainfall causing overflow of ponds.

Note that this concerns impacts to surface water itself. The indirect impact on creek sediments that might arise by contact with contaminated water is addressed under Soil Aspects.

### 7.6.3 Control and Management Strategies – Surface Water

The management strategies to minimise the risks to surface water have been used and progressively reviewed and improved at Beverley over the seven years of operations. These strategies will be applied at Four Mile. Those most directly related to the identified potential impact events are given in Table 7-6. A fuller list is given below:

- **Design Measures**
  - Engineered creek crossings where high opportunity for flood damage is present
  - Ponds, wellhouses and processing plant located on high ground above 1-in-100 year ARI flood areas
  - Use of 1-in-100 year ARI flood level map in design of pipe routes and flood protection to minimise creek crossings
  - Minimising production well installation in flood-prone areas.

- **Management Measures**
  - Visual Inspection around site and review of Flood Management Plan as appropriate
  - Visual assessment of infrastructure as part of routine maintenance and following all major rainfall events of greater than 1-in-10 year ARI
  - Sufficient freeboard in ponds to ensure that a high rainfall event does not result in over-topping
  - No reversing in wellfields rule to avoid damage to wellfield infrastructure.

### 7.6.4 Likelihood and Severity of Consequence, Risk and Risk Acceptance – Surface Water

The inherent risk for surface water aspect 3.1 was **low**. With the design and operational measures proposed (based on those in use at Beverley in 2008), the residual likelihood was reduced to **rare**, the risk was **low**, which is considered acceptable.
7.6.5 Specific Outcomes – Surface Water

The specific outcome to be achieved by the above management measures is:

- No compromise of pastoral use of downstream surface water bodies.

7.6.6 Outcome Measurement Criterion – Surface Water

The specific outcome measurement criterion to be achieved by the above management measures is:

- Water quality in downstream water storages within 5 km of the site will be measured as soon as it is safe to do so following surface water flow, if there has been any release of mining solution into a flowing stream. This must show no compromise of pastoral use that it is attributable to mine operations. A mass balance calculation using estimated spill volume and chemical quality and estimated stream flow shall be undertaken to ascertain if any compromise is plausibly due to the mine.

- The parameters of most relevance are those elevated (except pH) in mining solutions, i.e. salinity (via its surrogate Electrical Conductivity), pH, sulphate, chloride and uranium. There are no specific stock water guidelines for chloride.

The adopted trigger values (below which no problems when used as stock water for sheep, beef cattle or horses may be expected according to ANZECC/ARMCANZ 2000) are:

- salinity (via its surrogate Electrical Conductivity (EC)) – 4,000 mg/L (6,000 uS/cm)
- sulphate – 1,000 mg/L
- uranium – 0.2 mg/L.

In the event that any of these parameters are elevated above the ANZECC/ARMCANZ stock water guidelines (used as trigger values), a mass-balance calculation will be undertaken to assess if the presence of the parameter can reasonably be attributed to the mine, as the natural variability of water quality is high in arid areas.

7.6.7 Leading Indicator Criteria – Surface Water

No specific leading indicator criterion applies to surface water.

7.6.8 Company Compliance Monitoring Plan – Surface Water

The surface water monitoring plan is set out in Table 7-11.

<table>
<thead>
<tr>
<th>Locations</th>
<th>Method</th>
<th>Parameters</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>To be determined</td>
<td>Surface water grab sample (mass balance calculation to be undertaken after analysis)</td>
<td>pH, EC, SO₄, U</td>
<td>As soon it is possible to safely drive a vehicle to the sites after a mining or disposal solution spill if creeks were flowing at the time</td>
</tr>
</tbody>
</table>
Surface water sampling - discussion

Water quality in downstream water storages will be measured as soon as it is safe to do so following surface water flow if there has been any release of mining solution into a flowing stream.

The minimum parameters to be measured are:

- salinity (via its surrogate EC)
- pH
- sulphate
- uranium (detection limit 0.05 mg/L or better).

Note that other than salinity, these are the same parameters as those included for groundwater ECLs.

In the event that any of these parameters (except pH) are elevated above the ANZECC/ARMCANZ stock water guidelines (the more conservative of sheep or cattle), a mass-balance calculation will be undertaken to assess if the presence of the parameter can reasonably be attributed to the mine, as the natural variability of water quality in the arid Four Mile area can be high.

In the remote possibility that the water quality in a dam is compromised due to mining, the affected dam will be fenced off and an alternative clean water source will be made available for livestock and native fauna until the water quality in the dam is returned to below the trigger values. The plan to treat or dispose of water above the trigger values will be agreed to the satisfaction of the Director of Mines before it is implemented.

7.7 Hydrogeological Aspects

7.7.1 Context and Stakeholder Views - Hydrogeology

The protection of groundwater is of importance to stakeholders in the area. Groundwater is used by pastoralists as stock and sometimes domestic water supplies and some for road construction by various groups including Heathgate. Protection of groundwater is intrinsic to the Department of Water, Land and Biodiversity Conservation (DWLBC), the Environment Protection Authority (EPA), the Traditional Owners, and some Non Government Organisations (NGOs). Surface water also helps recharge the surficial aquifer (Willawortina Formation) which is used in some areas for stock water.

Due to its naturally radioactive nature (specifically, the high radium-226 concentrations) there are no potential beneficial uses of the Eyre Formation aquifer at the Beverley Four Mile Project area other than for mining.

It is noted that there would be no change to GAB extraction rates arising from the Beverley Four Mile Project, and no potential impact of the project on the GAB as the Four Mile area is hydrogeologically separate from the GAB (refer Section 3.10). Thus the risks and control and monitoring measures will be unchanged from those addressed in the existing Beverley MARP (Heathgate Resources Pty Ltd 2008c).
7.7.2 Potential Impacts – Hydrogeology

Potential impacts considered in Table 7-6 are:

4.1. Groundwater contamination of upper Eyre FM outside ML preventing stock watering
4.2. Contamination (including radiological) of the Namba aquifer units overlying the Four Mile East Ore Zone arising from mining activities.
4.3. Contamination (including radiological) of the Mt Painter Group Fractured Rock aquifer units underlying the Four Mile East Ore Zone arising from mining activities.
4.4. Net groundwater pumping of bleed stream impacts on Paralana Hot Springs

7.7.3 Control and Management Strategies – Hydrogeology

The management strategies to minimise the risks associated with groundwater have been used and progressively reviewed and improved at Beverley over the seven years of operations. These strategies will be applied at Four Mile. No historic excursions of mining solution or injected waste water into the official monitor well network have been recorded. The management strategies listed in Table 7-6 are summarised as follows:

- **Design Measures**
  - Well construction to meet well permit conditions
  - Exploration holes cement grouted
  - Production and monitor wells cement grouted and integrity tested
  - Wells that do not pass integrity tests are cemented up and abandoned
  - Monitor wells installed at appropriate depths, distances and spacing

- **Management Measures**
  - Monitor underlying and overlying aquifer water levels and quality
  - Monitor mining aquifer water levels and quality
  - Adjust injection and extraction balances in mined areas to maintain control of mining or disposal solution
  - Natural attenuation (refer Guidelines Appendix A, Section 8.6) is acknowledged as an appropriate control measure for ISR mines to avoid impact on aquifer environmental values. Heathgate has undertaken studies into natural attenuation to demonstrate that this will occur in the Beverley Four Mile East ore zone aquifer with some certainty and in an appropriate timeframe. These studies will be further validated through monitoring during mining and after mine closure. Additional study of the Beverley Four Mile West ore zone will also be undertaken prior to commencement of ISR mining there, and any amendments to the monitoring and rehabilitation plan arising from this study would be discussed with PIRSA, and implemented.
7.7.4 Likelihood and Severity of Consequence, Risk and Risk Acceptance - Hydrogeology

The inherent risks for hydrogeology aspects 4.1 to 4.4 were all low. In particular, risk 4.4 is not considered a credible risk due to the large distance between the springs and the mining areas, and the very low bleed rate that ensures that there is negligible net impact on groundwater movement.

The design and operational measures proposed (based on those in use at Beverley in 2008) reduce all residual likelihoods confirming the low risks which are considered acceptable.

7.7.5 Specific Outcomes – Hydrogeology

The specific outcomes to be achieved by the above management measures are:

- No compromise to pastoral use (should it meet pastoral water quality standards) of the overlying Namba Formation aquifer
- No compromise to pastoral use (should it meet pastoral water quality standards) of the underlying Mt Painter Group Fractured Rock aquifer
- No compromise of potential pastoral use (should it meet pastoral water quality standards) of the Eyre Formation aquifer outside the Four Mile mining lease
- No reduction, due to mining, of aquifer pressure driving Paralana Hot Springs.

7.7.6 Outcome Measurement Criteria – Hydrogeology

The specific outcome measurement criteria to be achieved by the above management measures are:

- Monitoring of ECL parameters demonstrates that the category of pastoral use of the Namba aquifer does not change adversely in relation to ANZECC/ARMCANZ categories of water use, as a result of mining operations
- Monitoring of ECL parameters demonstrates that the category of pastoral use of the Mt Painter Group Fractured Rock aquifer does not change adversely in relation to ANZECC/ARMCANZ categories of water use, as a result of mining operations
- No migration of mining and disposal solutions outside the ML as demonstrated by ECL monitoring and response (see Section 6.7.8, which includes contingency measures).
- Validation of natural attenuation modelling demonstrates that predicted outcomes will be met for the Eyre Formation aquifer.
- Aquifer pressure between Mining Zone and Paralana Hot Springs does not exhibit ongoing decline due to mining.

7.7.7 Leading Indicator Criteria – Hydrogeology

Lead indicators that will provide early warning of the possible impending breach of Outcome Measurement Criteria are:
Environmental, Social and Economic Aspects

- Overlying and underlying aquifers
  - Water levels and level trends in overlying Namba Formation monitoring wells (ECL parameters)
  - Water quality and quality trends in underlying Mt Painter Fractured Rock aquifer monitoring wells (ECL parameters).
  - Leakage from double-lined ponds.
- Mining aquifer
  - Water quality and quality trends in the mining aquifer monitoring wells (ECL parameters)
  - Water levels in monitoring wells between the mining aquifer and Paralana Hot Springs.

Discussion – Excursion Control Levels and Parameters

Excursion Control Levels (ECLs) are agreed concentrations of selected water quality parameters that have emerged from the last seven years of operating experience as the best indicators of the influence of mining or disposal solution on natural groundwaters. They were most recently reviewed and accepted by the South Australian Regulators in 2007 (Heathgate 2007b). The same principles will be applied at Four Mile.

ECL parameters are elevated or significantly different in mining and disposal solutions compared with natural groundwaters. The ECL parameters are:

- pH
- sulphate
- uranium.

The actual ECL limits will be determined following the installation of the monitoring network, and analysis of baseline chemical data collected from monitoring wells. ECL limits will be developed in general accordance with NUREG guidelines (NUREG 2003).

An excursion will be deemed to have occurred if any two excursion indicators in any monitor well exceeded their respective ECL or a single indicator exceeds its ECL by 20%.

Discussion – Leakage from Ponds

Experience in Australia and elsewhere has shown that whilst leakage rates from appropriately designed and constructed plastic-lined ponds is very small, even with best practice a small number of defects are possible.

For double-lined ponds with leakage detectors, Heathgate proposes to adopt an industry standard ‘Target Action Leakage Rate’ (TALR) above which leaks must be found and repaired. The rate chosen of 22 mL/m²/day is based on the paper by Peggs (2006). In practice, leakage rates are normally undetectable but the adoption of the TALR will avoid unnecessary and potentially counterproductive repair attempts for inconsequential leaks. It is noted that the thick unsaturated
zone beneath the ponds to the Willawortina aquifer some 50 m beneath provides an effective additional barrier against potential impacts of leaks below the TALR.

Tracking leakage against the TALR is a leading indicator of the potential for leakage of mining or disposal solution towards the Willawortina Aquifer. More practically it is also a leading indicator for rehabilitation, as it is in the company’s interest to have minimal leakage of these solutions into the soil beneath the ponds that may require cleanup on rehabilitation.

7.7.8 Company Compliance Monitoring Plan – Hydrogeology

Hydrogeological studies have been undertaken over the majority of the project area, with additional regional studies to the east. The majority of work has been undertaken in the Four Mile East deposit, as mining is proposed to commence in this deposit. The discussion below relates to monitoring at Four Mile East.

Additional hydrogeological studies will be undertaken prior to the commencement of commercial mining at Four Mile West. Additional monitoring will be undertaken there, based on both improved understanding of the detail and experience gained at Four Mile East. In the future, equivalent studies and a monitoring program would be prepared for any mining or infrastructure that may be later proposed for the southern portion of the Beverley Four Mile project area at least one year in advance of a proposed start of mining in those areas.

Beverley Four Mile East Zone - Monitoring

A monitoring well network for the Four Mile East ore zone is proposed which will monitor groundwater in all aquifers above, below, and adjacent to the mining zone within the Eyre FM aquifer. The network comprises three types of well:

- Lateral Monitoring Wells – These wells monitor the Eyre FM sandstone laterally adjacent to the mining zone.
- Overlying Monitoring Wells – These wells monitor the first permeable sand unit above the Eyre FM sands within the overlying Namba FM
- Underlying Monitoring Wells – These wells monitor the underlying Mt Painter Fractured Rock Aquifer underlying the ore zone.

Lateral Monitoring Wells

Overview

Lateral monitoring wells at Four Mile East must effectively monitor a considerable thickness of aquifer (up to 70 m). The monitoring well construction and sampling methods will ensure that the entire aquifer thickness is effectively monitored and mining fluids can not move past a monitoring point undetected.

Location

The following rationale underpins the design of the Lateral monitoring well network:
Environmental, Social and Economic Aspects

Well spacing – The specification of well spacing is based on a risk management approach. In areas where the likelihood of mining fluid reporting to a monitoring well is negligible (i.e. up-gradient) well spacing is increased. In areas where the likelihood of contact is greater (down-gradient) well spacing is decreased. The proposed spacing is:

- up-gradient (west): 750 m
- lateral to flow (north and south): 500 m
- down-gradient (east): 250 m

Wells are located within 250 m of the ore zone defined by the currently delineated 0.015 m% Grade-Thickness ore outline.

Well locations are refined to allow for cultural consideration, topography, and surface environmental constraints.

Twenty-four lateral monitoring wells are proposed. The monitoring well locations are presented in Figure 7-2.

Well Construction

- Wells will be constructed using 4 inch (100 mm) PVC casing.
- Screens will be slotted PVC screens completed as a single stage.
- Screened intervals will be selected to screen only permeable sand units with blank casing placed against lower permeability silt or clay units.
- The screened intervals will monitor sand units through the full thickness of the Eyre FM (up to approximately 70 m)
- Each screened interval will be developed individually, through isolation and airlifting.

Wells will be pressure cemented and IT tested to 1000 kPa.

Sampling

Sampling Methods

- Due to the very long screens on these monitoring wells (up to 70 m), sampling using the standard low flow pumps employed at Beverley is not feasible, since these pumps will only extract a small sample from a short screened interval.
- Depth probes (sondes) will be used to monitor these wells.
- These sondes will be run into each well on a wire-line for each sampling event.
- Sondes will log excursion control parameters with depth.
- Proposed excursion parameters are pH, EC and SO$_4$. 
In the event that a change in chemical parameters is observed, each screened interval will be sampled individually using pumps and packers to isolate the screen. Samples will be analyzed for a full suite of parameters in the laboratory. Assessment of the excursion and any required remediation work will be undertaken accordingly.

**Sampling Frequency**

It is proposed to run sondes in each well quarterly.
Environmental, Social and Economic Aspects

Figure 7-2 Lateral monitoring well locations – Four Mile East

Note: artificial sun-shading exaggerates surface relief
Well Purging

It is important that the water within the well screen is refreshed with groundwater from the aquifer to ensure that excursions are detected. There is no benefit in monitoring stagnant water within a well, which is not representative of the surrounding groundwater.

The proposed monitoring regime addresses this requirement in two ways:

- Isolated airlift development of discrete well screen interval will ensure that each well screen is open to the surrounding aquifer.

- The natural groundwater flow at the Four Mile East ore zone is in the order of 15m/year. This natural flow will result in continual refreshment of water inside the well screen with groundwater from the aquifer. Estimated refresh rates are approximately 6 days. Calculations of refresh rates are as follows (Armstrong, D pers. Comm. Nov. 2008):

\[
\text{Volume in Screen} = \pi r^2 L = 0.55 \text{ m}^3
\]

\[
\text{Inflow Rate} = K \frac{dh}{dl} (2r L) = 0.088 \text{ m}^3/\text{day}
\]

\[
\text{Refresh time} = \frac{\text{Volume}}{\text{Inflow Rate}} = 6.2 \text{ days}
\]

Where

- \( r \) (Screen Radius) = 0.05 m
- \( L \) (Screen Length) = 70 m
- \( K \) (aquifer permeability) = 5 m/day
- \( \frac{dh}{dl} \) (hydraulic gradient) = 0.0025

Overlying Monitoring Wells

Overview

Overlying monitoring wells are designed to detect leakage of fluids into the overlying Namba FM aquifer. These wells are located such that no production area is more than 250 m distant from any overlying monitoring well. This methodology is consistent with the methodology currently applied to overlying monitoring wells at the Beverley Mine.

Well Construction.

- Wells will be constructed using 4 inch (100 mm) PVC casing with slotted PVC screens.
- Screens will access the first permeable unit in the Namba FM overlying the Eyre FM
- Wells will be developed through airlift pumping
• Wells will be integrity tested to 1000kPa.

**Sampling**

**Sampling Methods**

• Wells will be sampled using low flow pumps and laboratory analysis for excursion control parameters.

• Wells will be purged until stable physical parameters of pH, EC and DO are observed

• This is consistent with the sampling procedure currently employed at the Beverly Mine.

**Sampling Frequency**

• It is proposed to sample each well monthly. Following one year of mining it is proposed that the sampling frequency be reviewed from a risk management approach.

**Underlying Monitoring Wells**

**Overview**

Underlying monitoring wells are designed to detect leakage of fluids into the underlying fractured rock aquifer. These wells are located such that no production area is more that 250 m distant from any underlying monitoring well. This methodology is consistent with the methodology currently applied to overlying monitoring wells at the Beverly Mine.

**Well Construction.**

• Wells will be constructed using 4 inch (100 mm) PVC casing pressure cemented to the base of the Eyre Formation.

• Screens will 20 m open holes below the base of the Eyre Formation

• Wells will be developed though airlift pumping

• Wells will be integrity tested to 1000 kPa.

**Sampling**

**Sampling Methods**

• Wells will be sampled using low flow pumps and laboratory analysis for excursion control parameters.

• Wells will be purged until stable physical parameters of pH EC and DO are observed

• This is consistent with the sampling procedure currently employed at the Beverly Mine

**Sampling Frequency**
Environmental, Social and Economic Aspects

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It is proposed to sample each well fortnightly. Following one year of mining it is proposed that the sampling frequency be reviewed from a risk management approach (no excursions - less frequent sampling is required).

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**Table 7-12  Company Compliance Monitoring Plan**

<table>
<thead>
<tr>
<th>Method</th>
<th>Parameter</th>
<th>Criteria</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eyre Formation, Lateral</td>
<td>pH, SO₄, U</td>
<td>ECLs</td>
<td>Quarterly</td>
</tr>
<tr>
<td>Monitoring Wells</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Namba Formation, Overlying</td>
<td>pH, SO₄, U</td>
<td>ECLs</td>
<td>Monthly</td>
</tr>
<tr>
<td>Monitoring Wells</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mt Painter Fractured Rock</td>
<td>pH, SO₄, U</td>
<td>ECLs</td>
<td>Monthly</td>
</tr>
<tr>
<td>Aquifer, Underlying Monitoring</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Wells</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**Eyre Formation – Contingency Measures**

An excursion will be deemed to have occurred if any two excursion indicators in any monitor well exceeded their respective ECL or a single indicator exceeds its ECL by 20%. Should monitoring of a monitor well or wells show an excursion, the affected well or wells will be re-sampled.

If the excursion is confirmed (which does not in itself constitute a breach of lease conditions), the Director of Mines and EPA RPD will be notified and the pumping rates in the nearby mining area will be adjusted to ‘pull’ the affected water back into the mining zone and weekly monitoring of the affected monitor wells instituted until the excursion is resolved.

Experience with non-regulatory monitor wells at Beverley has been that this will be sufficient to correct an excursion. However, if the excursion persists for four weeks or more, the following contingency measures will be undertaken to ensure and demonstrate that the lease condition has not been exceeded:

- Installation of two additional Eyre Formation monitor wells at approximately 50 m and 150 m distance from the affected well or wells towards the nearest Lease Boundary (or closer together if the Lease Boundary is closer than 150 m)

- The pumping regime at the appropriate mining or disposal area will be further adjusted, if required, to ensure an inward-sloping hydraulic gradient is established (as shown by monitor well water levels) to demonstrate that mining or disposal solution is being drawn back into the nominated mining or disposal area.

These additional wells will be monitored on a weekly basis for the ECL parameters until the excursion is resolved. Should the excursion have moved further into the additional well, enough further additional wells will be installed such that the full extent of the excursion is quantified to the satisfaction of the Director of Mines and EPA RPD.
7.8 Fauna Aspects

7.8.1 Context and Stakeholder Views - Fauna

A baseline fauna survey of the Beverley Four Mile Project area was undertaken by EBS in 2007 (EBS 2008). A full copy of this report is provided at Appendix G.

The nature of mining at Four Mile requires the disturbance and removal of some vegetation and disturbance of other fauna habitat. The fauna affected are widespread in the area and the proportion of habitat removal is very small compared with the surrounding area, such that no species are threatened by the Four Mile operations. Nevertheless, it is considered important to minimise the impact on fauna, which is the aim of the management strategies described shortly.

The conservation of native fauna and its diversity is of importance to stakeholders in the area. Fauna management is considered in pastoral leases (primarily control of pest species) and native fauna conservation is intrinsic to conservation interests including Vulkathunha-Gammon Ranges National Park and the private Arkaroola Wilderness Sanctuary and the Traditional Owners. It is of interest to the Commonwealth with respect to the protection of rare or endangered species and biodiversity conservation.

Small fauna may be killed during vegetation and soil clearing but the main effect on fauna is displacement into the surrounding habitat. Some additional fauna deaths occur accidentally due to incidents involving vehicles, falling into drill pits or drill holes, or theoretically from contact with mining solutions. Local populations of house mice have become established at the processing plant and camp and it could be possible for feral predators such as cats and wild dogs, or feral herbivores such as rabbits to increase and put additional pressure on native fauna.

7.8.2 Potential Impacts - Fauna

The potential impacts considered in Table 7-6 are:

5.1. Reduction in native species density and diversity caused by wellfield development, access road construction and operations.

5.2. Reduction in native species density and diversity resulting from an increase in feral animals caused by creation of food sources, modified habitat and waste management operations

5.3. Reduction in adjacent pastoralist viability due to increase in feral animals due to mining operations.

7.8.3 Control and Management Strategies - Fauna

The management strategies to minimise the risks to native fauna have been used and progressively reviewed and improved at Beverley over the seven years of operations. These strategies will be applied at Four Mile. Those most directly related to the identified potential impact events are given in Table 7-6. A fuller list is given below:

- Design Measures

11 There have been no known deaths to vertebrate fauna caused through contact with mining solution.
Minimise perennial vegetation clearing by design.
  - Fencing patches of vegetation and soaks to protect seed stock and habitat
  - Running pipeline on surface
  - Wellfield and project planning

- Fencing of process and pond areas to exclude larger fauna
- Establishment and maintenance of clean water sources as an alternative to process water and ponds.

- Management Measures
  - Enforcement of Environmental Clearance Permit system
  - Enforcement of speed limits within Mining Lease
  - Rapid backfilling and rehabilitation of mud pits
  - Presence of drilling crews (discouraging fauna near pits and operations)
  - Rescue of trapped fauna
  - Backfilling of exploration and delineation drill holes
  - Placing stockpiled vegetation as habitat
  - Recreational hunting banned within the lease area
  - Physical chasing away of birds from ponds
  - Increase personnel awareness via inductions and notices
  - Daily Plant and Wellfield Environmental Checklist
  - Prohibition on pets within the lease area
  - Trap and destroy feral species.

7.8.4 Likelihood and Severity of Consequence, Risk and Risk Acceptance - Fauna

The inherent risk for all fauna aspects was low. With the design and operational measures proposed (based on those in use at Beverley in 2008), all residual likelihoods were reduced and all residual risks were low, which are considered acceptable.

7.8.5 Specific Outcomes – Fauna

Specific outcomes to be achieved by the above management measures are:

- No net adverse impacts from the site operations on native fauna abundance or diversity in the lease area and in adjacent areas
Environmental, Social and Economic Aspects

- No introduction of new weeds, plant pathogens or pests (including feral animals), nor increase in abundance of existing weed or pest species in the lease area compared to adjoining pastoral areas.\(^\text{12}\)

### 7.8.6 Outcome Measurement Criteria – Fauna

Results of monitoring program show no reduction of native vertebrate density and diversity compared with local area background.

Control sites are chosen with the following criteria:

- control sites are planned approximately 5 km away from planned disturbance areas, as chosen by a suitably qualified and experienced specialist.

- confirmation is received from Beverley staff that the control site is not in known mineralisation.

Results of monitoring program show no increase in feral vertebrates, compared with local area background, based on assessment by the appropriately qualified and experienced specialists engaged to undertake and assess the monitoring program.

All complaints from neighbours regarding feral animal control are investigated and are demonstrated to be not due to mining operations.

The highly variable nature of fauna monitoring makes numerical comparisons of vertebrate abundance or diversity unreliable. For example, the number of small reptiles captured can vary significantly with air temperature, which in this region can vary by 10°C or more during the one or two weeks of a fauna survey.

### 7.8.7 Leading Indicator Criteria – Fauna

- Trends of the monitoring program.

### 7.8.8 Company Compliance Monitoring Plan - Fauna

The fauna monitoring program at Beverley has been developed using the years of experience at the site. The program set out in Table 7-13 is based on the program approved for Beverley ML 6321 in 2008 (Heathgate 2008c) and the baseline survey undertaken in 2007 but also takes into account the risk assessment and criteria developed above.

The fauna trapping site locations are shown in Figure 7-3. These locations will cover mining activities in both Four Mile East and West deposits. In the future, equivalent sites would be prepared for any mining or infrastructure that may be later proposed for the southern portion of the Beverley Four Mile project area at least one year in advance of a proposed start of mining in those areas.

\(^{12}\) Whist this outcome includes vegetation it is included here as the Mining Lease condition lists feral animals with weeds.
### Table 7-13 Company Compliance Monitoring Program - Fauna

<table>
<thead>
<tr>
<th>Location</th>
<th>Method</th>
<th>Parameter</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lease and Local Area at established points. See Figure 7-3</td>
<td>Terrestrial mammal and reptile trapping program utilising a line of pitfall traps with nearby Elliot and cage traps. Fauna will be identified, sexed, marked and released unless otherwise required by trapping permit (e.g. voucher specimens for SA Museum). Undertaken at all sites.</td>
<td>Total number of species and abundance at each site</td>
<td>Annually – 6 day survey</td>
</tr>
<tr>
<td></td>
<td>Bird transect – walked traverse logging species and abundance. Undertaken at all sites.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>bird transect – walked traverse logging species and abundance. Undertaken at all sites.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BU-12</td>
<td>Microchiropteran bat trapping - using harp trap each night.</td>
<td></td>
<td>Annually – 6 day survey</td>
</tr>
<tr>
<td>North Mulga Dam</td>
<td>Anabat – record ultrasonic echolocation calls and send to specialist consultant for analysis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Microchiropteran bat trapping – mist net set up on evenings when wind conditions allow.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Process Ponds</td>
<td>Bird transect - walked traverse logging species and abundance.</td>
<td></td>
<td>Monthly</td>
</tr>
<tr>
<td></td>
<td>Anabat – Record data and send to specialist consultant for analysis.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Four Mile GAB Bore wetland</td>
<td>Bird Transect - walked traverse logging species and abundance.</td>
<td></td>
<td>Monthly</td>
</tr>
<tr>
<td></td>
<td>Opportunistic sighting.</td>
<td></td>
<td>Annually</td>
</tr>
<tr>
<td>Lease and Local Area</td>
<td>Spotlight traverse – night drive with spotlight randomly around site and local area roads recording number and species of animals.</td>
<td></td>
<td>Annually</td>
</tr>
<tr>
<td>Wellfield</td>
<td>Bird Transect – walked traverse logging species and abundance.</td>
<td></td>
<td>Monthly</td>
</tr>
</tbody>
</table>
Environmental, Social and Economic Aspects

Figure 7-3 Fauna Trapping Site Locations
7.9 Air Quality Aspects

7.9.1 Context and Stakeholder Views – Air Quality

The main air quality aspects that are considered are both radiological. This region is naturally dusty and this dust and the small emissions of the power station are not appreciable issues other than very local OHS considerations. The two radiological air quality aspects relate to the gas radon (and its decay products) and uranium bearing dust.

Management of radiation is the primary focus of the Environment Protection Authority Radiation Protection Division (EPA RPD) through the RPC Act 1982. Other stakeholders are also interested in the minimisation of radioactive emissions and the protection of workers, the public and the environment from possible adverse impacts of enhanced radiation exposure.

The RMP and RWMP (separately approved under the RPC Act 1982) have been designed to enable Heathgate to critically review the radiological impact of the Beverley Mine site and to demonstrate compliance with the requirements of the Licence issued under that Act, administered by the EPA RPD. Similar plans will be developed for Four Mile.

The Plans provide details of any potential issues related to occupational and environmental radiation and satisfy the monitoring and reporting requirements under relevant regulations and Codes of Practice for the commercial mining and milling of radioactive ores.

Operations are conducted in accordance with the RMP and RWMP, the ARPANSA (2005) Code of Practice and Safety Guide and the National Standard for Limiting Occupational Exposure to Ionizing Radiation (ARPANSA 2002). Other key points are:

- the Radiation Protection Division of the EPA was consulted before the background monitoring program was established
- the ALARA principle is applied to minimise the radiation dose to personnel and the public
- operations covered by the ARPANSA (2005) Code need to demonstrate use of Best Practical Technology (BPT).

7.9.2 Potential Impacts – Air Quality

The potential impact considered in Table 7-6 is:

6.1. Radon release from processing area and water management ponds (and other sources) increasing radiation doses to the environment or the public

7.9.3 Control and Management Strategies – Air Quality

The management strategies to minimise the risks due to radiation are set out in the separately approved RMP and RWMP. Those most directly related to the identified potential impact event are given in Table 7-6 and below. Fuller details are given in the RMP and RWMP:

- Design Measures
  - Tank ventilation at appropriate height.
Environmental, Social and Economic Aspects

- Management Measures
  - Radon and Radon progeny monitoring and review
  - Good maintenance

Radon modelling and monitoring were undertaken during the 1998 EIS, which established that the risk of radon exposure from the processing area and ponds is low. This has been confirmed by operational monitoring for the last seven years at Beverley. Monitoring of other radiological measures has similarly confirmed low radiation exposure. As the same procedures and policies will be applied at Four Mile, it is expected that radiations risks will be similarly low at Four Mile.

7.9.4 Likelihood and Severity of Consequence, Risk and Risk Acceptance – Air Quality

The inherent risk for radiation aspect 6.1 was low. With the design and operational measures proposed (based on those in use at Beverley in 2008), residual risk is low, which is considered acceptable.

7.9.5 Specific Outcomes – Air Quality

Specific outcomes to be achieved by the above management measures are:

- No adverse impacts to workers, public or the environment due to radon release or radiological aspects of seepages and spills

7.9.6 Outcome Measurement Criteria – Air Quality

The measurement criteria for outcomes of implementing design control measures and operational management measures are:

- Estimated radiation doses to the public (and workers) are within applicable limits as defined under the RPC Act.

7.9.7 Leading Indicator Criteria – Air Quality

The leading indicators that are used to track air quality are:

- Monitoring of radon decay products and uranium dust in the processing plant and ponds remain below the investigation levels.

The details of the monitoring are available in the RMP. The investigation levels vary according to the place and mode of measurement but are all set below levels that could cause radiation doses to exceed the applicable limits if they were maintained long-term.

7.9.8 Company Compliance Monitoring Plan – Air Quality

The compliance monitoring program includes the monitoring of:

- Uranium dust and radon decay products in the processing plant, ponds and accommodation camp area.
Environmental, Social and Economic Aspects

- Monitored doses are calculated and are demonstrated to be within applicable limits as defined under the RPC Act 1982.

Detailed information on the monitoring methods, frequency and locations are available in the RMP as well as in the RWMP. Heathgate reports quarterly to the regulators including air quality measurements graphed against the internal investigation levels. The investigation of any excursions above these investigation levels (which vary according to the place and mode of measurement) and demonstration of the return to normal levels are included in these quarterly reports.

7.10 Heritage Aspects

7.10.1 Context and Stakeholder Views - Heritage

A Native Title Mining Agreement for Four Mile is currently being negotiated with the Adnyamathanha community representatives.

Aboriginal heritage issues are of very high importance to the Native Title Claimants and to Heathgate. The maintenance of a good and mutually beneficial relationship with the Native Title Claimants is a high priority for Heathgate. Information here is a summary only.

No items of significant European settlement heritage have been identified at Four Mile.

7.10.2 Potential Impacts - Heritage

The potential impact considered in Table 7-6 is a general one, viz:

- Impacts on Aboriginal heritage as a result of mine activity.

Potential impacts could be of a physical nature with cultural aspects, such as the disturbance of significant vegetation, artefacts or human remains or of a primarily cultural nature such as disturbance of a culturally significant site.

7.10.3 Control and Management Strategies - Heritage

The measures listed in Table 7-6 are all of an operational nature:

- Areas flagged if necessary, following an Aboriginal Heritage Clearance survey
- Checking of flagged areas for disturbance
- Maintain and improve the use of Aboriginal Heritage Clearance survey
- Protection of heritage sites in accordance with State and Commonwealth legislation.

7.10.4 Likelihood and Severity of Consequence, Risk and Risk Acceptance - Heritage

The inherent risk for heritage aspect 7.1 was high. With the design and operational measures proposed (based on those in use at Beverley in 2008), the residual risk was reduced to low (with a rare likelihood), which is considered acceptable.
7.10.5 Specific Outcomes – Heritage

Specific outcomes to be achieved by the above management measures are:

- No disturbance to Aboriginal artefacts or sites of significance unless prior approval under the relevant legislation is obtained
- Commitments to Traditional Owners as set out in agreements met.

7.10.6 Outcome Measurement Criteria – Heritage

The specific outcome measurement criteria to be achieved by the above management measures are:

- Documented Aboriginal Heritage Clearance surveys of all operational areas
- Audits show flagged areas are not disturbed.
- Commitments to Traditional Owners reviewed and discussed at the Beverley Advisory Committee to the satisfaction of members (as the agreement is confidential the measurement criterion will be the absence of disputes requiring legal action).

7.10.7 Leading Indicator Criteria – Heritage

The leading indicator will be near-miss incident reports relating to potential disturbance of flagged areas.

7.10.8 Company Compliance Monitoring Plan – Heritage

The map (not reproduced here) showing all identified sensitive areas will be updated after every clearance survey.

Flagged areas will be checked for disturbance six-monthly and after any relevant incident report.

7.10.9 Heritage Management

The Work Area Clearance methodology adopted by the company in association with the Native Title applicants, has been developed to minimise any potential deleterious impact upon Aboriginal cultural values at all stages of exploration and development within the area.

The survey team is selected by representatives of the Adnyamathanha community and consists of up to 8 members. The team is assisted by up to two anthropologists and usually about 5 Heathgate personnel.

The methodology entails distinct types of clearance:

- Hole by hole – in which individual pegs are placed where drilling is desired and the survey team inspects each one (used mainly in the early stages of exploration where very low drilling density is required – typically 100 m centres or more);
- Line – in which a line (usually an old pastoral station track) is driven or walked and the survey team identifies sensitive areas if present with respect to a 50 m zone on either side of the line. This is done on the understanding that drilling may take place anywhere within this zone other
Environmental, Social and Economic Aspects

than the identified sensitive areas and subject to the final individual drill hole sites being monitored by Heathgate’s Aboriginal Liaison Officers.

- **Area** – in which an area is driven or walked and the survey team identify sensitive areas if present. This is done on the understanding that drilling may take place anywhere within this area other than the identified sensitive areas and subject to the final individual drill hole sites being monitored by Heathgate’s Aboriginal Liaison Officers.

- **Blanket/production** – same as for area clearance except that the area in question has been identified as a future production area and thus close-spaced drilling (typically 25 m spacing) will be required. This type of clearance involves closer inspection so that further monitoring by Heathgate’s Aboriginal Liaison Officers is not required.

The map showing all identified sensitive areas is updated after every clearance survey.

In addition to conducting clearances, the survey team also, on an ad hoc basis, inspects areas previously cleared to confirm that sensitive areas have been protected and the works have been conducted in accordance with the relevant clearance reports.

### 7.11 Radiological Aspects

The Radioactive Waste Management Plan (RWMP) and Radiation Management Plan (RMP), which are both approved by the South Australian Environment Protection Authority, are the key documents for radiological aspects of the Beverley operation, concerning the protection of both the environment and the public (and workers).

In Table 7-6, and in Sections 7.4 to 6.10, radiological issues relevant to the various categories of aspect (surface water, air quality etc) are listed with reference to the appropriate specific identifier where that radiological issue is considered.

### 7.12 Ongoing Community Engagement Plan

Heathgate is committed to ongoing consultation and transparency and recognises the importance of information dissemination on any environment, heritage management and Aboriginal issues that might potentially be associated with the proposed Beverley Four Mile Mine.

Different mechanisms for consultation with various stakeholder groups have been established (refer Sections 6.1 and 6.2). The ongoing engagement plan is set out in Table 7-14.
### Table 7-14 Ongoing Community Engagement Plan

<table>
<thead>
<tr>
<th>Community Group</th>
<th>Forum</th>
<th>Frequency</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regional Aboriginal Communities</td>
<td>Beverley Four Mile Advisory Committee</td>
<td>Quarterly</td>
<td>Meetings are held in Adelaide, Port Augusta and at the Beverley site. In addition to providing a forum for dissemination of information, the advisory committee presents an opportunity for the Aboriginal community of the Northern Flinders Ranges to raise any issues of concern it may have.</td>
</tr>
<tr>
<td>Clearance visits</td>
<td>As required</td>
<td></td>
<td>Heathgate conducts a number of Aboriginal Heritage Clearances with Native Title Claimants as part of the ongoing exploration and mine development program. These clearances ensure that future activities will not interfere with Aboriginal heritage and that past activities have been conducted in accordance with previous clearance reports. They also allow further consultation to ensure the local Aboriginal people are up to date with any mine developments.</td>
</tr>
<tr>
<td>NAIDOC Day celebration</td>
<td>Annual</td>
<td></td>
<td>Each year, Heathgate hosts NAIDOC Day celebrations at Beverley. The day consists of speeches, flag raising, a mine tour and a BBQ in the creek featuring traditional camp oven cooked kangaroo and damper. The day provides many opportunities for Adnyamathanha and non-Adnyamathanha staff to interact with visiting Adnyamathanha people and to discuss any issues relating to the mine.</td>
</tr>
</tbody>
</table>
## Community Group Forum Frequency Notes

<table>
<thead>
<tr>
<th>Community Group</th>
<th>Forum</th>
<th>Frequency</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>State and Federal regulators and stakeholders</td>
<td>Beverley (Four Mile) Environmental Consultative Committee (BECC)</td>
<td>Six-monthly</td>
<td>Chaired by PIRSA and held in Adelaide, this has a current standard agenda covering:</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Welcome and opening remarks</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Minutes of previous meeting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Matters arising</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Status of operations and discussion of any incidents</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Meeting conditions of approval</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Approvals sought or granted</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Notification of changes to procedures</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Significant staff or organisational changes</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Public consultation activities</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Commonwealth matters</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- General business</td>
</tr>
</tbody>
</table>

There is also an opportunity for Heathgate to meet and discuss issues with the other active uranium miner in South Australia, Olympic Dam, in an informal meeting over lunch following the BECC meeting.

<table>
<thead>
<tr>
<th>State regulators and stakeholders</th>
<th>ISR Radiation Review Committee</th>
<th>Quarterly</th>
<th>Chaired by EPA RPD and held in Adelaide, this has a current standard agenda covering:</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Minutes of previous meeting</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Matters arising</td>
</tr>
<tr>
<td></td>
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<td>- Status of operations</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>- Approvals sought or granted</td>
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<td></td>
<td></td>
<td></td>
<td>- Incidents and notifications</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Occupational and environmental radiation monitoring results</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>- Other business</td>
</tr>
</tbody>
</table>

Note: it is under discussion whether every second ISR Radiation Review Committee might be subsumed into the BECC meeting due to the similarity of material covered (see next item).
Community Group | Forum | Frequency | Notes
--- | --- | --- | ---
Holder of sub-lease on Wooltana Station (pastoralist) | Informal meeting | Two-monthly | These discussions are generally held at the Beverley site and are a forum for exchange of business planning (mining and pastoral), discussion on maintenance or creation of watering points for stock, fencing etc. The sub-lease holder is also a neighbour, being based at nearby Wertaloona Station.
Nearby landholders | Informal meetings | Ad-hoc | The land uses of the properties surrounding Wooltana Station (owned by Heathgate) are pastoral and private (Arkaroola Wilderness Sanctuary) or government (Vulkathunha-Gammon Ranges National Park and Lake Frome Regional Reserve). As our closest neighbour, the most frequent discussions are with the owners of Arkaroola Wilderness Sanctuary.
Broader district | Informal meetings | Ad-hoc | Heathgate has been a participant in the review of the Leigh Creek Health Service. It is also in the process of becoming an SES Community Response Team.
## Community Group Forum Frequency Notes

<table>
<thead>
<tr>
<th>Community Group</th>
<th>Forum</th>
<th>Frequency</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>General Public</td>
<td>• updating and enhancing the Heathgate web site</td>
<td>Ongoing</td>
<td>Heathgate has continued with an active program to keep the wider community informed of the benefits the Beverley mine delivers for South Australia, the nation and the world, by contributing to the delivery of clean energy to the world. Several tours of the mine are typically conducted for the wider community each year. Sponsorships have included the Royal Flying Doctor Service ‘Wings for Life’ Ball in Adelaide and ‘Wilpena under the Stars’ Concert. Heathgate is a regular participant in industry and other conferences, workshops and seminars.</td>
</tr>
<tr>
<td></td>
<td>• an “open door” policy to community inquiries</td>
<td>Annual</td>
<td></td>
</tr>
<tr>
<td></td>
<td>• wide circulation of the project newsletter, <em>In Situ</em></td>
<td></td>
<td></td>
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<tr>
<td></td>
<td>• participation in industry forums</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>• involvement with organisation such as the Northern Region Development Board and SA Great</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>• involvement in the SA Chamber of Mines education program, including funding for educational packages for South Australian schools and the dedicated web site – <a href="http://www.uraniumsa.org">www.uraniumsa.org</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>• a range of sponsorships focussed primarily in the north of the State</td>
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</tr>
</tbody>
</table>
8.1 Baseline Data and Context

8.1.1 Baseline Data

An extensive baseline has been compiled for the Beverley Four Mile Project, and is available as a baseline reference for rehabilitation and closure. A summary of this baseline is provided in Chapter 3.

The Four Mile site has also had extensive environmental and other studies, as described elsewhere in this document, in particular in regard to climate, flora, fauna, heritage, hydrology, hydrogeology, soils, seismicity and radiological background. The Appendices include the baseline studies undertaken specifically for the Beverley Four Mile Project.

As also described elsewhere in this document (Chapter 6), extensive consultation has taken place.

8.1.2 Context

The Beverley Four Mile Project, as well as the existing Beverley Project, is located in the pastoral zone of South Australia and was developed as a greenfields site, i.e. there was no prior mining in the areas now occupied by or proposed for the Beverley mine. The long-term objective for rehabilitation is the return of the landscape of the Beverley site to pastoral use. The default case is that all infrastructure installed under Mining Act approvals will be removed and rehabilitated.

However, it is possible that some facilities (primarily access roads) to be built on the Four Mile area may be handed over for other activities on the cessation of mining, subject to appropriate approvals and handover arrangements. Any change to the full return to pastoral use will be subject to future stakeholder involvement and planning.

The objective of return to pastoral use is attainable given that:

- ISR mining leaves the soil profile largely intact and major soil changes through the construction of pads (for footings, hardstands, roads, etc.) or ponds are limited in area
- The largely Mitchell grass / chenopod plain vegetation has been shown to be highly resilient, under both past excessive grazing pressures and intensive drilling activities
- General drainage will be unaltered by the development and only minor changes in surface hydrology would occur
- The current and proposed construction and eventual rehabilitation of waste sites, including low-level radioactive wastes, pose no long-term hazards to biological communities, or to any user of the land surface.

The requirements for pastoral use, of a land condition similar to the present, are also likely to be the requirements for other land uses, dependent on the natural landscape, such as expanded conservation reservation or recreational usage.

Mining may be ongoing in the area after the Beverley orebodies are exhausted. It is possible that the processing plant, camp and airstrip at Beverley may be retained as a central facility for other deposits within economic distance. In this scenario, the Beverley wellfields may be closed and rehabilitated in advance of other infrastructure. The appropriate tenure will be maintained for infrastructure kept after the exhaustion of the Beverley orebodies.
Staged mine closure and rehabilitation will occur for the proposed Beverley Four Mile Project area, as has occurred on the existing Beverley ML 6321 where wellfields have been closed. This involves commencement of rehabilitation as soon as practical after the completion of mining. Hence, at the final closure of mining operations, rehabilitation to be carried out will largely be limited to the most recently active mining area and the dismantling of surface facilities.

### 8.2 Stakeholder Involvement and Issues

The proposed Beverley Four Mile Project is essentially a continuation of existing ISR mining at Beverley and as such there has been the extensive stakeholder involvement of two Environmental Impact Statements, the previous PER / MLA and MARP process from 2006 to 2008 for the Beverley extension area, a number of government inquiries and regular scheduled meetings with State (quarterly) and State and Federal authorities (six-monthly), as well as many other discussions (please refer Section 6).

The South Australian EPA-commissioned CSIRO review (CSIRO Land and Water 2004) also considered rehabilitation issues. The proposed rehabilitation measures have evolved since mining commenced with a number of undocumented small surface rehabilitation trials undertaken.

More recently (and as recommended by CSIRO Land and Water [2004]), Ecosystem Function Analysis (EFA; Tongway & Hindley 2004) has been undertaken at some early rehabilitation sites in 2006 and 2007, with the current intention of annual surveys. The trends established by EFA will allow further refinement of surface rehabilitation techniques as progressive rehabilitation begins in earnest, as well as provide evidence of appropriate rehabilitation outcome for areas rehabilitated.

As these results are interpreted and provided to the stakeholders, closure and rehabilitation of the proposed Beverley Four Mile MLA area will be further reviewed and determined in consultation with the appropriate regulatory authorities, the pastoralist, indigenous peoples and other direct stakeholders via the consultation processes set out in Section 6.

Heathgate’s detailed Mine Closure and Rehabilitation Plan, which will include a listing of individual or grouped infrastructure and specific treatments, will be initially provided to stakeholders three years prior to the anticipated final completion of commercial mining and processing, to allow sufficient time for any necessary negotiation. This will include detailed plans of areas for rehabilitation and any infrastructure that will be left, subject to appropriate approvals. Note that Heathgate currently assumes that all infrastructure will be removed.

### 8.3 Scope of Domain

All of the proposed Beverley Four Mile MLA area is expected to be returned to pastoral use, i.e. there is a single ‘domain’ in that sense. However, more effort will be required at the site of the satellite plant, whereas rehabilitation of the wellfields will be straightforward. Therefore two closure domains are proposed:

- Satellite plant and ponds
- Wellfields and other infrastructure.

Maps and specific procedures will be required for the decommissioning of the satellite plant and associated holding ponds, to meet the requirements of the *Radiation Protection and Control Act 1982* (SA), in particular as set out in the ARPANS (2005) *Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing*. This will be set out in appropriate detail in the Mine Closure and Rehabilitation Plan to be prepared closer to the completion of commercial mining at the Beverley Four Mile Project.
8.4 Potential Social and Environmental Impacts

Heathgate’s current planning associated with the current Beverley ML assumes that it will remove all facilities on decommissioning, and the same is expected for the proposed Beverley Four Mile MLA area. Some access roads and fencing may be left, at the request of the pastoralists.

The closure of the Beverley Four Mile Project would be expected to occur at the same time as closure of the Beverley operation, which, in the absence of other operations taking its place, will significantly reduce employment in the region. The economic contributions described in the previous Mining Proposal (Heathgate 2007a) will cease.

However, in the case of the local Aboriginal communities at Nepabunna and Iga Warta, a proportion of Aboriginal royalties, administration and community payments have been invested in long-term projects and investments, which will continue to benefit those peoples after final closure of the Beverley Four Mile Project.

There will also be the positive legacy of improved skills and employability of staff and contractors who have worked at the mine both in the local region and the main other areas workers have been drawn from (Adelaide and the Iron Triangle region of mid north South Australia).

As discussed earlier, it is possible that some facilities (e.g. access roads) may be handed over for other activities on the cessation of mining, subject to appropriate approvals and handover arrangements.

8.5 General Standards

The Mine Closure and Rehabilitation Plan will ensure that the following standards are taken into account:

- General economic standards:
  - That the community are left with no residual liability for site rehabilitation or maintenance
  - That any adverse economic effects are minimised
  - That provision is made for reasonable access for future mining (or reprocessing) of any remaining resource.

- General social standards:
  - Effective ongoing community engagement
  - Closure minimises the disruption/impact on the community.

Rehabilitation and mine closure and completion will be undertaken with reference to the recently released DITR (2006a,b) documents *Mine Closure and Completion* and *Mine Rehabilitation* and guidelines from PIRSA (2007a, 2008). The applicable legislation is listed in Table 7-1.

Rehabilitation and mine closure will involve the return of disturbed land to ‘a stable, productive and self-sustaining condition, after taking into account the beneficial uses [in this case, pastoral] of the site and the surrounding land.’ This includes:

- Physical, geochemical and ecological stability
- The protection of the quality of the surrounding water resources
Mine Closure and Rehabilitation Plan

8.6 Closure Outcomes and Criteria

8.6.1 General Outcomes

The general outcomes for closure of the Beverley Four Mile Project, as adapted from the DITR (2006a), are to ensure that:

- The interests of stakeholders are considered in the mine closure process
- The closure process can occur in an orderly, cost-effective and timely manner
- The cost of closure is properly provided for and that the community is not left with an on-going liability
- There are clear accountabilities and resources available to implement the Mine Closure and Rehabilitation Plan
- A point can be reached where Heathgate has met the closure criteria.

The general criteria for rehabilitation and closure of the Beverley Four Mile Project, as adapted from the DITR (2006a), are that:

- The post-mined landscape is safe and stable
- The post-mining land use (pastoral) is able to continue
- The rehabilitation monitoring demonstrates that the land is suitable for relinquishment.

The principal aims of the planning for closure of the Beverley Four Mile Project are:

- Non-mining aquifers are maintained with existing potential beneficial uses
- That the landforms are rehabilitated to ensure general conformity with the surrounding natural landforms and ecosystems
- That rehabilitation is carried out progressively, where possible

Requirements under other legislation e.g. the *Environmental Protection Act 1993* (SA) and the *Radiation Protection and Control Act 1982* (SA), in particular as set out in the ARPANSA (2005) *Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing*. 
Mine Closure and Rehabilitation Plan

Section 8

- The rehabilitation monitoring demonstrates that the land is suitable for relinquishment.

Heathgate intends to undertake the decommissioning and rehabilitation of the existing and the proposed operation. As surety, a bond that is adequate to cover the cost of decommissioning and rehabilitation would be provided to the South Australian Government. A cost estimate would be provided in the MARP. The bond will be reassessed and adjusted annually as required by the South Australian Government.

8.6.2 Specific Outcomes

**Hydrogeology**

The specific outcomes to be achieved with respect to hydrogeology are (refer Section 7.7.5):

- No compromise to potential pastoral use (should it meet pastoral water quality standards) of the overlying Namba Formation aquifer.
- No compromise to potential pastoral use (should it meet pastoral water quality standards) of the underlying Mount Painter Group Fractured Rock aquifer.
- No compromise of potential pastoral use (should it meet pastoral water quality standards) of the Eyre Formation aquifer outside the attenuation zone predicted by natural attenuation modelling.
- No reduction, due to mining, of aquifer pressure driving Paralana Hot Springs.

For Beverley ML 6321, initial closure criteria (to be confirmed when a more detailed rehabilitation program is proposed) are given in Table 7-1 of the existing Beverley MARP (Heathgate 2008). Similar criteria are proposed for Four Mile:

- Three consecutive years (minimum) of post-closure water quality from at least ten selected Namba Formation and at least five Mt Painter Group monitor wells are within two standard deviations of the mean of all previous measurements for pH, SO\textsubscript{4}, and U.
- Three consecutive years (minimum) of post-closure water quality from at least ten selected Namba Formation and at least five Mt Painter Group monitor wells demonstrate a sustained hydraulic gradient neutral or from those wells to corresponding wells in the mined Eyre Formation.
- Selected wells will be agreed with PIRSA and include the most and least saline monitor wells and a selection with good geographic coverage over the mined areas and salinity range.
- Eyre Formation (Four Mile Embayment):
  - Five consecutive years (minimum) of post-closure groundwater level monitoring show re-establishment of hydraulic gradients not exceeding the pre-mining north-easterly to easterly hydraulic gradients (i.e. natural groundwater throughflow is not accelerated by a steeper gradient).
- Outside mining and disposal-affected parts of the Eyre Formation:
  - Five consecutive years (minimum) of post-closure water quality from at least ten selected Eyre Formation monitor wells outside of the mining-affected areas are consistent with modelled predictions.
  - No compromise of the pre-mining category of pastoral use Eyre Formation monitor wells where that is predicted by modelling (i.e. changes of category, if predicted, do not extend beyond the area predicted).
Within mining-affected parts of the Eyre Formation:

- Five consecutive years (minimum) of post-closure water quality from at least ten selected Eyre Formation monitor wells within the mining-affected areas for pH, SO$_4$, U show trends consistent with natural attenuation in line with modelled predictions.

**Soil and vegetation**

The potential surface impacts following closure include changes to vegetation and habitat. The overarching outcome is for the area to be suitable for return to pastoral use. Heathgate use Ecosystem Function Analysis (EFA) to assess soil and vegetation impacts (refer Section 7.4.8 and, in particular, Section 7.5.8 and Table 7-9 of this report), and would use the same methodology for Mine Closure and Rehabilitation soil and vegetation assessment.

EFA uses a number of indices for both soil and vegetation related measurements:

- Stability
- Infiltration
- Nutrient cycling
- Lower plant cover (% and plants/ha)
- Upper plant cover (% and plants/ha).

Under EFA, these indices are combined in a manner that allows the progress of a monitored site towards self sustainability. Where a site reaches or can be confidently predicted to meet a sustainability threshold, the site is considered to be progressing satisfactorily towards that outcome even though the full obtainment of local norms may take some decades due to the slow growth rates of perennial plants.

In addition, regular photographs of the EFA sites will be taken. Annual EFA of analogue (background) sites at Four Mile is planned to commence in 2009. Results of the 2006 and 2007 monitoring for Beverley ML 6321 are given in Outback Ecology (2007). The background indices are variable within and between the three main landscapes (Mitchell Grass Plain, minor and major drainage lines – refer Section 3.11) and may be expected to vary with future climatic conditions; the same can be expected at Four Mile.

Insufficient information is available at this time to propose what proportion of the background indices should be used as numerical measurement criteria for EFA on rehabilitated areas. However, over the next few years additional years of EFA data will be examined to establish objective criteria as part of the final rehabilitation planning for both Beverley ML 6321 and Four Mile.

The proposition and approval of qualitative indices is scheduled for approval at least two years before final rehabilitation of Beverley. It should be noted that resolution of this matter at an early time (given that with the going ahead of Beverley Four Mile, the Beverley complex will remain in operation for some years following the end of mining at currently-known Beverley ML 6321 wellfields) is in Heathgate’s interest, and development of appropriate indices will be investigated over 2009, for consideration for Beverley Four Mile as well as ML 6321.

Insufficient information is available at this time to propose what proportion of the background indices should be used as numerical measurement criteria for EFA on rehabilitated areas. However, over the years leading up to the final decommissioning of Beverley (the processing plant and ponds are expected to be rehabilitated later then wellfields) the additional years of EFA data will be examined to establish objective criteria as part of the
Mine Closure and Rehabilitation Plan

8.7 Sustainable Closure Strategy

Both passive and active methods of rehabilitation will be used. Passive methods will be used in small areas of disturbance, where nearby plants provide some seed stock and shelter for the area being rehabilitated. Active methods will be used where the rehabilitation area is larger and needs to have an additional source of seed.

The general control and management measures with respect to groundwater are described in Section 7.7.3; outcome measurement criteria are given in Section 7.7.6, and leading indicator criteria are given in Section 7.7.7:

The general control and management measures with respect to soils and flora are described respectively in Sections 7.4.3 and 7.5.3; outcome measurement criteria are given in Sections 7.4.6 and 7.5.6, and leading indicator criteria are given in Sections 7.4.7 and 7.5.7:

8.8 Closure Maps and Sections

At this time all infrastructure is proposed to be removed and rehabilitated. Should some infrastructure be retained (subject to appropriate approvals and handover arrangements) plans clearly showing infrastructure to be kept and areas to be rehabilitated will be provided in the detailed Mine Closure and Rehabilitation Plan foreshadowed in Sections 8.2 and 8.3 above. All areas will be returned to the approximate pre-mining contours. As such no cross sections are provided.

8.9 Residual Risk Assessment

There are four main risks associated with potentially not meeting the desired rehabilitation outcomes. These are summarised in Table 8-1 with the identifiers R.1 and R.2 (revegetation aspects) and R.3 (groundwater aspects). The measures (set out above) result in low residual risks for each of these potential impact events. These low risks are considered acceptable.

<table>
<thead>
<tr>
<th>ID</th>
<th>Potential Impact Event</th>
<th>Residual Risk Level</th>
</tr>
</thead>
<tbody>
<tr>
<td>R.1</td>
<td>Failure of revegetation to meet pastoral use in a reasonable timeframe due to insufficient rehabilitation – soil and seed sources</td>
<td>Likelihood: Unlikely, Consequence: Minor, Risk: LOW</td>
</tr>
<tr>
<td>R.2</td>
<td>Failure of revegetation to meet pastoral use in a reasonable timeframe due to salinisation, acidification or other contamination of soil arising from accidental escape of mining or waste disposal fluid, pond overflows or chemical or fuel spills</td>
<td>Likelihood: Rare, Consequence: Minor, Risk: LOW</td>
</tr>
<tr>
<td>R.3</td>
<td>Compromise of protected potential beneficial uses of the overlying (Namba) or underlying (Fractured Rock) or off-lease Eyre Formation aquifers.</td>
<td>Likelihood: Rare, Consequence: Minor, Risk: LOW</td>
</tr>
</tbody>
</table>
Management Capability

Section 9

9.1 Previous Experience

Heathgate has owned the Beverley deposit since 1990 and operated the mine since 2000. The staff and long-term contractors comprise a mixture of personnel with up to eight years site experience (some of whom worked on the original Field Leach Trial). Senior staff also have experience at other mine sites as operators, contractors, consultants and regulators.

This experience is directly applicable to the planned operations on the proposed Beverley Four Mile Project, which will largely be a continuation of the ISR mining currently undertaken on Beverley’s existing mining lease ML 6321.

Heathgate maintains a computer-based Environmental Management System (EMS) as part of its broader Environmental, Safety and Health Management System (ESHMS) for its Beverley operation that will cover operations on the extended lease. The ESHMS is designed to enable organisations to address the balance between economic imperatives, worker safety, and environmental concerns by creating a system of processes and procedures that:

- bring focus to important safety and environmental goals; and
- establish and implement plans to achieve those goals.

The Beverley ESHMS is described in detail in the present MARP for the existing Beverley operations (Heathgate Resources Pty Ltd 2008c). In accordance with the Guidelines (Appendix A), the ESHMS will be described in full in the next stage of the approval process, for the MARP for the Beverley Four Mile operations. Note that this MARP may be a consolidated document covering both the existing and proposed Four Mile operations.

The ESHMS seeks to satisfy legal requirements, and the requirements of the AS 4801 and ISO 14001 Standards on which the system is based (although certification under these standards has not been sought).

In particular, Heathgate’s demonstrates its environmental performance through implementation of the EMS. The cornerstones of the EMS are:

- The Environment Policy;
- The development and implementation of Environmental Objectives and Targets;
- The ongoing monitoring and reviewing of environmental performance; and
- Continual improvement of Heathgate’s environmental performance.

Heathgate’s Environment Policy was last updated in April 2007. A copy of the policy, as displayed in Heathgate’s offices and at Beverley, is shown in Figure 9-1.

9.2 Proceedings in Place

There are no proceedings in place in relation to either Heathgate Resources Pty Ltd or Quasar Resources Pty Ltd.
Management Capability

Figure 9-1  Heathgate’s Environment Policy

Environment Policy

Heathgate Resources Pty Ltd (Heathgate) is committed to conducting all of its mine operation activities in an environmentally responsible and prudent manner with the objective of minimising any adverse impacts to the air, land and water resources, to the lowest reasonably achievable level. Heathgate utilises environmental objectives, targets and plans in an endeavour to continually improve its overall environmental performance.

Integral to the Environment Policy are goals focused on:

- Waste minimisation;
- Zero pollution events;
- Compliance with all applicable laws and regulations concerning the environment;
- Environmental awareness training; and
- Minimum site disturbance.

Heathgate insists that its employees, contractors and agents conduct all business activities in a manner that is protective of the environment.

Richard Phillips
Managing Director, Operations
April 2007
References


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Bureau of Meteorology, Climate of the Beverley Uranium Deposit Zone, December 1996


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DITR 2006b. Mine Rehabilitation. Leading Practice Sustainable Development Program for the Mining Industry. Australian Government Department of Industry Tourism and Resources


EBS (2006a). Southern EL 3251 Fauna Survey. A report prepared by Environmental and Biodiversity Services Pty Ltd for URS Australia Ltd.


NOTE: The reports by Ellis and that of Fitzpatrick listed below are commercial-in-confidence, other than Ellis 2006a (Supporting Report C, URS 2007).


References


Gerny, J.S. (1962), Rainstorms and Flood Runoff in South Australia, Engineering and Water Supply Department, Report G1

GHD, Beverley Uranium Mine Hydrological Assessment, March 2004


References


Heathgate Resources Pty Ltd 2008e. *Beverley Mine Radiation Management Plan (as amended)* (RMP).

Institution of Engineers Australia 1987. *Australian Rainfall and Runoff*.


References


References


Note: The list of Appendices is presented below.
The Appendices are provided separately.

A  DEWHA / PIRSA Guidelines
B  Soil Survey Report
C1 Hydrology Report – Four Mile Creek
C2 Hydrology Report – Paralana and Mulga Creeks
D  Seismicity Report
E  Baseline Vegetation Report
F  Annual Vegetation Monitoring Report 2007
G  Baseline Fauna Report
H  Conceptual Hydrogeological Model Report
I  Aquifer Testing of the Four Mile East Ore Zone
J  Groundwater Hydrogeochemical Data
K  Third Party Groundwater Users Survey
L  Flow and Solute Transport Modeling Report
M  Natural Attenuation Geochemical Modelling Report
N  Cores Attenuation Characteristics Report
O  Laboratory Batch Tests Attenuation Report