Contents

1 \textbf{PURPOSE} .................................................................................................................. 3

2 \textbf{SCOPE} ....................................................................................................................... 3

\hspace{0.5em} 2.1 Groundwater ........................................................................................................ 3
\hspace{0.5em} 2.2 Responsible ODC personnel ............................................................................... 5
\hspace{0.5em} 2.3 Review and modification ....................................................................................... 6

3 \textbf{DETAILED PROCEDURE} .......................................................................................... 7

\hspace{0.5em} 3.1 Groundwater abstraction and mine water balance ............................................. 7
\hspace{1em} 3.1.1 Background ........................................................................................................... 7
\hspace{1em} 3.1.2 Purpose .................................................................................................................. 7
\hspace{1em} 3.1.3 Deliverable(s) ........................................................................................................ 7
\hspace{1em} 3.1.4 Method ................................................................................................................... 7
\hspace{0.5em} 3.2 Groundwater level ...................................................................................................... 8
\hspace{1em} 3.2.1 Background ............................................................................................................ 8
\hspace{1em} 3.2.2 Purpose .................................................................................................................. 8
\hspace{1em} 3.2.3 Deliverable(s) ........................................................................................................ 8
\hspace{1em} 3.2.4 Method ................................................................................................................... 8
\hspace{0.5em} 3.3 Groundwater Quality ................................................................................................ 9
\hspace{1em} 3.3.1 Background ........................................................................................................... 9
\hspace{1em} 3.3.2 Purpose .................................................................................................................. 9
\hspace{1em} 3.3.3 Deliverable(s) ........................................................................................................ 9
\hspace{1em} 3.3.4 Method ................................................................................................................... 9
\hspace{0.5em} 3.4 Use of local groundwater for dust suppression ....................................................... 9
\hspace{1em} 3.4.1 Background ............................................................................................................ 9
\hspace{1em} 3.4.2 Purpose .................................................................................................................. 10
\hspace{1em} 3.4.3 Deliverable(s) ........................................................................................................ 10
\hspace{1em} 3.4.4 Method ................................................................................................................... 10

4 \textbf{COMMITMENTS} ......................................................................................................... 11

\hspace{0.5em} 4.1 Reporting ................................................................................................................ 11
\hspace{0.5em} 4.2 Summary of commitments ...................................................................................... 11

5 \textbf{DEFINITIONS AND REFERENCES} ............................................................................ 11

\hspace{0.5em} 5.1 Definitions ................................................................................................................ 11
\hspace{0.5em} 5.2 References ................................................................................................................ 11
\hspace{0.5em} 5.3 Bibliography ............................................................................................................... 12

6 \textbf{APPENDIX A: LOCATION PLANS AND GROUNDWATER BORE MONITORING FREQUENCY} \hspace{0.5em} 13

\hspace{0.5em} 6.1 Olympic Dam existing operations ............................................................................. 13

Uncontrolled when printed
1 Purpose

This document supports *IMS Element 8: Environment Standard, Doc No 012513194*

2 Scope

This Monitoring Program (MP) describes the environmental monitoring activities undertaken by BHP Olympic Dam Corporation Pty Ltd (ODC) for the purpose of quantifying any change in the extent or significance of impacts of ODC’s operations on groundwater, assessing the performance of the control measures employed to limit these impacts, and to meet relevant legal and other requirements.

This MP addresses a number of distinct elements of groundwater monitoring. For each element, the MP sets out background information, the purpose of the monitoring and the deliverables which are produced as a result of the monitoring. The MP also includes a description of the methods for measuring achievement of compliance criteria and the movement of trends towards leading indicators (where applicable).

The groundwater monitoring described in this MP relates solely to groundwater in the Olympic Dam region and Stuart Shelf (radius of approximately 85 kilometres (km)).

Groundwater monitoring relating to the Great Artesian Basin, approximately 100 km north of the Olympic Dam operation, is discussed in the *Monitoring Program - Great Artesian Basin (GAB), Doc No. 000036081*.

2.1 Groundwater

There are two important groundwater systems in the Stuart Shelf: the Andamooka Limestone aquifer and the Tent Hill aquifer. These form the overlying cover sequence at Olympic Dam and consist of Cambrian shale and limestone, and Late Proterozoic quartzite, sandstone and shale members, mostly of very low permeability. A schematic cross-section of these units as they occur beneath the current operation is shown in Figure 2-1 and regionally in Figure 2-2.

The upper Andamooka Limestone aquifer is the shallowest of the aquifers in the Stuart Shelf and forms the regional ‘water table’ aquifer north of Olympic Dam. The water table typically occurs about 50 metres (m) below ground (equating to 50 m Australian Height Datum (AHD)), with groundwater in the aquifer moving from west of the Stuart Shelf to the northern end of Lake Torrens, where the water table typically occurs less than 10 m below ground. Groundwater salinity is typically in the range of 20,000 to 60,000 milligram per litre (mg/L) on the Special Mining Lease (SML), increasing to as much as 200,000 mg/L closer to Lake Torrens. For comparison, seawater salinity is generally around 35,000 mg/L.

The Tent Hill aquifer (THA) is regionally extensive and is the most important aquifer within the southern portion of the Stuart Shelf, where the Andamooka Limestone aquifer is either very thin or absent. The THA includes the lower fractured portions of the Arcoona Quartzite and the underlying Corraberra Sandstone units of the Tent Hill Formation and is therefore sometimes referred to as the Arcoona Quartzite aquifer or the Corraberra Sandstone aquifer. The occurrence of this aquifer reduces north of the SML due to a deepening of the unit and associated reduction in permeability.

At Olympic Dam, the Tent Hill aquifer typically occurs 160 to 200 m below ground level (about -60 mAHD to -100 mAHD). The depth increases moderately to the north, west and south, with the base of the unit around 225 m below ground level (-125 mAHD) near the existing underground mine and more than 400 m below ground level (-300 mAHD) north of Olympic Dam.

Groundwater salinity in the Tent Hill aquifer is generally higher than in the Andamooka Limestone aquifer, with reported concentrations ranging from about 35,000 to more than 100,000 mg/L in the vicinity of Olympic Dam, and ranging to around 200,000 mg/L closer to Lake Torrens.

The upper section of the Arcoona Quartzite unit forms a regional aquitard. This is a low permeability layer that restricts the movement of groundwater between the Andamooka Limestone and Tent Hill aquifers.

The aim of this program is to manage the *environmental impacts* on groundwater associated with the existing surface and underground facilities by:
• Assessing the magnitude of groundwater abstraction and groundwater discharge into the mine, and determining the mine water balance;
• Determining the changes in groundwater levels for both aquifers across site, particularly in the vicinity of the Tailings Storage Facility (TSF) and the mine water evaporation pond;
• Determining any changes in radionuclide concentrations in groundwater;
• Identifying possible changes in groundwater chemistry that may occur.

To meet these objectives, data are collected on the local aquifers, and a monitoring program is conducted to measure groundwater levels and chemistry across site and regionally.

Figure 2-1: Simplified geological cross-section beneath the existing operations
2.2 Responsible ODC personnel

The Olympic Dam Asset President is responsible for ensuring that all legal and other requirements described in the Groundwater MP are met.

ODC employs an environmental scientist and sufficient other staff with experience and qualifications to fulfil the requirements of the Groundwater MP.
2.3 Review and modification

This MP is reviewed annually. Major changes or amendments following the review are documented in the EM Program Annual Targets, Actions and Major Changes document.

It should be noted that as a result of operational activities or through optimisation of sample design some existing monitoring sites may be lost and others added (where possible) to maintain the integrity of the sampling program. Access restrictions due to operational activities can result in some sites occasionally being unable to be monitored.
3 DETAILED PROCEDURE

Groundwater related data have been collected by ODC for over 30 years in the vicinity of Olympic Dam. The data provide baseline information to aid in the understanding of the natural systems. Data continue to be collected according to the schedules in section 6.

3.1 Groundwater abstraction and mine water balance

3.1.1 Background

ODC abstracts groundwater from the Andamooka Limestone and Tent Hill aquifer systems within the SML. The shallow Andamooka Limestone is completely dewatered in the underground mine area with inflows into the underground mine only from the deeper Tent Hill aquifer. In the TSF area and around the process plant there is considerable saturated thickness in the limestone due to seepage-induced mounding. Local groundwater is used primarily for dust suppression, construction work, underground mining operations and in the Backfill Plant.

Current water supply facilities include:

- Saline wellfields, comprising multiple bores which intersect a high-permeability area of the Tent Hill aquifer;
- Underground mine dewatering, primarily from the Tent Hill aquifer;
- Production bore LP2 located north of the TSF (adjacent to LT2), and the TSF5 dewatering system (located on the eastern wall of TSF5) producing from the TSF seepage mound in the Andamooka Limestone aquifer.

3.1.2 Purpose

- Derive a total groundwater extraction number for the mine area, as the basis for impact assessment.
- Monitor abstraction rates from all saline water supply sources.
- Maintain an understanding of the mine saline water balance through measurement, derivation or estimation of key parameters.
- Estimate groundwater discharge to the underground mine workings.

3.1.3 Deliverable(s)

- A review of abstraction rates and trends, and an assessment with respect to groundwater levels.
- A definition and map of the underground mine water balance.
- An estimate of the volume of groundwater discharge to underground.

3.1.4 Method

The following monitoring and recording is undertaken in relation to groundwater:

- Average daily abstraction (ML/d) from minor saline wellfields and bores.
- Total monthly abstraction (ML/d) from all groundwater abstraction sources.
- The abstraction rates are recorded in an on-site database for analysis and reporting.
- The mine water balance is calculated annually from a combination of measured, derived and estimated data. (EPA 1301.U-518).
3.2 Groundwater level

3.2.1 Background

Underground mine dewatering and seepage from surface facilities has resulted in altered groundwater levels in both the Andamooka Limestone and Tent Hill aquifers. Pre-mining, the potentiometric surface was approximately 50 m below the surface. Changes in groundwater levels due to mining activity are shown conceptually in Figure 2-1.

In the centre of the mine area, groundwater is constantly being depleted in both aquifers, creating a cone of drawdown which extends for approximately 5 km in the Tent Hill aquifer and approximately the same distance to the north, south and east in the Andamooka Limestone aquifer.

To the west, seepage from the TSF has created a groundwater mound in the Andamooka Limestone aquifer which has risen to a maximum height of approximately 30 m below the ground surface. The mound changed very little over extended periods, i.e. years, because of the low transmissivity in the limestone aquifer, limited hydrogeological interconnection to the Tent Hill aquifer and the limited number of man-made interconnections (exploration drill holes, ventilation shafts etc.). Abstraction from production bore LP2 since January 2000 has reduced the groundwater mound. Commissioning approval for TSF Cell 4 and Construction approval for TSF Cell 5 requires BHP Olympic Dam to ensure that groundwater levels do not rise above 80 m AHD (20 m below ground level). Note: The same groundwater level criteria will be adopted for TSF 6 post-commissioning. A contingency plan nominates remedial action that can be undertaken if required in future (BHP Billiton 2011).

The groundwater has no natural surface expression in the vicinity of the Olympic Dam operation, and is at sufficient depth as to not adversely affect native vegetation.

3.2.2 Purpose

- Define the extent of groundwater level changes that have resulted from Olympic Dam’s activities.
- Provide information that can be used to regulate the volume of abstraction from pumping wells near the TSF, in order to maintain groundwater levels in the region of the TSF to below a level at which native vegetation could be affected.

3.2.3 Deliverable(s)

- A review of the trends in local and regional groundwater levels and a comparison with historical groundwater levels.
- Data showing the tracking of trends towards leading indicators for groundwater impacts, and triggering an alert to management when levels approach the leading indicators.

3.2.4 Method

Groundwater levels are monitored annually, utilising a network of exploration and groundwater monitoring bores in both the Andamooka Limestone and Tent Hill aquifers (see section 6 – Appendix A).

Local groundwater levels are monitored at or adjacent the existing and expanded TSF, backfill limestone quarry and underground mine. Regional groundwater levels are monitored at locations on the Stuart Shelf outside the SML.

If for some reason a groundwater level cannot be obtained (e.g. blocked bore), the nearest suitable bore will be located and monitored if appropriate. Olympic Dam will maintain sufficient monitoring bores to satisfy the requirements for monitoring of groundwater levels around the TRS.

Groundwater levels at regional wells are used to infer any impact to third-party wells. To confirm a stable baseline groundwater level, the frequency of monitoring of regional wells in the vicinity of the Motherwell wellfield will be increased 12 months prior to commissioning of the wellfield. Regional monitoring frequency will also be increased in response to a propagating pattern of change in groundwater levels that may occur as a result of other groundwater affecting activities.

The groundwater levels are recorded in a database for subsequent analysis and reporting.
3.3 Groundwater Quality
(MC 2.8.2(e))

3.3.1 Background
Groundwater in the vicinity of the operation is of poor quality and, as defined by Environment Protection (Water Quality) Policy 2015, ANZECC (2000), is not suitable for supporting the environmental value categories (aquatic ecosystems; recreation and aesthetics; drinking supply; primary industry). Local groundwater is also unsuitable for ore processing at Olympic Dam.

Modification of local groundwater, such as through desalination, is not beneficial to the current mineral processing requirements at Olympic Dam. The use of local groundwater has been limited to dust suppression, soil conditioning during construction and some underground drilling activities.

Analysis of seepage from the base of the existing TSF has shown that it undergoes a process of in-situ neutralisation and attenuation as it passes through the upper layers of the Andamooka Limestone. Groundwater chemistry around the TSF is similar to the regional groundwater chemistry, with the exception of slightly increased uranium concentrations and slightly reduced pH. Effects on groundwater quality as a result of the expanded TSF are expected to be similar. ODC has been granted an exemption from certain requirements of the Environment Protection Act 1993 (specifically clause 10 of the Environment Protection (Water Quality) Policy 2015). The exemption pertains and applies to an attenuation zone roughly equivalent to the expanded SML.

3.3.2 Purpose
• Quantify any possible impacts of seepage from the TSF and mine water evaporation pond.

3.3.3 Deliverable(s)
• A review of trends in groundwater quality and a comparison to ANZECC criteria.

3.3.4 Method
Aquifer-specific monitoring bores (see Appendix A – Table 6-1) are pumped or bailed in order to obtain a representative groundwater sample for quality analysis. The samples are analysed for the following analytes (samples are filtered prior to metals analysis):
• TDS, pH, calcium, chloride, copper, iron, manganese, sulphate, uranium and vanadium (LT wells only).

In addition, samples from monitoring bores listed in Table 5.1 will be analysed for the following radionuclides:
• $^{238}\text{U}$, $^{226}\text{Ra}$, $^{230}\text{Th}$, $^{210}\text{Pb}$ and $^{210}\text{Po}$.

If for some reason a groundwater sample cannot be obtained (e.g. blocked bore), the nearest suitable bore is located and sampled if appropriate. Groundwater quality at regional wells is used to infer any impact to third-party wells.

3.4 Use of local groundwater for dust suppression
(MC 2.8.2(e))

3.4.1 Background
Sources of local groundwater are used around site for watering of roads to suppress dust. This may include water obtained from the mine as a result of underground mine dewatering or extracted from ventilation fan outflow, which may have elevated radionuclide content relative to other local groundwater sources. As noted in section 3.3, local groundwater is of very low quality and is unsuitable for other industrial or environmental uses. Radionuclide concentrations in locally sourced groundwater used for road watering are monitored annually.

Upper limits for radionuclide content are shown in Table 3-1, below.
Table 3-1: Upper limits for radionuclide content

<table>
<thead>
<tr>
<th>Radionuclide</th>
<th>Upper limit (Bq/L)</th>
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<td>$^{238}\text{U}$</td>
<td>50</td>
</tr>
<tr>
<td>$^{226}\text{Ra}$</td>
<td>5</td>
</tr>
</tbody>
</table>

3.4.2 Purpose
- Monitor sources of local groundwater used for road watering.
- Ensure negligible long-term effects from the release of mine water.

3.4.3 Deliverable(s)
- Data demonstrating that radionuclide concentrations are below upper limits.
- A review of results and provision for increased monitoring frequency where concentrations are trending towards upper limits.

3.4.4 Method
Sources of local groundwater used for dust suppression, including raise bore ponds and storage dams, are sampled at least once a year and checked for radionuclide concentrations. Where readings for a source are close to or above upper limits, additional monitoring will be conducted more frequently. Use of water from a source found to exceed the limit will cease until the radiation level has been found to have dropped below that limit.
4 COMMITMENTS

4.1 Reporting

The results and a discussion of the results are presented in the Annual EPMP Report as outlined in the Environmental Management Manual (EMM).

4.2 Summary of commitments

Table 4-1: Summary of commitments

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<th>Action</th>
<th>Parameter</th>
<th>Frequency</th>
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<td>Monitor</td>
<td>Groundwater abstraction and mine water balance</td>
<td>Daily-monthly</td>
</tr>
<tr>
<td>Monitor</td>
<td>Groundwater level – Andamooka Limestone and Tent Hill aquifers</td>
<td>As per Table 6-1</td>
</tr>
<tr>
<td>Monitor</td>
<td>Groundwater quality – Andamooka Limestone and Tent Hill aquifers</td>
<td>As per Table 6-1</td>
</tr>
<tr>
<td>Monitor</td>
<td>Quality of mine water used for dust suppression</td>
<td>Annual</td>
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<tr>
<td>Employ</td>
<td>An environmental scientist to undertake the requirements of the Groundwater MP</td>
<td>Ongoing</td>
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<td>Report</td>
<td>Monitoring results in the Annual EPMP Report to the Indenture Minister</td>
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<tr>
<td>Review</td>
<td>The Groundwater MP and modify as appropriate</td>
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5 DEFINITIONS AND REFERENCES

5.1 Definitions

Throughout the EPMP some terms are taken to have specific meaning. These are indicated in bold text in the documentation and are defined in the glossary in section 3 of the EMM. Defined terms have the same meaning wherever they appear in bold text. Some other terms and acronyms are also defined in the glossary, but do not appear in bold text.

5.2 References


BHP Billiton 2011, Olympic Dam Expansion Supplementary Environmental Impact Statement 2011, BHP Billiton, Adelaide, SA.

BHP Billiton Olympic Dam 2011, ‘Contingency measures and response plan for addressing unexpected groundwater level increase below the Olympic Dam Tailings Storage Facility (TSF) Cells 4 and 5, Report ODENV030’.

Environment Protection (Water Quality) Policy 2015 and Explanatory Report, Environment Protection Authority (SA)
5.3 Bibliography

Kinhill Engineers Pty Ltd 1997, 'Olympic Dam Expansion Project Environmental Impact Statement'.


Radiation Protection and Control Act 2021.


## APPENDIX A: LOCATION PLANS AND GROUNDWATER BORE MONITORING FREQUENCY

### 6.1 Olympic Dam existing operations

Table 6-1: Groundwater monitoring bores and frequency

<table>
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LT – Andamooka Limestone aquifer monitoring bore in the tailings area  
LM – Andamooka Limestone aquifer monitoring bore in the mine or metallurgical plant area  
LR – Andamooka Limestone aquifer monitoring bore in the region  
QT – Arcoona Quartzite aquifer (Tent Hill aquifer) monitoring bore in the tailings area  
QR / PT – Arcoona Quartzite aquifer (Tent Hill aquifer) monitoring bore in the region  
RD – Roxby Downs exploration drillhole not aquifer specific  
Figure 6-1: Key mine area monitoring bore locations
Figure 6-2: Local area groundwater monitoring bore locations