Chapter 4
Mining operations and processing
Chapter 4: Mining operations and processing

4.1 General

4.1.1 Site and locality

The Olympic Dam site is 575km north-north west of Adelaide in South Australia. The existing operations are conducted on a Special Mining Lease (SML). The expansion is proposed to be located adjacent to the existing underground mine, mineral processing plant and tailings storage facility and would require an expansion of the SML.

Roxby Downs is 14km south of the existing Olympic Dam operations by sealed road. If the expansion is approved Roxby Downs would be located 9km to 10km south of the processing plant and open pit respectively.

The town of Andamooka is 30km east of the Olympic Dam mine and can be accessed by a sealed road. Other regional towns are located at Woomera and Pimba, 85km and 95km respectively south of Olympic Dam.

4.1.2 Existing environment

A description of the existing environment of the Environmental Impact Statement (EIS) study area is provided in Chapter 13: ‘Effects on the Environment’ of this Assessment Report (AR) because the descriptions are common across the various project components and, accordingly, not repeated in this section.

Where relevant, a brief description of the existing environment has been provided in sections of this chapter to provide a comparison with the proposed use and potential impacts on a particular issue.

4.2 Project description – key elements

4.2.1 Mineral resources

The Olympic Dam ore body is a poly-metallic deposit which contains copper, uranium, gold and silver. In addition the ore body contains rare earths and iron (hematite). BHP Billiton Olympic Dam Corporation Pty Ltd (BHPB) has indicated that technology to extract additional minerals economically at Olympic Dam is not available at the current time, and/or incompatible with its proposed operations. The opportunity for recovery of additional minerals would be reviewed periodically by BHPB.

The ore reserves as provided by BHPB in the Draft Environmental Impact Statement (DEIS) are shown in the following table:

<table>
<thead>
<tr>
<th>RESOURCE CATEGORY</th>
<th>MILLIONS OF DRY METRIC TONNES</th>
<th>COPPER %</th>
<th>URANIUM OXIDE %</th>
<th>GOLD G/T</th>
<th>SILVER G/T</th>
</tr>
</thead>
<tbody>
<tr>
<td>Measured resource</td>
<td>1,329</td>
<td>1.11</td>
<td>0.33</td>
<td>0.32</td>
<td>2.17</td>
</tr>
<tr>
<td>Indicated resource</td>
<td>4,515</td>
<td>0.89</td>
<td>0.28</td>
<td>0.34</td>
<td>1.59</td>
</tr>
<tr>
<td>Inferred resource</td>
<td>2,497</td>
<td>0.73</td>
<td>0.25</td>
<td>0.25</td>
<td>1.00</td>
</tr>
<tr>
<td>Total resource</td>
<td>8,339</td>
<td>0.88</td>
<td>0.28</td>
<td>0.31</td>
<td>1.50</td>
</tr>
</tbody>
</table>
The following table provides information of mining rates and production for the existing operations, the proposed expansion and combined operations:

### 4.2.1.2 Indicative ore, mine rock and metal production

<table>
<thead>
<tr>
<th>PRODUCTION MEASURE</th>
<th>CURRENT OPERATION</th>
<th>PROPOSED EXPANSION</th>
<th>COMBINED OPERATIONS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ore mined (Mtpa)</td>
<td>12</td>
<td>60</td>
<td>72</td>
</tr>
<tr>
<td>Mine rock (Mtpa)</td>
<td>0</td>
<td>350-390</td>
<td>350-390</td>
</tr>
<tr>
<td>Total material movement (Mtpa)</td>
<td>12</td>
<td>410</td>
<td>422</td>
</tr>
<tr>
<td>Copper concentrate (tpa)</td>
<td>600,000</td>
<td>1,800,000</td>
<td>2,400,000</td>
</tr>
<tr>
<td>Refined copper (tpa)</td>
<td>235,000</td>
<td>515,000</td>
<td>750,000</td>
</tr>
<tr>
<td>Uranium oxide (tpa)</td>
<td>4,500</td>
<td>14,500</td>
<td>19,000</td>
</tr>
<tr>
<td>Gold bullion (oz/a)</td>
<td>100,000</td>
<td>700,000</td>
<td>800,000</td>
</tr>
<tr>
<td>Silver bullion (oz/a)</td>
<td>800,000</td>
<td>2,100,000</td>
<td>2,900,000</td>
</tr>
</tbody>
</table>

### 4.2.1.3 Start-up infrastructure/facility requirements

Prior to commencement of mining operations, a range of facilities and infrastructure would be required, including:

- An industrial area for mine maintenance including servicing haul trucks, equipment warehousing and hydrocarbon storage (DEIS Figure 5.13);
- An area of operations for the contractor involved in pre-stripping the overburden (including truck and shovel assembly facilities and offices);
- Relocation of the existing on-site desalination plant;
- A refuelling and explosive facility;
- Relocation of roads and services; and
- A power supply for electric rope shovels and electric drills.

BHPB has indicated that an extensive range of machinery would be required to excavate the pit, including:

- 14 large electric rope shovels to load 160 “ultra class” trucks each with a capacity greater than 300 tonnes;
- Various-sized diesel hydraulic shovels;
- Hydraulic excavators, front-end loaders, and bulldozers; and
- 150 ancillary heavy vehicles (graders, rollers, water trucks, drill rigs, scrapers, and fuel and lube vehicles).

The indicative location of the on-site facilities, including the initial infrastructure, is shown in the Supplementary Environmental Impact Statement (SEIS) Figure 1.11. Notably, all but the lay-down facility would ultimately be covered by the Rock Storage Facility (RSF) in the longer term.
4.2.2 Open-pit mine

The open pit is proposed to be developed by the establishment of a starter pit and subsequently expanded by a series of 150m to 400m wide ‘push-backs’ to expose additional ore. About 410 million tonnes per annum (Mtpa) of material would be removed from the open pit over the 40 years of operation, resulting in a void 4.1km long, 3.5km wide and 1km deep, covering an area of 1010ha. The DEIS indicated that before the ore body was reached, extensive earthworks over a period of up to five years would be required to remove the 300–350m of un-mineralised sediments (overburden).

Hard rock mining, using standard drilling, blasting, loading and haulage activities would commence from an estimated depth of 10–40m below the surface. Following blasting the fragmented overburden and ore would be loaded by electric shovels into haul trucks. Ore would be tipped into the run-of-mine (ROM) ore stockpile or directly into the crusher. Mine rock (overburden) would be taken to the RSF for long-term storage or to the new Tailings Storage Facility (TSF) to be used in perimeter walls. BHPB has investigated the option of installing an in-pit crusher and conveyancing system but determined that a conventional mining system would be more efficient at this time. It stated it would reassess this option throughout the mine life.

The open pit would be developed in a series of batters (faces) and benches. The height of the production benches would vary between 14m and 20m and the batter angle would vary from 60-90 degrees, depending on the geological structure. The overall pit wall angle would vary from 35-53 degrees depending on the requirements for local stability and the geological structure (DEIS Figure 5.15). The DEIS stated that the proposed slopes were consistent with industry practice.

Haul roads would be constructed from materials excavated from the pit and would be watered regularly by water carts using chemical dust suppressants to minimise dust and provide a compacted all-weather surface.

The construction and operation of the open pit would necessitate additional demands for water, electricity and workforce which are indicatively outlined below:

<table>
<thead>
<tr>
<th>EXPANSION REQUIREMENT</th>
<th>PROPOSED EXPANSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water demand (ML/d)</td>
<td>32</td>
</tr>
<tr>
<td>Electricity consumption (MWh/a)</td>
<td>283,000</td>
</tr>
<tr>
<td>Diesel usage (ML/a)</td>
<td>350</td>
</tr>
<tr>
<td>Peak construction/shut down workforce</td>
<td>3,000</td>
</tr>
<tr>
<td>Ongoing operational workforce</td>
<td>2,500</td>
</tr>
<tr>
<td>Total land disturbance: open pit and RSF (ha)</td>
<td>7,730</td>
</tr>
</tbody>
</table>
4.2.2.1 Dewatering of the open pit

Dewatering of aquifers in the area of the open pit would be required for the life of the expanded mine to control groundwater inflow, and to reduce pore pressures to improve the stability of the open pit walls. BHPB has estimated that groundwater would be extracted at a rate of 5 ML/d but in the initial 6 years could be up to 15 ML/d. BHPB has outlined the following design principles have been followed for the proposed dewatering program:

- Establishment of about 20 to 35 dewatering wells located in the Corraberra Sandstone and Arcoona Quartzite geological formations;
- Water entering the pit would be controlled via in-pit horizontal drains, in-pit wells and pumping from sumps in the pit floor;
- Low permeability cover sequence and basement rocks would be depressurised using in-pit horizontal drain holes (and possibly by drain holes drilled from an underground access tunnel);
- Additional wells may be required for areas of higher inflow;
- Stormwater run-off would be prevented from entering the open pit by surface grading and construction of an earth bund around the perimeter; and.
- Rainfall that enters the pit or accumulates from significant rainfall events would be managed by the use of primary and mobile transfer pumping stations and would either be discharged into natural depressions or used in the pit for dust suppression.

The groundwater from dewatering activities is expected to have a salinity varying from 40,000 to 200,000 mg/L total dissolved solids (TDS) and would be used primarily for dust suppression. Some could be desalinated on-site at the existing facility for use in the metallurgical plant.

4.2.3 Rock Storage Facility (RSF)

It is proposed that the Rock Storage Facility (RSF) would receive around 350 to 390 Mtpa of waste rock and would be developed progressively by selectively placing potentially reactive mine rock into the RSF and encapsulating this material with non-acid forming material. A layer of non-acid forming material would be placed over the natural soils and sand dunes in the RSF area to provide a level surface and to further mitigate the potential for acid leachate (DEIS Figure 5.16).

At 40 years, the footprint of the RSF would be expected to cover 6720ha at a height of 150m. As the rock material would be dumped at its angle of repose the external slope would be in the order of 37 degrees. The placement of a series of benches and batters would result in an overall average slope angle of 30 degrees. The DEIS indicated that the RSF would be stable at any height, and that the design has incorporated the following design principles:

- Establishing a 500m buffer between the RSF and the Arid Recovery area located north of the Olympic Dam operations;
- Allowing for the construction of the expanded metallurgical plant and mine maintenance industrial area;
- Providing a separate area for the stockpiling of low-grade ore;
- Minimising haulage costs;
- Creating access corridors to allow haul trucks to travel to the edges of the RSF;
- Maximising the distance between the RSF and Roxby Downs township and the proposed Hiltaba Village in order to minimise potential dust and noise impacts;
- Minimising the footprint of the RSF while maximising constructability, safety, operability and long-term stability;
- Encapsulating potential acid generating material within non-acid forming material; and
- Placing a 10m-thick layer of inert material (limestone) at the base of the RSF to provide an additional mechanism for neutralisation of any acidic material that may be generated.
4.2.4 Chemical storage and use

Increased mining and ore processing activities would require the use and storage of larger quantities of chemical compounds. The reagents would be the same as currently used in the metallurgical operations. An indicative list of the annual requirements of chemicals and the methods of storage proposed to service the mine expansion is shown in the DEIS Table 5.14.
4.2.5 Processing plant

The metallurgical processes used in the current operation would continue to be used, with the addition of copper concentrate production to the existing suite of refined metal production. The combined throughput of the existing and proposed processing operations would equate to six times more ore than is currently processed. To process the additional quantities of material, a new concentrator and hydrometallurgical facility would be constructed, and the existing copper solvent extraction plant, smelter and refinery would be modified and optimised.

The new metallurgical plant is proposed to be located to the south and south-west of the existing tailings storage facility (TSF), and is expected to cover an area of about 690ha. Figure 5.19 in the DEIS provided an indicative configuration of the metallurgical plant at year 40. Tailings from the existing and expanded operations would be combined and pumped to an expanded TSF. The construction and operation of the new metallurgical plant would necessitate additional demands for water, electricity and workforce which are indicatively outlined below:

<table>
<thead>
<tr>
<th>EXPANSION REQUIREMENT</th>
<th>PROPOSED EXPANSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water demand (ML/d)</td>
<td>175</td>
</tr>
<tr>
<td>Electricity consumption (MWh/a)</td>
<td>3,310,000</td>
</tr>
<tr>
<td>Peak construction workforce</td>
<td>3,000</td>
</tr>
<tr>
<td>Ongoing operational workforce</td>
<td>1,000</td>
</tr>
<tr>
<td>Total land disturbance – including TSF (ha)</td>
<td>4,690</td>
</tr>
</tbody>
</table>

The proposed metallurgical processes for the expansion project are proposed to operate as shown on Figure 5.21 of the DEIS.
4.2.6 Tailings Storage Facility (TSF)

The DEIS indicated that the proposed expansion would generate approximately 58Mtpa of tailings at full production, which would require up to nine new TSF cells, each approximately 400ha in surface area. This would be in addition to the existing four storage cells that currently receive approximately 10Mtpa of tailings from the underground operation, and cover an area of 400ha (tailings storage) and 133ha (evaporation ponds).

BHPB undertook an assessment of alternative methods for managing tailings, including:

- A central thickened discharge. This option was rejected because storage of the tailings would have been inefficient and the footprint would have been much larger;
- Co-disposal of tailings with mine rock in the RSF. This option was rejected because there would have been poor structural strength and greater seepage to groundwater; and
- Locating the TSF within the RSF. This option was rejected due to operational inefficiencies and safety risks with the operation of the large haul trucks.

The DEIS stated that the preferred design seeks to minimise the footprint, protect fauna from acidic liquor and control seepage. To achieve this design a total footprint of approximately 4400ha, including liquor balance ponds would be required, incorporating the following design components:

- Centreline construction using non-acid forming mine rock from the open pit, which would provide a stronger and more stable facility, enabling the cells to be built higher (from the current 30m to 65m) and hence reduce the footprint;
- External slope angle of 25 degrees;
- 300m x 300m decant pond to capture seepage of tailings liquor;
- 1.5mm thick HDPE liner under the decant pond and extending to 100m outside the decant pond (400m x 400m);
- Sand drain over the HDPE liner to assist in drainage and consolidation of the initial tailings deposition
- Upstream and downstream embankment toe drains;
- Thickened tailings from the current average solids density of 47% to a target of around 55%, thereby avoiding the construction of additional evaporation ponds; and
- Four 60ha liquor balance ponds to recover and reuse water, that would be netted or covered to restrict bird access.

Construction of the cells would require tailings to be deposited sequentially from pipeline spigots (distribution points) around the perimeter of each cell in a process known as sub-aerial deposition. The tailings “beach” would be allowed to dry and consolidate prior to additional tailings being deposited in 10m rises. BHPB has indicated that a crust would develop on the surface which would minimise the potential for dust generation. The perimeter embankment of the cells would be progressively raised as each cell was filled with tailings. Tailings would be capped when their target design height was reached to reduce long-term release of dust and radon. A plan view and cross sections of a tailings cell within the proposed TSF is shown in the DEIS Figure 5.22. A detailed description of the TSF design is shown in the DEIS Appendix F1.

In the SEIS, BHPB revised the locations of the cells and reduced their number from 9 to 8 as it was considered that construction of a new cell, TSF Cell 5, as part of the existing operations to replace existing TSF Cells 1 to 4 would provide sufficient capacity so as to not require the 9th contingency cell for the proposed expansion. The proposed change results in an overall increase in vegetation clearance of 80ha over the DEIS proposal.

The DEIS indicated that the proposed TSF would have factors of safety against failure that exceed the Australian National Committee on Large Dams (ANCOLD) minimum requirements under normal operation, steady state seepage and earthquake loading.
SEIS Figure 1.8 Revised layout of the proposed tailings storage facility cells
4.2.7 Gas-fired power station

To maintain commercial and technical flexibility, BHPB has sought approval for two electricity options, including a new 275kV transmission line between Port Augusta and Olympic Dam to be serviced by the National Electricity Market (discussed in Chapter 10: ‘Infrastructure corridors’ of this AR), as well as a 600MW combined gas cycle turbine power station at Olympic Dam to be supplied by a pipeline from Moomba. The ultimate arrangement could comprise either option or a hybrid of both.

The power requirements for the mine expansion, as indicated in the EIS and not including off-site infrastructure, is summarised in the following table:

4.2.7.1 Indicative electricity demand

<table>
<thead>
<tr>
<th>ELECTRICITY LOADS</th>
<th>EXPANSION MAXIMUM DEMAND (MW)</th>
<th>EXPANSION ANNUAL ELECTRICITY CONSUMPTION (GWH)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open pit mine</td>
<td>95</td>
<td>283</td>
</tr>
<tr>
<td>New concentrator plant</td>
<td>300</td>
<td>2365</td>
</tr>
<tr>
<td>New hydrometallurgical plant</td>
<td>40</td>
<td>315</td>
</tr>
<tr>
<td>Expanded smelter</td>
<td>3</td>
<td>24</td>
</tr>
<tr>
<td>Expanded refinery</td>
<td>12</td>
<td>95</td>
</tr>
<tr>
<td>New on-site administrative</td>
<td>4</td>
<td>18</td>
</tr>
<tr>
<td>Acid plant</td>
<td>42</td>
<td>331</td>
</tr>
<tr>
<td>Process infrastructure</td>
<td>20</td>
<td>158</td>
</tr>
<tr>
<td>Total additional demand</td>
<td>516</td>
<td>3588</td>
</tr>
</tbody>
</table>

* Note: There would be a reduction in the load demand of 250MW at mine full production capacity with the proposed establishment of a co-generation plant (refer to section 4.2.8).

In order to reduce on-site labour, components of the gas fired power station are proposed to be pre-assembled off-site. Construction of the site would include vegetation clearing for the power station footprint, together with an area to be used as a temporary lay-down facility for the storage of equipment and plant.
The following table is a summary of the indicative major features of the power station:

<table>
<thead>
<tr>
<th>KEY FEATURES</th>
<th>PROPOSED EXPANSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Maximum electricity capacity (MW)</td>
<td>600</td>
</tr>
<tr>
<td>Annual generation capacity (GWh)</td>
<td>5,100</td>
</tr>
<tr>
<td>Fuel</td>
<td>Natural Gas</td>
</tr>
<tr>
<td>Maximum gas demand (PJ/a)</td>
<td>45</td>
</tr>
<tr>
<td>Number of gas turbines</td>
<td>3–4</td>
</tr>
<tr>
<td>Number of steam turbines</td>
<td>1–2</td>
</tr>
<tr>
<td>Number of exhaust stacks</td>
<td>2–4</td>
</tr>
<tr>
<td>Height of stacks (m)</td>
<td>35</td>
</tr>
<tr>
<td>Average availability</td>
<td>95% (5% for maintenance)</td>
</tr>
</tbody>
</table>

Construction and operation of the proposed power station would result in additional demand for water, electricity and labour, which are indicatively identified in the following table:

<table>
<thead>
<tr>
<th>EXPANSION REQUIREMENT</th>
<th>PROPOSED EXPANSION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water demand during construction (ML)</td>
<td>200</td>
</tr>
<tr>
<td>Water demand during operation (GL/a)</td>
<td>0.3</td>
</tr>
<tr>
<td>Electricity consumption during operation (GWh/a)</td>
<td>60</td>
</tr>
<tr>
<td>Area for gas fired power plant (ha)</td>
<td>25</td>
</tr>
<tr>
<td>Total land disturbance (ha)</td>
<td>30</td>
</tr>
</tbody>
</table>

The DEIS envisaged that construction personnel would start at 250 and build to a peak of 900. All personnel would be accommodated in either Roxby Village or Hiltaba Village, and 30 people would be required to operate the plant.

Chemicals, primarily used for water treatment and cleaning are proposed to be kept in limited quantities on-site and would be located within bunded areas to contain spillages, should they be required.

**4.2.8 Co-generation power station**

To supplement the primary electricity demand, BHPB has also proposed to construct a co-generation power station at Olympic Dam. This would capture waste heat, generated from the burning of sulphur to produce the sulphuric acid required for the new hydrometallurgical plant. Over time, and as the operation reached full capacity, the co-generation power station could generate up to 250MW of the 650MW of power required.
4.2.9 Water supply

The additional water required for the mining and processing operations would primarily be obtained from the coastal desalination plant combined with water from saline aquifers in the SML and the broader Stuart Shelf area. Water required for dust suppression for the open pit mine would be obtained from mine de-pressurisation and/or from saline wellfields. Water for construction and operational purposes at Olympic Dam would be obtained from a combination of sources. BHPB’s existing Great Artesian Basin (GAB) allocation would be used for high quality water needs, and other wellfields for low-quality water needs.

SEIS Figure 12.1a Geological setting of the Stuart Shelf
A summary of water supply requirements for the mine expansion (not including off-site infrastructure), as determined by BHPB, is shown in the following table (DEIS Fig 5.26).

### 4.2.9.1 Indicative water source and demand

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>DEMAND</th>
<th>DESCRIPTION</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Construction activities</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Potable – GAB and local saline wellfields</td>
<td>Up to 7ML/d</td>
<td>Current use averages 37 ML/d, with a current approved maximum limit of 42 ML/d which would be used to supply potable requirements</td>
</tr>
<tr>
<td>Saline – mine depressurisation and saline wellfields</td>
<td>25 ML/d</td>
<td>20% from open pit depressurisation and 80% from aquifers in the mine area</td>
</tr>
<tr>
<td><strong>Operation (combined underground and open pit)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Existing metallurgical plant – GAB</td>
<td>36 ML/d</td>
<td>From existing approvals</td>
</tr>
<tr>
<td>Existing underground mine – GAB</td>
<td>1 ML/d</td>
<td>From existing approvals</td>
</tr>
<tr>
<td>New metallurgical plant – Point Lowly desalination plant</td>
<td>151 ML/d</td>
<td>Direct use in the plant. Some further treatment at on-site desalination plant to meet de-mineralised water requirements</td>
</tr>
<tr>
<td>Open pit mine and associated facilities – Point Lowly desalination plant</td>
<td>7 ML/d</td>
<td>As above</td>
</tr>
<tr>
<td>Dust suppression and other operational needs – Point Lowly desalination plant</td>
<td>25 ML/d</td>
<td>Alternatively saline water from open pit depressurisation or saline wellfields would be used</td>
</tr>
</tbody>
</table>

### 4.2.10 Industrial and general waste

#### 4.2.10.1 General

A waste management facility is proposed to the west of the open pit, adjacent to the current TSF. The facility would cover an area of approximately 560,000m², which at a maximum landfill height of 15m would accommodate 60 years of operational life, equating to an available volume of 7.5 million m³.

#### 4.2.10.2 Tyres

The most significant increase in waste generated from the proposed expansion would be an increase in rubber tyres, from 25tpa to about 8090tpa, principally from haul trucks used in the extraction of the open pit. BHPB is considering several options for tyre disposal. The hierarchy of preferred practice for the expanded project is to:

- Reduce the volume of tyres by implementing programs to increase the life of tyres;
- Retread or repair tyres where possible;
- Use waste tyres for industrial purposes such as berms, road demarcation and fencing;
- Treat waste tyres using energy recovery technologies such as incineration, co-combustion, tyre-derived fuel, pyrolysis, gasification, shredding and granulation; and
- Disposal in the RSF.
BHPB’s preference is to find a recycling solution for the tyres over disposal in the RSF, as the tyres may cause instability and potential for fire risk in the RSF. However, if disposal to the RSF is required, management practices to mitigate the risks would be applied.

4.2.10.3 Low level radioactive waste

Low level radioactive waste would continue to be produced at the expanded operation, mainly from laboratory waste (around 8m³/a) and used personal protective clothing (around 40m³/a). This waste is proposed to be disposed of in the TSF, as per current practices, consistent with relevant codes and legislation, including the *Code of Practice and Safety Guide for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing 2005*.

4.2.11 Closure and rehabilitation

4.2.11.1 General

The DEIS indicated that the closure of the open pit mine and associated processing facilities would be undertaken in accordance with BHPB’s corporate Closure Standard. The following guiding principles would apply:

- Closure planning would be incorporated into the design, construction and operation phases;
- Rehabilitation and stabilisation of disturbed areas would be undertaken as soon as it is safe and practical to do so;
- Reuse and recycling of redundant assets would occur during operations and at mine closure; and
- Decommissioning infrastructure would be undertaken in accordance with environmental, health and safety objectives.

The following table outlines the post-closure options proposed by BHPB.

4.2.11.2 Post closure options proposed by BHPB

<table>
<thead>
<tr>
<th>ITEM</th>
<th>POTENTIAL USES</th>
<th>RESPONSIBLE ENTITY POST CLOSURE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Open pit</td>
<td>Vacant Crown land with access restrictions for public and livestock. Research and education site for geological, environmental and engineering disciplines. A managed and regulated tourist attraction.</td>
<td>The SA Government would be responsible for the land, including, if relevant, the maintenance of viewing platforms and access to the pit by tourists, scientists and students.</td>
</tr>
<tr>
<td>Rock storage facility</td>
<td>Vacant Crown land with access restrictions for public and livestock.</td>
<td></td>
</tr>
<tr>
<td>Metallurgical plant</td>
<td>Research and education, tourism. Stock pasture or vacant Crown land.</td>
<td>Not stated</td>
</tr>
<tr>
<td>Tailings storage facility</td>
<td>Further mining and processing, if metal prices reach levels that made extraction of the residual metals economically viable. Vacant Crown land from which stock would be excluded.</td>
<td>Not stated</td>
</tr>
<tr>
<td>Underground operations</td>
<td>Decommission if no suitable future use is identified.</td>
<td>Not stated</td>
</tr>
</tbody>
</table>
4.2.11.3 Open pit

BHPB has indicated that the open pit would not be backfilled and would essentially remain as it was at the completion of mining activities (with minor slope correction undertaken). Haul roads would be blocked to prevent vehicle access and a bund and fence with warning signs would be installed around the perimeter of the void.

The open pit would be expected to fill with water due to recovery of the groundwater table. Modelling undertaken by BHPB suggests that the resultant hypersaline lake would be up to 350m deep. Over the very long-term it is expected that a salt crust (containing a wide range of concentrations of metals) would be formed on the surface of the lake due to increasing salinity.

4.2.11.4 Rock storage facility

BHPB has indicated that the RSF would remain as a permanent landform that would resemble natural mesas found near Coober Pedy and Port Augusta. The long-term aim would be to ensure that potentially reactive material remained contained within non-acid forming material. The following principles to achieve this have been proposed:

- No reactive material would be stored under the outer slopes;
- The outer slopes would be constructed using coarse non reactive material (such as durable sandstone, quartzite and limestone) that would be resistant to erosion by surface water run-off and wind;
- The outer slopes would be left at the constructed angle of repose (30 to 37°) to minimise the resultant surface area that is susceptible to erosion; and
- The upper surfaces would be covered with a coarse rock mulch layer that is stable and minimises the potential for wind and water erosion.

4.2.11.5 Processing plant

The DEIS suggested that the metallurgical plant post-closure could be used for research and education, tourism, and further mineral processing if the mining of ore from the RSF or TSF should become economic. BHPB also suggested that haul trucks could be used as a tourist exhibit near the open pit. If none of these options were feasible, the facilities would be decommissioned and demolished and the site could revert to stock pasture or become vacant Crown land. The reuse and recycling of plant and equipment would be a priority. Redundant material would be removed from the site by rail if benign, or buried on-site either in the RSF, TSF or in an appropriate landfill.

Any contaminated soils below the process ponds and from other parts of the site would be investigated and remediated in accordance with provisions of the Environment Protection Act 1993, Radiation Protection and Control Act 1982, the National Environment Protection (Assessment of Site Contamination) Measure 1999, and other relevant legislation. All surfaces would be re-contoured and deep-ripped to facilitate natural revegetation.
4.2.11.6 Tailings storage facility

The DEIS indicated that the TSF would remain as a permanent feature that resembles a low mesa typical of the regional landscape. The following broad concepts were provided in the DEIS:

- TSF cells would be rehabilitated as each cell reached the end of its operational life to ensure management of dust, surface water and radon gas;
- The TSF would be capped with sufficiently thick non-acid forming material to minimise the potential exposure of the public to acidic liquor and radioactive material;
- Access roads and tracks adjacent to the TSF would be ripped to restrict access;
- A fence would be constructed around the base of the TSF to prevent vehicle and stock access; and
- Signs warning the public of exposure to radiation and possible rock falls would be erected around the edge of the TSF.

4.2.11.7 Underground operations

The DEIS indicated that BHPB propose to assess future uses of underground facilities prior to closure of the mine. If no suitable future use is identified, it is proposed to decommission the underground facilities in accordance with BHPB's current Olympic Dam Closure Plan, which includes the following strategies:

- Subsidence risks would be investigated and addressed, if deemed necessary, by backfilling high-risk shafts with cemented aggregate fill (CAF);
- All surface infrastructure would be removed and recycled, or removed to an appropriate landfill site;
- All underground infrastructure would be removed if recyclable, or left in situ;
- The Whenan shaft, portals and raise bores would be sealed with pre-cast concrete;
- Soil would be mounded over the concrete seals; and
- The site would be re-contoured to reinstate natural contours and drainage lines, deep-ripped and allowed to naturally revegetate.

4.3 Summary of submissions

A significant number of submissions was received from the public, Non-Government Organisations (NGO’s), other organisations and institutions and SA Government agencies on the proposed expansion. Submissions have been grouped under the following issues:

- Mining and processing operations
- Tailings Storage Facility (TSF)
- Rock Storage Facility (RSF)
- Noise and vibration
- Air quality
- Groundwater
- Waste management
- Terrestrial impacts
- Surface water and drainage
- Radiation
- Risks/hazards
- Rehabilitation and closure
- Greenhouse gases
Under each grouping, the key matters raised in the SA Government’s submission and public submissions are listed as follows:

4.3.1 Mining and processing operations

4.3.1.1 SA Government submission

- Additional information required to justify not fully processing copper concentrate on-site and whether other minerals can be processed, e.g. iron ore;
- The potential options of partially backfilling the open pit as part of progressive development at the end of operations or fully backfilling were not discussed; and
- Insufficient information provided on potential risks of seismic events and impact on key infrastructure, including the impact of stress release induced seismic events due to establishment of the deep open pit.

4.3.1.2 Public submissions

- Further information required on future expansion scenarios (e.g. 1 million tonnes of copper) and not just 40 year life project (750,000 tonnes of copper);
- Additional information should be provided on the cost/benefit of only undertaking underground mining;
- There should be no processing of the uranium ore and the mine should only process copper and precious metals;
- Copper concentrate should be fully processed in South Australia and not exported overseas for processing;
- Use of electric vehicles versus diesel trucks in the mining process and its relationship to the diesel subsidy which BHPB should not receive; and
- Incorrect assessment of the seismic hazard/risk due to seismicity (particularly on Mashers Fault) stimulated by the planned open pit and potential impacts on mining infrastructure including the TSF.

4.3.2 Tailings Storage Facility (TSF)

4.3.2.1 SA Government submission

- Insufficient information provided on the parameters and material properties used to determine seepage rates and volumes from the TSF;
- Insufficient information provided and inconsistencies relating to the stability assessment for the TSF, including material strength parameters, location of the phreatic surface and failure modes;
- Impacts of the Tailings Retention System on avifauna and adequacy of monitoring methodology for assessing bird mortalities; and
- Feasibility of the proposed netting cover system for the decant and drainage area to withstand impacts from acid solution.

4.3.2.1 Public submissions

- The TSF should be fully lined to prevent seepage as contamination of the aquifer is unacceptable;
- Adequacy of the proposed TSF design in managing seepage and impacts on groundwater. Insufficient detail of modelling parameters and assessment of a fully lined TSF to enable comparison of seepage rates not undertaken;
- Additional information required on alternative tailings disposal options including disposal of tailings in the mine void or co-disposed with the waste rock, and disposal of waste rock in the mine void;
• The TSF should be isolated from the environment;
• Justification required as to why Olympic Dam should not meet the best practice standards for the Ranger Uranium mine;
• A detailed environmental risk assessment relating to establishment of the above ground TSF versus backfilling of the pit;
• Concern that radioactive tailings will migrate off-site and spill out of the TSF causing exposure to radon gas; and
• Look for non-water related dust suppression techniques.

4.3.3 Rock Storage Facility (RSF)

4.3.3.1 SA Government submission
• Insufficient information provided on the stability of the RSF during operation and following closure, including the failure modes that were considered and material strength parameters;
• Insufficient information provided on the development of the RSF, timing/schedule for establishing the non-acid forming cover on the batters and progressive rehabilitation; and
• Insufficient information provided on the parameters and material properties used to determine seepage rates and volumes from the RSF.

4.3.3.2 Public submissions
• Additional information required on disposal of waste rock in the mine void;
• A detailed environmental risk assessment relating to establishment of the above ground RSF versus complete backfilling of the pit;
• Incorrect calculation of the volume of waste rock which would result in a significantly larger RSF; and
• Look for non-water related dust suppression techniques.

4.3.4 Noise and vibration

4.3.4.1 SA Government submission
• Additional information required on noise impacts on Roxby Downs and Hiltaba Village from the mine and metallurgical plant and other infrastructure.

4.3.5 Air quality

4.3.5.1 SA Government submission
• Insufficient information provided on modelling of radon in the pit and potential impact on worker doses;
• More information required to estimate radiation dose for workers at the heavy industrial area;
• Additional information/modelling sought in relation to noise and air quality (including heavy metals, sulphur dioxide and nitrogen dioxide emissions) in relation to public health at Roxby Downs and Hiltaba Village; and
• Whether existing background levels of PM$_{10}$ were included in the modelling.

4.3.5.2 Public submissions
• Look for non-water related dust suppression techniques.
4.3.6  Groundwater

4.3.6.1  SA Government submission

- Insufficient information provided to support the conceptual groundwater models, particularly for the region north of the mine, across the Torrens Hinge Zone towards the GAB and the inferred divide to the south and west of Olympic Dam;
- Modelling of the final pit lake not undertaken to steady state conditions;
- Inadequate quantification of uranium series radionuclides in pit water, as a result of seepage from the RSF and TSF and the potential long-term impacts;
- The basis for the determination of the infiltration and seepage rates for the TSF and RSF not justified sufficiently to provide confidence in the outcome of the modelling;
- Further information required on the effectiveness of the Andamooka Limestone and sediments below the TSF to neutralise and attenuate seepage;
- Insufficient laboratory testing undertaken to determine geochemical properties of waste rock;
- Clarification required on the additional demand of water from the GAB associated with optimisation of the existing operations prior to any major expansion; and
- Monitoring Plan required to assess the impacts of drawdown on the Yarra Wurta Spring.

4.3.6.2  Public submissions

- No further extraction of groundwater from the GAB, use of GAB water to be phased out and BHPB should be required to pay the full cost of water;
- Details of current extraction rates, past performance in terms of volumes and drawdown and licence conditions should be provided; and
- Continued extraction of groundwater from the GAB is a risk to the mound springs and associated eco-systems.

4.3.7  Waste management

4.3.7.1  SA Government submission

- Insufficient information provided on the establishment of a new on-site landfill, including the storage and management of low level miscellaneous radioactive waste and consistency with current EPA Guidelines.

4.3.8  Terrestrial impacts

4.3.8.1  SA Government submission

Vegetation

- Potential impact that dewatering of the open pit will have on the Western Myall (Acacia papyrocarpa) and Mulga (A. aneura) in the vicinity of the open pit;
- Data on dust fall impacts on vegetation not included;
- The EIS does not clearly indicate that a key objective of the approach to the expansion should be to minimise vegetation clearance;
- Additional clarification required in the Significant Environmental Benefit (SEB) that confirms that rehabilitation will be undertaken of clearance areas (particularly infrastructure) post-construction and to ensure that relevant areas will be restored as near as practicable to original condition;
- Additional clarification to confirm that the impact upon groundwater dependent vegetation within the Yarra Wurta Springs will be minimised and
- Upgrade the existing Environmental Management and Monitoring Plan to cover declared weeds and pest and management provisions for kangaroos.
Fauna

- No discussion of potential impacts of seepage from the RSF and TSF on swales which support regional and in-situ ecosystems;
- Additional information required on monitoring methodology relating to birds and the TSF;
- Assessment of kangaroos grazing potentially contaminated soil has not been discussed;
- Inadequate discussion of land degradation by kangaroos and management measures that would be adopted;
- Monitoring required of the Lake Eyre Hardyhead populations within the Yarra Wurta Springs to ensure no negative impacts; and
- Appropriate management plans will need to be developed in consultation with the relevant Natural Resources Management Board to address vertebrate pests.

Soils

- Insufficient information provided on the current radionuclide distribution in surface soils across the SML;
- Insufficient information provided on the potential for increased land degradation due to increased numbers of off-road activities between Roxby Downs and Andamooka;
- Management measures to be developed for wind erosion control of disturbed areas;
- Inadequate coverage of the impact on soil due to the use of saline water for dust suppression and discharge of surface water run-off and seepage from the open pit; and
- Confirmation of the locations of all topsoil and sand stockpiles.

4.3.8.2 Public submissions

Vegetation

- The SEB design principles are consistent with the Native Vegetation Council SEB principles. However more information is required to enable an informed decision to be made;
- The amount of vegetation to be cleared has been underestimated by BHPB. SEB ratios used by BHPB and basis for off-sets not accepted;
- Concerns expressed at the extent of clearance that will be required for the proposed expansion and the adequacy of the SEB. Consideration should be given to loss of vegetation due to dust impacts and water run-off; and
- Concern at dust impacts on vegetation and the Arid Recovery.

Fauna

- Not acceptable that a large quantity of toxic liquor should be openly exposed to rare and migratory waterfowl;
- Risk assessment should be undertaken by BHPB of impacts of the TSF on wildlife compared with facilitating partial neutralisation and harvesting of recycled liquor and details provided;
- The TSF should be fully covered to prevent bird deaths and impacts on other fauna;
- Bird death counts from current tailings are underestimated and no effective solutions have been found to minimise this. Additional assessment required on the mortalities associated with the TSF;
- Queries relating to the netting proposed over the decant area of the TSF, whether durability testing has been undertaken, potential entanglement issues and procedures for deployment during extension of the decant structure, implication for OH&S. The results of bird netting trials and other proposed research should be provided. Other submissions indicated that the installation of netting should be a mandatory condition if approval is granted;
- Consideration should be given to neutralisation of the acidic liquor to minimise impacts on birds;
- Impact of radon gas on fauna and fish within 1000km of the site, and radon gas can attach to water which may be drunk by fauna which is not addressed in the EIS; and
- Need to consider ways to mitigate the impact on bird species due to the expanded tailings storage facility appearing like a wetland and attracting bird species.
4.3.9 Surface water and drainage

4.3.9.1 SA Government submission

- Insufficient information provided on surface water management measures proposed for the RSF, TSF, and low grade stockpile during establishment, operation and closure to ensure that potential impacts relating to acid drainage and sediment run-off on flora and fauna and groundwater are managed.
- Insufficient information provided on stormwater impacts from other operational areas.

4.3.10 Radiation

4.3.10.1 SA Government submission

Open Pit

- Clarification of the likelihood and concentration of radionuclides in the pit inflow water that may originate in the underground workings post-closure;
- Further details were requested regarding the modelling (including radon emanation rates for unbroken and broken ore) and proposed management of elevated radon decay product and dust exposures originating from the pit and the management of those exposures for employees and members of the public; and
- Risk that radon released from the pit may impact on radon decay product concentrations in the underground mine.

Rock Storage Facility (RSF)

- Clarification was requested on dust and radon releases from the RSF and of the long-term potential for seepage of uranium-series radionuclides from the base of the RSF to groundwater; and
- It was considered that the control measures for stormwater run-off from the RSF and low grade ore stockpiles did not address the potential for release of radionuclides.

Processing plant

- Additional information was requested regarding the typical radionuclide content of the process liquids and materials to support the requirements of the spill reporting criteria;
- Justification was sought for the selection of 9mSv as a maximum estimated dose received by workers in the smelter;
- Further information was requested regarding the monitoring program for airborne radionuclides in the smelter;
- Further information was requested to address the risks associated with non-routine exposures to radiation;
- Consider relocating administration staff that must currently comply with the ‘Member of Public’ dose limit; and
- Details were requested regarding the significance of the emissions from the calciner stacks as a pathway for exposure.

Transport

- Further information was requested regarding the radionuclide composition of the copper concentrate and the management options available to address build up of radioactive surface contaminants on transport, transfer points and transport corridors.
Tailings storage facility (TSF)

- Additional data was requested on Actinium-227 activity concentrations within the tailings and the movement of radionuclides via seepage from the base of the TSF to groundwater;
- Insufficient information provided on the baseline levels of radionuclides in groundwater; and
- Insufficient information provided on the radiation dose exposure risks and management of dust from the TSF.

Radioactive waste

- Additional details were requested on the management of low level radioactive wastes.

Radiation in the environment

- Additional data was requested supporting assumptions about project generated radionuclide distributions in soil.

Rehabilitation and closure

- Closure criterion for radiation protection of the environment required in addition to management strategies of ongoing radiological issues; and
- Additional information was requested supporting estimates of post rehabilitation doses to the public and environment.

4.3.10.2 Public submissions

Open pit

- Proposed mine and plant dust control measures were considered to be ineffective, and concern was raised over the distance that radionuclides may travel in airborne dust;
- Potential for pit releases of radon and radioactive dust presenting a significant hazard;
- Impact of chronic exposure to low levels of radiation where accompanied by requests for more details on monitoring;
- Further information was requested demonstrating how best practice in uranium mining will be incorporated into the project operations; and
- Suitability of current national radiation dose limits and BHP Billiton’s ability to meet reduced limits, should they be introduced in the future.

Processing plant

- It was considered that the potential for increased radiation exposure to smelter workers was inadequately addressed. Comprehensive independent monitoring requested;
- Validity of current radiation exposure monitoring in the smelter disputed;
- Validity of dose calculations provided in DEIS Appendix S disputed; and
- Epidemiological follow up and annual exposure reports were requested for all workers, including long-term worker health monitoring.

Transport

- Radiation exposure arising from fugitive dust emissions and spills along the transport points and corridors

Waste management

- Proposed methods for the long-term management of radioactive waste considered insufficient to prevent radioactive contamination of the environment. Alternative waste management options requested to demonstrate isolation of all tailings for a minimum of 10,000 years.
4.3.11 Risks/hazards

4.3.11.1 SA Government submission
  - Insufficient information on potential risks of seismic events and impact on key infrastructure and the impact of stress release induced seismic events due to establishment of the deep open pit.

4.3.11.2 Public submissions
  - Concern that radioactive tailings will migrate off-site and spill out of the TSF causing exposure to radon gas; and
  - Incorrect assessment of the seismic hazard/risk due to seismicity (particularly on Mashers Fault) stimulated by the planned open pit and potential impacts on mining infrastructure including the TSF.

4.3.12 Rehabilitation and closure

4.3.12.1 SA Government submission
  - Insufficient information provided on the proposed program for progressive rehabilitation, in terms of elements of the project and timing;
  - The effectiveness of proposed revegetation options not addressed sufficiently in light of saline soils due to use of saline water for dust suppression;
  - Lack of modelling to assess options for final covers for the TSF and RSF and effectiveness of the covers;
  - The rationale for the differing rehabilitation options, e.g. the variable application of topsoil and revegetation at different locations; and
  - Consider the implications of climate change projections suggesting less frequent, but more intense rainfall events and implications on filling of the open pit following closure under a “worst case” scenario.

4.3.12.2 Public submissions
  - Significant and detailed information required on the closure design for the TSF;
  - Rehabilitation costs must be factored into a rehabilitation bond; and
  - Significant and detailed information required on the closure design for the RSF. There appears to be no protection from erosion and no vegetation cover for the RSF.

4.3.13 Greenhouse gases

4.3.13.1 Public submissions
  - Commit to processing all ore in South Australia to avoid greenhouse intensive process overseas;
  - Approval sought for 1 million tonnes of Cu but EIS only estimates impact for 750,000 tonnes. Estimate emissions from full operating capacity;
  - Need to expand assessment to the likely life of the mine possibly 100 years;
  - Critical of diesel fuel rebate received by BHPB at the mine and concern about huge increase in diesel use given tightening supplies;
  - Should evaluate the impact of the diesel fuel rebate on the choice of fuel used in the mine; and
  - Should evaluate underground option to extract ore.
4.4 Key environmental, social and economic issues

The following are the key environmental, social and economic impacts associated with the proposed mining and processing operations:

- Alternative mining and processing operations, covering:
  - Mining method; and
  - Processing method.
- Air quality, covering:
  - Sulphur dioxide emissions from the existing and expanded operation;
  - Other emissions; and
  - Dust and particulates.
- Terrestrial impacts, covering:
  - Site contamination;
  - Impacts on vulnerable listed species reintroduced to Arid Recovery;
  - Impacts of the TSF on fauna and migratory species; and
  - Groundwater dependent ecosystems.
- Groundwater, covering:
  - Dewatering of the open pit;
  - TSF;
  - RSF;
  - Mine water supply; and
  - Risks
- Surface water and drainage;
- Solid waste;
- Wastewater from staff facilities;
- Noise and vibration;
- Visual amenity and landscape character;
- Radiation;
- Greenhouse gases;
- Hazards;
- Rehabilitation and closure; and
- Environmental management.

4.4.1 Alternative mining and processing operations

4.4.1.1 Issues

Mining method

The following issues have been assessed in relation to BHPB’s proposal to develop a new open pit mining operation in conjunction with the existing underground mine:

- Whether the proposed open pit mining method would be the most effective, as opposed to continuation of just the underground operations;
- The potential for extracting iron ore and rare earth minerals for sale; and
- Whether partial or full backfilling of the open pit void, with tailings or mine rock would be feasible, as this approach could have the potential to reduce the footprint of the RSF and reduce potential impact on flora, fauna, surface water and groundwater environmental values.
**Processing method**

Issues relating to the proposed processing of the ore include:

- Whether the proposed mineral processing methods (including not fully processing the copper concentrate to copper metal) are optimal.

Detailed evaluation of the economic impact of the proposed expansion is included in Chapter 12: 'Effects on Communities' of the AR.

### 4.4.1.2 BHPB EM Program and commitments

- **Environmental Management Program (EMP):** No specific EMP provided for this issue.
- **Commitments:** No specific commitments made in relation to this issue.

### 4.4.1.3 Assessment

**Mining method**

BHPB has sought approval to maximise its production of the metals currently mined at Olympic Dam, being copper, uranium, gold and silver. In its assessment of mining methods BHPB considered a number of mining methods, including:

- Expansion of its current underground operations;
- Ceasing the current underground operations and changing to open pit; or
- Operating both underground and open pit mining concurrently.

The latter of the options was selected by BHPB as it would provide maximum recovery of ores (potentially 98%), as opposed to 25% recovery for continuation of the underground operations. Continuation of the underground operations alone would result in sterilisation of ore and was not considered by BHPB or the SA Government to be the most efficient mining option.

On the basis of its assessment BHPB formed the view that other minerals such as iron and rare earths could not be processed economically using current technology. BHPB has indicated that it regularly reviews technologies to monitor the economic feasibility of processing additional minerals, and this approach is considered reasonable by the government.

Accordingly, the AR concludes that the mining methods proposed in the EIS are acceptable and consistent with global best practice, and will maximise the recovery of the Olympic Dam ore resource.

**Backfill of open pit and underground**

The SA Government sought further information about the potential to dispose of tailings within the underground mine towards the end of the 40 year mining period. In response, BHPB indicated that cemented aggregate fill would continue to be used to backfill the underground voids to maintain ground stability. BHPB further indicated that it was likely that the open pit would extend beyond 40 years and that the presence of un-consolidated tailings in the underground workings could present safety issues.

Additional information was sought from BHPB regarding its proposal to not backfill or partially backfill the open pit. In response, it stated in the SEIS that given the size of the resource - potentially greater than 100 years - it would take a similar timeframe to fully backfill the open pit, at both a significant economic cost, as well as increased greenhouse emissions. BHPB do not consider partial backfilling of the open pit to be a feasible option.
The proposed expansion would establish a single large open pit, which means that the opportunity that is presented in multi-pit mines for progressive backfilling during mining using tailings or overburden does not exist at Olympic Dam.

The AR concludes that the disposal of tailings within the underground workings is not feasible as it would put at risk worker safety and the exploitation of the ore body beyond the 40 year mine period.

Further, the AR concludes that the potential for the open pit mine to extend beyond 40 years negates the benefits of using the open pit for backfill. Specifically, the cost of total or partial backfill of the open pit has the potential to sterilise the mineral resource should mining continue beyond 40 years, and is unlikely to benefit the protection of environmental values - and could lead to increased environmental impact such as emission of greenhouse gases caused by the additional transportation of backfill material, increased dust emissions and increased radiation exposures.

**Processing method**

The DEIS indicated that the copper ore from the open pit would be processed by expanding the metallurgical plant to produce up to 350,000 tonnes of refined copper, and by the construction of a new concentrator and hydrometallurgical plant to produce 1.6Mtpa of concentrate for export. A common theme in the public submissions was the desire for the SA Government to require BHPB to undertake smelting and refining in South Australia to maximise the return to the State.

BHPB has indicated that processing all copper concentrate on-site would require both an additional smelter, which would not provide the optimal return on investment, and a different smelting technology due to differing ore composition, which would increase the complexity of its processing operations.

The processing of copper ores to produce a concentrate for off-shore smelting to a refined copper is common industry practice, and a decision made on a commercial basis. The State has a clear interest in ensuring that the project as proposed - which includes both metal refining and the production of concentrate - benefits the public. The economic and social impacts of the proposal are addressed in Chapter 12: 'Effect on communities' of this AR.

Many public submissions on the DEIS recommended that uranium should not be mined and processed. However, the extraction of copper alone was not considered to be economically feasible by BHPB. It is considered that it would not be possible to mine the copper alone, as uranium is intrinsically associated with the copper mineralisation and would be processed along with the copper.

Further, South Australia has a long history of safe and effective uranium mining, operating within a regulatory framework that is widely recognised as being effective and representing world’s best practice.

**RECOMMENDATION**

The AR concludes that the mining method and mineral processing regime proposed by BHPB are acceptable, and consistent with international and national practice. No conditions are considered necessary.
4.4.2 Air quality

4.4.2.1 Issues

The DEIS indicated that the Olympic Dam operation is the only major source of emissions with the potential to affect air quality in the region (DEIS Section 13.3.1). Roxby Downs is the nearest sensitive receptor, which at its closest point is 14km from the existing operations.

Should the expansion be approved, both Roxby Downs and Hiltaba Village would be significantly closer to the proposed expanded operations, being 6km from the southern and south-eastern boundaries respectively of the proposed RSF (DEIS Figure 5.5).

The primary source of process emissions from the existing Olympic Dam operation is the metallurgical plant, with the main pollutant of concern being sulphur dioxide (SO₂). For the expanded operations, the upgraded metallurgical plant and the new metallurgical plant would be the primary source of process emissions, with the main process pollutant of concern also being SO₂. In addition there is potential for significant emissions of fugitive dust during construction activities, and in development of the open pit and formation of the RSF. The discussion below considers SO₂, particulates and other gaseous emissions.

Sulphur dioxide emissions

Existing operation

The main process air pollutant (by mass) emitted from the existing metallurgical plant at Olympic Dam is SO₂, which is primarily derived from the smelting of copper sulphide ore. About 99% of the SO₂ emitted by the smelting process is recovered and converted into sulphuric acid in the acid plant. The remaining 1% of emissions arises from:

- A continuous emission of SO₂ from the acid plant tail gas stack under normal operating conditions (this emission arises as the acid plant is about 99% efficient in converting incoming SO₂ to sulphuric acid; the remaining 1% is emitted);
- Bypass events (due to plant start-up, shut-down, emergency and abnormal situations) when smelter off-gases are vented to the atmosphere without SO₂ removal by the acid plant; and
- Minor sources in the smelter area, which are continuously collected and discharged through the main smelter stack.

The National Pollutant Inventory (NPI) data for the Olympic Dam facility indicates that in 2008-09, which was the most recent year without substantial smelter shutdowns, a total of 3700t of SO₂ was emitted to the atmosphere. This reported level of SO₂ emissions is relatively small when compared to the Mount Isa product smelters and Kalgoorlie nickel smelters, where NPI data indicates that SO₂ emissions in 2009-10 were 180,000t and 27,000t respectively.

As a condition of licence under the Environment Protection Act 1993, BHPB is required to continuously monitor SO₂ emissions from the main smelter stack and acid plant tails gas stack and report monthly on the timing, nature and duration of incidents that have led to non-compliance with licence conditions.

In association with this reporting, BHPB is also required to undertake computer modelling using the CALPUFF® model, to estimate the ground-level concentration of SO₂ arising from plant emissions and present these as figures that show 1-hour maximum and 24-hour maximum ground-level SO₂ concentration contours. BHPB’s annual Environmental Management and Monitoring Report also shows the same ground-level SO₂ concentrations plus an annual average over a 12-month period.

It is noted that the DEIS (Tables 13.14 and 13.23; also pages 398 and 405) somewhat confuses the SO\(_2\) 1-hour SA EPA DGLC Guidelines criterion and the 1-hour Ambient Air NEPM. The tables refer to a 1-hour SA EPA ambient air quality goal for SO\(_2\) of 450 µg/m\(^3\), not to be exceeded once per year; however, this figure is the DGLC for use in computer modelling for new developments, and as such does not have an exceedence criterion. The SA 1-hour ambient air quality goal for SO\(_2\) is the Ambient Air NEPM figure of 0.2 parts per million (570 µg/m\(^3\) at 25°C), not to be exceeded more than one day per year.

Figure 13.14 in the DEIS showed that there were two bypass events in 2001 and 2002; modelling predicted 1-hour maximum ground-level concentrations at the Olympic Dam Village of approximately 600 and 650 µg/m\(^3\) respectively, exceeding the SA EPA DGLC Guidelines criterion. However, as the Ambient Air NEPM allows exceedence of 570 µg/m\(^3\) one day per year, the Ambient Air NEPM goal may not have been breached in these events.

Figures 13.15 and 13.16 in the DEIS showed that the predicted 24-hour maximum and annual average SO\(_2\) concentrations at Roxby Downs and the Olympic Dam Village have been well within the relevant Ambient Air NEPM goals in all of the years presented.

**Expanded operation**

Figure 5.5 in the DEIS showed that the proposed new metallurgical plant would be constructed about 3–4km to the south-west of the existing metallurgical plant.

The existing smelter would be upgraded to handle additional volumes of copper concentrate, from 600,000 tonnes per annum (tpa) up to 800,000tpa, to produce 350,000tpa of refined copper. Other modifications to the existing metallurgical plant include an additional anode furnace, additional concentrate drying capacity and an additional acid plant. This additional acid plant would be of capacity 1500 tonnes per day (tpd) compared with the existing acid plant capacity of 1800tpd.

The principal SO\(_2\) sources in the new metallurgical plant include a further four new sulphur-burning acid plants each of capacity 3500tpd.

In relation to SO\(_2\) emissions, the DEIS identified that the following mitigation and management measures would be used to minimise gaseous emissions from the expanded existing metallurgical plant and proposed new metallurgical plant:

- The existing main smelter stack would remain at 90m high, although the gas flow rate would increase from 475,000 to 635,000 Nm\(^3\)/h;
- The existing acid plant tails gas stack and bypass stack would remain at 90m high;
- There would be two stacks serving the four new sulphur-burning acid plants. These two stacks, and also the stack for the additional acid plant at the existing metallurgical plant, would be 50m high. All five new acid plants would be similar in design and operation to the existing acid plant; and
- A gas cleaning system similar to that installed for the existing anode furnaces would be installed on the additional anode furnace. As is currently the case, in the event of a gas cleaning system failure, these furnaces would stop processing to minimise further gaseous emissions.
Other emissions

A number of other air pollutants are currently emitted from point sources at Olympic Dam, as outlined in the DEIS (Section 13.3.3), including oxides of nitrogen (NOx, expressed as equivalent nitrogen dioxide [NO2]), carbon monoxide (CO), lead (Pb) and fluoride (as HF). These emissions arise primarily from the metallurgical plant and associated operations, and are emitted as gases via stacks with associated pollution control equipment.

Emissions elsewhere include carbon disulphide (CS2), which is emitted from the decomposition of xanthates within the flotation circuit, and Volatile Organic Compounds (VOCs) and Polycyclic Aromatic Hydrocarbons (PAHs), which are emitted primarily from the storage and usage of hydrocarbons such as diesel (SEIS Section 14.1.3). Gaseous pollutants are also released from mine ventilation raise bores and quarrying operations.

A new gas-fired combined cycle gas turbine (CCGT) power station with a capacity of 600MW, utilising gas from Moomba, is proposed to be built to the south of the new metallurgical plant (DEIS Figure 5.39). The CCGT stack height has been modelled at 35m. The primary emission from the CCGT would be NOx.

Combined, these proposals would result in a net increase in point source emissions of all of the above pollutants. The following information has been provided in the DEIS and SEIS:

- Tables 13.18 and 13.19 in the DEIS provide summaries of proposed point source emissions and averaged emission rates;
- Table 13.23 in the DEIS provide the results of modelling of DGLCs for equivalent NO2, CO, Pb, HF and CS2 and contour plots are provided for each (Figures 13.20b, c, d, e, f); and
- Table 14.10 and Figure 14.7 in the SEIS provide details of predicted DGLCs and contours for selected VOCs and PAHs.

Based on the modelling details provided in the Final Environmental Impact Statement (FEIS), none of the pollutants discussed in this section are predicted to exceed applicable air quality criteria in the locations of Hiltaba Village and Roxby Downs township.

Dust and particulates

The DEIS stated that minimal dust is generated by the current underground mining operation, with some limited quantities of dust being generated by the extraction of limestone from the on-site quarry. Particulate matter, saline aerosols and radon (and radon decay products) are also released from mine ventilation raise bores and quarrying operations. Issues relating to radon gas and radon decay product emissions are specifically included in the Radiation section (4.4.9) of this chapter.

Data included in the DEIS indicated that dust storms are a naturally occurring meteorological phenomenon, and that Roxby Downs is affected by an average of two dust storms per year.

The DEIS indicated that the expanded processing plant would result in additional emissions of particulates, and that there would be potential for significant fugitive dust emissions to be generated during construction activities for the new metallurgical plant and TSF, and in development of the open pit and RSF. Fugitive dust emissions are estimated and modelled in the DEIS Appendix L2.8.
Modelling of fugitive dust was undertaken for total suspended particulate (TSP); particulate matter with an aerodynamic diameter less than 10 microns (PM_{10}); particulate matter with an aerodynamic diameter less than 2.5 microns (PM_{2.5}); and dust deposition. The resulting dust contours are shown in the DEIS Figures 13.18a to 13.18d. It is noted that mitigation measure effectiveness factors and a pit retention factor were applied to the fugitive dust emission estimates (DEIS Appendix L Tables L2.10 to L2.24).

The results indicate that the predicted dust levels would generally comply with ambient air quality goals, though 24-hour levels of PM_{10} would exceed the ambient goal at Roxby Downs on 10 days per year, and Hiltaba Village for five days per year, compared with an allowable five exceedences in the Ambient Air NEPM goals. It is stated (DEIS page 403) that operational controls may be required to maintain concentrations of PM_{10} dust within applicable compliance limits during the predicted five to ten days per annum of worst-case weather conditions.

**Vegetation impacts**

The DEIS indicated that dust, saline aerosols, SO_{2} and other emissions from the mine and processing operations at Olympic Dam could have a compounding impact on native vegetation (DEIS Section 15.5.9) and that the impact of emissions on vegetation might reduce the habitat values of ecosystems for some animals. The DEIS noted that the effects of various emissions on plants are complex, and monitoring has established a footprint over which changes in the flora community and effects on plant health could be measured.

4.4.2.2 BHPB EM Program and commitments

**Point source emissions**

BHPB has set the following objective and criteria as part of its Environmental Management Program (EMP) which is detailed in the DEIS Appendix U, ID 3.3:

- **Objective**: No adverse impacts to public health as a result of point-source emissions from BHPB’s expanded operations at Olympic Dam.
- **Criteria**: Annual average SO_{2} concentration of less than 57 µg/m^{3}, 24-hour average of less than 228 µg/m^{3} and 1-hour average of less than 450 µg/m^{3} at sensitive receptors. Also annual average operational-contributed PM_{10} concentration of less than 30 µg/m^{3}, and a 24-hour average of less than 50 µg/m^{3} at sensitive receptors.
- **Management/monitoring plans**: No specific management plans are currently required. The existing Airborne Emissions Monitoring Program would be reviewed and updated where required.
- **Commitments**:
  - Sulphur dioxide (SO_{2}) emissions – to use real-time monitoring of sulphur dioxide in the smelter to assess the continuing adequacy and effectiveness of the ventilation system (SEIS Table 2.1 Commitments – page 59); and
  - Impacts from air emissions other than dust or sulphur dioxide – to ensure that emissions from the expanded operation do not adversely impact the health and wellbeing of nearby communities by adhering to relevant emissions criteria, and cooperating with the SA Government in the development of future emission limits as necessary to reflect the increasing body of knowledge surrounding the health impacts of pollutants (SEIS Table 2.1 Commitments – page 55).
**Fugitive particulate emissions**

BHPB has set the following objective and criteria as part of its Environmental Management Program (EMP) which is detailed in the DEIS Appendix U, ID 3.1:

- **Objective**: No adverse impacts to public health as a result of fugitive particulate emissions from BHPB’s expansion activities at Olympic Dam.
- **Criteria**: Annual average operational contributed PM$_{10}$ concentration of less than 30 µg/m$^3$, and a 24-hour average of less than 50 µg/m$^3$ at sensitive receptors.
- **Management Plan**: A (new) Dust Management Plan would be developed to record and monitor the following process of applying operational control:
  - A network of real-time dust monitors, which may include TSP, PM$_{10}$ and PM$_{2.5}$ monitors, around the mining operation, at the sensitive receivers, and at intervals between these receivers and the mining operation. These would be integrated within the mining process control system as an early warning of rising particulate concentrations at the sensitive receivers;
  - A real-time meteorological system, integrated with the real-time dust monitors, which would permit mining operations to be planned and adjusted to ensure the particulate criteria would not be exceeded at the sensitive receivers; and
  - Additional monitoring sites would be placed north, east and west of the operation to determine the concentration of particulates contributed by the expanded operation (DEIS 13.3.5).
- **Commitments**: To manage dust from mining operations (SEIS Table 2.1 Commitments – page 57–58) by:
  - Meeting the National Environment Protection (Ambient Air Quality) Measure (NEPM, i.e. PM$_{10}$ and PM$_{2.5}$) ground-level dust concentration (applied to operational dust contribution at Roxby Downs and Hiltaba Village) through design and operational management controls of mining operations at Olympic Dam;
  - Building good-quality haul roads and maintaining them with regular applications of saline water and/or the application of suitable dust suppressants; and
  - Installing a real-time dust and meteorological monitoring system to predict dust concentrations which would provide information for operational control of dust.

### 4.4.2.3 Assessment

**Sulphur dioxide**

The emissions inventory presented in the DEIS predicted that the total load of SO$_2$ emissions from the expanded operation would be nine times that of the existing operation. The air dispersion modelling undertaken (DEIS Figure 13.20a; SEIS Appendix G Figure G1.5) shows the predicted maximum 1-hour, maximum 24-hour and annual average SO$_2$ ground-level concentrations, compared to the 1-hour SA EPA DGLC Guidelines criterion and the 24-hour and annual Ambient Air NEPM goals.

These figures showed that in the worst-case year, the contour of the SA EPA DGLC Guidelines criterion for SO$_2$ (450 µg/m$^3$ 1-hour maximum average) lies across Roxby Downs (i.e. northern areas of Roxby Downs within the contour are predicted to slightly exceed the criterion). The DEIS also states that the next highest predicted 1-hour maximum SO$_2$ concentration at Roxby Downs was around 315 µg/m$^3$, which is within the SA EPA DGLC Guidelines criterion.

In relation to the predicted 24-hour maximum and annual average SO$_2$ concentrations, the DEIS indicated that the Ambient Air NEPM goals would be easily met in Roxby Downs and Hiltaba Village in the worst case year.
RECOMMENDATIONS

The Environment Protection Authority’s DGLC Guidelines 1-hour SO2 criterion has been met for all but the worst case modelled scenario at the northern areas of Roxby Downs township, and the AR concludes this is acceptable. As part of its EPA licence review, BHPB should review the final design of the efficiencies of the new acid plants and stack heights, to comply with the SA EPA DGLC Guidelines in all parts of Roxby Downs township and also at Hiltaba Village. Accordingly the following conditions are recommended in relation to the management and monitoring of SO2:

- The proponent must prepare and implement an Air Quality Management and Monitoring Program (AQMMP), for approval by the Indenture Minister with the concurrence of the EPA, that incorporates the following:
  - A Process Emissions Management Plan (including point and diffuse source emissions) prior to the commencement of processing; and
  - An Air Quality Monitoring Program, linked to the above management plan.

- The proponent must ensure the following criteria are contained in its AQMMP:
  - Ground-level SO2 concentrations at Roxby Downs and Hiltaba Village derived from operational sources at Olympic Dam must not exceed the following criteria:

<table>
<thead>
<tr>
<th>POLLUTANT</th>
<th>AVERAGING PERIOD</th>
<th>GROUND LEVEL AIR QUALITY CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphur dioxide (SO2)</td>
<td>1-hour</td>
<td>450 µg/m³</td>
</tr>
<tr>
<td>Sulphur dioxide (SO2)</td>
<td>24-hour</td>
<td>228 µg/m³</td>
</tr>
<tr>
<td>Sulphur dioxide (SO2)</td>
<td>Annual</td>
<td>57 µg/m³</td>
</tr>
</tbody>
</table>

- The proponent must ensure the following requirements are addressed in its AQMMP:
  - The installation of four meteorological and air quality monitoring stations to be located in Roxby Downs, Hiltaba Village, and north and west of the Olympic Dam mine site and processing operations;
  - Each meteorological station to be sited and designed in accordance with relevant Australian standards and be capable of continuously monitoring wind speed and direction, temperature, and humidity, and at least one station to also monitor solar radiation, atmospheric pressure, rainfall and evaporation;
  - The meteorological and air quality monitoring stations to have real-time data download to a central location (preferably at Olympic Dam) so that necessary pre-emptive or responsive action can be taken to deal with likely or actual exceedences of ground-level air quality criteria arising from operational sources;
  - Real-time radon (or radon decay product) monitors to be located at each meteorological and air quality monitoring stations to better measure radon transport from the mine and mineral processing areas to Roxby Downs and Hiltaba Village;
  - Continuous monitoring of SO2 concentrations must be provided for the main smelter stacks and the tail gas stack exit of each individual acid plant; and
  - Detailed information on the proposed pollution management measures to reduce SO2 emissions during acid plant start-up, shutdown and abnormal conditions, and abnormal smelter conditions.

- Prior to the operation of additional metallurgical plant the proponent must install and operate monitoring stations to continuously monitor SO2 at Roxby Downs and Hiltaba Village.
The AR also recommends the following notes to BHPB:

▪ The proponent in preparing the AQMMP should consider providing relevant detail on:
  – The detailed siting and design of meteorological and air quality monitoring stations;
  – Process management appropriate to air quality emissions;
  – Updated air emissions inventory for point, diffuse and fugitive dust emissions;
  – Air pollution control equipment and stack and vent configuration;
  – Point source air emissions test facilities and stack testing program to demonstrate compliance with the AQMMP;
  – Incident responses to exceedences or particular climatic conditions;
  – Community consultation and engagement;
  – Engagement with local health services for identifying and responding to any relevant health impacts (e.g. asthma management protocols); and
  – The continuing review of the literature on the impact of emissions to inform both monitoring and response.

▪ BHPB’s licence under the Environment Protection Act 1993 would likely be amended to encompass changes that would be necessary to accommodate the expansion project.

**Other emissions**

The AR concurs with the assessment provided in the DEIS that the operations at Olympic Dam are the only significant point source air emissions, other than SO\(_2\), in the context of the broader expansion proposal.

With respect to the information provided in both the DEIS and SEIS, it is considered that potential impacts arising from the other identified point source and diffuse emissions (NO\(_2\), CO, HF, CS\(_2\), Pb) should be successfully managed to the applicable standards administered by the EPA, including at the settlements of Hiltaba Village and Roxby Downs.

**RECOMMENDATION**

The AR recommends the following condition:

▪ The proponent must ensure the following criteria are contained in the AQMMP:

  Ground-level air pollutant concentrations at Roxby Downs and Hiltaba Village derived from operational sources at Olympic Dam must not exceed the following criteria for design of the expansion:

<table>
<thead>
<tr>
<th>POLLUTANT</th>
<th>AVERAGING PERIOD</th>
<th>GROUND-LEVEL AIR QUALITY CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrogen dioxide (NO(_2))</td>
<td>1-hour</td>
<td>158 µg/m(^3)</td>
</tr>
<tr>
<td>Carbon monoxide (CO)</td>
<td>1-hour</td>
<td>29 mg/m(^3)</td>
</tr>
<tr>
<td>Lead (Pb)</td>
<td>Annual</td>
<td>0.5 µg/m(^3)</td>
</tr>
<tr>
<td>Fluoride (as HF)</td>
<td>24-hour</td>
<td>2.9 µg/m(^3)</td>
</tr>
</tbody>
</table>

**Dust and particulates**

Modelling of fugitive dust was undertaken for TSP, PM\(_{10}\), PM\(_{2.5}\), and dust deposition, and the resulting dust contours are shown in the DEIS Figures 13.18a to 13.18d. Mitigation measure effectiveness factors and a pit retention factor were included in the modelling (DEIS Appendix L Tables L2.10 to L2.24).
The results indicated that the predicted dust levels in the modelling would generally comply with ambient air quality goals, however the predicted maximum 24-hour PM$_{10}$ ground-level concentrations (DEIS Figure 13.18b and SEIS Appendix G Figure G1.2) showed that in the worst case year the contour of the 24-hour PM$_{10}$ Ambient Air NEPM goal of 50 µg/m$^3$ would extend to central Roxby Downs and beyond Hiltaba Village.

The DEIS stated (Section 13.3.5) that the maximum 24-hour PM$_{10}$ concentrations were predicted to exceed the Ambient Air NEPM goal at Roxby Downs on 10 days a year and at Hiltaba Village on five days a year, during the worst-case year. The Ambient Air NEPM permits up to five exceedences of the 24-hour PM$_{10}$ goal per year.

In order to minimise the potential for adverse health impacts associated with particulate exposures, BHPB has committed to manage operationally contributed particulate concentrations to levels as low as reasonably practicable (‘ALARA’) and no greater than the following criteria (SEIS Table 14.6):

<table>
<thead>
<tr>
<th>PARTICULATE SIZE FRACTION</th>
<th>AVERAGING PERIOD</th>
<th>AMBIENT AIR QUALITY CRITERIA (µG/M$^3$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>TSP</td>
<td>Annual $^1$</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td>Deposition (g/m$^2$/month) $^2$</td>
<td>4</td>
</tr>
<tr>
<td>PM$_{10}$</td>
<td>24-hour</td>
<td>50</td>
</tr>
<tr>
<td></td>
<td>Annual $^3$</td>
<td>30</td>
</tr>
<tr>
<td>PM$_{2.5}$</td>
<td>24-hour</td>
<td>25</td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>8</td>
</tr>
</tbody>
</table>

$^1$ Non-NEPM standard – rescinded NHMRC Goal  
$^2$ Non-NEPM standard – ‘Fallout’ is not part of TSP  
$^3$ Not a NEPM standard

It is stated (DEIS Section 13.3.5) that operational controls may be required to maintain concentrations of PM$_{10}$ dust within applicable compliance limits during the predicted 5 to 10 days per annum of worst-case weather conditions. The AR considers that given mitigation measure effectiveness factors and a pit retention factor are already included in the modelling, dust management measures would need to be both comprehensive and effectively managed.

The AR also considers that detailed information on the proposed fugitive dust management methodologies would need to be provided to the EPA as part of the licence revision process for the expansion.

In the absence of a South Australian-based criterion for an annual average PM$_{10}$, BHPB has proposed using a New South Wales criterion of 30 µg/m$^3$. The AR considers that for reporting purposes, the existing national standards provide sufficient information to gauge operational performance, and that the annual average PM$_{10}$ criterion adds little additional value to understanding the impacts of particles on residential areas.

BHPB has committed to the installation of a real time dust and meteorological monitoring system at Olympic Dam, which would provide information for the operational control of dust. It should be noted that ‘Olympic Dam’ is used in the broader context of the mine and would include Roxby Downs township and Hiltaba Village. This is considered an achievable and essential component of the proposed Dust Management Plan.
RECOMMENDATION

The AR considers that the proposed configuration of monitoring stations (DEIS Section 13.3.5) is a practical approach to facilitate ready discrimination between operational and 'natural' particulate events, and thereby provide for evaluation of performance in managing operational particulate emissions and off-site impacts.

The AR also considers that the criteria proposed in the SEIS (Table 14.6, reproduced above) consistent with the National Environment (Ambient Air Quality) Protection Measure (2003), are adequate for the protection of the health of residents at Roxby Downs and the proposed Hiltaba Village.

The AR recommends the following conditions:

▪ The AQMMP must incorporate the following:
  – A Dust Management Plan; prior to the commencement of open pit mining;
  – An Air Quality Monitoring Program (AQMP), linked to the above management plan.

▪ The proponent must ensure the following criteria are contained in its AQMMP:
  – Ground-level PM$_{10}$ and PM$_{2.5}$ dust concentrations at Roxby Downs and Hiltaba Village derived from construction and operational sources at Olympic Dam must not exceed the following criteria:

<table>
<thead>
<tr>
<th>PARTICULATE SIZE FRACTION</th>
<th>AVERAGING PERIOD</th>
<th>GROUND LEVEL AMBIENT AIR QUALITY CRITERIA</th>
</tr>
</thead>
<tbody>
<tr>
<td>PM$_{10}$</td>
<td>24-hour</td>
<td>50 µg/m$^3$</td>
</tr>
<tr>
<td>PM$_{2.5}$</td>
<td>24-hour</td>
<td>25 µg/m$^3$</td>
</tr>
<tr>
<td></td>
<td>Annual</td>
<td>8 µg/m$^3$</td>
</tr>
</tbody>
</table>

▪ The proponent must ensure the following requirements are met in its AQMMP:
  – The installation of four meteorological and air quality monitoring stations to be located in Roxby Downs, Hiltaba Village, and north and west of the Olympic Dam mine site and processing operations;
  – Each meteorological station to be sited and designed in accordance with relevant Australian standards and be capable of continuously monitoring wind speed and direction, temperature, and humidity, and at least one station to also monitor solar radiation, atmospheric pressure, rainfall and evaporation;
  – Each air quality monitoring station to be sited and designed in accordance with relevant Australian standards for the continuous measurement of PM$_{10}$ and PM$_{2.5}$;
  – The meteorological and air quality monitoring stations to have real-time data download to a central location (preferably at Olympic Dam) so that necessary pre-emptive or responsive action can be taken to deal with likely or actual exceedences of ground-level air quality criteria arising from operational sources;
  – The meteorological and air quality monitoring system to be capable of differentiating the contribution that background TSP, PM$_{10}$ and PM$_{2.5}$, and operationally generated TSP, PM$_{10}$ and PM$_{2.5}$ make to total TSP, PM$_{10}$ and PM$_{2.5}$ concentrations over short periods (hourly and daily); and
  – Real-time radon (or radon decay product) monitors to be located at each meteorological and air quality monitoring stations to better measure radon transport from the mine and mineral processing areas to Roxby Downs and Hiltaba Village.
The following note is also recommended:

- The proponent in preparing the AQMMP should consider the following, in relation to preparing the Dust Management Plan (as part of the AQMMP) providing specific detail on:
  - pre-emptive particulate controls such as dust suppression on haul roads and conveyors, and best practice measures for minimising dust generation from unloading points, material stockpiles, crushers, rock storage facilities, and other potential fugitive dust emission sources; and
  - identification of remedial action at specific operational dust sources in response to actual or impending exceedences of the 24-hour average ground-level PM$_{10}$ and PM$_{2.5}$ air quality criteria referenced above, as determined from an air quality monitoring program established in accordance with an approved AQMP.

The notes recommended under AR Section 4.4.2.3 in relation to SO$_2$ are considered relevant to meeting the above condition about dust and other particulates.

**Vegetation impacts**

Dust, saline aerosols, SO$_2$ and other emissions from the operations at Olympic Dam could have a compounding impact on native vegetation (DEIS Section 15.5.9). The DEIS noted that the effects of various emissions on plants are complex, and monitoring has established a footprint over which changes in the flora community and effects on plant health could be measured.

The DEIS reported that monitoring in 2006 established that an area of 2670ha surrounding the existing metallurgical plant (extending up to 7.5km from the plant) showed detectable foliage damage attributable to gaseous emissions. For most sulphide ore smelting operations, SO$_2$ is the principal air pollutant of concern in terms of vegetation impacts, however saline emissions from certain raise bores at Olympic Dam show very clear localised impacts, and fluoride can affect plants at very low levels. It is also noted that SO$_2$ emissions at Olympic Dam are relatively low compared with other major smelters (DEIS Figure 15.8).

There would be a predicted nine-fold increase in SO$_2$ emissions associated with the expanded operations, and thus SO$_2$ emissions could be a more significant factor in potential flora impacts for the expanded operation (DEIS Section 15.5.9). However, the DEIS notes that direct extrapolation is not appropriate as the effect is non-linear.

Section 15.5.9 of the DEIS stated: "While the extrapolations for measurable effects to plants from gaseous emissions are not definitive, the available information indicates that the proposed expansion has the potential to increase the area over which impacts to vegetation may occur, and that this impact would be largely confined to the expanded SML. The residual impact is therefore categorised as moderate, reflecting a long-term impact to a common receiver."

The AR notes that BHPB would continue monitoring the effect of emissions on vegetation (DEIS Section 15.5.9).

**RECOMMENDATION**

Accordingly, the following condition is recommended:

- BHPB must undertake a research study to determine the threshold levels for effects of SO$_2$ on flora of the region. The scope of the research study must be agreed with the Indenture Minister within twelve months of the date of this decision.
RECOMMENDATIONS

While the undertaking to develop a Dust Management Plan by BHPB is acknowledged, and is appropriate for specific project components (such as the construction of the landing facility), it is considered that the potential health and environmental impacts of airborne emissions from an expanded mining operation would extend further than those arising solely from fugitive dust, and that management of these impacts would be a continuing and iterative process following commissioning and operation.

Accordingly, the AR considers that a key component of the EMP should be a broader Air Quality Management and Monitoring Program (AQMMP) as referred to in the recommended conditions above, that covers all relevant emissions during commissioning and operation, including process point source and diffuse emissions, consistent with the company goal of “zero harm”. The AR recommends the following notes to BHPB:

- The proponent’s licence under the Environment Protection Act 1993 and the Radiation Protection and Control Act 1982 would likely be amended to encompass changes that would be necessary to accommodate the expansion project.

- A requirement to implement, report on and update an approved AQMMP would likely be incorporated into BHPB’s licence under the Environment Protection Act 1993 to conduct activities of environmental significance at Olympic Dam.

- A requirement to ensure compliance with the ground-level air quality criteria listed above would likely be incorporated into BHPB’s licence under the Environment Protection Act 1993 to conduct activities of environmental significance at Olympic Dam.

- It may become a requirement of the licence issued under the Environment Protection Act 1993 for periodic independent auditing of the AQMMP.

- A requirement to report on radon (or radon decay product) monitoring results for each of the meteorological and air quality monitoring stations would likely be a condition of the licence approval under the Radiation Protection and Control Act 1982 for expanded mining and milling of radioactive ore at Olympic Dam.

- All particulate data to be reported with attribution of results, where clear evidence is available, to broad-scale natural events such as dust storms that might cause exceedences of the above standards. For other events, contributions from the mine/processing site would also need to be reported. The mechanism of apportioning particulates to mine/processing site will need to be resolved by BHPB in consultation with the EPA prior to any major earthworks associated with the expansion project commencing at Olympic Dam.
4.4.3 Terrestrial impacts

A comprehensive assessment of potential impacts on terrestrial ecology relevant to the whole EIS project area is covered in Chapter 13: ‘Effects on the environment’ of this AR, including:

- Soils;
- Native vegetation impacts;
- Impacts on threatened ecological communities;
- Impacts to State and Commonwealth “listed” flora and fauna;
- Introduction and/or spread of weeds;
- Impacts on threatened ecological communities; and
- Feral and abundant species.

Where the terrestrial impacts are considered to be specific to the mine and processing plant only, an assessment has been provided in this section.

4.4.3.1 Issues

Site contamination

The DEIS identified the potential for risks associated with the handling, storage, transport and use of significantly increased volumes of chemical substances and the potential for contaminated stormwater at the Olympic Dam site, as a result of flooding through the SML.

The chemical substances include diesel and other hydrocarbons, sulphur, acids, reagents and other chemicals (DEIS Appendix U, Section 2.1). While this has been the case throughout the 25 years of operation to date, the key difference between the current operation and the proposed expansion primarily relates to the significantly larger volumes of materials needing to be managed in many areas (DEIS Section 22.6.8). The potential for polluted stormwater to cause impacts at the site, generated from areas including the metallurgical plant, hardstand areas, haul roads and the rock storage facility, is also highlighted in the DEIS (Section 10.5.4).

The DEIS and SEIS referred to a number of measures to be implemented to manage site contamination, including:

- Ensuring all bulk storages of hazardous liquids comply with applicable standards and legislation for bunding. As a minimum SA EPA Guidelines for bunding would be applied (DEIS Section 22.6.8 and SEIS Section 5.4.6);
- Ensuring general deliveries of chemicals are managed at the stores warehouse under the control of trained personnel (DEIS Section 22.6.8);
- Requiring contractors to comply with standard procedures relating to the storage, use and disposal of chemical substances (DEIS Section 22.6.8);
- Ensuring collected stormwater is controlled within defined management areas with no discharge of stormwater permitted from the SML (SEIS Section 10.4);
- Ensuring current Olympic Dam spill management and reporting procedures are implemented and updated as required for the expansion (SEIS Section 10.4); and
- Ensuring any identified potentially contaminated soils are assessed and remediated post-closure (DEIS Section 10.5.4 and 23.8.3).
**Impacts on vulnerable listed species reintroduced to Arid Recovery**

Arid Recovery, located partially within and to the north of the current Olympic Dam SML, was established in 1997 to facilitate restoration of arid zone ecosystems and to monitor interactions between threatened species and a large scale mining operation (DEIS 15.3.10). ‘Arid Recovery and associated threatened fauna’ is listed as one of the main environmental values within the EIS study area (DEIS Section 15.4.1).

The DEIS assessed the impact of the proposed expansion on a number of protected fauna species which have been re-introduced to, or have self-established within, Arid Recovery since it was established. These are the Greater Stick-nest Rat, Burrowing Bettong, Greater Bilby, Western Barred Bandicoot, Numbat, Woma Python, Spinifex Hopping-mouse and Plains Rat. The main impacts assessed were behavioural impacts from noise and light, and indirect impacts to fauna from the impact of mine dust and other emissions on the vegetation within Arid Recovery.

The DEIS concluded that indirect impacts of mine dust and emissions posed a ‘credible risk’ to protected fauna species within the Arid Recovery. As a means of managing these impacts, BHPB recently extended the northern boundary of Arid Recovery and, as a result of this mitigation measure, assessed the overall residual impact to fauna as ‘moderate’ (DEIS Table 15.7).

In discussions regarding the impacts of noise and light on protected fauna species within Arid Recovery (DEIS Section 15.5.9 and Appendix N12), it was concluded that noise and lights effects would reduce habitat value within at least 2km of expanded mining operations. However, it was considered that the recent northerly extension to Arid Recovery would provide an opportunity for species to move to the north, which would lessen the impact from noise to a degree, and the use of screens and directional lights would mitigate the impact of increased lighting from expanded mining operations. In its consideration of the effectiveness of proposed mitigation measures, BHPB concluded the residual impact to these species from noise and light to be ‘high’ for the protected fauna species within Arid Recovery, reflecting a long-term impact to a sensitive receiver. The DEIS indicated that this issue would be an area of management focus for the proposed expansion (DEIS Sections 15.5.9 and 15.5.10).

**Impacts of the TSF on fauna and migratory species**

The DEIS stated that an objective of the expansion project is to protect listed threatened species (DEIS, Appendix U). It identified that the existing Tailings Retention System (TRS), which consists of 400ha of Tailings Storage Facility (TSF) and 133ha of evaporation ponds, attracts avian fauna due its resemblance to natural water bodies and the limited number of water bodies in the arid environment. The principal concern is the decant water in the TSF which is toxic, and consequently significant consumption of, or extended contact with the water may result in fauna mortalities.

In response to impacts of the TRS on fauna, monitoring, management and public reporting of fauna mortalities associated with the TRS commenced in 1996. Monitoring has determined mortalities from 49 bird species, have been reported, including six migratory waterbird species listed under the Environment Protection and Biodiversity Conservation Act 1999 (EPBC Act, Cwlth) and four bird species listed under the National Parks and Wildlife Act 1974. Also reported are mortalities of flocking waterbirds such as the Banded Stilt. The DEIS noted few mortalities for flocking bush birds. In addition, mortalities for seven species of mammal and eight species of reptile and amphibian have been recorded and publicly reported by BHPB.

Several management measures have been trialled over the years (fencing, gas cannons, strobe lights) with varying degrees of success (BHP Billiton 2005b). BHPB continues to investigate wildlife deterrent devices and systems (refer to AR section 4.4.3.2 below).
The proposed expansion provides an opportunity to address the issue of bird mortalities at the TRS through improved design. A summary of the design modifications proposed to reduce the risk to birds from the TRS were provided in the DEIS Sections 5.5.6 and 15.4.2. These are:

- Reducing the volume of liquor stored in the TSF by modifying the expanded metallurgical plant design to increase the volume of liquor recycled;
- Avoiding new areas of open liquor (the primary attractant) by:
  - Not building new evaporation ponds;
  - Constructing larger TSF cells to increase evaporation rates of liquor;
  - Restricting fauna access to liquor by collecting liquor not evaporated from beaches into a central decant area and covering the decant area with netting or similar; and
  - Restricting access to open liquor on the 60ha stormwater/tailings water balance ponds by covering them with netting or similar.

This approach in TSF design is expected to reduce the attractiveness of the area, by removing large open water bodies in a dry landscape, and only exposing a less attractive wet, muddy surface. However this theory is yet to be tested (DEIS, Appendix N11.5) and would require rigorous monitoring.

The DEIS also introduced the potential to transfer liquor from the existing evaporation ponds to the new TSF cells, substantially reducing the area of open liquor accessible to birds over the longer term. This approach is considered feasible given the total area of the proposed TSF cells when compared to the volume of liquor in the existing evaporation ponds.

**Impacts to waterbird species**

The DEIS assessed that the net effect of these design changes to potential impacts on waterbird species would be an improvement over the longer term. The primary reason is the elimination of all new open liquor ponds and the eventual reduction of existing evaporation pond liquor, despite the increased reflective area of wet beaches possibly attracting more birds.

**Impacts to shorebirds and other species**

Two significant changes to the TSF design – a 3300ha increase in wet beach area containing small rivulets, and sheet flow of acid tailings – may result in increased mortalities of shorebirds and other species attracted to the tailings beaches area. BHPB considered that the creation of a rocky edge on the central decant pond, to eliminate the shore habitat on the new TSF cells, would lessen the expected mortality increase to a degree. With these proposed changes, the DEIS concluded that the risk of mortalities to common waterbirds would be expected to be ‘moderate’, and ‘high’ on two species of threatened or rare waterbirds. Due to any impact likely to affect only a small percentage of the local population, local viability of these species would not be expected to be adversely affected.

The Banded Stilt has been singled out as a waterbird species for further consideration because it is a species which is known to flock in the region in the thousands, so may be at occasional risk of large numbers of mortalities from the TSF. The DEIS assessed that there was a remote chance that a large flock may land on the tailings ponds, resulting in a significant one-off impact on the species’ population. A worst case scenario was that a potential loss of up to 15% of the species’ population could occur should a large flock be attracted to the TSF during a breeding event (DEIS 15.5.7).

Results of a risk assessment discussed in the DEIS determined the risk to the Banded Stilt population to be ‘high’, which is considered ‘tolerable’ under the Australian Risk Standards with ongoing management and research occurring to reduce the risk.
Impacts on Yarra Wurta Springs and resident Lake Eyre Hardyhead population

The DEIS recognised the Lake Torrens saline springs, in particular the Yarra Wurta Springs, as an environmental value to be managed (Appendix U, ID 1.4). In this regard, the DEIS considered the potential for the project to impact on the groundwater dependent ecosystem of the Yarra Wurta Spring group, and thus the resident Hardyhead population, located at the northern end of Lake Torrens.

While no listed species were identified, the DEIS contained a discussion of the genetic significance of the Hardyhead population. The AR considers that although there are two separate populations with some genetic differences, research has shown that they are not different species or subspecies. Further, there were no significant features of the microbial mats (that are the precursor to stromatolites) and fossilised stromatolites.

An assessment of the impacts of groundwater drawdown from the construction of the mine pit and extraction of groundwater from the Motherwell saline wellfield was undertaken in both the DEIS and SEIS. While the DEIS questioned the origin of the groundwater feeding the springs, the assessment of impacts assumed that the spring sources groundwater from the Stuart Shelf (DEIS Section 12.6.4). A groundwater risk assessment presented in the SEIS (Section 12.1.4) assessed the risk to the springs as moderate, reflecting a long-term impact on a common receiver.

Discussion regarding potential impacts to the springs provided in the both the DEIS and SEIS is summarised as follows:

▪ Drawdown from the mine is not expected to extend as far as the springs, however modelling of a worst case scenario indicated that impacts on the Yarra Wurta Spring complex were conceivable, but may only materialise after a long time, more than 500 years post closure. Drawdown at the spring has been modelled at up to 4m, however, BHPB have stated that buffers not included in the modelling, such as structural controls between the mine and the spring, storage buffering effects from Lake Torrens, and groundwater levels around the lake’s edge (approximately 2m above spring water levels), may significantly reduce the predicted drawdown, and were not included in the worst case scenario modelling. In addition, the spring complex is believed to be fed from the north-east rather than the westerly direction of the mine (SEIS Section 12.1.4);

▪ Drawdown modelling included impacts from the Motherwell saline wellfield where extraction from the Motherwell saline wellfield would be expected to occur during the construction phase of the mine. While the outcome of modelling indicated that the drawdown would not extend beyond 25km and therefore would not affect the Yarra Wurta Springs, BHPB has made a commitment in the SEIS to monitor drawdown at the springs for the first six years, to determine whether ongoing extraction could continue without affecting the Yarra Wurta Springs. The residual impact to the spring and the Lake Eyre Hardyhead population was assessed as negligible in the DEIS; and

▪ Populations of Lake Eyre Hardyhead, microbial mats, and fossilised stromatolites at the Yarra Wurta Springs are not considered to be of significant scientific interest (DEIS Section 15.6 and Appendix N8).
4.4.3.2 BHPB EM Program and commitments

Site contamination

BHPB has set the following objectives and criteria as part of its Environmental Management Program (EMP) which is detailed in DEIS Appendix U, ID 2.1:

- **Objective:** No significant contamination to soils, surface water or groundwater as a result of the storage, transport and handling of hazardous substances by BHPB during expansion activities.
- **Criteria:** No lasting significant contamination arising from uncontrolled loss of chemicals to the natural environment (area to be defined).
- **Management Plan:** indicated that the current management plans relating to emergency response (spill management) and hazardous materials would be updated to include the expansion, including the new components.
- **Commitments:** Transport, handling and storage of fuels and other hazardous material in the Special Mining Lease (SML) would be in accordance with the relevant state and Australian statutory requirements. As a minimum, the South Australian Environmental Protection Authority standards would be used, which require bund sizes and volumes to be 120% of the net capacity of the largest tank and 133% for flammable material (SEIS Table 2.1 Commitments, page 55).

Impacts on vulnerable listed species reintroduced to Arid Recovery

BHPB has set the following objectives and criteria as part of its Environmental Management Program (EMP) which is detailed in DEIS Appendix U, ID 1.1:

- **Objective:** No significant adverse impacts to listed species (South Australian, Northern Territory, Commonwealth) populations in the expansion project area as a result of BHPB’s construction activities.
- **Criteria:** Not applicable to Arid Recovery Area.
- **Commitments:** Concerning impacts of the expanded operation on Arid Recovery (SEIS Table 2.1 Commitments, page 58):
  - Arid Recovery would continue to be supported by:
  - Maintaining a distance of 500m between the RSF and Arid Recovery;
  - Ongoing financial support; and
  - Scientific, managerial and professional support by BHPB for Arid Recovery;
- BHPB commits, in principle, to supporting relevant research, including establishing a regional hub for natural resources and environmental management and research. The cost of the commitment is estimated to be approximately $1.2m over three years.

Impacts of the TSF on fauna and migratory species

BHPB has set the following objectives and criteria as part of its Environmental Management Program (EMP) which is detailed in DEIS Appendix U, ID 4.5:

- **Objective:** No significant adverse impacts to listed fauna (South Australia, Commonwealth) as a result of BHPB’s expanded operations.
- **Criteria:** 1a) No significant adverse impact to listed migratory species; and 1b) No significant adverse impact on an important population of Banded Stilt.
- **Management Plans:** TSF Management Manual – the existing operating manual for the TSF would be reviewed to ensure expansion requirements were incorporated.
- **Commitments:** Concerning TSF and wildlife access (SEIS Table 2.1 Commitments, page 60):
  - The proposed expansion of the TSF would minimise impacts on birds, by:
    - Not building additional evaporation ponds;
    - Covering the central decant pond of each expansion TSF cell with netting or similar; and
    - Covering the balancing ponds with netting or similar
BHPB is committed to ongoing avian research to inform management measures and controls, improve monitoring methods, to assess environmental performance, and to enable continual improvement. Research into bird deterrents would continue, including:
- Investigation into more advanced radar;
- Trials of sound identification software for use as part of an on-demand deterrent system; and
- Collaborative research with Deakin University and the SA Department of Environment and Natural Resources into aversive stimuli and bird movements. The total value of this research study is approximately $5m over four years, and includes:
  - Research spectral sensitivity and flicker sensitivity to light of bird species found on the TRS;
  - Research, build and test prototype light sources, with the aim of being aversive to birds on the TRS;
  - Spatial, temporal and daily activities of birds in relation to the TRS and natural water bodies; and
  - Assessment of environmental, weather and celestial variability can predict spatial and temporal patterns of movement.

Impacts on Yarra Wurta Springs and resident Lake Eyre Hardyhead population

BHPB has set the following objectives and criteria as part of its Environmental Management Program (EMP) which is detailed in DEIS Appendix U, ID 1.4:

- **Objective**: No significant adverse impacts to groundwater dependent ecosystems as a result of drawdown associated with BHP Billiton’s expansion activities.
- **Criteria**: No significant decline in groundwater flow rate at Yarra Wurta Springs.
- **Management Plans**: Existing Water Management Plan would be revised for the expansion.
- **Commitments**: Water supply for the proposed expansion (SEIS Table 2.1 Commitments, page 52)
  - BHPB will provide the South Australian Government with a monitoring program, including contingency measures, for the proposed abstraction of groundwater from the Motherwell wellfield.

4.4.3.3 Assessment

Site contamination

A degree of localised potential pollution is considered almost inevitable with any development of this scope, scale and nature. The issue is to what extent the inherent risks can be managed, and the degree of rigour which is applied to the post-closure assessment and remediation process at the site(s). BHPB has characterised the potential for residual impact of site contamination as low for the storage of chemicals, fuel and collected stormwater (DEIS Section 10.5.4). Assumptions have been made based on the implementation of adequate containment (including bunding), contingency training of relevant personnel in spill management, and implementation of the requirements of an Environmental Management Program (DEIS Appendix U).

The AR considers the key expansion activity that poses the greatest potential for site contamination would be the expanded processing/metallurgical operations. There have been a number of spills of material at the existing operations, including spillages of hydrocarbons, sulphuric acid and various processing liquors and reagents. Whilst most have been successfully contained within the secondary (bunding) system or tertiary (stormwater collection and storage) system, there have been instances of spills and leaks which have occurred outside these systems, causing localised site contamination. Reporting of spills over 50m³ is currently undertaken by BHPB in line with the Bachmann Reporting Process.
RECOMMENDATION

Based on the measures proposed in the EIS, the AR considers that the pollution and potential site contamination risks associated with the proposed expansion at Olympic Dam are acceptable, and can be successfully managed to ensure the following outcome: that the proposed development does not compromise current and future land uses within the Special Mining Lease or adjoining areas, or cause adverse impacts on human health due to soil contamination. Accordingly, the following conditions are recommended:

▪ The hazardous and dangerous storages areas and/or activities within the SML must be designed to ensure that chemicals are stored in bunded and sealed compounds/areas capable of preventing the escape of material into the soil, surface waters or underground water resources.

▪ All stormwater retention ponds which are designed to constitute a component of a tertiary containment system for chemical spills must be designed and constructed to prevent the escape of material into the soil, surface waters or underground waste resources.

The following note to BHPB is also recommended:

▪ The EPA Guidelines Bunding and Spill Management (2007) and Wastewater Lagoons (Draft, 2010) contains information that can help the proponent comply with the chemical storage and containment requirements above.

Impacts on vulnerable listed species reintroduced to Arid Recovery

The AR considers that the information provided in the DEIS is an accurate representation of the potential impacts of the expansion on Arid Recovery. This AR accepts the assessment that the direct impact of the expansion to resident protected species will likely be mitigated by the recent extension of habitat to Arid Recovery and maintenance of a 500m buffer zone as committed by BHPB.

Accordingly, the AR concludes that impacts to listed species, reintroduced into the Arid Recovery area, can be appropriately managed.

Impacts of the TSF on fauna and migratory species

The AR considers the information provided in the DEIS to be an accurate representation and assessment of the fauna impacts that would result from the expanded TSF.

The liquor contained within the TSF facility is toxic to avifauna in terms of acidity (pH range from less than 2 to 3.5) and could lead to mortalities following extended exposure, ingestion and/or inhalation of gaseous sulphides. BHPB has acknowledged that the current comprehensive TSF monitoring contains a degree of uncertainty, in that it could underestimate the impacts due to scavenging and sinking of carcasses before they can be counted. Fauna mortality numbers are reported publicly on an annual basis. Summary data was included in the FEIS (DEIS Section 15.5.7 and SEIS Section 16.5).

It is considered that an expansion of the surface area of this facility (up to eight times larger than the current TSF) would cause an increased risk of mortality to wildlife, although it must be acknowledged that bird-impact mitigation design features have been proposed in the TSF expansion designs.

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* "Tertiary containment system" means a system designed to contain chemical spills that may escape from primary containment in tanks and secondary containment in bunded areas.*
BHPB considered a wide range of alternate methods and design options to reduce the risk of impact to avifauna. The costs, benefits and limitations for each option have been considered and reasons for selecting the preferred method and rejecting alternatives have been presented.

The AR considers the controls and management measures proposed by BHPB are appropriate to minimise the risk of impact to avifauna. Further, the AR supports the ongoing commitments to further research.

The AR considers that an updated monitoring program should aim to improve the accuracy of the measurement of bird impacts associated with the current and expanded TSF, and would benefit future avifauna management decisions by BHPB.

Given the risk posed to flocking migratory wader bird species such as the Banded Stilt by the TSF, and difficulty predicting when such large flocking events may occur, it is recommended that BHPB investigate the development of a real-time continuous monitoring system to monitor the arrival or presence of large flocks of listed migratory waterbirds landing on the TSF. Furthermore, a real-time continuous monitoring system would allow BHPB to rapidly respond to large scale flocking events should this be a proven, effective mitigation measure.

**RECOMMENDATION**

The AR recommends the following conditions:

- The proponent must prepare and implement a Bird Impact Management and Monitoring Plan (BIMMP) relating to listed migratory species and Banded Stilts, for approval by the Indenture Minister, prior to the commissioning and operation of the new tailings storage facility (TSF), that is designed to minimise, record and report actual and extrapolated/modelled bird mortalities as a result of exposure to the TSF. The BIMMP must:
  - Outline a process to identify, monitor and respond to potential impacts on birds. To this end the plan should include indicators and/or criteria that will be applied to measure success in achieving environmental protection objectives, and as far as possible mitigating any adverse impacts;
  - Consider knowledge gaps in scientific understanding, and associated key uncertainties;
  - Include a process for interim treatment, measures or controls to manage uncertainty and risk; and
  - Include processes and accountabilities for monitoring, analysing and contributing to adaptive management and continuous improvement processes.

- The proponent must annually prepare and submit a monitoring report to report against the actions and criteria contained in the BIMMP.

- The proponent must review the BIMMP in accordance with the EPMP required under clause 11 of the Olympic Dam Indenture or as required by the Minister.

The AR recommends the following note:

In preparing the BIMMP it is recommended that the proponent considers the following principles and actions:

- The use of best practicable technology to decrease attractiveness of tailings to avifauna, and to deter and disperse avifauna.

- A set of environmental protection objectives aimed at mitigating any adverse impacts to birds from the TSF.
- The development and implementation of a rigorous TSF monitoring program with the aim of reducing the degree of uncertainty around actual mortality numbers.

- The investigation, development and implementation, if practicable, of an ongoing real-time surveillance system, and automated deterrence/hazing systems, to detect the approach and arrival of flocking bird species and deter them from entering the TSF.

**Impacts on Yarra Wurta Springs and resident Lake Eyre Hardyhead population**

The AR considers that based on the assessment provided in the SEIS, impacts to the Yarra Wurta Springs from the proposed Olympic Dam expansion would be unlikely. Despite this, BHPB has chosen to apply precaution and apply management provisions to monitor the springs for effects. Details on the potential impacts on Yarra Wurta Springs are included in further detail in the groundwater section (4.4.4) of this AR.

While many aspects of the Yarra Wurta Springs are represented in springs with similar ecological characteristics, the ecological consequences of impacts, such as drawdown, are difficult to prove outside of modelling, so the precautionary approach taken by BHPB is supported by this AR.

Although the Yarra Wurta Spring contains a Hardyhead population that is separate to populations found elsewhere, and some genetic differences have been noted between the populations, research has shown that they are not different species or subspecies. BHPB has committed to update its existing fauna monitoring program to ensure the incorporation of groundwater communities/ecology that would include the Hardyhead species.

It was noted in the DEIS (Appendix N8) that this species has one of the highest salinity tolerances of any fish, but it should be noted that in other sites, low flow springs/waterholes have been observed to become so saline that the Hardyhead sub-population became extinct at some spring fed waterholes e.g. Billa Kalina springs (pers. obs. Travis Gotch, DENR). In these sites, there is a seasonal cycle of colonisation and extinction, with the fish easily able to recolonise from other sub-populations. In the case of Yarra Wurta, this is the source population, so a local extinction would conceivably be final, resulting in the loss of a unique population. This could also potentially impact the periodic (and very rare and poorly understood) colonisation of Lake Torrens.

Even less understood are the stromatolites and microbial mats present at these springs. No detailed studies are known to have been undertaken into freshwater stromatolite biology in this region, so attempting to assess the significance of flow reduction impacts on these organisms is difficult.

Monitoring has been proposed by BHPB for impacts to the spring from drawdown. Water chemistry and maintenance of flow are considered the key drivers for ecosystem health at Yarra Wurta. Any reduction in flow would see a reduction in habitat area – Population Viability Analysis would show this increases the chance of local extinction.

**RECOMMENDATION**

The AR considers that based on the assessment provided in the SEIS, impacts to the Yarra Wurta Springs and the Hardyhead population from the proposed Olympic Dam expansion would be unlikely. Accordingly, no specific conditions are recommended, as the AR considers that appropriate conditions have been recommended in the Groundwater section of this chapter, 4.4.4.

The AR, however, recommends the following notes:

- Detailed baseline information for the Yarra Wurta Springs should be developed with enough statistical power to account for natural variation and ‘noise’ including:
- Spring flow rate, wetland area and salinity;
- An assessment of the flow would need to be carried out that accounted for local variations in barometric pressure, tidal influences and evaporation rates; and
- Baseline data on the relative abundance/health of the Lake Eyre Hardyheads and microbial mats.

- The monitoring program would have to adequately account for the likely impact timeframe from the Motherwell Saline Wellfield and the mine open pit drawdown.

- To enable the development of mitigation strategies in the event that potential impacts emerge at the Yarra Wurta Springs that are attributable to the operation of the Motherwell wellfield, the proponent should develop action triggers, based on the groundwater model and monitoring at key points.

4.4.4 Groundwater

The SEIS indicated that BHPB would seek to protect the following environmental values in relation to groundwater:

- Groundwater systems of the Stuart Shelf;
- Neighbouring groundwater systems of the GAB and Arckaringa Basin;
- Groundwater dependent ecosystems in the Stuart Shelf; and
- Users of the relevant groundwater resources.

For the purposes of the AR, the groundwater concerns raised and addressed during the EIS process have been grouped as follows:

- Drawdown impacts on the groundwater resources;
- Seepage impacts on the groundwater resources;
- Potential impacts on natural springs (Yarra Wurta and Great Artesian Basin springs); and
- Potential impacts on third-party users.

4.4.4.1 Issues

Drawdown impacts on the groundwater resources

The DEIS described two saline aquifers present in the area of the mine and processing operations, namely:

- The Andamooka Limestone which occurs about 50m below the surface and has a salinity ranging from 20,000 to 60,000 mg/L total dissolved solids (TDS); and
- The Tent Hill aquifer which consists of the Arcoona Quartzite and Corroberra Sandstone and occurs below the Andamooka Limestone between 160 to 200m below surface and has a salinity ranging from 35,000 to over 100,000 mg/L TDS.

The DEIS indicated that neither aquifer is connected to the GAB which at its closest point is located 90km north of Olympic Dam. A conceptual model provided in the DEIS suggested that the GAB aquifers are separated by geological and structural controls in the Adelaide Geosyncline and Torrens Hinge Zone. Springs associated with the GAB are supported by artesian flow and are not believed to be supported by groundwater flow from the aquifers at Olympic Dam.
Recharge to the Stuart Shelf aquifers occurs from the Arcoona plateau in the south and from the Arkaringa Basin in the west. Groundwater from the Tent Hill and Andamooka Limestone aquifers drains into the current underground mine and associated ventilation shafts and is extracted at rates varying from 1.3 to 2.1 ML/d. The extraction of groundwater has resulted in a 100m drawdown within the aquifers near to the mine and a cone of depression which extends 10km to the north-east of the existing mine and 5km to the south-west.

Groundwater for dust suppression is also extracted from four production wells completed in the Tent Hill aquifer for the current underground operation, at an average rate of 0.2 ML/d. Drawdown of up to 40m has been observed in the vicinity of the production wells.

BHPB developed a conceptual model of the groundwater system of the Stuart Shelf, in which the mine is located, which included its hydraulic interconnection with neighbouring groundwater systems. The understanding of the regional Stuart Shelf groundwater system was based on regional interpretation of available information and a program of new investigation wells drilled by BHPB. These wells have limited, short-term time series monitoring data available. Within these constraints, BHPB has predicted the potential long-term impacts of both the mine pit dewatering and the permanent pit beyond the mine life, on the Stuart Shelf aquifers, environmental receptors, users of the resources, and other inter-related groundwater systems.

![SEIS Figure 12.8 Interpreted regional watertable of the Arkaringa-Stuart Shelf groundwater flow system (GFS) overlain on geological provinces](image)

Due to the limited field data available to calibrate the groundwater model and the associated level of uncertainty in the model predictions, the Government requested BHPB undertake additional groundwater model sensitivity runs to enable a risk assessment of the potential impacts of the mine dewatering to be undertaken.
The following issues were considered relevant for assessment purposes:

- Potential that construction of the open pit would result in a decline in aquifer water levels within the Andamooka Limestone that in the long-term may cause the Yarra Wurta Springs to dry up;
- That construction of the open pit could, in the long-term, impact on the groundwater resources of the GAB and Arckaringa Basin; and
- That there could be depletion of local and regional groundwater resources within the Stuart Shelf.

**Seepage impacts on the groundwater resources**

Seepage from the existing TSF and evaporation ponds at an estimated rate of 0.5 to 1.5 ML/d has resulted in a groundwater mound in the Andamooka Limestone that has risen to about 30m below surface. The DEIS indicated that heavy metals in the seepage are attenuated by the sediments and limestone with the pH increasing to close to neutral. In addition, the DEIS indicated that BHPB’s groundwater monitoring for the existing operation shows that water quality below the TSF is similar to the regional water quality, with the exception of slightly elevated uranium concentrations and slightly lower pH.

Groundwater flow from the Andamooka Limestone aquifer to the Tent Hill aquifer through the Arcoona aquitard is thought to occur in an area where a groundwater mound has occurred in the Andamooka Limestone beneath the TSF, and also in areas of increased drawdown in the Tent Hill aquifer.

**Tailings Storage Facility (TSF)**

The following issues were considered relevant for assessment purposes:

- Whether the proposed tailings management measures reflect best practice, and whether alternative methods such as thickened and paste technologies would be feasible;
- Contamination of groundwater in the Andamooka Limestone aquifer on both a local and regional scale;
- The attenuation capacity of the underlying sediments and limestone and the adequacy of geochemical modelling and testing that has been undertaken to demonstrate that the underlying sediments and limestone are effective in attenuating seepage;
- Potential surface expression of the fluids and impact on native vegetation resulting from seepage from the TSF entering shallow geologic sedimentary units adjacent to the TSF; and
- Potential instability of the TSF resulting from discharge of tailings and impacting environmental receptors.

**Rock Storage Facility (RSF)**

The following issues were considered relevant for assessment purposes:

- Potential contamination of groundwater in the Andamooka Limestone aquifer on both a local and regional scale;
- The attenuation capacity of the underlying sediments and limestone being effective in attenuating seepage; and
- Potential surface expression of the fluids and impact on native vegetation and fauna resulting from seepage from the RSF entering shallow geologic sedimentary units adjacent to the RSF.
Potential impacts on natural springs

The following issues were considered relevant for assessment purposes:

- Potential that operation of a supplementary saline wellfield could result in a decline in aquifer drawdown levels within the Andamooka Limestone that could impact on Yarra Wurta Springs; and
- Potential that groundwater drawdowns could impact on the GAB springs

On a regional scale, groundwater moves slowly in a west to south-west direction to discharge at the northern end of Lake Torrens. A number of hypersaline springs and seeps are located around Lake Torrens. Yarra Wurta Springs, the closest groundwater-dependent ecosystem to Olympic Dam, which are located on the northern extent of Lake Torrens, support an ecosystem with an obligate dependence on groundwater. Yarra Wurta Springs consists of two highly saline springs located approximately 1km apart, which support vegetation within and surrounding the pools and along the drainage line, a community of invertebrates, and the Lake Eyre Hardyhead.

At Yarra Wurta Springs a number of invertebrates have been previously recorded, including the brine shrimp, small cladocerans, several species of ostracods, chironomids and rotifers. The DEIS indicated that none were rare, threatened or otherwise significant. The Yarra Wurta Springs also supports a population of the Lake Eyre Hardyhead. The survey of additional springs in the Lake Torrens catchment did not detect additional populations of the species.

Microbial mats and rock formations at Yarra Wurta Spring were considered in the EIS to be precursors to stromatolites and fossilised stromatolites and were considered to be similar to those occurring throughout the world, and were considered in the EIS to be of minor scientific interest.

No stygofauna were identified in the 21 groundwater wells that were sampled - 15 within the area influenced by current mining operations and six outside this zone. The DEIS concluded that their presence was unlikely given the high salinity and low permeability of the aquifer.

A number of freshwater swamps and terminal drainage features occur on the Stuart Shelf. Coorlay Lagoon, the closest to Olympic Dam, is 25km to the south.

Potential impacts on third-party users

The following issues were considered relevant for assessment purposes:

- Potential that operation of a supplementary saline wellfield could result in a decline in aquifer drawdown levels within the Andamooka Limestone and Tent Hill aquifers that could impact on the ability of third-party groundwater users to extract water from their wells; and
- Potential impact on third-party users ability to extract water from their wells due to the construction of the open pit resulting in a decline in water levels within the Andamooka Limestone and Tent Hill aquifers.

The DEIS indicated the presence of 14 groundwater wells within a 60km radius of the current operations that are in use, of which seven are located on pastoral leases held by BHPB.
4.4.4.2 BHPB EM Program and commitments

Drawdown impacts on the groundwater resources

BHPB has set the following objective and criteria as part of its Environmental Management Program (EMP) which is detailed in the DEIS Appendix U, ID 1.4:

- **Objective**: Not applicable to groundwater drawdown.
- **Criteria**: Not applicable to groundwater drawdown.
- **Management plans**: Revise existing Water Management Plan for the expansion.
- **Commitments**: No additional water for the proposed expansion would be obtained from the GAB beyond sustainable yields and that which is available under approvals from the SA Government (SEIS Table 2.1 Commitments, page 52).

Seepage impacts on the groundwater resources

BHPB has set the following objective and criteria as part of its Environmental Management Program (EMP) which is detailed in the DEIS Appendix U, ID 4.2 and 4.3:

- **Objective**: Maintain structural integrity of the RSF and expanded TSF (ID 4.2).
- **Criteria**: No unplanned structural failures to the TSF or RSF.
- **Management Plans**: The existing TSF Management Manual would be reviewed to incorporate expansion requirements. RSF Management Manual (new) An operating manual for the RSF would be developed to include controls and contingencies as per this Plan.
- **Commitments**: Closure Plan for the TSF – tailings cells would be capped when they reach their target design height (SEIS Table 2.1 Commitments, page 59).

- **Objective**: No significant adverse impacts to ecological communities as a result of seepage from the RSF and expanded TSF (ID 4.3).
- **Criteria**: No loss of native vegetation outside bunded TSF area as a result of seepage to groundwater from the TSF.
- **Management Plans**: The existing TSF Management Manual would be reviewed to incorporate expansion requirements. RSF Management Manual (new) An operating manual for the RSF would be developed to include controls and contingencies as per this Plan.
- **Commitments**:
  - Impacts of seepage from existing and future TSF (SEIS Table 2.1 Commitments, page 59) The design of the TSF incorporates controls to minimise seepage including:
    - Increasing the volume of liquor recycled from the TSF;
    - Constructing larger cells with greater evaporation capacity;
    - Collecting liquor through a central decant arrangement;
    - Installing a liner beneath the central decant systems; and
    - Recycling water from the mound beneath the TSF;
  - Impacts of seepage from the RSF (SEIS Table 2.1 Commitments, page 58). Potentially reactive mine rock would be enclosed with the RSF.

Potential impacts on natural springs

BHPB has set the following objective and criteria as part of its Environmental Management Program (EMP) which is detailed in the DEIS Appendix U, ID 1.4:

- **Objective**: Not applicable.
- **Criteria**: No significant decline in groundwater flow rate at Yarra Wurta Springs.
- **Management Plans**: Existing Water Management Plan would be revised for the expansion.
- **Commitments**: Water supply for the proposed expansion (SEIS Table 2.1 Commitments, page 52):
  - BHPB will provide the SA Government with a monitoring program, including contingency measures, for the proposed abstraction of groundwater from the Motherwell wellfield.
Potential impacts on third-party users

BHPB has set the following objective and criteria as part of its Environmental Management Program (EMP) which is detailed in DEIS Appendix U, ID 1.4:

- **Objective**: No significant adverse impacts to the availability and quality of groundwater to existing third-party users as a result of groundwater drawdown associated with BHPB’s expansion activities.

- **Criteria**: No material change in the availability and quality of groundwater bores operated by third-party users.

- **Management Plans**: Existing water management plan would be revised for the expansion.

- **Commitments**: Water supply for the proposed expansion (SEIS Table 2.1 Commitments, page 52):
  - If monitoring results indicate that third-party users are likely to be affected by declines in groundwater levels resulting from the proposed mine expansion, alternative water supply options would be investigated. These may include relocating or deepening existing groundwater wells, or providing an alternative water supply. Options would be considered in consultation with the third-party user.

4.4.4.3 Assessment

Drawdown impacts on the groundwater resources

Dewatering of the open pit and mine void

The DEIS indicated that the establishment of the open pit would result in the creation of a permanent evaporative sink within the regional groundwater system, which would lower water levels in the Andamooka Limestone and Tent Hill aquifers. It has been predicted that a permanent lake would form at the base of the open pit post mine closure. The lake has been estimated to be approximately 350m deep and 650m below ground level, which would be below both the Andamooka Limestone and Tent Hill aquifer systems. A salt crust would be expected to form on the surface of the lake more than 3000 years post closure of the mine.

The DEIS indicated that contamination of the Andamooka Limestone and Tent Hill aquifers with saline brine from the mine void is considered unlikely as the lake in the base of the mine void would be below the aquifer systems and the direction of groundwater flow would be towards the mine void.

BHPB has indicated that dewatering of the Andamooka Limestone and Tent Hill aquifers and other formations would need to commence prior to excavation to ensure safe mining conditions. Initially the volume of dewatering would be expected to be around 15 ML/d and reduce to an estimated 5 ML/d within five years (DEIS 12.4.2, SEIS 12.5.4). The groundwater produced from the dewatering activities would be used for dust suppression and engineering needs during the construction phase of the mining operation. Management options for potential excess water generated from the dewatering activities presented in the SEIS include managed aquifer recharge (MAR). Should BHPB choose to undertake this option, an approval would be required under the *Natural Resources Management Act 2004*.

The FEIS indicated that post-closure, groundwater would be expected to flow into the open pit at a rate of 3.5 ML/day. The current conceptualisation of the groundwater flow regime and the modelling results indicated that regional impacts on the groundwater resources of the Stuart Shelf would not occur until after the 40 year planning horizon adopted for the DEIS.

**Modelled drawdown impacts**

The conceptualisation by BHPB of the Stuart Shelf, Arckaringa Basin and GAB groundwater flow systems presented in the SEIS is considered acceptable by this AR.
Calibrated groundwater model

The AR considers it acceptable that modelling be undertaken to provide an indication of the impacts that may result, from the proposed expansion of the Olympic Dam mine. It would be unrealistic to expect BHPB to undertake an extensive field investigation program to further/enhance their knowledge of the groundwater regimes, prior to approval of the Project.

There is limited, pre-existing, regional, long-term monitoring data with which to calibrate the groundwater model and this data is primarily restricted to the existing operation where monitoring data have been collected since 1983. As part of the EIS process BHPB has undertaken a regional investigation program where 154 drillholes have been completed to enable ongoing monitoring in the future. Field investigations have focussed on:

- Yarra Wurta Springs;
- Motherwell Wellfield and extension investigations; and
- Mine pit dewatering and depressurisation.

In the absence of long-term regional monitoring data it is essential that sensitivity analyses be run on the groundwater model to highlight potential drawdown impacts. Impacts to groundwater resources within the Stuart Shelf and adjoining groundwater flow systems have been assessed using the regional groundwater model.

The current conceptualisation and modelling results indicate that the regional impacts on the groundwater systems would not occur until after the 40 year planning horizon adopted for the EIS. At the year 2050, within the Andamooka Limestone, the 1m groundwater level drawdown contour would extend 5km to the north of the open pit, and 20km to the south (SEIS Appendix F4 – Section 5.2 and Figure 5.2). Greater drawdowns have been predicted within the Corraberra Sandstone at the year 2050 (SEIS Appendix F4 – Section 5.2 and Figure 5.6). Drawdowns are expected to extend more radially with the 1m contour occurring at a ~25km radius from the open pit. Drawdowns of ~100m are expected within the open pit. Recharge to the calibrated model occurs from rainfall and inflow from the Arckaringa Basin on the western margin of the model domain. Inflow from the Arckaringa Basin is based on values determined from the Prominent Hill groundwater flow model. There is currently no understanding as to how this inflow would change the groundwater level drawdown in the Stuart Shelf (Andamooka Limestone aquifer).

The Prominent Hill mine is located to the west and outside of the model domain. Groundwater for that mining operation is sourced from two wellfields constructed in the Arckaringa Basin. Prominent Hill has an expected mine life of approximately 10 years and the BHPB calibrated model predicts a drawdown of <1m at the year 2050 at the western edge of the model domain. Therefore any drawdown impacts on the western margin of the model domain and subsequent changes to inflow from the Arckaringa Basin are unlikely to impact on the Prominent Hill operation.

Indications are that the regional Stuart Shelf groundwater system may not reach equilibrium for some thousands of years post mining. The implications of this are that water levels in the Andamooka Limestone and Tent Hill aquifers would continue to decline (for at least 1000 years) which may result in:

- Dewatering of the Andamooka Limestone and Tent Hill aquifers to such an extent that it would no longer be a viable water supply option for future developments that require large volumes of water. The Andamooka Limestone and Tent Hill aquifers are currently used by pastoral and mining industries (including the dewatering of current Olympic Dam mine), and have a groundwater salinity in the range of 10,700 mg/L to 260,500 mg/L (Table 12.2 SEIS). The high groundwater salinity limits the beneficial uses of the groundwater; and
- Possible flow reductions at Yarra Wurta Springs.
Calculated groundwater drawdown impacts at various points within the groundwater model domain have been determined from regional contour diagrams (SEIS Appendix F4). A summary of the drawdown impacts as determined by the calibrated model is presented in the table below. The extent of drawdown contours used by BHPB was set at the 1m drawdown contour and drawdown values from the calibrated model have been used.

**Summary of drawdown impacts as determined by the calibrated model**

<table>
<thead>
<tr>
<th>FEATURE</th>
<th>AQUIFER</th>
<th><strong>DRAWDOWN @</strong></th>
<th><strong>40 Years</strong></th>
<th><strong>500 Years</strong></th>
<th><strong>Long-term (&gt;500 years)</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>Open Pit</td>
<td>Andamooka Limestone</td>
<td>10m</td>
<td>&gt;30m</td>
<td>&gt;30m</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arcoona Quartzite /</td>
<td>100m</td>
<td>110m</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Corraberra Sandstone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SML Boundary (expanded)</td>
<td>Andamooka Limestone</td>
<td>&lt;1m on the W boundary to 10m on the SE boundary</td>
<td>&lt;4m on the NW boundary to &gt;20m on the SE boundary</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arcoona Quartzite /</td>
<td>&lt;1m on the N boundary to &gt;20m on the S boundary</td>
<td>~5m on the N boundary to 40m on the S boundary</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Corraberra Sandstone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Yarra Wurta Springs</td>
<td></td>
<td>&lt;0.25m</td>
<td>1m</td>
<td>&gt;1m (sensitivity analyses indicate drawdowns in the order of &gt;4m could occur at the springs)</td>
<td></td>
</tr>
<tr>
<td>GAB Springs</td>
<td>Cadna-owie / Algebuckina</td>
<td>No impact is expected</td>
<td>No impact is expected</td>
<td>No impact is expected</td>
<td></td>
</tr>
<tr>
<td>Third-party Users</td>
<td>Andamooka Limestone</td>
<td>&lt;1m</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Arcoona Quartzite /</td>
<td>&lt;1m</td>
<td>1 to 4 m</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Corraberra Sandstone</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Torrens Hinge Zone</td>
<td></td>
<td>&lt;1m</td>
<td>&lt;1m</td>
<td>&gt;2m may occur at the Andamooka Limestone / Torrens Hinge Zone interface</td>
<td></td>
</tr>
<tr>
<td>Western boundary of model domain</td>
<td>Andamooka Limestone</td>
<td>&lt;1m</td>
<td>&gt;2m</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*The drawdown values are approximate*
The following is a summary of the key modelling results (SEIS Appendix F4):

- Indications that drawdown would be expected to occur in the Andamooka Limestone aquifer over much of the groundwater model area. Drawdown would be greatest at the open pit and to the south of the pit with drawdown levels of over 30m expected at the open pit. Over the remainder of the area drawdown levels of less than 4m are anticipated;
- Drawdown levels within the Tent Hill aquifer would be expected to extend approximately 50km to the south and 80km to the west of the open pit;
- Indications that the groundwater model has not reached equilibrium at 500 years and would be unlikely to have done so by 1000 years (SEIS Section 12.2.1);
- Groundwater levels in the Andamooka Limestone and Tent Hill aquifers would have a gradient towards the open pit mine void during the operation of the mine and post closure; and
- Indications that the decline in groundwater levels would not have a significant impact on groundwater receptors within the Stuart Shelf.

**Sensitivity analysis: summary of the aquifer parameters determined from field results and used in calibrated groundwater model**

<table>
<thead>
<tr>
<th>HYDROGEOLOGICAL UNIT</th>
<th>MODEL LAYER</th>
<th>HYDRAULIC CONDUCTIVITY (KH) (M/DAY)</th>
<th>Ss (/M)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>In Model</td>
<td>Pumping Tests</td>
<td>In Model</td>
</tr>
<tr>
<td>Andamooka Limestone (ZAL)</td>
<td>2</td>
<td>8.6x10^{-6} to 22</td>
<td>10^{-4} to 5x10^{-4}</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td>8.6x10^{-6} to 22</td>
<td>10^{-4} to 5x10^{-4}</td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>8.6x10^{-6} to 0.2</td>
<td>5x10^{-5} to 0.2</td>
</tr>
<tr>
<td>Arcoona Quartzite (ZWA)</td>
<td>6</td>
<td>8.6x10^{-6} to 8.6x10^{-4}</td>
<td>5x10^{-5} to 0.2</td>
</tr>
<tr>
<td>Corraberra Sandstone (ZWC)</td>
<td>7</td>
<td>8.6x10^{-6} to 0.2</td>
<td>5x10^{-5} to 0.2</td>
</tr>
<tr>
<td>Adelaide Geosyncline Rocks (Torrens Hinge Zone)</td>
<td>8</td>
<td>9x10^{-6}</td>
<td>5x10^{-4} to 1x10^{-6}</td>
</tr>
</tbody>
</table>

It should be noted that many of the aquifer parameters used in the calibrated groundwater model are within the range of values measured in the field, however hydraulic conductivities in the Andamooka Limestone are in the lower range of values from field analyses; and aquifer storage is in the higher extent of the range.

Sensitivity tests were undertaken by BHPB to determine levels of uncertainty in the groundwater model predictions and the range of aquifer parameters tested in sensitivity tests is provided below in the Table below.
Range of aquifer parameters tested in sensitivity tests

<table>
<thead>
<tr>
<th>HYDROGEOLOGICAL UNIT</th>
<th>MODEL LAYERS</th>
<th>HYDRAULIC CONDUCTIVITY SENSITIVITY ANALYSIS RANGE (M/DAY)</th>
<th>SPECIFIC STORAGE SENSITIVITY ANALYSIS RANGE (/M)</th>
<th>PARAMETER CHANGES COMPARED TO CALIBRATED MODEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Andamooka Limestone (ZAL)</td>
<td>2</td>
<td>50 and 20 (conductivity values only changed for the 2 zones north and northeast of the mine site (additional sensitivity test requested by DFW).</td>
<td>1x10⁻⁴ (sensitivity scenario II – excluding mine area)</td>
<td>Reduction in specific storage. Increase in specific storage. Reduction in specific storage and increase in hydraulic conductivity</td>
</tr>
<tr>
<td></td>
<td>3</td>
<td></td>
<td>2.5x10⁻³ (sensitivity scenario III – excluding mine area)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td></td>
<td>1x10⁻⁶ (additional sensitivity test requested by DFW)</td>
<td></td>
</tr>
<tr>
<td>Arcoona Quartzite (ZWA)</td>
<td>6</td>
<td>8.64x10⁻⁴ (sensitivity scenario IV – Kv only)</td>
<td>-</td>
<td>Increase in hydraulic conductivity.</td>
</tr>
<tr>
<td>Corraberra Sandstone (ZWC)</td>
<td>7</td>
<td>0.43 (sensitivity scenario V - Kh)</td>
<td>-</td>
<td>Increase in both vertical and horizontal hydraulic conductivity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.043 (sensitivity scenario V - Kv)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adelaide Geosyncline Rocks (Torrens Hinge Zone)</td>
<td>8</td>
<td>8.64x10⁻³ (sensitivity scenario VIII - both Kh and Kv)</td>
<td>-</td>
<td>Increase in both vertical and horizontal hydraulic conductivity.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.64x10⁻² (sensitivity scenario IX - Kh but for only a thin high permeable channel N-NNE of Olympic Dam, layers 1 &amp; 2 only)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In total, 12 sensitivity analyses were conducted as part of the SEIS, as follows:

- 6 sensitivity analyses were conducted on the groundwater model, each varying only a single parameter (K or Ss) for a single geological unit: two each for the Andamooka Limestone, Torrens Hinge Zone and one each for the Arcoona Quartzite and Corraberra Sandstone;
- 3 sensitivity analyses were conducted varying recharge and inflow into the groundwater model domain;
- 3 sensitivity analyses were conducted on TSF and RSF seepage rates and configuration; and
- 1 sensitivity analysis was conducted with no Motherwell Wellfield extraction.

No sensitivity analyses were undertaken for a decrease in the specific storage for the Corraberra Sandstone or Torrens Hinge Zone.

The sensitivity analyses as presented in the SEIS Appendix F4 show that groundwater level drawdown impacts increase to all groundwater receptors within the Stuart Shelf groundwater system with changes to aquifer storage and conductivity, and also recharge, with the following indicated:
Sensitivity analyses indicated changes in the amount of drawdown would be commensurate with the volume and availability of groundwater in the model. Regionally, increases in drawdown would be in the order of <1 to 6m within the Andamooka Limestone aquifer and in the order of <1 to 10m within the Tent Hill aquifer. These increases in drawdown levels indicate the groundwater model is sensitive to changes in aquifer storage and conductivity;

- A maximum drawdown of up to 4m (at 500 years) may occur at Yarra Wurta Springs, which would be an increase of 3m drawdown over the calibrated groundwater model;
- A maximum drawdown of up to 9m (at 500 years) may occur at 19 Mile Bore, which would be an increase of 7m drawdown over the calibrated groundwater model;
- A maximum drawdown of up to 5m (at 500 years) may occur at Loch Well, which would be an increase of 4.5m drawdown over the calibrated groundwater model;
- Negligible changes in aquifer drawdown were reported at bore RT-9, which is completed in the Brachina Formation aquifer and located in the Torrens Hinge Zone;
- A drawdown of >8m may occur along the western margin of the model domain (at 500 years), which would be an increase of 6m over the calibrated groundwater model;
- Increased seepage beneath the TSF and RSF (5% of rainfall) would still result in seepage flowing towards the open pit; and
- Many scenarios show that the groundwater model is not approaching equilibrium at 500 years and therefore drawdown may be greater than reported.

**RECOMMENDATION**

The AR concludes that the magnitude of water level declines as determined by the calibrated model is considered to be acceptable. However, modelling long-term groundwater changes on this scale is difficult and carries a degree of uncertainty. The AR recommends the following condition:

- The proponent must review and update on a 3 yearly basis the regional groundwater model presented in the EIS and used to predict regional groundwater drawdowns. Review of the groundwater model is to be undertaken by an independent expert in accordance with the Murray-Darling Basin Commission Modelling Guidelines (as the nationally recognised groundwater modelling guidelines), as amended from time to time. In reviewing and updating the regional groundwater model a report must be prepared that includes at least the following specific items:
  - Updated understanding of the hydrogeology of the Torrens Hinge Zone;
  - Updated aquifer parameters for the Torrens Hinge Zone to be used in modelling upgrades;
  - Updated understanding of the recharge mechanisms to the Stuart Shelf, including recharge from rainfall and inflow from the Arckaringa Basin; and
  - Updated understanding of impacts to the regional groundwater system resulting from the open pit void.

**Mine water supply**

The DEIS indicated that no additional water would be sourced from the GAB beyond the current special water licensing arrangements under the Olympic Dam Indenture. Current licensing arrangements provide for the management of extractions from the two wellfields (Wellfield A and Wellfield B), with current extraction rates in the order of 35 ML/d.

Supplementary water supplies would be required during the construction phase of the proposed expansion providing an estimated 35 ML/d from local saline wellfields (10 ML/d) and the Motherwell Wellfield (25 ML/d). It is not explicitly stated in either the DEIS or SEIS how long the Motherwell Wellfield would be used, however the project configuration has been based on an 11 year construction phase (and modelling of Motherwell Wellfield covered a period of 8 years).
BHPB propose to use the Motherwell wellfield during the construction phase of the expansion, however the wellfield could be used for a longer period as a low quality water resource, subject to the aquifer response to extraction. The operation of the Motherwell Wellfield has been incorporated into the regional groundwater model and the results indicate that drawdowns in the order of 2–4m would be expected at the wellfield, with the drawdown expected to extend up to ~23km regionally. Yarra Wurta Springs are located approximately 45km to the north-east of Olympic Dam and approximately 40 to 45km to the north-east of the proposed position of the Motherwell Wellfield.

Extended operation of the Motherwell Wellfield may present a greater risk to Yarra Wurta Springs during the mine operation than dewatering activities, but the extent and magnitude of impact would be dependent on production rates from the wellfield. It is recommended that monitoring should be undertaken to identify potential impacts to Yarra Wurta Springs.

RECOMMENDATION

Extraction of water from the Motherwell Wellfield and other saline wellfields, not associated with mine dewatering, are to be managed in accordance with the Olympic Dam Indenture, and would require the granting of a Special Water Licence. The AR recommends the following notes:

- The proponent will be required to establish a monitoring program required for the Motherwell Wellfield and other water supply wellfields in accordance with requirements under the Olympic Dam Indenture (Special Water Licence), and that monitoring data would include as a minimum:
  - Total abstraction and individual well abstraction on a monthly basis;
  - Water pressure and levels in monitoring and production wells; and
  - Water quality at monitoring and production wells on an annual basis.

Impacts to vegetation from groundwater drawdown

The DEIS indicated that Coorlay Lagoon, 25km south of Olympic Dam, is the only place in the EIS study area where the water table is close to the surface; however due to the salinity levels, it is unlikely that there is any vegetation reliant on the groundwater. Monitoring would be undertaken, of the Acacia woodlands in particular, to monitor for impacts from drawdown, and contingency options considered if impacts became evident (DEIS Sections 12.3.6 and 15.5.8 and SEIS Sections 12.2.3 and 12.5.5).

Seepage impacts on the groundwater resources

Thickened tailings and water balance

BHPB has indicated that the proposed expansion would generate approximately 58Mtpa of tailings at full production, with disposal of the tailings at between 52–55% solids. The EIS indicated that establishment of a tailings storage facility (TSF) would include nine new cells - eight operational and one for contingency - each approximately 400ha in surface area with a total footprint, including liquor balance ponds, of 4400ha. As TSF Cell 5 has been constructed as part of the current operations, this was amended in the SEIS to eight new cells.

The selection of tailings density and the ultimate design of the TSF impacts on key environmental values include:

- Water usage;
- Local groundwater;
- Long-term landform stability;
- Avifauna; and
- Native vegetation.
The mineral extraction process can be considered in two parts – firstly the concentrator and thickeners, and secondly the hydrometallurgical plant leading to the TSF. In the first area the water is treated as “clean” into which is fed the primary “make up” water and the thickener overflow from the deep cone thickeners is suitable for putting back into the process. The unrecoverable water contained in the tailings voids is the principal form of clean water leaving the process and is minimised by the extent of thickening undertaken.

Once the range of minerals is recovered from the primary ore in the concentrator they are processed in the hydrometallurgical plant. The water recovered from the various parts of the plant is mineralised and can no longer be reused economically and this water is injected back into the tailings stream for delivery to the TSF from which it is evaporated. This means all reusable water is retained in the plant, the tailings and reject water are disposed of in a single stream.

The EIS indicated that it was not optimal to produce higher solids content tailings or to produce tailings to a paste consistency. In addition it indicated that the establishment of a paste disposal facility would require a larger surface area with more clearance of native vegetation, and that unlike the lower solids-content tailings, water recycled from paste disposal could not be used to supplement process water due to its chemistry and salinity levels.

In its submission on the DEIS the SA Government requested additional information to justify why tailings could not be thickened to a higher density than the proposed 52–55% solids.

In the SEIS, BHPB indicated that it rejected the options of paste thickened tailings and conveyance and stack disposal methods because it would:

- Impact the water balance for the process plant;
- Result in a larger TSF footprints due to steeper beach angles;
- Result in less efficient drying of the tailings; and
- Require high energy consumption due to difficulty in pumping the paste tailings.

BHPB indicated that the operational tailings density was selected in order to optimise the process water balance, enabling the maximum of 26 ML/d being returned back into process. BHPB also indicated that thickening beyond the proposed design level would have no benefits as no additional recovered liquor could be re-used in the processing operations and would therefore need to be disposed in evaporation ponds. The establishment of further large evaporation ponds was not desirable.

BHPB indicated that thickening the tailings to 60% solids content would result in an additional 13 ML/d of liquor requiring evaporation.

While BHPB's experience with the current operations indicates that the proposed water balance could be achieved, to maintain flexibility it proposed to incorporate a covered balance pond for short-term water balance disruptions.

The information provided by BHPB confirms that the tailings could be produced at a higher consistency than 55% solids, and indeed that the thickener underflow is designed to have an optimum consistency of 70% solids that will then be diluted by liquor emanating from various parts of the metallurgical process back to 55% at discharge. The information indicates a practical design constraint for the thickener arises beyond 70% solids, as the tailings consistency would result in a viscosity in the underflow that could provide operational difficulties.
The information indicates that the deep cone thickener design has been based upon the following criteria:

- Design is based on 70% solids at an ore Specific Gravity (SG) of 3.2.; and
- The key intent is to reduce primary water consumption, which also drives:
  - Acidic liquor recycling demand from the TSF facility;
  - Reductions in volumes of liquor that the TSF has to manage; and
  - Acid balance – in this case an acid credit of 2.8 kg/t;
- The key performance measure is to achieve a constant unit volume of water advancing into the hydromet circuit regardless of ore SG.

The size of the TSF cells and the number of cells planned to be in operation at any time has been designed to provide sufficient beach area to enable the excess process water to be evaporated such that no additional evaporation ponds will be needed to get rid of the water unsuitable for reuse.

RECOMMENDATION

The AR considers that the tailings design takes into account the needs of the entire process, and on the basis of the water balance data provided by BHPB, the consistency of the tailings at discharge is as high as is practical while optimising the whole of process water balance and minimising the consumption of clean primary water.

Seepage from TSF and RSF

Seepage is expected to occur from both the TSF and RSF into the local groundwater system resulting in the creation of a local groundwater level mound which, if not properly managed, could impact on groundwater dependent vegetation.

The DEIS indicated that in the initial stages of operation, seepage from the TSF would be about 4 cubic metres/hectare/day. The seepage is expected to reduce to about 1 cubic metre/hectare/day when steady state conditions are developed. These modelled seepage rates are less than the current TSF Cells 1–4 and this is considered to be related to the higher tailings solids content for the expansion (52-55%), when compared to the existing operations (47%), and the higher surface area for evaporation of liquor. The EIS indicated that seepage rates would reduce to a long-term rate equivalent to about 1% of the total rainfall following closure.

Modelling by BHPB indicates that a mound in the order of 6–8m would be formed 40m beneath the TSF in response to seepage. In comparison, mounding in the order of 17m occurs beneath the existing TSF operations. Modelling results also indicate that aquifer water levels are likely to fall 15–30m at the boundary of the SML both during operations and post closure.

The proposed TSF design incorporates measures to minimize infiltration and enhance neutralization of seepage fluid. These include the establishment of larger storage facilities to encourage evaporation of the liquor, proof-rolling the clay base of the storage facility and establishment an HDPE liner and drainage collection system in the decant area where the highest hydraulic heads occur. In addition, the proposed designs incorporate toe and heel drains which would intercept near surface seepage, to be returned to the storage area.

An updated model was provided in the SEIS to test the sensitivity of seepage predictions from the TSF. BHPB has indicated that the groundwater model is regional in scale and while it does provide information on the local scale it does not simulate the variability in the subsurface geological features. BHPB has indicated that its experience from the operation and management of the existing TSF system suggests that lateral seepage does not occur beyond the vicinity of the TSF. Groundwater monitoring data indicates that this comment is reasonable.
As the TSF and RSF are located in close proximity to the open pit dewatering prior to and during operation, combined with the natural dewatering post closure of the mine, would create a cone of depression in the Andamooka Limestone and Tent Hill aquifer systems. The direction of groundwater flow in both aquifers would be towards the open pit, therefore any seepage from the TSF and RSF would eventually flow into the open pit. Natural attenuation of the seepage is also expected to occur within the sediments and Andamooka Limestone located below the TSF and RSF.

Groundwater below Olympic Dam is unsuitable for domestic and stock use due to its high salinity and elevated concentrations of metals. The Environment Protection (Water Quality) Policy 2003 indicates that groundwater affecting activities should not alter the groundwater chemistry even if the existing water quality exceeds the specified criteria. An exemption from the Policy (and associated attenuation zone) or amended criteria to reflect the existing natural water quality would likely be required should the expansion proceed.

Public submissions have indicated that the entire TSF should be lined to prevent seepage and groundwater impact. BHPB proposes to install a lining system in the drainage area below the liquor decant pond. The groundwater environmental values determined for the site relate to the protection of groundwater users and ecological communities. The impacts on existing groundwater users and the ecological communities were discussed in the preceding section of this chapter and it was concluded that significant impacts attributable to seepage were unlikely to occur.

BHPB proposes to install additional groundwater monitoring bores around the perimeter of the expanded TSF and RSF to monitor groundwater quality and the groundwater mound. The current monitoring and reporting program would also be extended to include the additional bores.

In the event that the base seepage is higher than estimated the result would be an increase in the elevation of the groundwater mound below the TSF. Groundwater extraction (pumping) could be undertaken should the groundwater mound approach a maximum level that will ensure no impact to native vegetation.

BHPB proposes to include management measures to minimise infiltration into the RSF and enhance neutralisation of seepage fluid. These include incorporating acid neutralising rock (limestone) at the base of the RSF and the mixing of non-acid forming rocks with potential and actual acid-generating rock. The assessment by BHPB indicates that there are sufficient volumes of rock to neutralise acid-generating waste rock that would be disposed in the RSF. In addition, attenuation of any seepage would also be expected to occur within the sediments and Andamooka Limestone located below the RSF.

**RECOMMENDATION**

The AR concludes that the seepage issues can be appropriately managed using the approach proposed in the FEIS.

**Neutralisation of acid drainage from TSF and RSF**

BHPB has undertaken analysis and modelling to assess the overall risk for acid generation and the impact of acid mine drainage (AMD) on groundwater, and potential neutralisation capacity of the sediments and limestone below the TSF and RSF. The DEIS indicated that the very high neutralising capacity of the soils and strata underlying the TSF would be more than sufficient to account for any long-term acid generation from the sulphide content of the tailings.

A number of issues were raised by the SA Government in relation to the composition of seepage from the proposed TSF, RSF and low grade stockpile and the capacity for acid neutralisation, including:
▪ The nature of downward movement of acidic seepage from the storage facilities and its interaction with potentially neutralising rocks, especially the Andamooka Limestone (the mechanism of neutralisation);
▪ The objectives of the kinetic testing, rationale for selection of test samples, and the reasons for early cessation of a number of the tests;
▪ Explanation of test methods and inconsistency of nomenclature and data reported; and
▪ The fate of ammonia present in tailings process water

The SA Government review of the FEIS questioned details regarding the location and mechanisms of acid neutralisation by rocks incorporated in the RSF, as well as aspects of the proposed interaction of acid seepage from the RSF and TSF with the underlying Andamooka Limestone. The AR accepts BHPB’s conclusion that while some uncertainties remain concerning the interaction of seepage with the sediments and limestone below the TSF and RSF, such as through the formation of preferred flow channels, there would be excess acid neutralising capacity provided by the limestone and other rocks.

The information provided in relation to the fate of acid seepage from the existing TSF - indicating that acid neutralisation occurs within approximately the upper metre of the Andamooka Limestone - provides support to the modelling that suggests acid neutralisation would occur within approximately 3m of the limestone boundary. As the future tailings would have a similar composition to the tailings from the current operations, the information provides credible evidence of the future behaviour of acidic drainage for the proposed expansion.

Information was requested regarding the nature of the test rocks (core sections and samples from underground workings), and the selection criteria for the 19 test samples. BHPB indicated that the primary objectives of kinetic testing was to obtain indicative estimates of the steady-state oxidation rates and concurrent solute release rates from each of the major lithological units that would be placed in the RSF. BHPB has indicated that the kinetic test objectives were set conservatively in light of the low risk environment.

BHPB has undertaken significant testing to determine the geochemical composition of the cover sequence rocks and provided a series of diagrams illustrating their content of wt % CO2 (as a measure of potential acid neutralisation capacity) and wt % S (as a measure of potential acid generation). These diagrams include maximum and minimum values, as well as the average for each lithology, as intercepted in 20 diamond drill holes. It would have been beneficial if similar diagrams were presented for the basement lithologies that would comprise major proportions of the future RSF. Nevertheless, the diagrammatic and other compositional information relating to the 5 cover sequence rocks involved in the kinetic testing provide support to BHPB’s position relating to the geochemical homogeneity and dolomitic nature of the Andamooka Limestone, and the overall acid neutralising potential of the lithologies.

The BHPB Olympic Dam geochemical database indicates a low potential for the generation of AMD from storage of rocks of the basement and cover sequence in the RSF. The average reported total S content of all lithologies is <1.0 wt % and below the values normally associated with a significant risk of AMD production. The rocks predicted to comprise the largest proportions of the RSF have very low total S content. For example, the Arcoona Quartzite – Red (ZWAR) of the cover sequence is predicted to comprise 26 wt % of the RSF has average Sulphur content of only 0.04 wt %, and the Granite-Hematite rock (GRNH) of the basement has average Sulphur content of 0.22 wt %. These equate to maximum sulphide (as pyrite) contents of no more than 0.1 and 0.4 wt %, respectively. Accordingly, the Maximum Potential Acidity is minimal.

Static testing of Net Acid Generation confirms the very low potential for acid development and further suggests that a significant proportion of the Sulphur content in the waste rocks is in the oxidised (sulphate) form, able to contribute little to the overall acidity of the drainage.
Taking together the low potential for AMD generation and the appreciable Acid Neutralisation Capacity (ANC) present in most of the cover sequence lithologies, especially the major unit of Andamooka Limestone (average ANC 481 kg H₂SO₄/t), the balance is strongly towards effective neutralisation of any acidic solutions that might arise within the RSF. In view of the slow rates of groundwater movement, the naturally saline nature of the groundwater, and flow of groundwater in the mining area ultimately to the open pit, there appears to be very little risk to regional groundwater from the future storage of waste rock in the RSF.

Given the low average sulphide content of the waste rocks, any AMD development in the RSF is likely to be localised and result from any ‘unusual’ rock types of small volume. The proposed measures to prevent lateral escape of surface water would minimise the risk of environmental impact from such limited AMD production. The ability to track the sulphur content of waste delivered to the RSF and to envelope any particularly acid-generating mine rock with rocks of elevated ANC is an additional option not present in most mining operations, which provides a further safeguard against AMD production.

The Kinetic testing undertaken by BHPB indicates there is a low risk posed by the leaching of solutes from the waste rock and hence a minimal risk of acid mine drainage conditions.

Ammonia would also be present in the tailings. The form in which ammonia occurs is pH-dependent - it becomes more mobile as the pH rises, not less, as for all of the other components of the potential TSF seepage. At the pH 8–9 that is anticipated to occur in the underlying limestone/dolomite, it will be largely in its most mobile form of dissolved ammonia. Consequently, ammonia should also be included as a routine component of the water quality analysis suite.

The groundwater modelling indicated that groundwater drainage would be towards the final mine void, which coupled with the limited lateral movements of shallow groundwater during periods of maximum water loss to seepage, would further diminish the risk to groundwater from acid drainage.

Infiltration through TSF and RSF post-closure
Following the review of initial information on the proposed TSF and RSF post-closure encapsulation provided in the DEIS, further information was sought in the SEIS in relation to the basis for the determination of infiltration rates through the proposed TSF and RSF, including modelling based on currently available information from the site, or literature on soil and rock geotechnical and permeability parameters and site climatic conditions. This information was sought as the final covers would influence the amount of rainfall that would enter the TSF and RSF and contribute to the potential for ongoing seepage.

The SEIS provided a report indicating the results of modelling of the infiltration rate through a range of alternative encapsulation materials for the RSF. A review of this information indicated that the model methodology used for the RSF in the SEIS was reasonable. However, it is noted that the analysis considered sand and gravel sized material, whereas the SEIS and Appendix N referred to the use of coarse rock mulch as the uppermost layer.

The SEIS indicated that for the coarsest material assessed (sandy gravel) the infiltration rate would vary from 7.3–12% of rainfall, and that the average percolation rate, assuming additional silt and sand material, would be about 4.6% of rainfall.

BHPB indicated that the groundwater model showed that any seepage from the TSF and RSF would be captured by the open pit, and that there would be a rapid decline in solute release over time, the nature of capping would not be the controlling factor in the management of seepage.
RECOMMENDATION

The AR considers that it is important to ensure that appropriate closure strategies are developed for the TSF and RSF which minimises ongoing seepage post-closure. The issue of capping design and modelling is one of many control strategies that would be relevant to mine closure and rehabilitation. Refer to section 4.4.12 of this chapter for assessment of rehabilitation and closure of the mine.

Stability of TSF and RSF

It is important that the TSF is stable to ensure that impacts on flora, fauna, surface water and groundwater are acceptably low.

In its assessment of the DEIS, the SA Government requested additional stability analysis for a potential block sliding mechanism with a failure surface located in low strength clay material that may be located in the foundations. The stability assessment undertaken by BHPB considered both static conditions and seismic conditions. The AR considers that the properties and parameters of construction materials, foundation soils and tailings proposed to be used by BHPB in the conceptual design and in the stability assessment are acceptable.

The revised stability assessment provided in the SEIS indicated factors of safety for circular and block failure respectively of 1.5 to 1.72 for static conditions and 1.14 to 1.15 for pseudo-static conditions (seismic loading). These factors of safety meet or exceed the normally accepted lower bound values of 1.5 and 1.1 for static and pseudo-static conditions respectively as established by the Australian National Committee on Large Dams (ANCOLD) Guidelines, widely used for determining whether dam structures have acceptable stability.

The construction and operation of the TSF will require authorisation under the Radiation and Protection Control Act 1982 and this would require BHPB to provide detailed site-specific design and engineering information to confirm the structure is appropriate to minimise seepage.

The AR makes the following conclusions in relation to the TSF and RSF and potential impacts to groundwater:

- The proposed TSF design which seeks to balance tailings density and water management is considered acceptable for the site conditions that are experienced at Olympic Dam;
- Fully lining the TSF facility is not warranted on the basis of protection of the indicated environmental values and existing industrial beneficial use of groundwater;
- Seepage from the TSF which enters the groundwater system will ultimately be captured by the open pit;
- The underlying sediments and limestone are expected to neutralise acidity of any seepage and attenuate heavy metals and radionuclides;
- The storage of tailings, mine rock and low grade ore both during mining and after closure would pose little risk to regional groundwater, existing groundwater users and other environmental receptors;
- The TSF (and RSF) have been designed with appropriate material properties and have acceptable stability; and
- Implementation of a rigorous monitoring program complemented by regular analysis of the time series monitoring data are expected to provide progressive validation of the model predictions.
RECOMMENDATION

The AR recommends the preparation and implementation of a site Monitoring Program by BHPB to monitor TSF and RSF seepage impacts. The AR recommends the following conditions to address groundwater impacts:

- The proponent must prepare and implement a Site Groundwater Monitoring Program designed to achieve the following outcomes as measured against the respective approved criteria, for approval by the Indenture Minister, before commencing construction of the RSF or TSF:

<table>
<thead>
<tr>
<th>OUTCOME</th>
<th>CRITERIA</th>
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<tbody>
<tr>
<td>No adverse impact on vegetation as a result of seepage from the tailings storage facility and rock storage facility.</td>
<td>Compliance criteria: Groundwater level outside the perimeter of the tailings storage facility must not be higher than 80 metres AHD or as otherwise agreed by the Minister.</td>
</tr>
<tr>
<td>No compromise of current and future land uses on the Special Mining Lease or adjoining areas as a result of seepage from the tailings storage facility and rock storage facility.</td>
<td>Compliance criteria: A numerical groundwater simulation model confirmed by monitoring that continues to demonstrate that all movement of TSF and RSF seepage is captured by the final open pit. A numerical geochemical model confirmed by monitoring that continues to demonstrate that all TSF and RSF seepage is attenuated within the Special Mining Lease.</td>
</tr>
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- The proponent must provide a report by a suitably qualified independent consultant which certifies that the final designs for the TSF and RSF are likely to achieve the outcomes contained within the Site Groundwater Monitoring Program, when measured against the respective approved criteria must be provided to the Indenture Minister prior to commencement of construction of the TSF and RSF.

The AR also recommends the following note:

- The proponent will need to apply to the EPA for an exemption to the Environment Protection (Water Quality) Policy 2003 or seek to have the current environmental values applying to groundwater at Olympic Dam modified in the Environment Protection (Water Quality) Policy 2003.

Potential impacts on natural springs

Yarra Wurta Springs

Modelling results show that drawdowns in the range of 1m up to 4m may occur at Yarra Wurta Springs 500 years post closure of mining operations (SEIS Appendix F4 - final groundwater model Figure 5.9 and sensitivity analyses – Figure 6.25). Drawdown is not anticipated to occur at Yarra Wurta Springs during the operation of the mine (40 years) as a result from mine dewatering activities or operation of the Motherwell Wellfield.

Water levels would not approach stabilisation at the end of groundwater model run, therefore the long-term (>500 years) impact at Yarra Wurta Springs is unknown based on the sensitivity analyses. The regional groundwater model has been constructed such that the Yarra Wurta Springs are fully reliant on groundwater flow from the Andamooka Limestone (from the west). This is a conservative approach that accentuates potential impacts on the springs. Water chemistry samples collected during field work undertaken to date indicate that the springs may in fact be supported, fully or partially, by groundwater flow from the east to north-east of the springs (from the
Adelaide Geosyncline (Torrens Hinge Zone). In addition, structural features (e.g. the Torrens Fault) that exist between the mine and Yarra Wurta Spring and the effect of storage buffering by Lake Torrens, have not been incorporated into the groundwater model.

Whilst additional work to determine the hydrogeology of Yarra Wurta Springs may show that the springs are fully supported by groundwater flow from the east to northeast, groundwater level drawdown within the Andamooka Limestone may still have an impact on the Yarra Wurta Springs due to a new equilibrium being formed in the local water regime.

Assessment of the potential impacts of the proposed expansion on the Yarra Wurta Springs would benefit from long-term regional groundwater monitoring data to refine the calibration of the transient groundwater model in the area.

For an assessment of the groundwater dependent ecosystems-specific impacts on the Yarra Wurta Springs, see Section 4.4.4 of this chapter.

In conclusion, the AR considers there is a low risk that declines in the regional groundwater level in the Andamooka Limestone from the proposed expansion would have an impact on the Yarra Wurta Springs. However ongoing work should be undertaken to further understand the spring’s hydrogeology and regional groundwater monitoring should occur to identify and manage any potential impacts.

**Great Artesian Basin (GAB) Springs**

Information presented in the SEIS, along with other relevant technical information shows that the hydrochemistry of groundwater from the artesian portion of the GAB, which supports the GAB Springs, has a different signature to the groundwater hydrochemistry in the Stuart Shelf, Arckaringa Basin and non-artesian portion of the GAB.

Conceptualisation of the regional groundwater regime has the Torrens Hinge Zone acting as a divide/buffer between the Stuart Shelf and the GAB. Aquifer parameters used in the modelling have been set to reinforce this concept. Modelling results, including sensitivity analyses, show that the proposed development would have negligible drawdown impact on the Torrens Hinge Zone and subsequently the GAB Springs.

Field work was presented in the EIS to support the determination aquifer parameters for the Torrens Hinge Zone and provide support for the existence of the groundwater divide separating the flow patterns of the Stuart Shelf from the artesian portion of the GAB. Regional groundwater contours (SEIS Figure 12.8) indicate that the inferred direction of groundwater flow is from the Torrens Hinge Zone northwards to the GAB, as groundwater elevations for the GAB aquifer are up to 10m lower than the inferred groundwater contours.

BHPB modelling results indicate that a drawdown of >2m may occur in the Andamooka Limestone abutting the Torrens Hinge Zone 500 years after mine closure, thereby maintaining a positive flow pattern towards the GAB. Sensitivity analyses for the Andamooka Limestone aquifer parameters indicate that declines in water levels in the order of >8m could occur at the Andamooka Limestone/Torrens Hinge Zone interface, whilst still maintaining a positive flow towards the GAB. In addition, sensitivity analyses for Torrens Hinge Zone aquifer parameters indicate minimal change in drawdown across the Torrens Hinge Zone. The ‘impermeable’ nature of the Torrens Hinge Zone prevents the drawdown levels in the Andamooka Limestone extending to the GAB.
In conclusion, the AR considers that a low probability exists for hydraulic effects on the Great Artesian Basin springs located to the north, northeast and east of this area to be impacted by the drawdown of groundwater levels in the Stuart Shelf aquifers as a result of Olympic Dam Expansion activities. However, regional groundwater monitoring should be undertaken to validate the model predictions and identify any potential impacts that need managing.

**RECOMMENDATION**

The AR recommends the following conditions to manage potential impacts to the Yarra Wurta Springs and GAB from the proposed Olympic Dam expansion:

- The proponent must prepare a Regional Groundwater Management and Monitoring Program (RGMMMP) for the GAB and Yarra Wurta Springs to manage potential impacts from the Olympic Dam Expansion, for approval by the Indenture Minister, within 12 months of the date of this decision. The Regional Groundwater Management and Monitoring Program must include the following:
  - Ecological monitoring, measured spring flow rates (taking into account local variations in barometric pressure, tidal influences and evaporation rates), open pit dewatering volumes resulting from both the dewatering activities and pit inflows, groundwater levels, salinities and water chemistry and comparison between baseline measurements and ongoing monitoring;
  - The proponent must implement the approved Regional Groundwater Management and Monitoring Program;
  - Monitoring data must be used to update the Regional Groundwater Management and Monitoring Program, the regional model (as required above) and to develop trigger points for action; and
  - If an update of the regional groundwater model and/or monitoring indicates that a trigger point is reached, the proponent must develop mitigation strategies and, if necessary, contingency options, such as a possible relocation of Lake Eyre Hardyheads to an alternate habitat.

The following notes are also recommended:

- If the action triggers are exceeded during extraction from the Motherwell Saline Wellfield, and, in the opinion of the Indenture Minister the exceedence constitutes a significant risk to the environmental values of the Yarra Wurta Spring complex, the Minister may direct the proponent to cease extraction from the Motherwell saline wellfield, or to take action to maintain pressure levels.

- In order to achieve the requirement for the preparation and implementation of the RGMMMP, the results of monitoring within the Yarra Wurta Springs and GAB Springs, should be reported in the annual Environmental Management and Monitoring Report, including updated research as follows:
  - The significance that declines in groundwater levels in the Andamooka Limestone may have on the Springs;
  - The groundwater processes supporting the Yarra Wurta Springs;
  - Regarding the structural controls that exist between Yarra Wurta Springs and the open pit; and
  - The storage buffering of Lake Torrens to the drawdown of groundwater levels within the Andamooka Limestone.
Potential impacts on third-party users

A total of 14 groundwater wells were identified by BHPB within the extended study area surrounding Olympic Dam, of which:

- 7 are located on pastoral leases held by BHPB;
- 4 are located on Parakylia Station; and
- 3 are located on Parakylia South Station.

All wells have been constructed in either the Andamooka Limestone or Tent Hill aquifers. All non-BHPB wells are located to the west of Olympic Dam, 50km-plus of the SML boundary.

Groundwater level drawdown, as determined by the calibrated groundwater model, within the Tent Hill and Andamooka Limestone aquifers would be expected to develop slowly and extend between 20km to 45km from Olympic Dam during operation and 500 years post closure (SEIS Section 12.5.7). Modelling results indicate that no third-party groundwater users would be expected to be influenced by the expanded operation at Olympic Dam up to the year 2150 (SEIS Section 12.5.7).

Groundwater modelling to 500 years post closure shows that drawdown impacts ranging from less than 1m to up to 4m could potentially occur at the 12 private (non-BHPB) wells (SEIS Section 12.5.7). However, sensitivity analyses indicate that declines in aquifer water levels in the order of up to 9m could occur at these wells 500 years post closure. Declines in aquifer water levels of up to 1m could be expected 50 years after commencement of operations (SEIS Appendix F4 – Figures 6.25 – 6.27). No salinity changes are anticipated at any of the private wells.

Well life expectancies are in the order of 50–100 years, therefore drawdown impacts are not anticipated before wells are due to be replaced. The significance of this is that the replacement wells (if they are to be replaced) could be drilled and constructed according to the groundwater conditions at the time of construction. Therefore there is a low probability that the proposed expansion would impact on the ability of existing third-party users to take water from their wells.

BHPB has committed to monitoring groundwater quality and quantity within a selection of operating wells within the Olympic Dam region. If monitoring results indicate that third-party users are likely to be affected by drawdown resulting from the proposed expansion, alternative water supply options would be investigated, in consultation with the affected party. Options would include:

- Relocating or deepening the affected well; and/or
- Providing an alternative water supply.

RECOMMENDATIONS

The AR considers only a low probability exists for drawdown impacts to affect pastoral usage from private wells resulting from the proposed expansion. To ensure the protection of third-party water users, the following condition is recommended:

- Outside of the Designated Areas prescribed pursuant to the Olympic Dam Indenture, the proponent must offset drawdown impacts to existing third-party users identified in the EIS resulting from the proposed expansion during the operational phase of the mine.

The AR also recommends the following note:

- Clause 13 of the Olympic Dam Indenture makes special provision for the company to maintain water supply to existing third party users within the Designated Area around the water supply wellfields.
4.4.5 Surface water and drainage

4.4.5.1 Issues

The DEIS seeks to protect existing surface water quality. It is considered that the key issue would be the potential impacts to flora and fauna before final closure as a result of surface water run-off containing acid drainage, heavy metals and radionuclides from the surface of the RSF, low grade ore stockpile and TSF into adjacent surface swales.

While surface water is scarce, when available it is used by pastoralists for stock, by native fauna, opportunistically for recreational activities, and also supports aquatic ecosystems that have inherent biodiversity value (DEIS Section 11.4.). BHPB has stated that the design and operation of the proposed expansion has been modified to provide protection of the surface water quality (DEIS Section 11.4.2).

4.4.5.2 BHPB EM Program and commitments

Stormwater discharge

BHPB has set the following objective and criteria as part of its Environmental Management Program (EMP) which is detailed in DEIS Appendix U, ID 4.4:

- **Objective**: No significant adverse impacts to environmental receptors as a result of stormwater discharges to soil, surface water or groundwater associated with BHPB’s expansion activities.
- **Criteria**: All contact stormwater maintained within designated stormwater management areas.
- **Management plan**: To prepare a Stormwater Management Plan, with plans for the construction and operation of the proposed expansion (mining, processing, desalination plant, infrastructure corridors, Roxby Downs and Hiltaba Village) that would incorporate relevant controls, monitoring requirements and mitigation measures (DEIS Section 11.5.1, 11.5.3).

Major storage seepage

BHPB has set the following objective and criteria as part of its Environmental Management Program (EMP) which is detailed in DEIS Appendix U, ID 4.3:

- **Objective**: No significant adverse impacts to ecological communities as a result of seepage from the RSF and expanded TSF.
- **Criteria**: No loss of native vegetation outside bunded TSF area as a result of seepage to groundwater from the TSF.
- **Management plan**:
  - TSF Management Manual – The existing operating manual for the TSF would be reviewed to ensure that expansion requirements were incorporated; and
  - RSF Management Manuel (new) – An operating manual for the RSF would be developed to include controls and contingencies as per this Plan.
4.4.5.3 Assessment

Rock Storage Facility (RSF)

It is considered that the DEIS provided limited information about the potential impacts of run-off from the RSF into the surrounding swales. It is considered likely that these swales would support regional and in-situ ecosystems. In response to these concerns, follow-up hydrological and pollutant transport studies were completed for the SEIS. This work used two separate modelling approaches to examine infiltration and run-off from the RSF, both of which applied a conservative approach to the generation and mobilisation of potentially contaminated run-off/leachate. The outcome of these studies states that run-off would be possible to surrounding swales, with the potential to impact on the water quality from elevated pollutant concentrations.

Some mitigation strategies were discussed in the SEIS including progressive treatment of the RSF surface to enhance ponding and delay run-off. The most effective strategy proposed by BHPB is an engineered structure to retain 1-100 year stormwater flows. Such structure(s) are proposed to be constructed at suitable points that will avoid contaminated runoff leaving the area of the Special Mining Lease.

Tailing Storage Facility (TSF)

The DEIS presented detailed design reports and analysis of the potential for near surface lateral seepage through TSF walls and potential impacts on surface water quality (Appendix F1). These designs incorporated both upstream and downstream toe drains around the TSF to enable capture of near surface lateral seepage. Furthermore, the embankment would include an internal limestone barrier/cut off drain and basal collector to mitigate seepage, should a high water level occur in the TSF pond.

BHPB has acknowledged that the geotechnical investigations used to predict seepage control of the TSF only represent areas of the TSF that would have similar or better conditions to that determined from the geotechnical investigations undertaken (DEIS Appendix F1). Further, given the large scale of the TSF there would be areas that would differ in seepage, which would require closer supervision during construction. It is considered that operational monitoring of the TSF would be required, and where necessary mitigation of any near surface lateral seepage through TSF walls.

The current Olympic Dam Environmental Management Program provides that areas of lateral seepage are identified during regular inspections around the perimeter of the TSF, with this seepage captured in interception systems and returned to the TSF or evaporation ponds. In this regard, the proposed draft Environmental Management Program (DEIS Appendix U, ID 4.3) states that ongoing monitoring of the TSF and RSF would be necessary to ensure controls are functioning properly and the environment is not at risk.

This AR considers that the impacts of the TSF and RSF on surface waters and sub-surface waters will be acceptable, subject to the measures proposed in the FEIS and the conditions recommended below.
RECOMMENDATION

The AR recommends the following conditions to address surface water impacts:

- The proponent must prepare and implement a Site Groundwater and Surface Water Monitoring Program designed to achieve the following outcomes as measured against the respective approved criteria, for approval by the Indenture Minister, before commencing construction of the RSF or TSF:

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<tr>
<th>OUTCOME</th>
<th>CRITERIA</th>
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<tbody>
<tr>
<td>No adverse impact on local drainage patterns and water quality that would</td>
<td>Compliance criteria: Any surface water outside of containment structures designed to manage runoff must comply with the Environment Protection (Water Quality) Policy 2003</td>
</tr>
<tr>
<td>compromise existing users or water dependent ecosystems.</td>
<td></td>
</tr>
</tbody>
</table>

- A report by a suitably qualified independent consultant which certifies that the final designs for the TSF and RSF are likely to achieve the outcomes contained within the Surface Water Monitoring Program, when measured against the respective approved criteria must be provided to the Indenture Minister prior to commencement of construction of the TSF and prior to the placement of rock within the RSF.

The AR also recommends the following notes:

- Each portion of the RSF, including the proposed low grade ore stock pile, should incorporate an engineered structure designed to capture all the run-off from the RSF during a 1-in-100 year rainfall event and avoid contaminated runoff leaving the area of the Special Mining Lease.

- Each TSF cell should include upstream and downstream toe drains to manage near surface lateral seepage (i.e. capture the seepage). Measures should be put in place to manage any observed seepage from the toe drains for the TSF cells, to reduce the potential for surface water impacts. These measures should include the transfer of captured seepage in interception systems to be returned to the TSF or evaporation ponds.

- Licence conditions that relate to monitoring and management of such surface water containment facilities may be imposed under the Environment Protection Act 1993.

4.4.6 Solid waste

4.4.6.1 Issues

New waste management centre

An area of around 560,000m² would be assigned for the future development of a new waste management facility which would be suitable for around 60 years of the operation life of the mine at the predicted waste generation rates (DEIS Section 5.6.2 and SEIS Section 5.4.1). The DEIS stated that the new waste management facility would consist of:

- A transfer station to be used for waste segregation;
- A recyclable/reusable materials store located near the rail head; and
- A general waste landfill facility of approximately 56ha for industrial wastes with a small content of putrescibles. Cover to the landfill would be provided on a daily basis with construction of waste cells in accordance with EPA guidelines.
The proposed landfill facility would be designed and operated in accordance with the relevant sections of the EPA Guidelines: *Environment Management of Landfill Facilities (Municipal solid waste and commercial and industrial general waste)* dated January 2007 (SEIS Section 5.4.1). Potential risks are proposed to be reduced through the:

- Negligible proportion of putrescibles;
- Low rainfall climate;
- Separation from ground and surface water bodies by a greater margin than that specified in the SA EPA Guideline;
- Largely inert composition of the waste stream;
- Significant current and proposed resource recovery activities; and
- Promotion of waste management practices that divert the hazardous waste stream to alternative locations, and appropriate methods for recovery, treatment and disposal.

**General waste and used tyres**

Approximately 8000tpa of waste tyres, principally from haul trucks required for the open-pit operation, would be generated from the proposed expansion - currently 25/tpa - when operating at full capacity (DEIS Section 5.6.3 and SEIS Section 5.4.3). The waste tyres have the potential to cause adverse environmental impacts if they are not properly managed and disposed of.

The DEIS and SEIS stated that the preferred practice for the management of waste tyres would be to:

- Implement programs to increase the life of tyres;
- Retread or repair, where possible;
- Use waste tyres for industrial purposes such as berms, road demarcation and fencing;
- Treat waste tyres using energy recovery technologies such as incineration, co-combustion, tyre-derived fuel, pyrolysis, gasification, shredding and granulation; and
- Disposal in the RSF in a documented location.

The SEIS identified that if a recycling solution for the used tyres could not be found, disposal to the RSF would be required. Appropriate management practices would be applied to mitigate the following risks, including:

- Stability issues in the RSF if tyres are stacked too high;
- Metal leaching if the tyres are shredded before disposal; and
- Potential fire hazard if tyres are not covered with inert material.

The draft General Waste and Used Tyre Management Plan identifies the need for a waste monitoring program to ascertain volumes of waste for each waste type generated and volumes of waste avoided/reduced and recycled as part of monitoring performance of utilising the waste hierarchy (SEIS Appendix N6). This would include the amount of reused tyres versus tyres encapsulated in the RSF.

**Acid plant catalyst fines**

Approximately 225,000 L of acid plant catalyst fines, which would include approximately 6–9% vanadium pentoxide, would be generated by the acid plant gas converters every three years as part of the expanded operation (DEIS Section 5.6.6. and SEIS Section 5.4.2). The waste catalyst fines have the potential to cause adverse health and/or environmental impacts if they are not properly managed and disposed.
The EIS stated that the acid plant catalyst fines would initially be transferred to lined steel drums and stockpiled prior to disposal or recycling. Recycling or reuse options are being investigated by BHPB, however if no suitable recycling or reuse option is found, catalyst fines for the expanded operation would continue to be disposed of in trenches excavated into the TSF, and their location documented, as is the current practice.

The SEIS further stated that BHPB waste management practices, in line with the waste hierarchy, have investigated (and in some cases continue to investigate) several recycling and reuse options for the treatment of catalyst fines, including:

- on-site amalgamation of fines into a useable product suitable for reuse in a gas converter;
- reuse of the catalyst fines in a smaller capacity gas converter;
- return of spent catalyst to the manufacturer for re-manufacturing into catalyst;
- transport of the catalyst to a vanadium producer for processing into a saleable vanadium product;
- two methods of fixation, modification and stabilisation, whereby the vanadium pentoxide base material would be rendered inert through either the modification, or phase change of vanadium pentoxide to vanadium oxide, or the encapsulation of the catalyst material in a non-leachable matrix; and/or
- burial in landfill, or charged into slopes as backfill material together with cement aggregate fill (CAF).

**Radioactive waste**

Management of low level radioactive waste is considered in the radiation section of this chapter (refer section 4.4.9).

### 4.4.6.2 BHPB EM Program and commitments

BHPB has set the following objective and criteria as part of its Environmental Management Program (EMP) which is detailed in DEIS Appendix U, ID 4.6:

- **Objective**: Minimise general waste generated by BHPB's expansion activities and maximise the re-use of general waste where practicable.
- **Criteria**: Increase the proportion of general waste reuse/recycling.
- **Management plan**: BHPB has proposed management plans that include:
  - Landfill Management Plan (new) – the existing waste management plan would be reviewed and would incorporate plans for management of the landfill and the various waste types generated during operation of the expansion, and would incorporate controls, monitoring requirements and contingency measures; and
  - Used Tyre Management Plan (new) – with the large volume of waste tyres to be generated by operations, a specific Used Tyre Management Strategy would be developed for investigations into technology options for strategic use of used tyres.

### 4.4.6.3 Assessment

**New waste management centre**

The design and operation of the proposed landfill facility aligned with EPA Guidelines: *Environment Management of Landfill Facilities (Municipal solid waste and commercial and industrial general waste)* would ensure that adverse impacts upon the environment as a result of the management and disposal of waste are minimised. In particular the locality, design and construction of the landfill would enable the impacts associated with the generation and control of landfill gas and leachate to be assessed and managed.
The establishment of the waste management facility is a prescribed activity of environmental significance as per Schedule 1, Part A, 3(3) Waste or Recycling Depot of the Environment Protection Act 1993. In accordance with Section 36 of the Environment Protection Act an authorisation in the form of a licence is required to undertake a prescribed activity. Therefore, should the proposed expansion be approved, the company would be required to obtain an EPA licence prior to the receipt of waste at the waste management facility.

In the SA Government’s assessment of the DEIS, concern was raised that the proposed location of the solid waste disposal area would be adjacent to the northern part of the existing TSF Cells 3 and 4 in an area where seepage from the TSF is currently being collected and returned to the TSF. Establishing a new solid waste depot at the proposed location has the potential to impact the existing management and monitoring of seepage that is occurring in this area. This issue would need to be considered in the EPA licensing process.

**RECOMMENDATION**

The AR supports the location of a landfill facility at the minesite and notes that a secondary authorisation under the Environment Protection Act 1993 would be required. Accordingly, the AR recommends the following notes:

- The landfill facility will require authorisation under the Environment Protection Act 1993. As part of the licensing process the EPA will likely require detailed designs, drawings and specifications for the proposed on-site solid waste landfill facility at Olympic Dam prior to such a facility being constructed. Specifically, the EPA will require the following details:
  - Design and proposed construction of new landfill cells in accordance with the SA EPA Guidelines: Environmental Management of Landfill Facilities (Municipal solid waste and commercial and industrial general waste) including:
    - Detailed design drawings;
    - Landfill Construction Quality Assurance Plan;
    - Landfill Construction Management Plan; and
    - Landfill Environmental Management Plan incorporating details of the closure and post closure management.

- Any application for licensing of the new on-site waste landfill should include a risk assessment that considers the location and management requirements of the adjoining TSF.

- ‘As construct’ reports of the on-site landfill cells must be provided to the EPA for approval prior to waste being deposited within any landfill cell. Refer to the draft SA EPA Guideline Construction specifications and reports: For landfills, leachate ponds, composting facilities and wastewater lagoons (2009).

**General waste and used tyres**

The draft General Waste and Used Tyre Management Plan (SEIS, Appendix N6) states that it would contain strategies to reduce, reuse and recycle all waste material streams where environmentally and commercially satisfactory arrangements are possible. The draft General Waste and Used Tyre Management Plan does not clearly outline which of these strategies would be implemented for which waste streams and how this would align with the management of the solid waste landfill facility.

The AR considers the final General Waste and Used Tyre Management Plan should incorporate all waste streams received at the waste management facility. The final plan would require approval by the EPA prior to construction of the new waste management centre.
The AR considers the proposed preferred practice of implementing programs to increase the life of tyres, retread or repair where possible, reuse tyres for civil engineering applications or as tyre derived fuel are acceptable.

The investigation into the feasibility by BHPB for an on-site recycling process for used tyres (by mechanical or thermal means) during the definition phase of the expansion project, with disposal within the RSF if recycling or reuse is found to be unviable is deemed an acceptable approach by the AR.

In the event that a recycling solution for the used tyres is not found, disposal to the RSF subject to the instigation of management practices to mitigate the risks associated with stability issues, metal leaching and potential fire hazard are acceptable.

**RECOMMENDATION**

The AR recommends the following note:

- It is likely that a requirement to prepare a General Waste and Used Tyre Management Plan which incorporates all waste streams for the waste management facility prior to receipt of waste at the waste management facility would become a condition of licence under the Environment Protection Act 1993.

**Acid plant catalyst fines**

The AR considers the proposed investigation into the recycling and reuse options for the management of catalyst fines including amalgamation into a useable product suitable, reuse in a gas converter, the return of spent catalyst for re-manufacturing or processing into a saleable vanadium product and treatment to render it non-leachable are acceptable.

In the event that a recycling, reuse or treatment solution for the catalyst fines is not found, disposal to the TSF in excavated trenches with their location documented (as is the current practice) is considered acceptable.

### 4.4.7 Wastewater from staff facilities

#### 4.4.7.1 Issues

The DEIS indicated that the operation of the open pit mine would require approximately 2500 workers and a 3000 person peak construction/shutdown workforce. Part of the infrastructure required to cater for the workforce would be a sewage system. It is anticipated that a workforce of this size would generate large volumes of wastewater, up to 0.4 ML/d.

The DEIS indicated that wastewater would be handled by a new on-site sewage treatment plant to be located to the north of the concentrator. Class B treated water is proposed to be produced and would be recycled into appropriate process uses.

#### 4.4.7.2 BHPB EM Program and commitments

- **Environmental Management Program (EMP):** No specific EM Program in relation to this issue.
- **Commitments:** No specific commitments made in relation to this issue.
4.4.7.3 Assessment

The DEIS provided limited detail regarding the proposed 2500 equivalent person (EP) on-site sewage treatment plant (Section 5.6.4). Given the location of the proposed sewage treatment plant, and the other activities also being undertaken at the site, environmental issues such as noise and odour are unlikely to be an issue for the proposed sewage treatment plant. The wastewater and solid waste generated from the sewage treatment plant does however have the potential for adverse health and/or other environmental impacts (such as site contamination) if it is not managed appropriately, or not treated sufficiently for their intended use.

The AR supports the development of the sewage treatment facility at the mine site and notes that a secondary authorisation will be required under Schedule 1 of the Environment Protection Act 1993, from the EPA. Approval would also required from the SA Department of Health under the Public and Environmental Health Act 1987.

RECOMMENDATION

The AR recommends the following note:

- The wastewater facility will require authorisation under the Environment Protection Act 1993. As part of the licensing process the EPA will require detailed designs, drawings and specifications for the on-site sewage treatment system at Olympic Dam and must be provided to the EPA for approval prior to the on-site sewage treatment plant being constructed. Specifically, the EPA will require the following details:
  - Type of wastewater inflows (including an outline of on-site sources) to be accepted into the treatment plant;
  - Maximum design capacity of the treatment plant in ML/d and population equivalents;
  - Type of wastewater treatment plant to be used;
  - Standard of treatment to be achieved;
  - Where and how treated wastewater reuse will occur; and
  - Schematic plans showing location and design of the proposed treatment plant and reuse areas including pipework layout.

4.4.8 Noise and vibration

4.4.8.1 Issues

Noise from the existing underground mining and processing operations was inaudible 14km away at the Roxby Downs township during the baseline noise study (DEIS Section 14.3.1). During the baseline noise study, noise measurements in Roxby Downs township showed that the night-time background noise level is currently approximately 35 decibels (dB(A)).

As noise from the existing mining and processing operations is inaudible, and background noise levels are approximately 35 dB(A), noise from the existing operation comfortably meets the night-time noise criteria of 45 dB(A) in Roxby Downs, as determined in accordance with the Environment Protection (Noise) Policy 2007 (Noise Policy). Noise from the existing operations was audible at the site of the proposed Hiltaba Village with recorded background noise levels (L_{Aeq}) of between 31 dB(A) and 42 dB(A) (DEIS Section 14.3.2) which were also well within the noise criteria applicable to such an area under the Noise Policy.

Should the project be approved, the closest part of the proposed open pit mining and rock storage facility would be located around 6km from Roxby Downs and 6km from the proposed Hiltaba Village, while the expanded ore processing plant would be located several kilometres further away from both population centres. The AR considers that significant potential noise and vibration issues associated with the proposed expansion include:
Impact of noise on the proposed accommodation facility at Hiltaba Village and the town of Roxby Downs, particularly with respect to sleep disturbance; and

Potential impact of ground vibrations associated with blasting operations for the open pit.

4.4.8.2 BHPB EM Program and commitments

BHPB has set the following objective and criteria as part of its Environmental Management Program (EMP) which is detailed in DEIS Appendix U, ID 3.2:

- **Objective**: No adverse impacts to public health as a result of noise emissions from BHPB’s expanded operations.
- **Criteria**: Maintain noise from the expanded operations at Olympic Dam to less than 30 dBL_{Aeq} (24 hour) within residential dwellings.
- **Management plan**: A new Noise Management Plan, involving:
  - BHPB has extensive experience in open pit mining operations and managing noise emissions within compliance limits. To achieve compliance from the Olympic Dam open pit during the worst-case weather conditions – as in night-time temperature inversions - operational response plans would be developed for noise generation from mining activities (DEIS Section 14.6); and
  - Existing operational management plans would be updated to confirm the findings of the noise modelling, including:
    - Development of a refined and validated acoustic model based on the as-built mining and metallurgical operations;
    - Installing a meteorological system that incorporates climatic conditions such as wind speed and direction into the acoustic model so that noise levels contributed during operations at Roxby Downs and Hiltaba Village could be predicted;
    - Monitoring of sound at key receptor locations to assess compliance with the adopted criteria and to ensure the reliability of the acoustic model; and
    - Implementing an operating response plan for situations where noise levels were predicted to exceed the compliance criteria (DEIS Section 14.5.2).
- **Commitments**: BHPB would maintain noise levels generated from the expanded mining and processing operations to below 45 dB at the exterior of residential dwellings in Roxby Downs and Hiltaba Village (SEIS Table 2.1 Commitments, page 55).

4.4.8.3 Assessment

**Noise**

The AR seeks to ensure that the proposed development achieves an outcome of no measurable health or amenity impacts to Roxby Downs and Hiltaba Village residents from noise. BHPB are obligated to meet the requirements of the Environment Protection Act 1993 and Environment Protection (Noise) Policy 2007 (Noise Policy), and any subsequently updated versions. This includes criteria for industrial noise (noise sources associated with the operation of the mining and metallurgical operations), as well as requirements for construction and site preparation noise. Due to the unique circumstances of Hiltaba Village, it has been agreed by the SA EPA and BHPB that World Health Organisation (WHO) Guidelines for Community Noise 1999 should be adopted 24 hours per day in recognition of the requirements of shift workers (DEIS Section 14.2).

Under temperature inversion conditions, noise levels from the expanded operation would reach 43 dB(A) and 42 dB(A) L_{Aeq} at Roxby Downs and Hiltaba village respectively (DEIS Section 14.5.2). Based on these predictions, noise from the expanded operation at Hiltaba Village would comply with the selected criteria, whilst noise at Roxby Downs would exceed the selected criteria under temperature inversion conditions. Under all other meteorological conditions, the DEIS indicated that compliance would be achieved at both Roxby Downs and Hiltaba Village.
Subsequent to the publication of the DEIS, a number of minor modifications were made to the expanded operation layout (SEIS Section 15.1). Under the proposed configuration, the SEIS stated that noise from the expansion would exceed the selected noise criteria at both Roxby Downs and the proposed Hiltaba Village. Noise levels would reach 44 dB(A) at Roxby Downs and 48 dB(A) at Hiltaba Village under temperature inversion conditions (SEIS Appendix A6, Attachment C). The SEIS further stated that conditions conducive to the formation of temperature inversions would be expected to occur about 95 nights per year, for a few hours each night. In accordance with the Guidelines for the use of the Environment Protection (Noise) Policy 2007, this weather pattern is significant enough to warrant further consideration.

The predicted noise levels for Roxby Downs and Hiltaba would be in excess of the relevant night-time noise criteria applicable under the Noise Policy by 4 dB(A) and 3 dB(A) respectively. The SEIS noted that the most significant potential contribution to noise in Roxby Downs and Hiltaba would be generated by the horn on the CAT797B trucks. In response, the SEIS recommended that CAT797B horns not be operated in the Mine Maintenance Industrial Area (MMIA) during night-time hours under adverse weather conditions, or a temperature inversion (SEIS Appendix A6, Attachment C).

Alternatively, it was recommended in the SEIS that an acoustically treated workshop be constructed for the testing of loud equipment (such as the CAT797B horn). Without the operation of the horn, the SEIS stated that noise levels of 43 dB(A) and 44 dB(A) under temperature inversion conditions are predicted for Roxby Downs and Hiltaba Village respectively.

The AR supports the mitigation measures proposed in the SEIS.

Assuming compliance with the above recommendation, compliance with the Noise Policy and the WHO Guidelines for Community Noise (assuming attenuation across the building façade of greater than 15 dB(A)) would be achieved at Hiltaba Village, and the night time criteria exceeded in Roxby Downs would occur on some occasions by up to 3 dB(A).

The overall time during which this exceedence is likely has been predicted to comprise approximately 10% of the year (by duration). In situations where criteria are predicted to be exceeded, noise predictions show that the WHO Guidelines for sleep disturbance would still be met at both Roxby Downs and Hiltaba Village. Clause 20 of the Noise Policy allows for certain considerations to be made where predictions indicate a likely exceedence of the relevant noise criteria.

**RECOMMENDATION**

The AR considers that such a minor level and frequency of exceedence of the relevant noise criteria is acceptable in this situation. No condition has been recommended. However, the following note has been recommended:

- In order to achieve relevant criteria prescribed in the Environment Protection (Noise) Policy 2007 truck horn testing within the mine maintenance and industrial areas at Olympic Dam may require a warehouse-type building with suitable acoustic insulation to reduce noise emissions.

**Hiltaba accommodation**

In response to queries regarding the noise attenuation to be achieved inside the Hiltaba Village accommodation, as well as the modelling criteria (and whether it considered all noise sources), the SEIS stated that it had been demonstrated that, with the windows closed, the proposed accommodation units would reduce external noise levels within the accommodation by between 24 and 30 dB(A) (SEIS Section 15.1). Based on the predicted external noise levels at Hiltaba Village, this would ensure that noise levels within the accommodation units would not exceed 30 dBAeq, in accordance with the WHO Guidelines for Community Noise.
The AR considers that this approach is appropriate given the harsh weather conditions anticipated at Hiltaba Village, and the likelihood that an employee or contractor suffering sleep disturbance would not leave the window open.

RECOMMENDATION

The AR recommends the following condition be attached to the approval for Hiltaba Village:

- Accommodation units at Hiltaba Village must be designed and constructed so that external noise sources do not exceed 30dB(A) when measured within sleeping areas at all times of the day when windows are closed.

Vibration

The DEIS indicated that vibration levels for the proposed operation have been assessed in accordance with the provisions in AS 2187.2 (Storage and Use of Explosives). This standard specifies ground vibration limits (peak particle velocity (PPV)) for residential zones of 5 mm/s for 95% of blasts, and 10 mm/s for the remaining 5% of blasts. The PPV is used to represent the intensity of the ground vibration.

It should be noted that the human body typically can detect PPV of 0.2 mm/s with levels of 1.0 mm/s being clearly perceptible (International Standard Organisation ISO10137 1992). The PPV needed to cause cosmetic building damage to ordinary structures varies in worldwide standards from 5–50 mm/s (Effects of Mine Blasting on Residential Structures, EF Gad, et al, 2005). The assessment presented in the DEIS indicated that ground vibrations at Roxby Downs and Hiltaba Village would be expected to be 0.5 mm/s, which is well within the limits. Therefore ground vibrations may be felt by persons at Roxby Downs and Hiltaba Village despite being within the acceptable levels.

Blast overpressures at Roxby Downs and Hiltaba Village would be expected to be 109 dBL, which are below the standard of 115 dBL for 95% of blasts per year with a maximum of 112 dBL.

The AR seeks to ensure that the proposed development achieves an outcome of no damage to public infrastructure and buildings that compromises their safety and utility or public amenity in accordance with applicable Australian Standards.

RECOMMENDATION

The AR concludes that blast vibration and overpressure levels are expected to be within the applicable Australian Standard. It recommends the following condition:

- The proponent must achieve the human comfort criteria defined in the Australian Standard AS2187.2 (2006) (or as amended) and monitor and report air blast overpressure and vibration levels in Roxby Downs and Hiltaba Village to demonstrate ongoing compliance with that standard.
4.4.8 Visual amenity and landscape character

4.4.8.1 Issues

The DEIS described the existing landscape character surrounding the mine site as mainly desert landscape of open woodland and shrubland on dunes and sandplains, and low shrubland on inter-dune swales and gibber plains, gently undulating in parts.

The current mine has several visual features, including the metallurgical plant, TSF, associated infrastructure including roads, office and workshop buildings and electricity transmission lines. The existing TSF is visible from at least 5km away and the metallurgical plant and smelter stacks create tall industrial features that are visible from Roxby Downs and up to 30km away in Andamooka.

The DEIS considered a number of key viewpoints in assessing the visual amenity of the proposed mining expansion, including:

- To the east on Andamooka Road (approximately 12km away), and from the Andamooka township;
- The northern fringe of Roxby Downs approximately (10km away);
- The Olympic Dam Village and existing airport;
- Roxby Township;
- Sunset Picnic Ground (a community recreation area); and
- The Arid Recovery which abuts the proposed RSF area to the north.

The DEIS assessment looked at the ability of the landscape or existing infrastructure to absorb the visual impact of the proposed expansion. It stated that when siting the Roxby Downs expansion area, some of the natural dunes and vegetation would be retained to minimise the potential impacts on visual amenity from the mine and processing facility, in particular the visually dominant RSF and TSF. A number of measures were discussed in the DEIS (Section 20.5.3) to minimise potential visual impacts from the mine and processing plant expansion, including:

- Encouraging the selection of appropriate building colours for infrastructure that suit the surrounding landscape;
- Establishing appropriate landscaping to provide screening; and
- Rehabilitating access tracks, lay-down areas and construction worksites as soon as possible after construction activities.

4.4.8.2 BHPB EM Program and commitments

- **Environmental Management Program (EMP):** No specific EMP provided for this issue.
- **Commitments:** No specific commitments were made by BHPB in relation to this issue.

4.4.8.3 Assessment

The metallurgical plant and associated infrastructure would be an extension of, or adjacent to existing facilities with the tallest smelter stack being 90m in height. It is considered that the expansion would be a continuation of an existing large industrial site in an arid environment, and as such the AR concurs with the DEIS that the residual visual effect would be negligible, as the proposed expansion to the plant would blend with the existing industrial nature of the environment.

The AR concurs with the assessment provided in the DEIS that the proposed RSF and expanded TSF would be not dissimilar in shape to a mesa, which are characteristically flat topped with relatively steep sides, and are a natural occurrence in the arid zone of South Australia. The closest examples of mesas to the site are those located at the Breakaway Reserve near Coober Pedy. The visual effects from the proposed RSF and TSF would be quite substantial making them the most
dominant feature in the local and regional landscape, with a visibility of up to 30km from the site. This would largely be due to the contrasting variation in the series of extremely large horizontal terraced forms of the RSF and TSF to the open flat/undulating expanses surrounding them. Viewed at ground level the TSF would have a low flat profile, the red sandy colour of which would be similar to the surrounding sands and earth. The RSF colours would vary from red to white to grey depending on its geological composition. From an aerial perspective the RSF, TSF and open pit would be highly visible, expanding the extent of the existing landmark location.

Despite the visual intrusion, the AR considers that the open pit, RSF and TSF have the potential to become attractions for tourists interested in viewing the operations or final land forms post closure. The Arid Recovery area would be 500m from the RSF at its southern edge and when viewed from the viewing platform within the Arid Recovery, the RSF would have significant visual impact. From close up, the surface of the RSF would appear unnatural. However, it would provide an effective screen to the industrial infrastructure, which may assist in improving views from the Arid Recovery area.

The DEIS refers to the preservation of numerous dunes and natural vegetation around Roxby Downs, with dune heights in some locations being up to 6m high. The overall visual aspect would be one of a succession of low ridgelines. Roxby Township is in effect moderately screened from the visual prominence of the mine infrastructure, RSF and TSF due to this and its many trees. Hiltaba Village and the new airport would be closer to the mine than Roxby Township and as such the distant views of the vertical infrastructure of the mine would be visible as the landscape is more open with less vegetative cover and smaller dunes.

RECOMMENDATION

In conclusion, the continuing presence of the mine as a dominant visual feature of the landscape results from the fact that it is in a visually exposed location, comprising man-made elements in a natural landscape of open and vegetated expanses. It has existed there for many years, and the AR considers that the additional infrastructure would be consistent with the existing industrial landscape.

The AR concurs with the DEIS that when viewed from a distance it would be possible that the RSF and TSF mounds would not be dissimilar to a natural mesa landform, and that the open pit, RSF and TSF could become potential tourist attractions both during operations and post closure of the mine. No conditions have been recommended.

4.4.9 Radiation

The DEIS (Table 6.4) outlined the role of the Radiation Protection and Control Act 1982 (RPC Act) in relation to other legislation applying to the expansion proposal and the requirement for a licence to conduct the activities.

The primary condition of the RPC Act licence (known as LM1) is compliance with the Commonwealth Code of Practice on Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (2005). A requirement of the Code is that the operator must have an approved occupational Radiation Management Plan (RMP) and an approved environmental Radioactive Waste Management Plan (RWMP) to protect the environment and ensure radiation doses to workers and members of the public are not only below relevant limits, but also are as low as reasonably achievable as low as reasonably achievable, economic and societal factors being taken into account (ALARA). The DEIS Sections 2.11.6 and 24.4.6 noted the incorporation of the RWMP within the Olympic Dam Environmental Management System (EMS).
4.4.9.1 Issues

The proposed expansion has raised a number of issues relating to the possible impact of major project components on occupational, environmental and public radiation exposures, during the operational and post–closure stages. The following is an assessment of the significant radiation issues raised in submissions on the DEIS, and proponent responses associated with new, or changed, major project components and impact areas.

Occupational exposures

Open pit

The proposed expansion will involve the construction of a pit, which in 40 years time will be approximately 4km in diameter and 1.2km deep. Workers involved in the mining and movement of the low grade uranium ore and waste rock from the pit would be exposed to radiation via the same exposure pathways as workers in the underground mine. That is, exposure to external gamma radiation through working on the ore body on the pit floor, inhalation of long lived alpha emitting dusts, and inhalation of radon decay products (RDP). However, as there are no existing open pit uranium mines of this scale, there is some uncertainty in estimating the resulting worker radiation exposures. There is therefore a risk that maximum radiation exposures of workers in the pit may exceed the 10 millisievert per year (mSv/y) dose constraint.

In particular, there is a risk of insufficient pit ventilation to routinely remove radon and its radon decay products and ensure annual doses to workers are kept below the 20mSv annual limit, or below the 50% dose constraint target value.

There is also a risk that the anticipated increase in RDP dose conversion factor, indicated by the ICRP in its statement of November 2009, may result in estimated doses to workers in the pit exceeding the annual dose limit, or dose constraint.

The DEIS stated that real-time RDP, dust and gamma monitors could be employed, along with mechanical ventilation of targeted areas, PPE, the use of filtered air in mobile equipment and shift controls, could be used to further minimise dose as required.

Exposure to gamma radiation

The annual doses to workers in the proposed Olympic Dam pit from gamma exposure are expected to average less than 2mSv, ranging up to about 4mSv (DEIS Appendix S 2.2.2). This estimate is based on geometry of the ore body, ore grade and exposure times. The maximum gamma dose (approximately 4mSv/y) is found in the Ranger pit where the ore grades are five times higher and hence, the maximum value estimated for the Olympic Dam pit would be a very conservative estimate (SEIS Appendix M1.2.1).

Exposure to radioactive dust

Exposure to long lived alpha emitting dusts arises from any ore breaking activity and from the crushing, movement and stockpiling of the ore and the lower activity overburden material. Dust generation in the pit, and particularly the movement of dust within the pit atmosphere, was discussed and modelled in the DEIS Section 13.3.5 and Appendix L2.

Dose estimates were based on comparisons with other open pit operations around the world, conservative assumptions including average ore grade, reduced particle size (1μm AMAD compared with 10μm measured in the underground mine), and near maximum probable dust concentrations (0.3mg/m³) (DEIS Appendix S and SEIS Appendix M1.2.2). The SEIS stated an estimated average dose from dust exposure in the pit could be up to 0.4mSv/y. Based on the above assumptions the ‘worst case’ or maximum dust dose for a full time pit worker was estimated to be around 1.7mSv/y.
Exposure to radon decay products

This AR considers the greatest uncertainty in total dose estimation for pit workers lies in radon decay products (RDP) exposure as this strongly depends on variable factors such as pit geometry (i.e. area of exposed ore), ore grades, radon emanation rate from ore, overall pit air changes, local air movement within the pit itself, and available control options.

The DEIS stated pit worker RDP doses would be at most, 2.3mSv/y. Additional supporting information on the theoretical basis for radon emanation rate estimates and the modelling methods used to estimate RDP doses was provided in SEIS Appendix M1.2.3.

Based on presumed pit dimensions at 40 years and radon emanation rates for different uranium ore grades, the DEIS determined a total radon production rate for the pit. The DEIS then examined potential RDP exposures to pit workers under three ventilation conditions.

First, the average radon concentration was calculated for the entire pit. The DEIS (Appendix S 2.2.2) and SEIS (Appendix M1) then used a simple air change model (Thompson) to predict air change in the pit, gross radon and RDP concentrations, and hence worker doses. This indicated an average RDP dose for workers of 0.14mSv/y. This figure was then doubled to 0.3mSv/y to further account for poor ventilation in the pit.

Second, an estimate of RDP concentrations was made assuming temperature inversions form in the pit on 25% of the nights of each year. The modelled inversions effectively placed a ‘lid’ at 100m over the workers in the base of the pit for a period of 12 hours. The SEIS (Section 26.2) stated that under these conservative assumptions and expected work rosters, workers in the pit might receive an additional dose of 1.8mSv/y. The SEIS implied that this would result in an average RDP dose of around 2mSv/y (1.8mSv/y + 0.3mSv/y).

Third, the SEIS (Section 26.4.2) noted a ‘worst case’ estimate in which the pit ventilation rate was 10 times lower than expected, resulting in average RDP doses of 1.4mSv/y. With inversion conditions added (1.8mSv/y), the total average dose would be around 3.2mSv/y.

An additional factor to be considered is the proposed doubling of the RDP dose conversion factor as outlined by the ICRP\(^6\) in its 2009 statement on radon. This would imply that the estimated average RDP doses for pit workers under the ‘worst case’ conditions noted above, could reach 6.4mSv/y.

The SEIS (Section 26.4.2) stated that the impact of the proposed RDP conversion factor changes would be low, and the predicted total pit doses from all sources would still be below the annual 20mSv dose limit although reaching approximately the 10mSv/y dose constraint under the most conservative conditions.

Underground mine

The DEIS states that the major exposure pathways in the existing underground mine are inhalation of radon decay products (RDP) and external gamma ray exposure. Inhalation of radioactive dust contributes around 5% of total dose. The average dose for the period provided in the DEIS was stated to be 3.5mSv. The DEIS states that the most exposed work group was raise drillers, with an average dose of 5.9mSv, and the highest annual dose for an individual for this period was 9.9mSv.

There is a risk that radon released at the surface from the open pit and RSF may enter the underground mine via the ventilation intakes thereby significantly impacting on levels of radon decay products in the underground mine.

\(^{6}\) International Commission on Radiological Protection (ICRP)
Chapter 4: Mining and processing operations (Sept 2011)

The SEIS (Section 26.2.1) considered the possibility that overall RDP exposures may increase slightly through radon from surface facilities being drawn into the underground mine ventilation system. The SEIS stated that modelling predicts surface radon concentrations in the vicinity of the plant will increase to approximately 100Bq/m³. Assuming this air is in equilibrium when drawn underground, average doses underground may increase by up to 1.4mSv/y, assuming no change to existing controls underground.

The SEIS stated that the current method of exposure control (i.e. to restrict access to areas of temporarily elevated radon levels) will be sufficient to manage any such increase in RDP concentrations, although this may result in an increased number of area activity shutdowns.

**Processing plant**

The DEIS (Appendix S 2.3) states that doses to workers in the existing plant averaged 2.4mSv for the 2001 – 2007 period. The DEIS examined plant radiation exposures in two parts: exposures to smelter workers and doses to other plant workers due to distinct differences in exposure pathways between the two groups. The DEIS states that radon decay product (RDP) exposures were consistently low for all plant workers and contributed less than 10% of the average dose for the period.

The DEIS states that gamma exposures are more significant in the remainder of the plant and average doses for the period consist of approximately 2mSv/y in the concentrator, 1.4mSv/y in the hydromet section, 1–2mSv/y in maintenance and services work groups, 0.9mSv/y in the refinery and 0.5mSv/y for administration workers.

The proposed expansion will require the optimisation of the existing smelting to process around 800kt/y copper concentrate to produce 350kt/y refined copper. The existing metallurgical plant will be optimised, and when combined with an additional metallurgical plant, will eventually produce and export 1.6Mtpa of copper concentrate. Uranium oxide production on-site is expected to increase to approximately 19kt/y, via the additional calciners in the new metallurgical plant.

The following risks related to increased radiation exposure have been identified in relation to an expansion of processing activities in the plant as a whole and the smelter in particular:

*Increased exposures from large-scale operations*

There is a risk of greater worker radiation exposures from additional large gamma, dust and radon sources arising from the increased scale of operations.

The DEIS (Appendix S Section 2.3.2) stated that the proposed expansion would not result in any significant change to the methods of processing ore derived from the open pit compared to current operations, and therefore the sources of occupational exposure to radiation in the proposed metallurgical plant were expected to be similar to those in the existing plant.

The DEIS predicted a slight increase in the average doses to plant workers due to the additional dust and radon sources associated with the pit, RSF and associated facilities (<1mSv/y combined). Gamma doses were not predicted to change significantly. The predicted average doses to hydrometallurgical and refinery workers were stated to be between 3mSv/y and 5mSv/y.

As part of the expansion there would be new ore crushing and transfer areas located on the pit rim. The DEIS stated that, allowing for dust suppression and other control methods, workers in this area are expected to receive a maximum of 1.6mSv/y from dust.

The Village and HIA will be demolished to make way for the pit. Doses to workers in the new HIA (to be relocated to 3km south of the current Village), are estimated be 0.5mSv/y– 0.6mSv/y (SEIS Section 26.4.4).
The DEIS stated that the Administration area (currently subject to the public dose limit) would possibly receive an additional 0.7mSv/y, as a result of dust and radon from the expanded operations, resulting in an approximate average dose of 1.2mSv/y.

**Increased exposures in the smelter**

The DEIS states that doses to existing smelter workers are dominated by inhalation of polonium-210 (\(^{210}\text{Po}\)) released in fume from the furnaces during tapping operations (Gamma exposures were generally below 20% of total dose). The annual average smelter dose varied, but reached a maximum of 5.5mSv in 2005 and individual doses reached a maximum of 17.7mSv. The DEIS states that the doses attributed to inhalation of \(^{210}\text{Po}\) are ‘worst case’ estimates as they did not include the effect of wearing respiratory protection, which is mandatory during tapping operations.

The DEIS (Section 22.6.5 and Appendix S 2.3.2) stated that an increase in fugitive dust and fume emissions in the expanded smelter would occur due to the substantial increase in production rate. Additional ventilation systems and other radiation protection measures will be installed around the new facilities (e.g. around tap holes & launders). The SEIS also stated real time sulphur dioxide monitoring equipment would be installed as sulphur dioxide (SO\(_2\)) is a good surrogate for \(^{210}\text{Po}\). A \(^{210}\text{Po}\) monitor would be installed when available and the SEIS (26.4.1) also outlined a series of design and administrative controls to manage dust and fume in the smelter.

The DEIS stated that it is probable that doses will be higher than recent optimal conditions and an average dose of 5mSv/y and individual maximum of 9mSv/y is predicted. The SEIS (26.4.1) stated that this dose estimate does not incorporate respiratory protection and hence is an overestimate.

**Risk of an increase in number of environmentally significant spills and accidental exposures**

The SEIS (26.4.5) stated that the number and size of spills may be expected to increase, simply due to the expanded size of the operation. The method used to predict the number of spills was the use of simple scaling from the current frequency of events.

The DEIS Section 22.4.5 outlined the design and operational controls used to prevent spills and the procedures to manage the spills should they occur. The DEIS also stated that hazard and operability (HAZOP) reviews would be conducted for all new and expanded plant during the detailed design stages.

The DEIS also committed to have adequate incident response procedures in place and to comply with existing reporting requirements

**Transport**

Refer to Chapter 10: 'Infrastructure corridors' for a full assessment of the issues associated with transporting radioactive product.

**Environmental exposures**

Dust is released from the existing underground mine via the ventilation raises, and from the surface via ore and mullock transport and stockpiles. Process dusts and fume are released from the processing plant. Radon is released to the environment from the underground mine workings, rock stockpiles, plant and TSF. Radionuclides are released to the environment via seepage from surface stormwater ponds and seepage from the TSF. The Annual Licence (LM1) Report provides estimated radon and particulate emission rates for the existing operations.

Air and waterborne transport are two main pathways by which radioactive materials might enter the general environment, as external gamma exposures, such as from stockpiles and tailings, are considered negligible (DEIS Appendix S Section 2.5.1). The receptors are people living nearby exposed through inhalation of dusts and RDP, and flora and fauna exposed via inhalation of particulates and RDP, or their deposition to surface soils and vegetation and subsequent uptake of radionuclides.
Radionuclides from the expanded operation may enter the natural environment via three main pathways; radioactive dust in the air, or via transport in surface water or groundwater. Spills of materials containing radionuclides may also result in localised soil contamination within the SML area. As a result, there would be a risk of unacceptable radiation impacts on flora and fauna arising from the expanded operations.

The SEIS (Section 26.6.1) provided a compilation of data reported over the previous 25 years, and included results from additional fieldwork conducted specifically for the preparation of the EIS. The DEIS (Appendix S Section 2.5.1) notes that waterborne pathways are either non-existent or insignificant in the arid Olympic Dam environment. Groundwater is very saline and does not reach the surface. The DEIS (Appendix S Section 2.5.4) stated that the major pathway for ecological exposure results from long-term dust deposition.

In summary, the DEIS (Section 15.5.9) stated that there is currently evidence of an increase in radionuclide concentrations in soils within and around the SML to the extent of approximately 3km of the operation. Soil radionuclide concentrations beyond that zone were stated to be generally within the range found in the local area and worldwide. The one exception was $^{210}$Pb where there was an indication of a slight increase in soil concentration over background levels but still within natural background variations observed worldwide.

The maximum predicted soil concentrations within the SML boundary were estimated using an air dispersion model accepted by the EPA and also conservative dust deposition and soil mixing assumptions.

The potential effects of the observed environmental radionuclide concentrations on non-human receptors were investigated using the ERICA screening method$^7$ with screening levels derived from doses that have been demonstrated to have a slight impact in most sensitive plant species (based on UNSCEAR levels) and also using the default ERICA screening level.

In conclusion, the DEIS (Section 15.5.9) stated that the radiological risks to non-human biota as a result of increased dust deposition from the expanded Olympic Dam operation will be negligible.

**Air transport**

The SEIS (Section 26.6) states that recent monitoring confirmed radon levels were elevated near the current operations and fall to background levels at a distance of 4km. Radon levels measured at Roxby Downs between 1987 and 1995 are in the range 5–55 becquerel per cubic metre ($\text{Bq/m}^3$). Dust (and fume) is released from both ore handling and subsequent processing activities. A comparison of dust measurements taken at Roxby Downs (SEIS Table 26.19) indicates no significant increase in airborne dust levels since the project began.

**Radon and dust releases from the RSF**

There is a risk that during operation, radon and dust emissions from the RSF will significantly impact on exposures to people and the environment.

The DEIS (Appendix S 2.5.2) stated that the RSF would be the major source (~73%) of radon released from the expanded operations. The DEIS (5.4.6) stated the RSF would contain non-mineralised and low-grade material with the low-grade material placed so as to permit recovery for future processing should that become economic.

The SEIS noted that modelling of radon release from the RSF assumed a worst-case situation involving open storage of low-grade material with no covering with non-acid forming rock.

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$^7$ Environmental Risk from Ionising Contaminants: Assessment and Management (ERICA) developed by the European Commission.
The SEIS (26.2.2) stated that the radiological impacts of dust emissions from the RSF would be low and that due to the low-grade material involved, dust produced by the operation of the RSF would become primarily a nuisance long before becoming a radiological issue.

The DEIS stated that radon and RDP will be the major source of radiation exposure at Roxby Downs. The DEIS noted that BHP Billiton has committed to a dust management program and will install a real time dust and meteorological system around the mine and towards Roxby Downs and Hiltaba (Appendix U1, ID 3.1) to predict dust concentrations and where necessary, direct remedial action at specific dust sources.

**Closure of the TSF and RSF**

There is a risk of human radiation exposure post closure arising from inadequate rehabilitation of the TSF and RSF. The SEIS (Section 26.5.1) provided a summary of expected radiation levels based on current closure design objectives aimed at ensuring doses to members of the public would be consistent with existing background levels and less than 1mSv/y.

Final containment of the tailings (and rock storage facility) would be via capping with a suitably thick barrier of non-acid forming mine rock. Ongoing test-work is occurring to determine the optimum depth of material required to minimise radon emanation, minimise water ingress and maintain maximum stability of the resulting landform.

The DEIS (Appendix F1) and the SEIS (Section 26.5.1) indicated that the assessment of radiation doses to people arising from potential failure scenarios for the RSF and TSF post-closure cannot be definitive, as this is dependent on final post-closure cover design and the standards and techniques acceptable at the time of closure. As noted above, BHP Billiton has committed to undertake a structured radiation risk assessment for the TSF (known as a Features, Events and Processes study) in conjunction with relevant regulatory agencies.

The DEIS summarised the potential risks associated with the failure to successfully rehabilitate the TSF and RSF and achieve stable landforms. The risks identified the effects slope erosion and water infiltration for the TSF and RSF and in addition, wind scour for the RSF. The basic design of both the TSF and RSF is intended to ensure long-term stability and thus post closure slope failure was rated as a low risk.

**Groundwater**

The DEIS (Appendix S Section 2.5) states that around 8Mt of tailings solids and up to 9GL of processing liquor are currently discharged to the TSF annually from the existing operation. The DEIS (Section 5.6.5) also states that some low level radioactive waste (including laboratory waste) is also disposed of in the TSF.

The tailings and processing liquids are held in specially constructed TSF cells (solids) and evaporation ponds (liquids). Around 1.2–3.1 ML/d of liquor is recycled back to the metallurgical operations and around 0.5–1.5 ML/d from the TSF seeps to groundwater where a groundwater ‘mound’ has formed below the TSF.

The chemical and radiological characteristics of the existing solid and liquid wastes are described in the DEIS (Section 5.5.6, Tables 5.18 - 21). The chemical characteristics (including uranium) of groundwater existing in the mound below the TSF are also summarised in the DEIS (Appendix K4 Table 2.5). The DEIS (Appendix K4, 2.5.3) states that the observed 20m mound in the Andamooka Limestone below the TSF contains uranium at levels higher than surrounding regional groundwater. The DEIS further states that the uranium levels decrease to background values outside the immediate influence of the TSF and evaporation ponds.

In summary, although there is the potential for radionuclides to enter groundwater below the current operations, the DEIS states that this is not a possible source of exposure for the surface environment. Waterborne pathways are subsequently described as negligible.
Seepage from TSF and RSF

Regarding the risk of lateral and vertical seepage of radionuclides from the TSF and RSF eventually leading to impacts on the human and non-human environment during operations and after closure, the DEIS and SEIS (Section 26.2.3) stated that despite seepage expected to occur from the base of the TSF, the contaminants would precipitate within 5m of the base. The SEIS provided evidence that this is due to the neutralising effect of the acidic seepage interacting with underlying alkaline sediments in the underlying geology resulting in precipitation.

The SEIS stated that there would be no impact on workers, members of the public or biota from seepage from the TSF. That is, there will be no surface expression of any potentially contaminated groundwater during operation of the TSF. The maximum lateral movement of groundwater from the area of the TSF is predicted to be 500–1500m before being drawn into the pit.

Lateral seepage through the tailings cell walls is minimised through the construction techniques used and exterior drainage will collect any seepage that did occur for recycling to the TSF. The proposed construction of the RSF involves encapsulation of low grade and more reactive material to minimise acid generation.

The proposed construction of the RSF also requires a base of non-acid forming or acid-neutralising rock to neutralise any acid bearing pore water generated within the structure by percolation of rainwater. The SEIS (Section 26.2.2) stated any resulting seepage from the base of the RSF could occur in very localised areas. It was expected that the radiological contaminants would be strongly attenuated in the calcareous clays and limestone beneath the RSF. The effects of liquor neutralisation and contact with clays and sediments on radionuclide attenuation were discussed in the SEIS Section 26.2.3. The SEIS stated that the RSF seepage rate is expected to be a small fraction of that expected from the TSF for which the DEIS test work has indicated minimal long-term impacts.

Open Pit post-closure

There is a risk that radionuclides in tailings liquor seeping from the base of the TSF during and after operation, and from the underground mine workings post-closure, may accumulate in the pit and present a radiological hazard to people and the environment.

The DEIS predicts that any seepage that does occur from the base of the TSF post closure, will diminish over time and flow to the pit to be captured within a hypersaline lake that is predicted to form in the pit base within 100 years of mine closure. The DEIS (Section 11.5.4) predicts the lake will be several hundred metres deep and in the long-term - more than 3000 years - form a salt crust, isolating the water underneath.

An estimate of pit water quality out to 3000 years, noting that uranium concentrations remained low, is provided in the DEIS Table 11.3. Uranium was the only radionuclide represented in the estimate as it was considered the most soluble of the uranium decay series, and hence the best indicator of radionuclide build up in the pit water (SEIS Section 26.2.4).

The potential impact of water from the closed underground mine workings was not included in the DEIS. However, the SEIS used current uranium concentrations in the groundwater mound below the TSF, and uranium and radium in mine water, to revise the radionuclide estimate for the pit lake. On the basis of conservative assumptions regarding the amount of mine water entering the pit, the SEIS concluded that the resulting radionuclide content of the pit water would be low. The resulting uranium and radium levels to be expected in the salt crust were determined to be equivalent to soil with a concentration of 10ppm uranium-238 ($^{238}\text{U}$). This is within the range of ‘normal soils’ although slightly higher than the world average (3ppm)$^8$.

$^8$ UNSCEAR 2000 (United Nations Scientific Committee on the Effects of Atomic Radiation)
Radioactive waste management

The existing Waste Management Centre receives relatively small volumes of very low-level radioactive waste in the form of lightly contaminated steel, tyres, plant and equipment, PPE, etc. Potentially recyclable lightly radioactively contaminated material is currently held separately from other waste material. There is a risk of environmental impacts arising from the disposal of low-level radioactive contaminated solid wastes in the proposed landfill.

The 2009 Environmental Management and Monitoring Report (EMMR) notes that low-level radioactively contaminated waste is disposed of in the landfill whereas the DEIS stated (5.6.5) that low-level radioactive waste will continue to be disposed of on the TSF.

The DEIS (Table 5.22) outlined several categories of waste that would be disposed of in a new waste management facility. The DEIS noted that recycling of metal waste would continue provided surface contamination levels for removal from site were met.

Receptors

Members of the public

Doses to people living at Roxby Downs are estimated to be 25µSv/y, consisting of approximately 20µSv/y from RDP and less than 5µSv/y from inhalation of dust (DEIS Appendix S 2.5).

There is a risk that the expanded operations may result in a significant increase in dose to members of the public living at Roxby Downs.

The main pathways for exposure to mine based radiation in Roxby Downs and Hiltaba are inhalation of RDP from radon gas released from the pit workings, ore stockpiles, tailings and from the RSF, and inhalation of dust blown from the pit, processing plant, and RSF.

The DEIS and SEIS confirmed that the expansion of the Olympic Dam mine is likely to result in increased levels of radiation exposure to members of the public in Roxby Downs, Andamooka and the new Hiltaba Village.

The CALPUFF model was used to predict doses at Roxby Downs and Hiltaba Village from dust and RDP exposures arising from the expanded operation (DEIS Appendix S Section 2.5.3). The resulting estimates of total dose were approximately 0.13mSv/y for both locations. Of this, approximately 0.12mSv/y was from the inhalation of RDP. The estimated total dose is well below the public exposure limit of 1.0mSv/y.

The total dose estimated for Andamooka residents resulting from the expansion is 0.015mSv/y (SEIS Section 26.5.1).

Inhalation of RDP

This AR used two alternative air transport models (TAPM and Ausplume) to assess the predicted radon levels (and hence RDP exposures) at Roxby Downs. These models incorporated the same conservative inputs as reported in the DEIS. The models indicated annual average radon concentrations at Roxby Downs of 1.8 Bq/m³ and 2.8 Bq/m³ for the TAPM and Ausplume models respectively. This is less than that predicted in the EIS (3.4 Bq/m³).

RDP dose estimates at Roxby Downs and Hiltaba Village derived from the predicted radon levels, suggest the approximate doses reported in the DEIS are reasonable and suitably conservative.

One additional factor that will influence future member of the public (and worker) doses is the RDP dose conversion factor as recommended by the ICRP. As noted earlier, there is the possibility that the dose conversion factor will change in the foreseeable future.
**Inhalation of dust**

Annual average dust concentrations at Roxby Downs and Hiltaba Village were estimated in the DEIS (Section 13.3.2) using a standard air dispersion model. The AR considers the assumptions used in the dose estimate (DEIS Appendix S Section 2.5.2) are suitably conservative and the estimated doses (approximately 0.003mSv/y). Although the estimated doses are some 10 times greater than that currently measured, they remain at the limit of detection of the current monitoring methods used\(^9\) and are a very small fraction of the annual dose limit of 1.0mSv/y.

**Ingestion of rainwater and home-grown foods**

The SEIS (Appendix M4.2) states that in 2005 and 2006, radionuclide surveys were conducted in the region of the Olympic Dam mine and processing plant. Flora and fauna were sampled and analysed.

The SEIS (Table 26.20) states results for pre-operational flora surveys and noted results of recent surveys in 2005 and 2006. While these studies suggested elevated levels of \(^{210}\)Po and lead-210 (\(^{210}\)Pb) in mulga (Acacia aneura) out to a distance of 25km, these results were not confirmed in a subsequent 2009 survey.

The SEIS (Tables 26.21 and 26.22) states that soil radionuclide concentrations (although inherently variable) have not changed markedly over the period of the current operation as a result of dust deposition. The SEIS states that there is no evidence of a trend to increasing soil concentrations over time, indicating minimal impact from the existing operation.

The SEIS (Section 26.6) stated that ingestion of rainwater collected from rainwater tanks at Olympic Dam and Andamooka would result in doses to people that were well within the relevant guidelines\(^10\) and no different to background radiation doses arising from drinking Murray River water.

Consumption of locally grown produce, and native plants and wildlife that contain radionuclides is an additional but minor pathway that has been calculated to result in doses that were no different from background levels.

**Ingestion of bush food**

Fauna monitoring was originally conducted early in the Olympic Dam project’s operation to assess member of public exposure from consumption of animals (SEIS Section 26.6.1). Another survey was carried out in 2006 to specifically examine radionuclide concentrations in kangaroos from within and outside the mine lease area.

The SEIS (Appendix M 4.7) states that only two of 15 cases examined indicated significantly higher radionuclide concentrations in ‘mine’ kangaroo tissues. The SEIS concluded that no significant differences could be observed between ‘control’ and ‘mine’ kangaroo tissues in the majority of samples and that consumption of the fauna would have no effect on human health.

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\(^9\) For example, see the Olympic Dam Environment Management & Monitoring Report - 2010

\(^10\) Australian Drinking Water Guidelines (NHMRC, 2004).
4.4.9.2 BHPB EM Program and commitments

BHPB has set the following objective and criteria as part of its Environmental Management Program (EMP) which is detailed in DEIS Appendix U, ID 3.5 and 4.7:

- **Objective**: No adverse impacts to health of employees or members of the public from exposure to radiation from BHP Billiton’s expansion activities
- **Criteria**: Radiation doses to members of the public less than 1 mSv/y above natural background and 20 mSv/y above natural background for designated workers

- **Management plan**:
  - Radioactive Waste Management Plan - there are specific requirements under the Mining Code and these are currently incorporated within the EMS. These requirements are being reviewed and updated to incorporate any additional requirements of the expansion. It is intended that the current RWMP would be updated to encompass the expanded activities.
  - Dust Management Plan (new) – a dust management plan would be developed to record and monitor operational control (ID 3.5).
  - Incident Response Plan – the existing Olympic Dam Corporation Incident Response Plan would be modified to address aspects of the transport of concentrate (ID 3.5).

- **Commitments**: Regarding workforce exposure to radiation (SEIS Table 2.1 Commitments, page 54):
  - BHPB would comply with internationally accepted radiation limits for workers and the public, and would set a goal of maintaining doses at less than 50% of the internationally acceptable annual average limit for workers (20mSv/y – that is, maximum doses to workers should not exceed a dose constraint of 10mSv/y. A dose constraint is a level set as part of the dose optimisation process. It marks the upper value of predicted doses and acts as an operational limit, as opposed to a regulatory limit);
  - BHPB would conduct an International Commission on Radiological Protection ALARA optimisation study during the detailed design phase of the open pit and metallurgical plant;
  - A real-time dust and meteorology monitoring system would be installed at Olympic Dam to predict dust concentrations, which would provide information for operational control of dust;
  - Potentially reactive mine rock would be enclosed within the RSF; and
  - The design of the TSF would incorporate controls to minimise seepage, including:
    - Increasing the volume of liquor recycled from the TSF;
    - Constructing larger cells with greater evaporation capacity;
    - Collecting liquor through a central decant arrangement;
    - Installing a liner beneath the central decant system; and
    - Recycling water from the mound beneath the TSF;
  - Tailings cells would be caped when they reach their design height and when it was safe for vehicles to access the TSF surface; and
  - BHPB would conduct a formal post-closure radiation risk assessment.

4.4.9.3 Assessment

The assessment has been conducted by verifying the estimated radiation doses and environmental impacts using the information provided in the Draft EIS and SEIS or reported elsewhere, by comparison with other similar situations, and through the use of alternate exposure models where possible.

**Occupational radiation exposures**

**Open pit**

The three exposure pathways have been assessed separately to determine if total doses to pit workers can be expected to remain below the 10mSv/y dose constraint.
Exposure to gamma radiation

Dose data reported in the 2009 Annual Radiation Report\textsuperscript{11} confirms that currently, the most exposed underground workers at Olympic Dam are production chargers and raise rig operators with an average gamma dose of around 2.2mSv/y. The DEIS (Appendix S Section 2.2.2) has referenced underground production chargers with an average gamma dose of 3mSv/y. It can be expected that external gamma radiation exposures in the open pit will be approximately half those for the underground mine, as workers will not be surrounded by ore. In addition, the predicted average dose 1.4mSv/y for pit workers is considered reasonable given that open pit gamma exposures are more amenable to control than underground as worker locations have greater flexibility and high-grade areas can be avoided.

The use of a theoretical gamma exposure model\textsuperscript{12} (DEIS Appendix S 2.2.2) clearly overestimated actual gamma dose observed in operating pits. When applied to the Ranger mine, the model indicates doses several times higher than those actually observed. However, this model is useful in that it can place a maximum value (around 6.5mSv/y) on gamma dose that might be expected in the Olympic Dam pit.

Allowing for differences in exposure times and significant difference in ore grades, the maximum doses received under similar conditions at Ranger (4.3mSv/y) indicates the maximum predicted gamma dose for Olympic Dam pit workers (4mSv/y) given in the DEIS Appendix S Table S2 is a reasonable estimate (SEIS Section 26.6.1).

This AR considers the predicted gamma dose range estimate to be acceptable given the ore grade, pit geometry, worker exposure times, potential for shielding by large equipment items, comparison with the results from standard exposure geometry models, and comparison with gamma doses from the Ranger open pit uranium operation.

Exposure to radioactive dust

This AR considers that the estimates of radioactive dust exposure within the pit, based on the expected dust composition, assumed dust concentrations and particle size, are considered suitably conservative and demonstrate that exposures from this source will be acceptable. It is noted that no allowance was made for respiratory protection or filtered air in mobile equipment in the dose estimates. These factors would greatly reduce actual dust exposure.

Exposure to radon decay products

This AR considers that the DEIS and SEIS provided sufficient detail, incorporating a number of conservative exposure assumptions, for a cautious RDP dose estimate to be made for workers in the pit.

For the purposes of this assessment, the total radon production rate for the pit at 40 years was calculated using the basic assumptions provided in the EIS regarding pit geometry at 40 years and emanation rate data in Table 3 (SEIS Appendix M1.5). These calculations verified the EIS estimates. In particular, using these assumptions, the predicted average RDP concentration in the pit and under ‘normal’ and inversion conditions were also verified.

It is noted that the DEIS dose estimates do not assume any respiratory protection provided for individuals on the ore body or when working inside filtered air-conditioned equipment. Such protection would result in a reduced exposure to RDP.

\textsuperscript{11} Annual Radiation Protection Report: 1 July 2008 – 30 June 2009
\textsuperscript{12} Thomson & Wilson (1980)
However, under the unlikely ‘worst case’ conditions (in which pit ventilation is 10 times lower than expected), the AR notes total doses - combined maximum RDP, gamma and dust doses - would rise to around 12mSv/y without the use of any respiratory protection or other controls.

Ensuring maximum doses always remain below the 10mSv/y dose constraint as the pit develops, will depend on operational controls coupled with real time monitoring of gamma, dust and RDP levels, and the setting of pit specific ‘action levels’ associated with these exposure pathways. It is important that the exposure controls for the pit be developed and implemented in parallel with an ongoing and comprehensive occupational and environmental monitoring program. These controls must be specified in the approved Radiation Management Plan prior to the commencement of the pit operations.

In conclusion, based on the information presented, the AR considers that the predicted RDP exposure for workers to be an acceptably conservative estimate. The conservative dose estimates also demonstrate that the potential impact of a doubling of the RDP conversion factor by the ICRP will be manageable. The use of real time monitoring of RDP, gamma and dust levels in the pit can be expected to further reduce total doses to pit workers to below the 10mSv/y dose constraint.

**Underground mine**

It is noted that BHPB expects existing control mechanisms would be sufficient to manage possible impacts of any increase in levels of dust and radon drawn into the underground mine as a result of the expanded surface operations.

The AR considers the estimated potential increase in dose to underground workers is reasonable given the projected average radon concentration of surface air. It considers that BHPB will be able to manage the projected impacts of the surface operations on existing underground mine air quality conditions without additional controls.

**Processing plant**

*Increased exposures from larger scale operations*

Existing controls have maintained average and maximum doses, reported for non-smelter workers, to well below 10mSv/y. Given there will be no change to the nature, or general scale of individual plant components of the processes in the metallurgical plant, the AR considers that assumptions underlying the predicted doses to workers in the plant are reasonable.

This AR considers that workers in the Administration area must become classified as radiation workers as their average doses are expected to be slightly above 1mSv/y. BHPB will need to make provision for relocating members of the public and pregnant workers off-site as required. It may be appropriate that a lower dose constraint, 3mSv/y for example, could be applied to this group of workers.

In conclusion, this AR considers sufficient information has been provided to determine that non-smelter worker doses can be expected to remain below the 10mSv/y dose constraint with the controls as described. In addition, the proposed ALARA study should further refine the effectiveness of the plant design and proposed controls, prior to authorisation to construct any new or expanded plant.

*Increased exposures to workers in the smelter*

Publicly reported dose summaries indicate smelter workers are the work group with the greatest potential routine exposures in the plant (although all doses have been less than the annual dose limit). It should be noted that the doses reported for smelter workers assume no respiratory protection is worn, and hence doses are considered ‘worst case’ estimates.


$^{210}$Po levels in the existing smelter should be carefully monitored during the process of increasing production rate to ensure additional controls are effective and exposures are kept as low as reasonably achievable. While monitoring should include the installation of a real time $^{210}$Po monitor as soon as available, the AR considers the use of a real time SO$_2$ monitor is an acceptable interim monitoring measure, as SO$_2$ is a surrogate for $^{210}$Po. SO$_2$ can be used as a surrogate as both $^{210}$Po and SO$_2$ are generated and released together from the same high temperature sources (i.e. molten copper and slag in the furnaces, or when poured from the furnaces).

In addition, the use of accurate respiratory protection factors would greatly assist dose assessment in the smelter and elsewhere in the plant.

A sub-group of smelter workers are involved in slag crushing and recycling. Slag has the potential to generate significant gamma dose rates due to its radium-226 ($^{226}$Ra) content. The AR considers that any potential for increased exposures due to greater slag production would be manageable and would be addressed during the operational approvals stage.

Given that the expansion would involve maximising the output of the existing smelter, the AR recommends that improvements to the design of the existing smelter are included in the proposed optimisation study.

**Risk of an increase in number of environmentally significant spills and accidental exposures**

None of the publicly reported spills or incidents involving radioactive materials from the current operations has resulted in any significant impacts on people or the environment. The AR considers this reflects both the low specific activity of the materials themselves, and the development of suitable plant design, operational controls and clean-up procedures.

The AR considers the use of design, operational controls and response procedures would adequately manage any accidental releases or spills. It should be noted that all design and control measures must satisfy a further detailed construction and operational authorisations process for the expanded operation, and must be operated and monitored in accordance with the approved RWMP.

**Environmental exposures**

The DEIS (Appendix S2.5.4) described the results of using the ERICA tool for estimating potential radiological risk to the terrestrial environment surrounding the Olympic Dam expansion area. The major pathway for ecological exposure was stated to be from long-term dust deposition.

The AR considers that in the absence of formal guidance on the protection of non-human species, the use of the ERICA tool is appropriate for estimating impacts on the non-human environment. While other tools are available, the ERICA framework is the only approach currently being investigated for use in the Australian context. While there are uncertainties in the use of ERICA in the Australian context, the results of the ERICA assessment indicate a negligible impact would be expected for non-human biota.

**Radon and dust releases from the RSF**

The AR considers that radon and dust radiation exposures associated with the operation of the RSF could be managed with the controls as proposed. The estimates of radon and dust release from the RSF are suitably conservative, and BHPB has committed to real-time dust and atmospheric monitoring during the operation of the RSF to assist with the development of dust control strategies associated with different dust sources.
Given the non-acid forming and low grade material involved (and hence generally low gamma dose rates), the open ventilation of the RSF surface, and potential for use of filtered air mobile equipment, doses to workers involved in the operation of the RSF are expected to be a less than those for workers in the pit. It should also be noted that actual construction and operation of the future RSF would be subject to authorisation requiring specific controls on radon and dust exposures.

The AR considers that real time radon monitoring would similarly assist with the development of radon emission controls. Radon emissions could be further reduced by the selective coverage of low-grade material if required.

**Closure of the TSF and RSF**

This AR considers that the DEIS and SEIS have provided sufficient information and a suitable indication of the possible closure criteria and closure risk assessment process, including a commitment to conduct a Features, Events and Processes study, to have confidence that post closure radiation exposures can be kept to below the 1mSv/y public dose limit.

There will clearly be enough non-acid forming material available to supply the cover required to minimise radon emanation, gamma dose rates and dusting from the surface of both the TSF and the RSF. However, these exposures are controlled only for so long as the containment retains its integrity. This then becomes an engineering question that is discussed in greater detail elsewhere in the AR (e.g. Section 4.4.12.3).

There are elements of the final post-closure design that depend on the outcome of further test work. This AR considers that the impending closure of the existing TSF Cells 1, 2 and 3 should be used as a test bed for closure assessment to evaluate identified risks including, water infiltration, slope erosion and wind scour processes. Further work should also evaluate the ‘worst case’ movement of released material and radiological impacts in the event the TSF and RSF containments eventually fail. This test work (and the Features, Events and Processes study) should form part of a comprehensive decommissioning and rehabilitation plan for the TSF and RSF to ensure international best practice is established.

It should be noted that actual decommissioning and rehabilitation of the future TSF and RSF will be subject to authorisation under the RPC Act licence. These authorisations will require detailed site-specific design and engineering information to confirm each structure is appropriately constructed, stable, and will minimise radiological impacts of future seepage and other releases to the environment.

**Seepage from TSF and RSF**

This AR considers that the TSF and RSF, as proposed, can be constructed and operated satisfactorily with minimal radiological impact on local aquifer systems. Sufficient information has been provided to indicate that seepage from the RSF would be significantly less than seepage from the TSF. In addition, the EIS has provided sufficient information to determine that groundwater impacted by seepage from the TSF would not travel far from the TSF itself before flowing to the open pit.

Post-closure, the DEIS predicts that any seepage that does occur from the base of the TSF, will diminish over time and flow to the pit to be captured within a lake that is predicted to form in the pit base.

The AR considers that, to ensure the long-term stability of the TSF and RSF structures and minimise future seepage, a comprehensive decommissioning, rehabilitation and closure plan for both the TSF and RSF is required. This AR also recommends that the existing TSF Cells 1, 2 and 3 closures be used to conduct long-term (decades) testing of seepage rate decline, modelled rehabilitation structures, and processes.
Actual construction and operation of the future TSF and RSF would be subject to authorisation under the RPC Act licence. These authorisations would require detailed site-specific design and engineering information to confirm each structure is appropriate and will minimise radiological impacts of seepage.

Open pit post-closure

The SEIS (Section 26.2.4) makes the assumption that 25% of all future groundwater entering the pit comes from the mine workings and has uranium and radium levels as currently observed in mine water. This is considered a reasonable approach. In a more extreme situation where seepage from the base of the TSF occurred to the extent that 50% of groundwater entering the pit resembled mine-water, the resulting salt crust uranium and radium concentrations would still fall within the range natural variations observed in soils worldwide\textsuperscript{13}. It is noted that other factors that would tend to either dilute or cover the salt crust, such as wash-down of surface soil and non-acid forming cover sequence material, have not been included.

This AR considers that the EIS has provided sufficient information to assess this risk. Assuming significant input from either mine or seepage from the base of the TSF, the long-term pit water and salt crust radionuclide content should not represent a significant radiological hazard to people or the environment. However, it is expected that this issue will be considered as part of the overall rehabilitation and closure plan to ensure future exposures can be minimised.

Radioactive waste management

If contaminated metals and other low level radioactive wastes are to be disposed of in the TSF and the new waste management facility, these materials must be placed in specific locations to ensure appropriate containment and rehabilitation.

Some low level radioactively contaminated material could be safely recycled with appropriate controls provided the process meets legislative requirements. As contamination is often minor and restricted to the surface of an item, the bulk activity of the material is negligible. Recycling of such lightly surface contaminated items is possible after careful consideration of contamination limits, measurement protocols and intended future use. The EMMR notes that remaining low level radioactively contaminated waste is currently disposed of in the landfill.

The AR considers that low level radioactively contaminated waste can continue to be buried within the landfill provided an appropriate rehabilitation and closure plan is developed for the site. This plan should form part of the greater rehabilitation and closure plan for the TSF and RSF to ensure long-term containment consistent with international best practice.

Receptors

Members of the public

The current inhalation dose estimated for people at Roxby Downs was reported in the DEIS (Appendix S Section 2.5.1) as less than 0.025mSv/y, of which 0.005mSv/y is from inhalation of dust. It should be noted that both values are below the minimum level of detection (MDL) of the methods used and hence can only give an indication of the small scale of the doses currently received from RDP and dust\textsuperscript{14}. Simply scaling up from these results based on current and predicted radon and dust emissions, would lead to large errors in predicted doses from the expanded operation, hence modelling was undertaken.

\textsuperscript{13} UNSCEAR 2011

\textsuperscript{14} For example, see the Olympic Dam Environment Management & Monitoring Report - 2010
Inhalation of RDP
To ensure doses are minimised, the AR concurs with BHPB’s commitment to set an operational dose constraint of 0.3 mSv/y for public doses. In addition, appropriate radon and dust emission controls should be in place (primarily on the RSF) prior to the intersection of ore at the base of the pit.

Inhalation of dust
This AR considers the dose estimate for the inhalation of radioactive dusts at Roxby Downs and Hiltaba Village is reasonable.

Ingestion of rainwater and home-grown foods
The AR accepts that the analysis of rainwater from tanks at Roxby Downs and Woomera confirms that there would be little difference in dose received via the ingestion of rainwater from these sources, compared to the ingestion of tap water from the GAB and the River Murray.

Based on the EMM Annual Report 2010 analysis of water supplies, the predicted dose (S5.2.3) from the ingestion of locally grown vegetables and the consumption of tank water at Roxby Downs (0.01mSv/y) is low and is considered acceptable.

Ingestion of bush food
The AR accepts that the predicted low frequency of consumption of scarce bush food in the region would result in very small annual doses - approximately 0.01mSv/y – as noted in the DEIS (Appendix S 2.5.3). Nevertheless, the operational Environment Management and Monitoring Plan will continue to monitor radionuclides in the environment.

To minimise exposures in accordance with the ALARA principle, appropriate environmental radon and dust emission controls must be in place (primarily on the RSF) prior to the intersection of ore grade material at the base of the pit. In addition, BHPB has indicated that a network of meteorological sites would be established across the SML to provide more detailed information on environmental factors affecting dust transport (e.g. wind speed and direction, and temperature inversions) and how they interact with mining operations, and public doses.

In conclusion, the AR considers that sufficient information has been provided to provide confidence that BHPB understands the radiation protection issues for members of the public at Roxby Downs and Hiltaba, arising from the proposed expansion.

Further, the AR considers that BHPB has demonstrated that radiation exposures estimated for members of the public living at Roxby Downs and Hiltaba during the operational phase of the expanded mine and plant, are based on conservative assumptions and indicate actual doses would be a small fraction of the annual limit for members of the public.

RECOMMENDATIONS
This AR considers that the estimates of radiological impacts arising from the proposed operation are based on suitably conservative assumptions and indicate that with appropriate controls and monitoring, the environmental impacts would be acceptable, and radiation doses to workers and members of the public would remain below appropriate limits. In addition, with appropriate controls, average doses to workers and members of the public would remain below the respective dose constraints set by BHPB of 10mSv/y and 0.3mSv/y for the duration of the operation, and well below the dose limits prescribed within the National Code of Practice For Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (2005).
This AR notes that the proposed expansion construction works, operational controls and associated monitoring programs would be subject to additional authorisations. Under RPC Act licence conditions, BHPB would be required to seek authorisation to commence each stage of the project; that being construction, commissioning and operation, and decommissioning and rehabilitation of the site. Each authorisation would require a Radiation Management Plan and Radioactive Waste Management Plan applicable to the project stage and approved by the EPA. These detailed plans would address all risks of radiation exposure to workers, the environment and the public and the control methods and monitoring that would be employed to ensure that doses would be as low as reasonably achievable.

The AR recommends the following condition of approval:

- The proponent must achieve the following outcomes as measured against the respective approved criteria:

<table>
<thead>
<tr>
<th>OUTCOME</th>
<th>CRITERIA</th>
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<tbody>
<tr>
<td>Radiation doses to the public arising from the expanded Olympic Dam operations and radioactive waste management are below internationally agreed levels and are as low as reasonably achievable.</td>
<td>Compliance criteria: Radiation doses to the public must be within the dose limits recommended in the Code of Practice for Radiation Protection and Radioactive Waste Management in Mining and Mineral Processing (ARPANSA 2005 or, as amended). Leading Indicator: A reference level must be set for public doses at Roxby Downs and Hiltaba. The reference level must be 0.3mSv/yr unless otherwise agreed by the relevant Minister.</td>
</tr>
<tr>
<td>Radiation doses to non-human biota arising from the expanded Olympic Dam operations and radioactive waste management area as low as reasonably achievable.</td>
<td>Leading Indicator: The proponent must set a reference level for impacts on non-human biota (interim criteria for non-human biota may be set until such time as an agreed national approach is determined).</td>
</tr>
<tr>
<td>Radiation doses to the public and non-human biota arising from the transport of radioactive material are below internationally agreed levels and are as low as reasonably achievable.</td>
<td>Compliance criteria: Transport of radioactive material complies with the Code of Practice for the Safe Transport of Radioactive Material (ARPANSA 2008 or, as amended).</td>
</tr>
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The AR also recommends the following notes:

- When seeking authorisation from the SA EPA to construct (as required under the conditions of the Radiation Protection and Control Act 1982 licence), the proponent must submit a summary report on the results of the radiation protection optimisation program. This report will be in addition to the Radiation Management Plan and Radioactive Waste Management Plan that need to be submitted though it is expected that the findings of the radiation protection optimisation program will be incorporated into those plans. The radiation protection optimisation program should include consideration of the current design of the smelter and other relevant plant infrastructure to determine engineering controls to support the increase in production rate.
- When undertaking the radiation protection optimisation study during the design phase of the new plant and open pit mine, the proponent must also consider the design of the existing smelter and other relevant existing plant infrastructure to determine engineering controls to support the increase in production rate.
In keeping with the EPA’s regulatory practice to enact national codes of radiation protection, the proponent will be required to seek authorisation to commence each stage of the project; that being construction, operation and decommissioning and rehabilitation of the site. Each authorisation will require a Radiation Management Plan and Radioactive Waste Management applicable to the project stage and approved by the EPA. These plans must address all risks of radiation exposure to workers, the environment and the public and the control methods and monitoring that will be employed to ensure that doses will be as low as reasonably achievable.

The proponent is reminded of its routine reporting requirements under licence conditions and radiation accident or emergency reporting pursuant to Regulations 31 and 32 of the Radiation Protection and Control (Ionising Radiation) Regulations 2000.

It is expected that the proponent will incorporate the following requirements within the Radiation Management Plan (RMP) that must be approved by the EPA as conditions of the licence under the Radiation Protection and Control Act 1982 to conduct expanded mining or milling of radioactive ore at Olympic Dam:

- The proponent will conduct radon emanation measurements on the overburden, waste rock and exposed ore as the pit develops. This data should be used to model Radon Decay Product exposures within the pit;
- The proponent will undertake real-time gamma, radon, dust and pit atmospheric monitoring during the development of the pit and Rock Storage Facility to assist the development of control strategies associated with different sources of dust and radon;
- The Radon Decay Product dose assessments must be re-modelled for the pit and underground mine, should the International Commission on Radiological Protection introduce a change to the recommended RDP dose conversion factor; and
- The proponent must develop a program to derive realistic respiratory protection factors for use in the smelter and elsewhere in the Plant to provide an accurate estimation of dose.

It is expected that the proponent will incorporate the following requirements within the Radiation Waste Management Plan that must be approved by the EPA as conditions of the licence under the Radiation Protection and Control Act 1982 to conduct expanded mining or milling of radioactive ore at Olympic Dam:

- A comprehensive rehabilitation and closure plan for the landfill containing low-level radioactive contaminated material, to ensure it meets international best practice for disposal (either in situ, or moved to a more appropriate location);
- A plan to address the recycling where appropriate, of large lightly contaminated equipment items in accordance with international best practice; and
- The conduct of regular (e.g. 5 – 10 years) soil surveys within and outside of the Special Mining Lease as part of the RWMP, to assess the radiological impacts of dust deposition for the expanded operations using appropriate models (e.g. ERICA).

It should be noted that any Radiation Management Plan and Radioactive Waste Management Plan that is approved by the EPA under the Radiation Protection and Control Act 1982 for the expanded Olympic Dam operation will be subject to regular review to ensure monitoring and control methods demonstrate best practice and exposures are as low as reasonably achievable (ALARA).
4.4.10 Greenhouse gases

A general assessment of the greenhouse gas impacts for the whole project (and not just the mine and processing plant has been provided in Chapter 13: ‘Effects on the environment’ of this AR. Where a greenhouse gas matter is specific to the mine and processing plant, it has been included in this chapter.

4.4.10.1 Issues

The DEIS indicated that in terms of emissions intensity, BHPB predict that the increased size of the operation would result in a decrease from around 105kg of CO₂e per tonne of ore milled to around 79kg of CO₂e per tonne of ore milled over the long-term, following an initial increase to 119kg of CO₂e per tonne of ore milled during the early mining operations when large quantities of mine rock but little ore would be moved.

Justification for the use of a truck fleet for the transport of ore and waste rock instead of a conveyor system, and the implications of using vehicles on power use and greenhouse emissions was raised in a submission.

There is legitimate government and community interest in understanding how BHPB would meet its emission reduction goals. It is considered that the project could achieve significant emission reductions compared with a business as usual approach while remaining an economically productive opportunity.

4.4.10.2 BHPB EM Program and commitments

BHPB has set the following objective and criteria as part of its Environmental Management Program (EMP) which is detailed in DEIS Appendix U, ID 3.6:

- **Objective:** Contribute to stabilising global atmospheric gas concentrations to minimise environmental impacts associated with climate change.
- **Criteria:** Apply a management goal of reducing greenhouse gas emissions (reportable under the National Greenhouse and Energy Reporting (Measurement) Determination 2008) to an amount equivalent to at least a 60% reduction (to an amount equal to or less than 40%) of 1990 emissions, by 2050.
- **Management plan:** Develop a Greenhouse Gas and Energy Management Plan for the proposed expansion. The plan would:
  - Establish modelling to project the likely emissions from the expanded Olympic Dam operation from commencement to 2050;
  - Establish targets and timelines for greenhouse gas reduction;
  - Identify greenhouse gas reduction strategies and projects (DEIS Section 13.2.5); and
  - Be reviewed annually.
- **Commitments:** Greenhouse gas emissions from the expanded project (mining and processing plant) would be addressed by (SEIS Table 2.1 Commitments, page 52):
  - Constructing an on-site cogeneration power station (250MW capacity) for recovering waste heat;
  - Producing an annual ‘road map’ that quantifies emission reduction opportunities and achievements (applies to whole project);
  - Supporting government in the development of a sector agreement on greenhouse gas and use of renewable energy (applies to whole project); and
  - Including the effects of an emissions trading scheme on the viability of greenhouse gas abatement projects, and hence the projected emissions trajectory for the expanded operation in Olympic Dam’s Greenhouse Gas and Energy Management Plan (applies to whole project).
4.4.10.3 Assessment

The AR considers that the combination of the 2050 goal, the Greenhouse Gas and Energy Management Plan (GG&EM Plan), and future expectations on carbon pricing provide an appropriate framework within which BHPB would make design and operational decisions around the management of its greenhouse gas emissions, should the expansion project be approved.

BHPB considered the option of installing an in-pit crusher and transportation of the crushed ore using a conveyor system (instead of trucks) in order to minimise the significant volumes of fuel required, and hence minimise emission of greenhouse gases. This option was rejected as it would require the final pit slopes to be established at the outset, otherwise there would be a need to relocate the infrastructure as the open pit was developed. BHPB has indicated that it would review the option of installing an in-pit crusher and conveyor system during development of the resource.

The AR concludes that this is a reasonable approach.

Further analysis, modelling and projections of greenhouse gas emissions have not been provided, and BHPB has indicated that such work would be carried out through the GG&EM Plan. Where material has not been provided or lacks sufficient detail, it is not considered to affect the adequacy of the FEIS, provided that the GG&EM Plan:

▪ Be used to incorporate the issues raised;
▪ Provides a successful vehicle for managing greenhouse emissions on an ongoing basis; and
▪ Provides public accountability for project performance.

RECOMMENDATION

Refer to Chapter 13: 'Effects on the environment' for the full suite of recommended greenhouse and sustainability conditions.

4.4.11 Hazards

4.4.11.1 Issues

The DEIS Section 22.5 addressed the areas of site security, policies for mine site traffic, and risk management of stored hazardous materials and explosives. The following issues in relation to hazards have been specifically addressed in the AR:

▪ The proposed storage, transport, handling and use of chemical compounds used for processing and mining operations (including explosives, fuels and additives);
▪ Potential impact on occupational safety from instability of the open pit, the RSF and seismic activity;
▪ The potential impact on humans, building structures, and mining and processing plant and equipment as a result of seismic events caused by the release of in-situ rock stresses by deep mining activities; and
▪ Potential hazards associated with road and rail transport during construction and operations (this matter has been addressed in Chapter 11: 'Road transport' of this AR).

The DEIS Section 22.6.8 dealt with “hazardous substances” – specifically the requirement to comply with regulatory requirements for the storage of dangerous goods and the construction of bulk storage facilities in accordance with relevant legislation and standards.
The DEIS also discussed the use of “ANFO” (ammonium nitrate and fuel oil) as the preferred explosive for the proposed open pit expansion. Ammonium nitrate (AN) is classified as a security sensitive substance and an explosive in South Australia by Governor’s proclamation of 25 January 2006. It is BHPB’s intention to deliver large quantities of bulk AN to the Olympic Dam mine site for conversion into ANFO. BHPB does not currently have a storage licence or security management plan for bulk AN at Olympic Dam. Refer to Chapter 11: ‘Road transport’ of this AR for further details regarding the transport and storage of AN.

4.4.11.2 BHPB EM Program and commitments

BHPB has set the following objective and criteria as part of its Environmental Management Program (EMP) which is detailed in DEIS Appendix U, ID 2.1 and 4.2:

- **Objective**: No significant contamination to soils, surface water or groundwater as a result of the storage, transport or handling of hazardous materials by BHPB during expansion activities (ID 2.1). Maintain structural integrity of the RSF and expanded TSF (ID 4.2).

- **Criteria**: No lasting significant contamination arising from uncontrolled loss of chemicals to the natural environment (area to be defined) (ID 2.1). No unplanned structural failures to the TSF or RSF (ID 4.2).

- **Management plan**: To update the Emergency Response Plan to ensure additional requirements of the proposed expansion were incorporated, particularly for accident spills associated with possible derailment, truck accident or vandalism. The Management of Hazardous Materials Document and Operational HSEC Plan would also be updated. (ID 2.1)

- **Commitments**:
  - Occupational health and safety (SEIS Table 2.1 Commitments, page 54) – A “safety case” for the current operations is being conducted and would incorporate all components of the proposed expansion, and would include:
    - Identification of the hazards and risks of the proposed expansion;
    - A description of how the risks would be controlled, and
    - An outline of the safety management system and its implementation, monitoring and review of its effectiveness.
  - Transport, storage and handling of fuels and other hazardous materials in the SML would be in accordance with the relevant state and Australian statutory requirements. As a minimum, the SA EPA standards would be used, which require bund sizes to be 120% of the net capacity of the largest tank and 133% for flammable material (SEIS Table 2.1, page 55).

4.4.11.3 Assessment

The issues concerning hazards at the Olympic Dam mine site are subject to regulation under South Australian law, including the following Acts and associated regulations and codes of practice:

- *Explosives Act 1936*;
- *Dangerous Substances Act 1979*;
- *Occupational Health, Safety and Welfare Act 1986; and*
- *Mines and Works Inspection Act 1920*.

**Storage/handling of dangerous goods and explosives**

It is considered that the expansion of the mining operations at Olympic Dam requires a review of the hazards and associated risks that the increased mining and processing operations would present. An increase in mining and ore processing would result in increased storage and use of explosives and other hazardous materials, and increased volumes of these materials transported around the mine site. The review procedure should include updating emergency management procedures for unintended escape of hazardous materials at the mine site; and review of site and personnel security policies as a result of increased quantities of explosives and chemicals.
The DEIS outlined the following measures to manage the storage and handling of dangerous goods including:

- Specific operational procedures have been developed for spills and accidental release of a range of hazardous materials (DEIS Section 22.5). A process to notify external agencies if a spill triggers external reporting requirements is currently in place. In particular, Regulation 8 of the Dangerous Substances Regulations 2002 specifies when such notification is to be given to the Competent Authority of an accident involving dangerous substances;

- BHPB’s commitment to addressing specific legislative requirements for spillage prevention, control and management during the detailed design stage of the proposed expansion (DEIS Section 22.4.5);

- Development of a ‘safety case’ for the existing operation that would incorporate the proposed expansion (DEIS Section 22.5). The ‘safety case’ approach should reveal the need for protocols to mitigate the risks associated with the storage and use of hazardous materials and explosives as the mining program expands; and

- A Security Operations Plan, which refers to persons requiring authorisation to enter the mine site, with further authorisation required for the solvent extraction area, and the gold, silver and uranium production areas (DEIS Section 22.4.5). Security functions related to explosives and AN stores were not specifically discussed in the DEIS.

The AR considers the measures proposed, in addition to legislative requirements outlined above would be sufficient to manage hazards at the mine site.

**RECOMMENDATION**

The AR recommends the following note:

- Detailed planning for the storage and transport of bulk ammonium nitrate will be required to be undertaken prior to construction occurring at the mine site, and in consultation with the South Australian explosives regulatory authority, SafeWork SA to satisfy licensing requirements under the South Australian Explosives Act 1936.

**Major hazard facilities**

From a major hazard facilities (MHF) regulatory perspective, the expansion would increase the overall aggregate threshold level of hazardous chemicals to be used or stored on-site, and the overall risk profile for the site would increase correspondingly.

The ‘design for safety’ of hazardous chemical processing/storage plants, process integrity, safety and controls, including physical layout should be considered during the project design and planning stage for the purpose of consequential risk analysis to determine appropriate risk control measures to prevent a MHF-related catastrophic incident.

**RECOMMENDATION**

The AR recommends the following notes:

- In order to achieve compliance with clause 24 of the State Emergency Management Plan, pursuant to Section 9(e) of the South Australian Emergency Management Act 2004, the proponent would be required to update the Emergency Response Plan in consultation with SafeWork SA. The MHF-related operational hazards and risks should be reviewed during the pre-commissioning, commissioning and operational phases, in consultation with SafeWork SA.

- There may be a requirement for Major Hazard Facility licensing under SA Work Health and Safety (WHS) Regulations (to be effective as from 1 January 2012) when Schedule 15 chemicals threshold quantity level is triggered.
**Potential impacts of simultaneous work**

Simultaneous construction of the new mining, processing and storage facilities plant, equipment and infrastructure in conjunction with existing operations is considered by the AR to pose risks to workers for tasks that could impact on each other.

For hazards promulgated by simultaneous work, the SEIS indicated that risks would be controlled by the provision of exclusion zones and effective barriers, adequate coordination between activities, (including contractor management and coordination), and by undertaking risk assessment in consultation with workers. Further controls that would be implemented include detailed work planning prior to commencement, constructability reviews, workshops and construction (training) modules. Extended shutdowns have also been proposed by BHPB to achieve separation.

**RECOMMENDATION**

The AR concludes that the approach proposed by BHPB is acceptable. No conditions have been recommended.

**Increased hazards and risks**

The DEIS foreshadowed an increase in hazards and risks associated with the construction phase and the ongoing operations of all four major components of the existing metallurgical plant. Given that BHPB propose to continue to use the existing metallurgical processes as per the current operation, it is anticipated that there would be no significant change in hazard level (or a low likelihood of new hazards being introduced). However, the overall workplace incident occurrence may increase due to the increased activities on-site and the addition of new employees. Therefore, it is recommended that BHPB review the hazard and risk matrix/register for any potential shift in risks from ‘tolerable’ to ‘intolerable’ prior to commencing the expanded operations (SEIS Chapter 31 Hazard and Risk).

In the event that BHPB was to modify or optimise the existing copper solvent extraction plant, smelter and refinery to process the additional ore from both the existing and expanded operation, a risk assessment of the modified or optimised processes must be conducted as part of the project risk management to ensure new hazards and unintended consequences are appropriately addressed/controlled before and during the process changes.

The AR considers that operational hazards and risks should be reviewed by BHPB prior to commissioning and operational phases in consultation with SafeWork SA. In addition, the expansion of mining and ore processing activities would require BHPB to have the capacity to respond to an emergency with support from State-funded emergency services agencies. If the project proceeds, the South Australian Fire and Emergency Services Commission (SAFCOM) would require BHPB to involve SA emergency services agencies in all phases/processes of risk assessment where there is an expectation that the SA government would be required to assist, to ensure appropriate planning and coordination for an emergency response.
RECOMMENDATION

The AR concludes that the approach proposed by BHPB is acceptable. No conditions have been recommended.

Stability of the open pit

The AR considers that the open pit mining development must deliver the following outcomes:

- A safe working environment;
- Continuity of economic return to the State and community from the mine and related industries; and
- Stability during operation and post closure, particularly in terms of interaction with adjacent project components. (e.g. the RSF in terms of the potential for failure to lead to the exposure of acid generating or radioactive rock)

BHPB has indicated that stability studies for the proposed open pit have been undertaken since 2006 and are ongoing. The key aim of the geotechnical investigations and associated preliminary designs undertaken by BHPB was to minimise the potential risk of significant failure of the pit walls, and thus minimise related occupational health and safety risks. It was recognised by BHPB that the area in the vicinity of the open pit would require depressurisation to control groundwater inflows and to ensure that significant pore pressures did not build up behind the excavated slopes leading to slope failure.

In response to submissions in relation to the stability of the open pit (including in relation to material strength parameters, rock mass characteristics, groundwater characteristics, failure mechanisms and factors of safety), the SEIS provided information on the underlying rock materials obtained from extensive drilling and reference to the existing borehole database, resulting in the geotechnical logging of more than 500 boreholes to enable information to be compiled for ten cross sections across the proposed open pit. The determination of the conceptual design for the open pit slopes included the collection and analysis from:

- Detailed logging and data collection – acoustic televiewer, core orientation, geotechnical logging, point load strength testing and sampling;
- Laboratory testing;
- Uniaxial compressive strength tests, 152 in cover sequence, 509 in basement;
- Young's Modulus, 435 tests;
- Brazilian tensile strength tests, 163;
- Direct shear tests, 44 in cover and 74 in basement;
- Triaxial strength testing, 40 cover sequence, 43 basement;
- Mineralogical analysis, Plasticity testing (Atterberg Limits), particle size distribution of the shear infill in cover sequence;
- Direct shear of natural rock defects, 40 in cover sequence and 43 in basement of the shear infill;
- Rock mass assessment;
- Probabilistic evaluation of rock mass properties;
- Statistical evaluation of structural data in the cover sequence and basement rock units;
- Collation of information on in-situ rock stress;
- Collation of geological and geotechnical information from the underground operation;
- Modelling of underground and open pit infrastructure interaction;
- Development of a structural geological model for specific domains around the open pit;
- Development of a geological and alteration models; and
- Hydrogeological investigations.
The SEIS stated that BHPB established four geological structural domains for the cover sequence and thirty two structural domains (representing volumes of rock with similar defect orientation and spacing) for the basement sequence. In addition, the analysis by BHPB determined specific rock mass models for the cover sequence and basement rocks, based on the lithological and structural differences. For the cover sequence consideration was also given to the distribution and degree of fracturing and deformation.

Rock mass parameters - uniaxial compressive strength, point load strength index, rock quality designation and geotechnical strength index - were determined for cover sequence materials, both undeformed and deformed, and for the basement materials. This information was used to determine appropriate rock mass shear strengths for the cover sequence and basement using the Hoek & Brown Failure Criterion.

Hydrogeological investigations were undertaken in parallel with the geotechnical investigations and included:

- Collation of existing measurements and abstractions of groundwater;
- Installation of 89 vibrating wire piezometers;
- Pump tests; and
- Borehole permeability tests.

Calibrated three dimensional and quasi three dimensional models were developed to predict pore pressures during pit development for a range of potential intervention options, including:

- No groundwater intervention;
- Perimeter ground water well in the cover sequence; and
- Depressurisation drain hole in the cover sequence and the basement rocks in addition to perimeter groundwater wells in the cover sequence.

Pore pressure grids were developed for all of the above scenarios, though the third option was adopted for use in the stability modelling.

BHPB undertook an extensive assessment of the stability for the proposed open pit which included using a range of rock mass properties, pit geometries, groundwater conditions, and investigation of a range of potential failure modes in order to assess:

- Bench slope angles;
- Inter-ramp slope angle;
- Overall slope angles;
- Impacts of pore pressures and depressurisation requirements;
- Interaction with the existing and proposed underground workings; and
- Impacts and interaction of key infrastructure including shafts and surface infrastructure.

The stability analysis included Limit Equilibrium techniques for circular failures and failure through the rock mass and along a discrete geological structure. In addition, BHPB also undertook Finite Element modelling to confirm failure mechanisms, to compare the estimate of factor of safety of the limit equilibrium methods, estimate displacements and estimate the impact of underground development and stability. Three dimensional modelling of the open pit and underground operations was also undertaken.
The stability of the open pit slopes were assessed in terms of either a factor of safety or probability of failure for a factor of safety being less than 1 in accordance with the following criteria:

<table>
<thead>
<tr>
<th>SLOPE SCALE</th>
<th>FACTOR OF SAFETY</th>
<th>PROBABILITY OF FAILURE FOR FACTOR OF SAFETY ≤ 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bench</td>
<td>1.1</td>
<td>30-50%</td>
</tr>
<tr>
<td>Inter-ramp</td>
<td>1.2-1.3</td>
<td>3-5%</td>
</tr>
<tr>
<td>Overall</td>
<td>1.3</td>
<td>1%</td>
</tr>
</tbody>
</table>

BHPB proposes to install real-time geotechnical monitoring equipment to determine ground movement and slope stability in both the underground operations and open pit.

**RECOMMENDATION**

The AR concludes the following:

- The methodology used by BHPB to determine material properties for input into the assessment of the stability of the open pit slopes is consistent with leading industry practice.

- The assessment criteria used for determination of pit wall stability is consistent with leading industry practice and on the basis of the assessment by BHPB the proposed slope angles for the open pit have acceptable factors of safety against instability, assuming the implementation of depressurisation drain holes in the cover sequence and the basement rocks, in addition to perimeter groundwater wells in the cover sequence.

**Stability of the RSF**

The AR recognises that the RSF design is preliminary and subject to change, however it is important that BHPB has demonstrated that stability of the RSF is achievable both during operation and post-closure for the protection of environmental values including flora, fauna, surface water, groundwater and human health and safety. Loss of stability of the RSF, particularly post closure, could lead to the exposure of material that is acid generating and/or radioactive. As the DEIS acknowledged, the immediate proximity of the RSF to the open pit also emphasises the importance of demonstrating that the RSF stability would not be impacted by major failures in the adjacent open pit.

Further information was sought in the SEIS to confirm that the RSF would be geotechnically stable during operation, and in the long-term in terms of erosion.

The SEIS provided a stability assessment of the proposed RSF at its full height of 150m and assessed whether any failures of the RSF could impact the stability of the open pit, and whether any failures in the open pit could impact the RSF. In addition, the SEIS provided information on the potential for long-term erosion to impact the final landform of the RSF.

The assessment by BHPB considered conceptual design slopes and use of typical strength parameters in the published literature, including:

- Rock fill – unit weight (18 kN/m³), cohesion (50 kPa), angle of friction (35 degrees); and
- Foundation soils (sands and sandy clay) – unit weight (18 kN/m³), cohesion (5 kPa), angle of friction (25 degrees).
The conceptual design included the following parameters:

- Waste rock slopes angles varying between 35–40 degrees;
- Lifts during deposition of 50m, with the exception of 20–30m for the poorer rock units; and
- Berms installed to ensure an overall slope angle of 30 degrees.

BHPB indicated that overall factors of safety would be greater than 1.2. As the RSF would be expected to be free draining, BHPB has indicated that it is unlikely there would be a build up of pore pressures within the RSF. Other assumptions made in the analysis include:

- The water table is below the foundations of the RSF;
- The foundations comprise predominantly sand with discontinuous sandy clay to depths ranging from 1–20m; and
- Design earthquake loading would cause some displacement (predominantly settlement) and this would be within tolerable limits.

The assessment also considered the potential for a total failure of the RSF to result in a surcharge load on the open pit and the potential for a failure of the open pit slope to impact the RSF. Rock mass strength parameters for the various materials were consistent with those determined for the open pit assessment.

The construction and operation of the RSF would require authorisation under the Radiation Protection and Control Act 1982 (RPC Act), which would require BHPB to provide detailed site-specific design and engineering information to confirm the structure is appropriate to minimise seepage.

**RECOMMENDATION**

The AR concludes the following:

- The methodology used by BHPB to determine the material properties for input into the assessment of the stability of the RSF is consistent with current industry practice.
- The assessment criteria used for determination of the RSF stability is consistent with industry practice.
- The risk of exposure of either low grade ore containing radionuclides and acid forming materials as a result of instability of the RSF is acceptably low.

Further discussion on the RSF can be found under Section 4.4.12 ‘Rehabilitation and Closure’ of this chapter.

**Seismicity**

The EIS indicated that seismic events with acceleration coefficients of 0.09 could occur within the Olympic Dam area, with the probability of exceeding these figures considered to be low, at 10% in 50 years. BHPB has indicated that building structures would be designed and built in accordance with the Australian Standards for Earthquake Actions (AS1170.4). On this basis, BHPB concluded that the risk of the predicted seismic events causing environmental impact throughout the life of the project would be considered low.

Current underground stoping areas experience some induced seismicity caused by de-stressing of rock generally after blasting. Underground blasts at the existing operations are monitored for seismic activity, with the risk to workers controlled by putting in place a time dependent exclusion zone to prevent persons entering affected areas after blasts.
BHPB has assessed the potential for earthquakes to be generated as a result of de-stressing rocks during development of the open pit, using 3D finite element modelling of the proposed and existing operations and existing and future underground workings (SEIS Section 8.1). In the SEIS (Appendix D1) BHPB’s consultants concluded that:

▪ The modelling indicated that seismicity as a result of the proposed open pit would be expected to be similar to the seismicity that has occurred in the past as a result of the current underground operations; and

▪ The zone of influence would grow proportionally, relating to the shape and size of the open pit, resulting in release of energy in smaller more frequent increments. For a significant seismic event to occur, the mine would need to isolate a large area of Masher’s Fault with a very high confinement, generate large amounts of strain, and cause an instantaneous release of the stored energy by inducing damage related to the release of the stored energy.

The growth of the open pit would be relatively slow - large blasts over a large area- compared to current underground stoping - large blasts in an isolated and confined area. Under these circumstances, the de-stressing of rock that follows after an open pit blast would likely be more widely distributed than an underground blast.

BHPB has indicated that some low magnitude mining induced seismicity would occur, however it was unlikely that these events would be noticed by the public or on-site, and it is expected there would be little if any damage to the mine or associated infrastructure.

The AR notes that in the SEIS (Appendix O) vulnerability analysis is proposed for specific pit scenarios in final design stages where dynamic loading could exist. A detailed design is required for the analysis, and the AR recommends geological structures be included in such analysis.

The open pit design will change over time and the current modelling has been done for the proposed pit. If designs are changed, re-modelling must be done.

BHPB has made provision for all proposed new infrastructure, including the TSF, to be designed to withstand a 1-in-10,000 year earthquake event loading.

**RECOMMENDATION**

The AR concludes that the approach by BHPB to modelling in relation to seismic impacts is acceptable, and that the proposed development of the open pit will result in similar levels of seismicity to the current underground operations. The AR further concludes that it is not likely that mining-related seismicity would lead to any impact on the community, or damage to the mine or any third-party infrastructure.

### 4.4.12 Rehabilitation and closure

#### 4.4.12.1 Issues

The DEIS outlined the following rehabilitation and closure strategies proposed by BHPB:

▪ The open pit would not be backfilled and would essentially remain as it was at the completion of mining activities. Some slope correction would be undertaken and a bund and fence with warning signs would be installed around the perimeter of the void;

▪ The RSF and TSF would remain as a permanent landform that would contain potentially reactive - chemically and radiologically - material, with a self-sustaining final cover which minimises the potential for infiltration of water;

▪ The metallurgical plant post-closure could be used for research and education, tourism, and further mineral processing if the mining of ore from the RSF or TSF becomes economic;
• All surfaces would be re-contoured and deep ripped to facilitate natural revegetation;
• Shafts, portals and raise bores would be sealed with pre-cast concrete and soil would be mound
over the concrete seals;
• All surface infrastructure would be removed and recycled, or removed to an appropriate landfill
site; and
• All underground infrastructure would be removed if recyclable, or left in situ.

The DEIS indicated that mine closure would be undertaken in accordance with the BHPB
Corporate Closure Standard and in accordance with the overriding principles of the current Olympic
Dam Rehabilitation and Closure Plan.

4.4.12.2 BHPB EM Program and commitments

BHPB has set the following objective and criteria as part of its Environmental Management
Program (EMP) which is detailed in DEIS Appendix U, ID 1.1:

• **Objective**: No significant adverse impacts to listed threatened species (South Australia,
Northern Territory, Commonwealth) populations in the expansion project area as a result of
BHPB’s construction activities.
• **Criteria**: Not relevant to rehabilitation and closure.
• **Management plan**: BHPB has committed to developing a new Rehabilitation and Closure Plan
that would cover:
  – Pit water quality and quantity;
  – RSF and TSF rehabilitation trials;
  – Characterisation of the mine rock;
  – Optimising revegetation and rehabilitation;
  – Metal uptake by vegetation; and
  – Rehabilitation success.
• **Commitments**:
  – The existing Rehabilitation and Closure Plan for the current Olympic Dam operation would
be updated to include the expanded components of the proposed expansion after the
detailed design phase of the project has been completed. BHPB would continue to consult
and engage with relevant government departments and other stakeholders to further develop
and refine closure criteria, including final land uses, rehabilitation, management and ongoing
monitoring. The Plan would be reviewed annually and updated if required (SEIS Table 2.1
Commitments, page 57);
  – Erosion-control measures would be installed to mitigate the risk of open-pit wall instability
post-closure (SEIS Table 2.1 Commitments, page 57); and
  – Tailings cells would be capped when they reached their target design height, and when it
was safe for vehicles to access the TSF surface (SEIS Table 2.1 Commitments, page 59).

4.4.12.3 Assessment

The AR considers that the relevant receptors for assessing the risks associated with closure
(including post closure) are:

• Human and environmental users of groundwater and surface waters;
• Any remaining residents of the township of Roxby Downs, Hiltaba and Andamooka and
surrounding pastoral areas;
• Flora and fauna of the mine and adjacent areas;
• The landowner (SA Government); and
• The public.
The potential risks for these receptors would broadly involve the following issues:

- Impacts on human and fauna health and safety associated with radiological and chemical emanations (e.g. radon, metals etc) and physical hazards (e.g. dust, voids and faces);
- Contamination of groundwater by leaching/seepage, particularly from the tailings and rock storage facilities;
- Long-term stability, sustainability and erosion of structures and the effects from these factors, such as sediment loading in local watercourses;
- Potential long-term liability for the landowner - and ultimately the public - associated with monitoring and maintenance of the pit, TSF and RSF in perpetuity;
- Long-term ecological sustainability of the site and surrounds; and
- Visual amenity for residents and visitors.

Assessment of risks

In the DEIS (Section 7.5 of Appendix C ) and SEIS (Section 28.1.1) BHPB provided initial information on the anticipated rehabilitation and closure risks for this project, including a risk assessment covering the decommissioning and rehabilitation phase of the operations. Department of Primary Industries and Resources of South Australia (PIRSA) has compared the broad environmental risks associated with the mine closure based on that information, and in accordance with the PIRSA ‘Guidelines for Miners: Preparation of a Mining Lease Proposal or Mining and Rehabilitation Program (MARP) in South Australia’.

The AR considers that the BHPB commitments generally cover the main issues relevant to rehabilitation and closure. As the project develops, additional information will become available to inform the decommissioning, rehabilitation and closure strategies for the project. Additional risk assessment should be undertaken progressively as more information arises. The updated risk assessment should be informed by:

- The likelihood of early, unplanned closure;
- Environmental values to be protected, established with relevant stakeholders. These should drive the development of appropriate closure outcomes and strategies;
- The need to avoid inheritance of any ongoing liability for the mine by the landholder (ultimately the SA Government via the pastoral lease);
- The potentially latent nature of residual impacts post-closure; and
- Expectations that rehabilitation should be undertaken progressively wherever practical.

It is expected that the updated risk assessment would establish clear outcomes for the rehabilitation and closure phases. An outcome is a statement of the acceptable impact on the environment caused by the proposed mining activity, for example ‘No reduction in the quantity and or quality of groundwater for existing users and environmental receptors’.

The AR considers that the anticipated long-term risks posed by the proposed expansion can be managed by BHPB.

Long-term stability of the TSF and RSF

The proposed cover for the TSF would be required to resist degradation from erosion post-closure in order to ensure that the acid-forming and/or radioactive waste materials stored in these facilities would not be exposed and discharged into the receiving environment at a rate that would cause unacceptable impact.
The SEIS detailed:

- Natural rates of erosion for the proposed capping material;
- The climatic environment at Olympic Dam and the general lack of erosion from the existing 20 year old TSF; and
- Calculations of erosion rates, capping depths and timeframes.

The SEIS referred to the 9758Mt of overburden material to be mined from the proposed open pit that would become available for constructing a cap over the 4000ha TSF, at an assumed thickness of 10m. On the basis of the likely broken density of 2 t/m³ there would be more than adequate quantities of suitable material to construct a cap designed to ensure long-term coverage of the surface of the TSF.

Information concerning rates of erosion under various climatic conditions and a simple estimation of the time taken for a 10m cap of quartz to erode were also provided in the SEIS. The indicative erosion rate information used by BHPB was sourced from other literature and not from test work carried out on specific rock material from Olympic Dam.

The AR considers the long-term erosional stability of the TSF and RSF, to ensure that the encapsulation strategy is effective, should be informed by further modelling as closure planning proceeds.

Financial assurance for rehabilitation

BHPB should note that the SA Government will require, through the Indenture legislation, a rehabilitation bond or similar financial assurance to ensure the Mine Rehabilitation and Closure Plan liability is not passed to the landholder - ultimately the SA Government - following closure of the mine and associated project components.

The AR concludes that the potential long term risks associated with closure and rehabilitation have been adequately understood and can be managed through the application of best practice rehabilitation methods. Further refinement and updating of the post closure risk assessment and development of a detailed mine closure plan is needed as the project progresses to ensure that rehabilitation success can be demonstrated and that no long term liabilities for the community are created.

RECOMMENDATION

The AR recommends the following conditions.

- The proponent must develop and submit to the Indenture Minister for approval a Mine Closure and Rehabilitation Plan within 2 years from the date of this decision, or prior to construction of the TSF, whichever date is the earliest. The plan must:
  - Include a set of environmental outcomes that are anticipated to be able to be achieved indefinitely post mine closure. An outcome is a statement of the acceptable impact on the environment caused by the proposed mining activity;
  - Include assessment criteria that are clear and unambiguous and are specific to the achievement of the agreed environmental outcomes and should include:
    - Specific parameters to be measured and monitored;
    - Specification of the locations where the parameters will be measured, or how these locations will be determined;
    - Clear statement of the acceptable values for demonstrating achievement of the outcome, with consideration of any inherent errors of measurement;
    - The frequency of monitoring; and
    - Identification of what background or control data is to be used or specifying how these will be acquired if necessary.
Include an updated risk assessment of the project developed in consultation with relevant stakeholders, to determine the long-term risk to the public and the environment from the mining and processing operations, tailings storage facility and rock storage facility, including radioactive emissions. The updated risk assessment must inform the potential environmental outcomes that can be achieved indefinitely post mine closure, must consider the potential for and impacts resulting from early, unplanned closure or suspension of operations and demonstrate that all practical options for progressive rehabilitation have been addressed.

- The proponent must implement the approved Mine Closure and Rehabilitation Plan.
- The proponent must review the Mine Closure and Rehabilitation Plan as required by the Indenture Minister.

The AR also recommends the following notes to BHPB:

- The existing TSF Cells 1, 2 and 3 closures should be used to conduct long-term (decades) testing of seepage rate decline, modelled rehabilitation structures, and processes.
- The existing TSF Cells 1, 2 and 3 should be used as a test bed for closure assessment to evaluate identified risks including, water infiltration, slope erosion and wind scour processes.
- During operation the proponent should undertake site trials of the preferred covers that have been determined from the modelling on the completed Tailings storage facility Cell 1-3 of the existing operations in accordance with a program detailed in the approved Closure and Rehabilitation Plan.

### 4.4.13 Environmental management

#### 4.4.13.1 Issues

Issues related to environmental management for the proposed expansion relate to whether:

- Appropriate environmental values been established for the project through a consultation process with relevant stakeholders;
- Residual risks have been appropriately determined;
- The outcomes/objectives for the identified environmental impacts are reasonable and achievable, are acceptable to relevant stakeholders, and meet applicable legislative requirements;
- Clear and measurable assessment criteria to demonstrate the achievement of outcomes have been defined; and
- The management and monitoring programs have been developed on the basis of the outcomes and assessment criteria.

#### 4.4.13.2 BHPB EM Program and commitments

The DEIS Appendix U provided an outline of the proposed Environmental Management Program for all activities relevant to the proposed expansion, which included:

- A description of the ‘Objectives’ (or outcomes) relating to the environmental values;
- ‘Assessment criteria’; and
- ‘Management plans’.
These have been based on the Environmental Management Program for the existing operations. Further, BHPB indicated in the EIS that it currently implements an Environmental Management System (EMS) that is ISO 14001 certified. The EMS would be revised and updated to incorporate the proposed expansion components, outcomes of the environmental impact assessment, its commitments and approval conditions.

BHPB indicated that a number of environmental management plans would need to be prepared as final planning for the project occurred and in advance of construction (DEIS Section 24.4.2 and Table 24.1). This information was re-iterated in the SEIS Section 29.8.

Table 2.1 in the SEIS provides a consolidated list of conditions.

4.4.13.3 Assessment

The current requirements for environmental management of the Olympic Dam operations are governed by the Olympic Dam Indenture, a schedule to the *Roxby Downs (Indenture Ratification) Act 1982* (the Indenture). In particular, Clause 11 of the Indenture requires BHPB to prepare a program for the protection, management and rehabilitation of the environment every three years and annual reporting.

For the current underground operation, BHPB has established an Environment Protection and Management Program (EPMP) as the Program to comply with Clause 11. The EPMP comprises the Environmental Manual, Environmental Management Program and Monitoring Program.

The EPMP is prepared by BHPB and reviewed by SA Government agencies every three years. The Indenture Minister can:

- Approve the EPMP as submitted by BHPB; or
- Refuse to approve the EPMP; or
- Approve the EPMP with conditions.

Clause 11 does not provide details of:

- What should be included in the program;
- Provisions for enforcing compliance with the program;
- Any requirement for independent audits; and
- The requirements for public release of the program and annual reports.

The AR considers that a new program for the proposed expansion must include agreed environmental outcomes and assessment criteria. The assessment criteria must be clear, unambiguous and specific to demonstrate achievement of the agreed outcomes and should include:

- Specific parameters to be measured and monitored;
- Specification of the locations where the parameters will be measured, or how these locations will be determined;
- Clear statement of the acceptable values for demonstrating achievement of the outcome, with consideration of any inherent errors of measurement;
- The frequency of monitoring; and
- Identification of what background or control data is to be used or specifying how these will be acquired if necessary.
It is important that any monitoring program indicates:

- What will be measured, the accuracy of measurements if applicable and who will be responsible for them;
- Where will it be measured - including controls and baseline - and how;
- Frequency of measurement;
- Record keeping; and
- Frequency of reporting to external stakeholders.

An outline of BHPB’s proposed Environmental Management Program for all activities relevant to the proposed expansion was provided in the DEIS Appendix U. The SEIS indicated that management programs and monitoring plans are being developed to manage the environmental aspects and potential impacts for the various components of the project. BHPB has provided a list of management plans and monitoring programs that would be developed, should the project be approved. In addition, the SEIS provided examples of interim draft management plans for some of the components of the project. In the main these indicated BHPB’s intent and framework for establishing the relevant plans.

**RECOMMENDATION**

The AR recommends the following condition:

- The proponent must prepare an Environment Protection Management Program (EPMP), in accordance with Clause 11 of the Indenture, for approval by the Indenture Minister and must include the following:
  - The scope of the area and proposed operations covered by the EPMP;
  - Environmental outcomes relating to potential environmental impacts;
  - Compliance criteria, to demonstrate the clear and unambiguous achievement of the environmental outcomes;
  - Leading indicator criteria to provide an early warning that compliance criteria may not be met;
  - Target criteria to reflect a level of impact that is as low as reasonably achievable;
  - The specific parameters to be measured and monitored;
  - Information about the strategies and other measures BHPB intends to implement to achieve the outcomes or to investigate and respond to any non-compliance with the compliance, leading indicator, or target criteria, without limiting the measures that may be implemented to those specified in the plan;
  - Information on BHPB’s management systems that will be relied upon to ensure compliance with the compliance criteria, leading indicator criteria, and target criteria;
  - Protocols for reporting to the Indenture Minister any non-compliance with the compliance criteria as soon the approval holder becomes aware of the non-compliance; and
  - Any other specific obligations and management or monitoring plans specified by these conditions or required by other State legislation.

- All criteria in the EPMP must specify:
  - The specific parameters to be measured and monitored;
  - The locations at which monitoring will take place, or how these locations will be determined;
  - The acceptable values for demonstrating achievement of the outcome, with consideration of any inherent errors of measurement;
  - The frequency of monitoring or how it will be determined; and
  - The baseline or control data to be used or how it will be acquired (if necessary).

- The proponent must prepare an annual environmental management and monitoring report, in accordance with Clause 11 of the Indenture, for public release to report on compliance with the EPMP.

- The proponent must implement the approved EPMP.
The AR recommends the following general notes:

▪ The proponent is reminded of its general environmental duty, as required by Section 25 of the *Environment Protection Act 1993*, to take all reasonable and practical measures to ensure that the activities associated with the construction and operation of the mine and mineral processing facilities do not pollute the environment in a way that causes or may cause environmental harm.

▪ An environmental authorisation in the form of a licence issued under the *Environment Protection Act 1993* is required for the operation of the open cut mine, rock storage facility, metallurgical plant and tailings storage facility components of the project approved via this notice. The proponent is advised to contact the EPA before acting on this approval to ascertain licensing requirements.

▪ The following activities are likely to require a licence under the *Environment Protection Act 1993* in relation to the components of the development application hereby approved and/or requiring future approval:
  – Chemical storage and warehousing facilities;
  – Chemical works – inorganic;
  – Petroleum production, storage or processing works of facilities;
  – Abrasive blasting;
  – Concrete batching works;
  – Ferrous and non-ferrous metal melting;
  – Metallurgical works;
  – Mineral works;
  – Waste or recycling depot;
  – Activities producing listed wastes;
  – Crushing, grinding or milling: rock, ores or minerals;
  – Fuel burning: rate of heat release exceeding 5 megawatts;
  – Extractive industry;
  – Sewage treatment works; and
  – Fuel burning.

▪ As many of the above activities are listed on the current licence under the *Environment Protection Act 1993* for BHPB’s operations at Olympic Dam, BHPB should contact the EPA to ensure that the current licence is appropriately amended to reflect any additional activities and/or expansion of existing activities prior to such activities commencing operation.

▪ The proponent is reminded of its notification requirements pursuant to section 83 of the *Environment Protection Act 1993* if serious or material environmental harm from pollution is caused or threatened in the course of an activity.

▪ The proponent is also reminded of its notification requirements pursuant to section 83A of the *Environment Protection Act 1993*, if the proponent becomes aware of the existence of site contamination at the site or in the vicinity of the site (whether arising before or after the commencement of this section) that affects or threatens water occurring naturally under the ground or introduced to an aquifer or other area under the ground.

▪ If polluted soils and/or groundwater are identified at the site during the detailed design or construction stage, then an assessment must be carried out by a suitably qualified and experienced environmental consultant to ensure that the site is suitable for the proposed use. Any such assessment must be undertaken in accordance with Schedules A and B of the *National Environment Protection (Assessment of Site Contamination) Measure 1999*. The assessment must be in a form of an environmental assessment report and include a definitive statement that the site is suitable for the proposed use.