11 SURFACE WATER

11.1 SURFACE WATER MANAGEMENT

11.1.1 STORMWATER REUSE

Issue:

Clarification was sought about the potential for stormwater capture and reuse of grey water in Roxby Downs and reserves.

Submission: 9

Response:

Stormwater and wastewater (including grey water) would be collected, treated and reused, which in turn would conserve potable water.

As outlined in Section 11.5.1 of the Draft EIS and the Roxby Downs Draft Master Plan (refer Appendix F4 of the Draft EIS), new drainage networks and stormwater retention basins would be built to capture stormwater flows for treatment and reuse where appropriate. The Roxby Downs Draft Master Plan specifies that the design of the expanded town would be engineered to enable wastewater to be responsibly stored and reused wherever practicable, taking into consideration allowance for the population of Hiltaba Village. The proposed design also includes allowance for an additional reticulation network to distribute treated wastewater to selected irrigation sites, including adjacent public reserves, sports grounds, the golf course and Olympic Way landscaping.

11.1.2 MANAGEMENT

Issue:

Clarification was sought on the proposed management plan for potential accidental spills and resultant contaminated soils outside bunded areas.

Submission: 1

Response:

As discussed in Sections 10.5.4 and 11.5.2 of the Draft EIS, the risk of soil and surface water contamination from spills and leaks outside bunded areas is low due to the provision of appropriate bunding around chemical storages and the predominantly low topographic relief, leading to little to no lateral movement of contaminants.

Consistent with industry best practice, BHP Billiton has also committed to the more stringent design capacities specified by the South Australian EPA Guidelines for bunding, and therefore the size and volume of bunds would be 120% of the net capacity of the largest tank and 133% of the net capacity of tanks of flammable material (as per SA EPA Guideline 080/07).

As part of contingency management, all parts of the expanded operation would undergo hazard and operability (HAZOP) reviews to identify the potential for spills and the likelihood of spillages. A draft environmental management plan for chemical/hydrocarbon spillage was included in Appendix U of the Draft EIS. As outlined in Draft EMP ID 2.1 Chemical/Hydrocarbon Spillage, the current operation's spill management and reporting procedure would be extended to apply to the expanded operation.

The spillage of process materials and products is treated seriously by BHP Billiton and systems and procedures are in place to ensure that spills are identified, reported, cleaned up and investigated to prevent recurrence. In the event of a spillage, a number of controls are available for operational personnel to contain the spill, including temporary bunds and spill kits, which operational and emergency response personnel are trained to use. The lack of permanent flowing creeks or rivers in the project area provides BHP Billiton with confidence that accidental spills, should they occur outside a bunded area, would be contained and remediated before reaching ephemeral waterways or significant receiving environments.

11.2 ROCK STORAGE FACILITY

11.2.1 MODELLING OF RUN-OFF WATER FLOW AND QUALITY

Issue:

Further information was requested to characterise the water quality and management of potential run-off from the rock storage facility (RSF) and low-grade ore stockpile (LGS), during operation and closure. This information was requested to aid the interpretation of potential impacts on ecosystems in the surrounding swales and to assess the effectiveness of proposed management measures.

Submissions: 1, 2, 13 and 71

Response:

In response to these submissions, more detailed assessments of the quality of run-off water for the RSF and the LGS have been undertaken since the Draft EIS was published. The findings of the run-off water quality assessment are provided in Appendix E1 of the Supplementary EIS, and summarised in the discussion below and in Tables 11.1 to 11.7.

The physical parameters expected to affect run-off quantity include the physical properties of the exposed rock pile surfaces (e.g. particle size, permeability and matric suction) and the magnitude of the rainfall event. The factors expected to affect water quality include the type and area of rock exposed, evaporation and depth of influence (resulting in a reversal in water flows to the surface that would lead to the net transport of salts to the soil surface), rate of weathering and solute release, the duration of exposure before it is covered by the next layer of material, the period of accumulation or weathering between run-off events, and water quality. Estimates of the run-off water quality that may occur during the operational phase were based on the development schedules of the RSF and LGS, utilising the rock storage facility and low-grade ore production schedules. At closure, the outer surfaces of these facilities would be materials sourced from the overburden sequence, and this was considered when estimating the post-closure run-off water quality, as discussed below.

The proposed schedule for ore production and lithological surface exposure of the RSF and LGS were developed and considered in this assessment (see Section 3.1 of Appendix E1 of the Supplementary EIS for details). The detail on the design of the RSF was also discussed in Section 5.4.6 of the Draft EIS and considered further in Section 5.2 of the Supplementary EIS. The timing of the extraction and placement of class A, B, C and D mine rock, including exposure and encapsulation of the reactive material, was also discussed in Section 5.2 of the Supplementary EIS. The placement schedule for the different rock units has been further developed since the Draft EIS was published and is also discussed further in Section 5.2 of the Supplementary EIS.

A key outcome of the assessment was that run-off would not occur from all material types under all conditions. For example, the sand and Andamooka Limestone (ZAL) materials would be expected to generate run-off fairly readily, with run-off occurring for an event with a one-year return period. The peak run-off would occur for the two-hour duration event, whereas the highest concentrations would occur for a five-minute event (i.e. 0.083-hour event). The Tregolana Shale and sandstone materials on the other hand would be least likely to generate run-off and would require a 1-in-100-year event before any run-off would be generated. It is therefore apparent that the type of material exposed at the surface of the RSF and the LGS would dictate the possibility of run-off occurring in the first instance, and also the volume of run-off that would occur. To improve the confidence in the assessment undertaken, a range analysis was performed whereby two cases were evaluated. Case 1 considered low run-off conditions, whereas Case 2 considered conditions that could lead to high run-off volumes. It is important to note, however, that the highest solute concentrations would occur for the lowest flow run-off occurrences.

The detailed assessment concluded that events that realistically could generate run-off that would be released from the RSF and the LGS surface during the operational period would have a relatively low probability of occurring. Post-closure, after potentially reactive materials (i.e. class A and B material) were progressively encapsulated during construction by about 1 m or more of benign material (i.e. class C and/or D material), the water quality in the run-off would be expected to become progressively cleaner after the first flush and background concentrations would be re-established.

The results are summarised below for the RSF and the LGS, respectively. The results are presented first for the operational period and then for the post-closure conditions.

RSF Case 1 – Low run-off conditions

The volume of run-off that could be generated throughout the life of the RSF was estimated from the area of exposure of each rock type and adding together the flows from each area to provide the sum total flow from the RSF. The results are illustrated in Figures 11.1 and 11.2, for the short- and longer-duration events respectively. Note that for the short-duration events (0.083 hours or five minutes) with a return period of less than 1 in 5 years, no run-off would occur. For the longer-duration events (two hours), run-off would not be expected for events with a return period of less than 1 in 20 years.

As shown in Figures 11.1 and 11.2, while the very short-duration events may generate run-off for the shorter return periods, the total volume of water that would be generated is very small. For example, the run-off generated by a 1-in-100-year storm event lasting five minutes would be less than 700,000 m³ at the end of the RSF life, when its footprint area would be at a maximum. The total rainfall that would occur during such an event (1-in-100-year – 0.083-hour storm) is only about 17 mm, for which only a part of the RSF would yield run-off. It should be noted that a rainfall intensity of 204 mm/h was stated in Table 8.2 of the Draft EIS, however the total rainfall of 17 mm for the same event is the rainfall intensity (204 mm/h) multiplied by the duration of the event (0.083 h). Therefore, very little run-off would actually be expected to occur due to surface undulations, local ponding and attenuation. Note that in the Draft EIS the run-off was estimated using a fixed run-off coefficient of 0.75 for all materials to be placed in the RSF; as indicated by the modelling, the actual run-off is predicted to vary by material and rainfall intensity and duration. The Draft EIS therefore overestimates the modelled run-off that would be expected to occur.

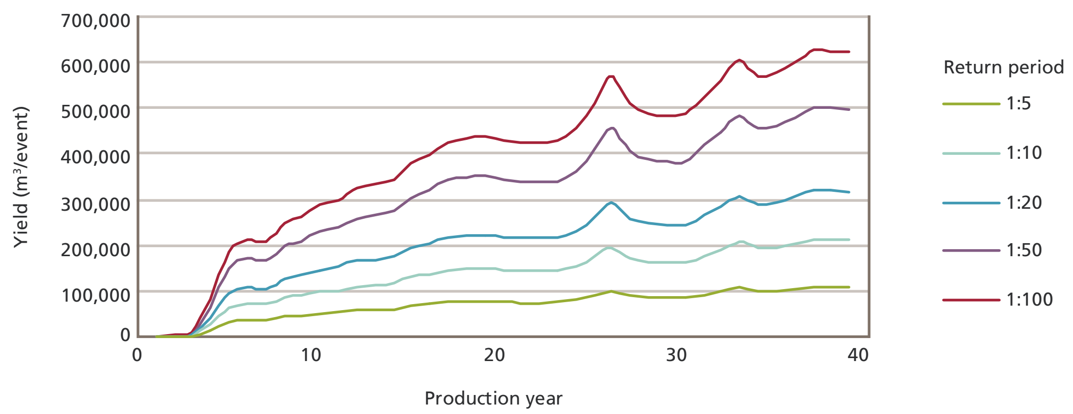


Figure 11.1 Case 1: Estimated run-off volumes for five-minute duration events

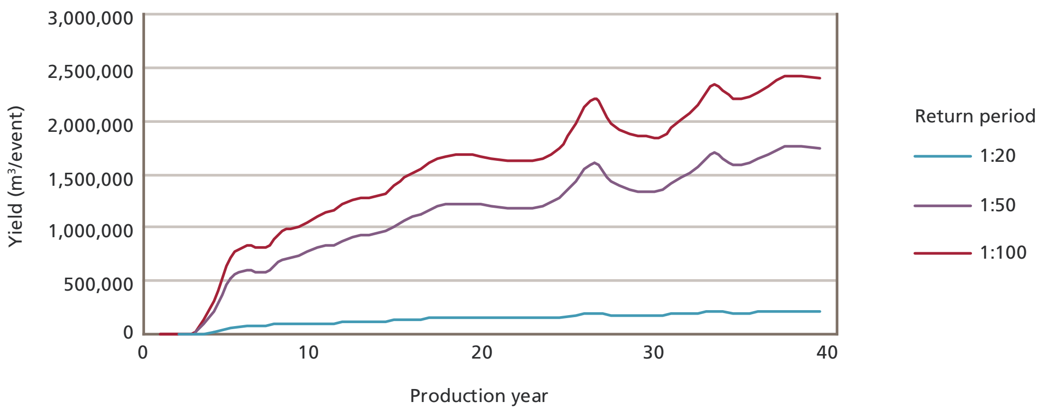


Figure 11.2 Case 1: Estimated run-off volumes for two-hour duration events

The longer-duration events would generate flows only at the longer return periods of 1 in 20 years and above. As noted above, not all of the run-off that could be generated would be expected to flow to the surrounding natural terrain since flows would be ponded on the surface of the facility due to surface imperfections and depressions and would then evaporate or infiltrate (see below for further details). Disregarding flow attenuation on the surface of the facility (i.e. water ponding in shallow depressions on the surface of the RSF and being prevented from flowing off the surface), the maximum estimated volume of run-off that would need to be contained would occur when the RSF was at its full extent and the volume would be about 2.5 million m^3. As noted in Chapter 11 of the Draft EIS, the 1-in-100-year event run-off could be readily contained within the sub-catchments of the expanded SML.

The water quality estimates for the five-minute (0.083-hour) and two-hour run-off events are summarised respectively in Tables 11.1 and 11.2.

Table 11.1 Summary of estimated Case 1 – RSF water quality during operations for events of five-minute (0.083-hour) duration

Input variable	**Units**	**Value**						
Return period	(year)	1	2	5	10	20	50	100
Storm duration	(hour)	0.083	0.083	0.083	0.083	0.083	0.083	0.083
Total precipitation (intensity x duration)	(mm)	3.5	4.7	6.2	7.9	10.1	14.3	17
Depth of influence	(m)	1	1	1	1	1	1	1
Duration of accumulation	(years)	0.5	0.5	1	1	1	1	1
Parameter		**Maximum concentration**						
pH		n/r	n/r	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5
Sulfate	(mg/L)	n/r	n/r	8,001	6,511	5,328	4,081	3,304
Chloride	(mg/L)	n/r	n/r	5,445	4,273	3,342	2,361	2,097
Iron	(mg/L)	n/r	n/r	0.200	0.200	0.200	0.200	0.200
Aluminium	(mg/L)	n/r	n/r	0.200	0.200	0.200	0.200	0.200
Arsenic	(mg/L)	n/r	n/r	0.060	0.060	0.060	0.060	0.060
Cobalt	(mg/L)	n/r	n/r	3.218	2.525	1.975	1.395	1.137
Copper	(mg/L)	n/r	n/r	0.120	0.120	0.120	0.120	0.120
Lead	(mg/L)	n/r	n/r	0.010	0.010	0.010	0.010	0.010
Manganese	(mg/L)	n/r	n/r	17.6	13.8	10.8	7.67	6.10
Molybdenum	(mg/L)	n/r	n/r	18.1	14.2	11.1	7.84	6.36
Nickel	(mg/L)	n/r	n/r	0.150	0.150	0.150	0.150	0.150
Thorium	(mg/L)	n/r	n/r	0.001	0.001	0.001	0.001	0.001
Uranium	(mg/L)	n/r	n/r	0.300	0.300	0.300	0.300	0.300
Zinc	(mg/L)	n/r	n/r	10.0	7.87	6.15	4.35	3.57

Note: n/r = no run-off.

Refer to Appendix E1 for a more detailed analytical summary.

Table 11.2 Summary of estimated Case 1 – RSF water quality during operations for events of two-hour duration

Input Variable	Units	Value						
Return period	(year)	1	2	5	10	20	50	100
Storm duration	(hour)	2	2	2	2	2	2	2
Total precipitation								
(intensity x duration)	(mm)	3.5	4.7	6.2	7.9	10.1	14.3	17
Depth of influence	(m)	1	1	1	1	1	1	1
Duration of accumulation	(years)	0.5	0.5	1	1	1	1	1
Parameter		**Maximum concentration**						
pH		n/r	n/r	n/r	n/r	6.5–8.5	6.5–8.5	6.5–8.5
Sulfate	(mg/L)	n/r	n/r	n/r	n/r	1,235	956	801
Chloride	(mg/L)	n/r	n/r	n/r	n/r	703	544	456
Iron	(mg/L)	n/r	n/r	n/r	n/r	0.200	0.200	0.200
Aluminium	(mg/L)	n/r	n/r	n/r	n/r	0.200	0.200	0.200
Arsenic	(mg/L)	n/r	n/r	n/r	n/r	0.060	0.060	0.060
Cobalt	(mg/L)	n/r	n/r	n/r	n/r	0.416	0.322	0.270
Copper	(mg/L)	n/r	n/r	n/r	n/r	0.120	0.120	0.120
Lead	(mg/L)	n/r	n/r	n/r	n/r	0.010	0.010	0.010
Manganese	(mg/L)	n/r	n/r	n/r	n/r	2.285	1.769	1.482
Molybdenum	(mg/L)	n/r	n/r	n/r	n/r	2.337	1.809	1.516
Nickel	(mg/L)	n/r	n/r	n/r	n/r	0.150	0.150	0.150
Thorium	(mg/L)	n/r	n/r	n/r	n/r	0.001	0.001	0.001
Uranium	(mg/L)	n/r	n/r	n/r	n/r	0.191	0.148	0.124
Zinc	(mg/L)	n/r	n/r	n/r	n/r	1.294	1.002	0.840

Note: n/r = no run-off.

Refer to Appendix E1 for a more detailed analytical summary.

As shown in Tables 11.1 and 11.2, short-duration, low-run-off events generally result in higher solute concentration estimates; the low flows associated with these events, however, would not be expected to be released from the RSF. The concentrations estimated for the longer-duration, higher-flow events generally are significantly lower. In other words, there is a downward trend in solute concentration estimates inversely proportional to the magnitude of the storm event.

RSF Case 2 – High run-off conditions

The primary difference between the low-run-off Case 1 and this case is that the properties adopted for the rock to be placed in the RSF are more conservative and lead to more rock types generating higher run-off. This is done by classifying material types as more finely grained than would be expected so that a greater proportion of the rock exposed on the surface of the RSF could generate run-off. It is important to note, however, that in the context of the overall water balance, increased run-off generally leads to decreased infiltration and vice versa, so that conservative assumptions adopted for run-off cannot coexist with conservative assumptions for infiltration. The estimated run-off for the high-run-off case is shown in Figure 11.3 and 11.4.

As these figures show, there are noticeable increases in the estimated flows when compared to the low flow estimates. It is noted, however, that the peak flow for a 1-in-100-year run-off event would still be contained in the expanded SML sub-catchments. The peak flow of about 3 million m^3 would equate to an estimated incremental accumulation of about 55 mm across these catchments.

The corresponding water quality estimates are summarised in Tables 11.3 and 11.4.

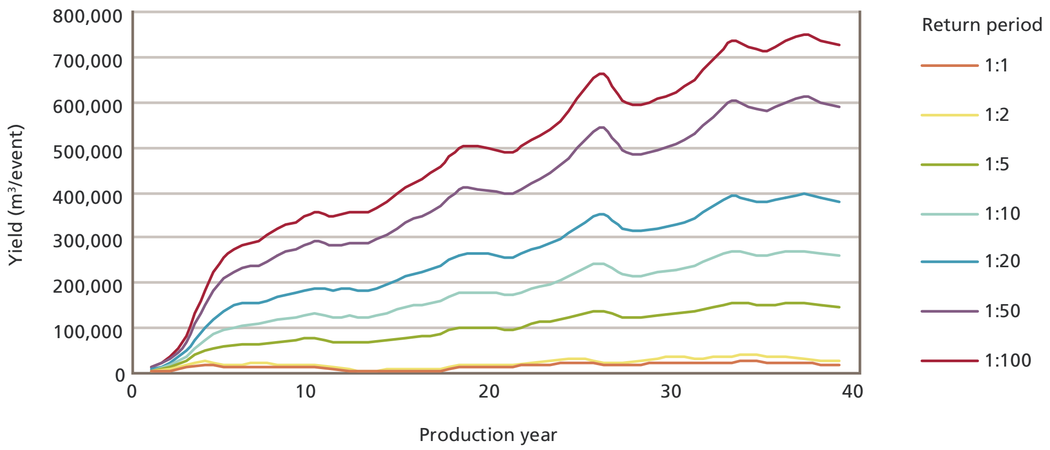


Figure 11.3 Case 2: Estimated run-off volumes for five-minute duration events

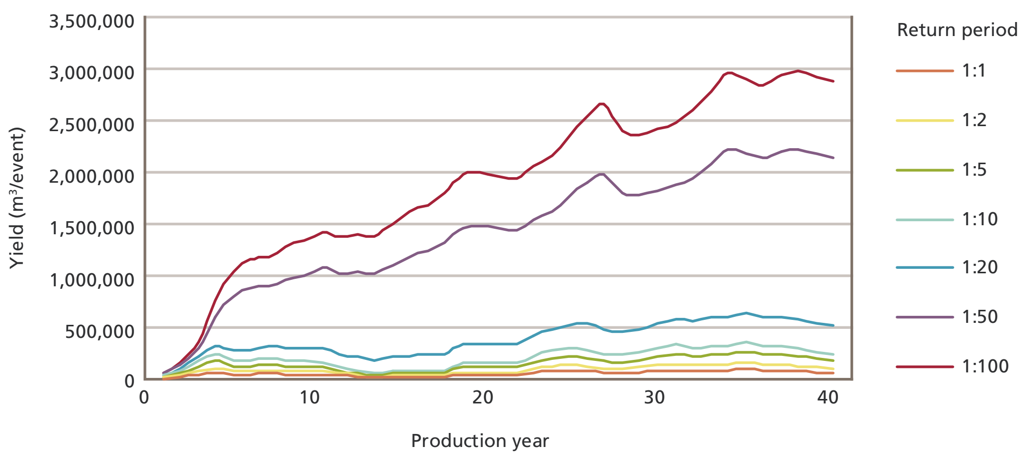


Figure 11.4 Case 2: Estimated run-off volumes for two-hour duration events

Table 11.3 Summary of Estimated Case 2 – RSF run-off water quality during operations for events of five-minute (0.083–hour) duration

Input parameter	Units	Value						
Return period	(year)	1	2	5	10	20	50	100
Storm duration	(hour)	0.083	0.083	0.083	0.083	0.083	0.083	0.083
Total precipitation (intensity x duration)	(mm)	3.5	4.7	6.2	7.9	10.1	14.3	17
Depth of influence	(m)	1	1	1	1	1	1	1
Duration of accumulation	(years)	0.5	0.5	1	1	1	1	1
Parameter		**Maximum concentrations**						
pH		6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5
Sulphate	(mg/L)	1,752	1,474	4,910	4,501	3,866	3,042	2,571
Chloride	(mg/L)	3,785	2,819	5,016	4,014	3,160	2,240	1,980
Iron	(mg/L)	0.200	0.200	0.200	0.200	0.200	0.200	0.200
Aluminium	(mg/L)	0.200	0.200	0.200	0.200	0.200	0.200	0.200
Arsenic	(mg/L)	0.060	0.056	0.060	0.060	0.060	0.060	0.060
Cobalt	(mg/L)	0.076	0.056	2.584	2.114	1.673	1.190	0.988
Copper	(mg/L)	0.120	0.120	0.120	0.120	0.120	0.120	0.120
Lead	(mg/L)	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Manganese	(mg/L)	0.353	0.263	13.582	11.111	8.795	6.255	5.399
Molybdenum	(mg/L)	0.383	0.285	13.262	10.848	8.623	6.173	5.117
Nickel	(mg/L)	0.076	0.056	0.150	0.150	0.150	0.150	0.150
Thorium	(mg/L)	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Uranium	(mg/L)	0.076	0.056	0.300	0.300	0.300	0.300	0.300
Zinc	(mg/L)	0.379	0.282	7.79	6.36	5.04	3.58	3.00

Refer to Appendix E1 for a more detailed analytical summary.

Table 11.4 Summary of estimated Case 2 – RSF run-off water quality during operations for events of two-hour duration

Input parameter	Units	Value						
Return period	(year)	1	2	5	10	20	50	100
Storm duration	(hour)	2	2	2	2	2	2	2
Total precipitation								
(intensity x duration)	(mm)	3.5	4.7	6.2	7.9	10.1	14.3	17
Depth of influence	(m)	1	1	1	1	1	1	1
Duration of accumulation	(years)	0.5	0.5	1	1	1	1	1
Parameter		**Maximum concentrations**						
pH		6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5
Sulfate	(mg/L)	481	346	462	346	620	671	580
Chloride	(mg/L)	920	662	883	662	598	512	432
Iron	(mg/L)	0.200	0.200	0.200	0.200	0.200	0.200	0.200
Aluminium	(mg/L)	0.200	0.200	0.200	0.200	0.200	0.200	0.200
Arsenic	(mg/L)	0.018	0.013	0.018	0.013	0.060	0.060	0.060
Cobalt	(mg/L)	0.018	0.013	0.018	0.013	0.243	0.270	0.229
Copper	(mg/L)	0.064	0.046	0.061	0.046	0.120	0.120	0.120
Lead	(mg/L)	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Manganese	(mg/L)	0.086	0.062	0.082	0.062	1.273	1.419	1.203
Molybdenum	(mg/L)	0.093	0.067	0.089	0.067	1.245	1.386	1.181
Nickel	(mg/L)	0.018	0.013	0.018	0.013	0.132	0.145	0.123
Thorium	(mg/L)	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Uranium	(mg/L)	0.018	0.013	0.018	0.013	0.118	0.130	0.110
Zinc	(mg/L)	0.092	0.066	0.088	0.066	0.737	0.813	0.689

Refer to Appendix E1 for a more detailed analytical summary.

As before, the estimated solute concentrations for the short-duration low-run-off events are higher than those estimated for the longer-duration events. The concentration estimates for the two-hour events for some parameters show step increases for certain events. For example, the sulfate concentration between the 1-in-2-year and 1-in-5-year return period events increases rather than decreases. This is because some of the materials that previously would not have generated run-off now contribute to the solute loadings.

The concentration estimates in the preceding tables represent the maximum concentrations that would occur for single events that occur only once in a given operational year. Multiple events in any given year would lead to lower concentrations for subsequent events, as solutes would be removed with each event and therefore would not be available in the subsequent event(s).

LGS run-off flow and quality estimates

Since cover sequence materials would not be placed on the LGS, the exposed materials all belong to the same group of material properties. The estimated run-off volumes for the LGS are shown in Figures 11.5 and 11.6 for the five-minute (0.083-hour) duration and the two-hour duration events respectively. The LGS would not yield run-off for short-duration events with a return period of less than 1 in 5 years. At increased duration, run-off would occur only for events with a return period of 1 in 20 years or more.

Solute concentrations in run-off from the LGS during the operational phase are shown in Tables 11.5 and 11.6 for the five-minute (0.083-hour) duration and the two-hour duration events respectively.

Table 11.5 Summary of estimated LGS run-off water quality during operations for events of five-minute (0.083-hour) duration

Input parameter	Units	Value						
Return period	(year)	1	2	5	10	20	50	100
Storm duration	(hour)	0.083	0.083	0.083	0.083	0.083	0.083	0.083
Total precipitation (intensity x duration)	(mm)	3.5	4.7	6.2	7.9	10.1	14.3	17
Depth of influence	(m)	1	1	1	1	1	1	1
Duration of accumulation	(years)	0.5	0.5	1	1	1	1	1
Parameter		**Maximum concentrations**						
pH		n/r	n/r	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5
Sulfate	(mg/L)	n/r	n/r	3,701	3,059	2,609	2,151	1,973
Chloride	(mg/L)	n/r	n/r	6,964	5,466	4,275	3,020	2,540
Iron	(mg/L)	n/r	n/r	0.200	0.200	0.200	0.200	0.200
Aluminium	(mg/L)	n/r	n/r	0.200	0.200	0.200	0.200	0.200
Arsenic	(mg/L)	n/r	n/r	0.060	0.060	0.060	0.060	0.060
Cobalt	(mg/L)	n/r	n/r	15.7	12.3	9.6	6.8	5.7
Copper	(mg/L)	n/r	n/r	0.120	0.120	0.120	0.120	0.120
Lead	(mg/L)	n/r	n/r	0.010	0.010	0.010	0.010	0.010
Manganese	(mg/L)	n/r	n/r	26.9	21.1	16.5	11.6	9.8
Molybdenum	(mg/L)	n/r	n/r	29.3	23.0	18.0	12.7	10.7
Nickel	(mg/L)	n/r	n/r	0.150	0.150	0.150	0.150	0.150
Thorium	(mg/L)	n/r	n/r	0.001	0.001	0.001	0.001	0.001
Uranium	(mg/L)	n/r	n/r	0.300	0.300	0.300	0.300	0.300
Zinc	(mg/L)	n/r	n/r	15.455	12.129	9.487	6.701	5.637

Note: n/r = no run-off.

Refer to Appendix E1 for a more detailed analytical summary.

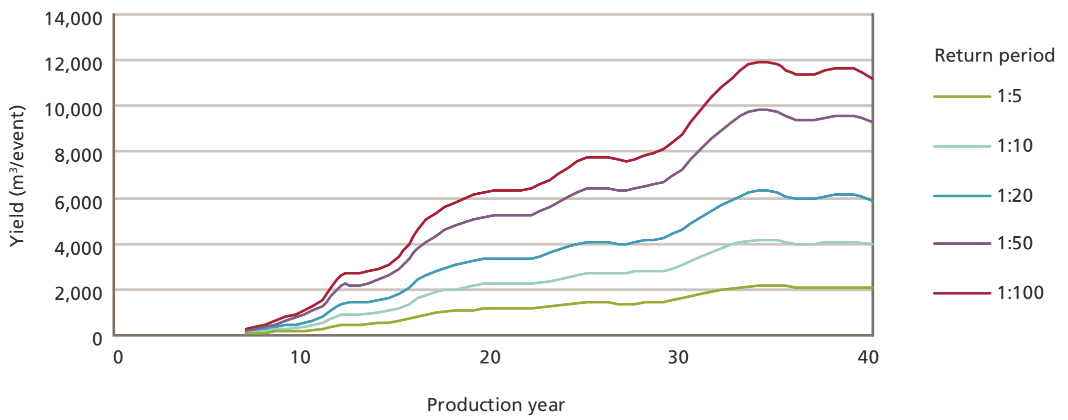


Figure 11.5 Low-grade ore stockpile: Estimated run-off volumes for five-minute duration events

Table 11.6 Summary of estimated LGS run-off water quality during operations for events of two-hour duration

Input parameter	Units	Value						
Return period	(year)	1	2	5	10	20	50	100
Storm duration	(hour)	2	2	2	2	2	2	2
Total precipitation								
(intensity x duration)	(mm)	3.5	4.7	6.2	7.9	10.1	14.3	17
Depth of influence	(m)	1	1	1	1	1	1	1
Duration of accumulation	(years)	0.5	0.5	1	1	1	1	1
Parameter		**Maximum concentrations**						
pH		n/r	n/r	n/r	n/r	6.5–8.5	6.5–8.5	6.5–8.5
Sulfate	(mg/L)	n/r	n/r	n/r	n/r	882	648	541
Chloride	(mg/L)	n/r	n/r	n/r	n/r	900	696	583
Iron	(mg/L)	n/r	n/r	n/r	n/r	0.200	0.200	0.200
Aluminium	(mg/L)	n/r	n/r	n/r	n/r	0.200	0.200	0.200
Arsenic	(mg/L)	n/r	n/r	n/r	n/r	0.060	0.060	0.060
Cobalt	(mg/L)	n/r	n/r	n/r	n/r	2.024	1.567	1.313
Copper	(mg/L)	n/r	n/r	n/r	n/r	0.120	0.120	0.120
Lead	(mg/L)	n/r	n/r	n/r	n/r	0.010	0.010	0.010
Manganese	(mg/L)	n/r	n/r	n/r	n/r	3.469	2.685	2.250
Molybdenum	(mg/L)	n/r	n/r	n/r	n/r	3.779	2.926	2.452
Nickel	(mg/L)	n/r	n/r	n/r	n/r	0.150	0.150	0.150
Thorium	(mg/L)	n/r	n/r	n/r	n/r	0.001	0.001	0.001
Uranium	(mg/L)	n/r	n/r	n/r	n/r	0.300	0.233	0.195
Zinc	(mg/L)	n/r	n/r	n/r	n/r	1.996	1.546	1.295

Note: n/r = no run-off.

Refer to Appendix E1 for a more detailed analytical summary.

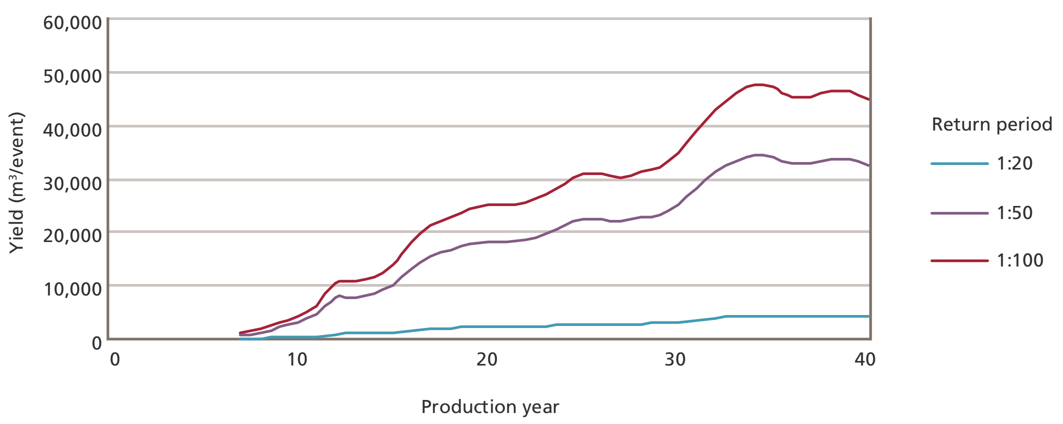


Figure 11.6 Low-grade ore stockpile: Estimated run-off volumes for two-hour duration events

Post-closure run-off water quality

The proposed closure strategy for the RSF, and for the LGS if it remains in place, would be to ensure that the outer surfaces of these facilities comprised overburden or cover sequence materials (i.e. class C or D materials). The estimated solute concentrations in run-off are summarised in Table 11.7 and would apply to both the RSF and the LGS. The estimates represent the maximum concentrations that would result for a single first event after closure. Since that event would remove most of the available solutes, and since the cover sequence materials would not be expected to continue to generate solutes, the concentrations in all subsequent run-off events would decrease and continue to decrease until background surface water quality for the region was reached. However, some of the solutes that are limited by solubility constraints may continue to be released at their equilibrium concentration until the accumulated secondary mineral phases had been depleted, after which time background concentrations would result.

Table 11.7 Summary of estimated maximum post-closure single event run-off water quality for events of five-minute (0.083-hour) duration

Input parameter	Units	Value						
Return period	(year)	1	2	5	10	20	50	100
Storm duration	(hour)	0.83	0.83	0.83	0.83	0.83	0.83	0.83
Total precipitation								
(intensity x duration)	(mm)	3.5	4.7	6.2	7.9	10.1	14.3	17
Depth of influence	(m)	1	1	1	1	1	1	1
Duration of accumulation	(years)	1	1	1	1	1	1	1
Parameter		**Concentrations**						
pH		6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5	6.5–8.5
Sulfate	(mg/L)	3,958	2,948	4,564	3,858	3,090	2,214	1,893
Chloride	(mg/L)	7,571	5,638	3,594	2,740	2,122	1,490	1,442
Iron	(mg/L)	0.200	0.200	0.200	0.200	0.200	0.200	0.200
Aluminium	(mg/L)	0.200	0.200	0.200	0.200	0.200	0.200	0.200
Arsenic	(mg/L)	0.060	0.060	0.060	0.060	0.060	0.059	0.060
Cobalt	(mg/L)	0.152	0.113	0.112	0.091	0.072	0.051	0.046
Copper	(mg/L)	0.120	0.120	0.120	0.120	0.120	0.120	0.120
Lead	(mg/L)	0.010	0.010	0.010	0.010	0.010	0.010	0.010
Manganese	(mg/L)	0.707	0.526	6.781	6.079	4.953	3.584	3.291
Molybdenum	(mg/L)	0.766	0.571	0.256	0.180	0.135	0.093	0.079
Nickel	(mg/L)	0.150	0.113	0.150	0.150	0.150	0.120	0.108
Thorium	(mg/L)	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Uranium	(mg/L)	0.152	0.113	0.300	0.300	0.300	0.249	0.208
Zinc	(mg/L)	0.759	0.565	2.854	2.528	2.053	1.482	1.278

Refer to Appendix E1 for a more detailed analytical summary

Summary

Run-off yield equivalent to, or less than, about 20–25 mm would not be expected to generate significant quantities of flow that could be transported away from either the RSF or the LGS.

For these yields the water would tend to pond locally due to surface imperfections and then either evaporate or infiltrate. Consequently, none of the low-flow, short-duration (five-minute; 0.083-hour) events with a return period of 1 in 100 years or less would be expected to yield run-off. Events of a two-hour duration and a return period of 1 in 50 years or more could generate run-off locally (i.e. only some of the rock types exposed at the surface of the facility). The Case 2, or high-run-off analysis, suggests that two-hour events with as low as 1-in-5-year or 1-in-10-year return periods could generate run-off. However, the net yield from these events would be expected to be very low.

Therefore, events that realistically could generate run-off that would be released from the RSF and the LGS surface during the operational period would have a relatively low probability of occurring.

Post-closure, after potentially reactive materials (i.e. class A and B material) were progressively encapsulated during construction by about 1 m or more of benign material (i.e. class C and/or D material), the water quality in the run-off would be expected to become progressively cleaner after the first flush and background concentrations would be re-established.

11.2.2 MANAGEMENT

Issue:

Additional information was requested on surface water management measures proposed for the rock storage facility (RSF) and low-grade ore stockpile (LGS) during operation and closure to ensure that potential impacts relating to stormwater run-off, acid drainage and sediment run-off were managed.

Submissions: 2, 13 and 71

Response:

Section 11.2.1 of the Supplementary EIS discussed stormwater run-off from the RSF and LGS and concluded that run-off would occur from these facilities for high rainfall intensity and duration events, but it would only be the low-probability events (e.g. >1-in-50-year event with a duration greater than two hours) that would create more than just local ponding. Also, even from a peak flow event (i.e. a 1-in-100-year rainfall event lasting for two hours) this would equate to an estimated incremental accumulation of about 55 mm within the sub-catchments of the expanded SML (which corresponds to a total water depth of about 300 mm in the sub-catchments). It is also noted that this would only occur in the latter stages of the RSF development, when its ultimate footprint was reached.

With regard to the potential for acid drainage, infiltration modelling was completed to assess the overall water balance for the RSF and LGS (see Appendix F7 of the Supplementary EIS for details). The assessment indicated that infiltration from the surface that would report to the base of the RSF as percolation would be in the range of 1–4% of mean annual rainfall. At those low rates, the percolation would infiltrate to the underlying soils and would report to groundwater and would therefore be unlikely to be released laterally from the toe of the RSF as seepage. Consequently, toe seepage would not contribute as acid drainage to the surface run-off flows from the RSF.

With regard to management of run-off, the requirement for engineered structures was investigated by assessing the ecotoxicity of the solute loads and volumes of stormwater run-off on the local ecosystems (see Section 11.3.1 for details). This assessment established that some species might be adversely affected, so a precautionary approach would be applied, particularly in the latter stages of the RSF development, when run-off volumes increased. As a consequence, it is proposed that an engineered structure such as a berm, catch bank or similar would be constructed to contain stormwater for a 1-in-100-year event within the sub-catchments intersected by the ultimate footprint of the RSF. Initial calculations suggest that this structure would need to be less than 1 m high.

As the RSF would be developed over many years, and the LGS would not start until year six after mining operations commenced, run-off quantities and qualities would be further evaluated during the first few years of operation, when the footprint of the RSF was small and the risk of run-off release negligible. The containment structure would be designed and constructed well before the RSF footprint expanded to a size where large run-off volumes could be generated.

The placement of low-grade ore in the LGS would not begin until six years after the commencement of the RSF. This means that the monitoring of the quantity and quality of run-off from the RSF could be used as a basis for developing appropriate run-off control and/or containment measures that may be implemented before the LGS was developed.

After closure, the containment of surface run-off from the RSF would become less critical since the above containment structure would already be in place, and since the water quality would be expected to improve over time, as discussed above.

11.3 CLAY PAN ECOLOGY

11.3.1 POTENTIAL IMPACT AND MANAGEMENT

Issue:

Further information was sought on the potential for acidic run-off to occur from the rock storage facility (RSF) and the impact of stormwater run-off and dust leachability on ecosystems in the natural swales or clay pans in and around the expanded Special Mining Lease.

Submissions: 1, 2, 13 and 71

Response:

Acidic run-off

It was questioned whether there is a potential for surface water to react with RSF and low-grade ore stockpile (LGS) exposed rock to generate acidic run-off with dissolved heavy metals (referred to acid drainage in the submission) prior to capping with inert material.

Further studies, as detailed in Appendix E1 of the Supplementary EIS, have modelled the amount and composition of run-off from the LGS for rainfall events of various return periods ranging from 1 to 100 years and storm durations of about five minutes (i.e. 0.083 hours) to 72 hours. The low-grade ore (class A material) is potentially reactive and theoretically could generate acidic run-off with dissolved heavy metals. However, results of the modelling indicate that even with no cover, the LGS would not generate run-off for rainfall events of short duration (0.085 hours) of a return period of less than 1 in 5 years. For the two-hour duration events, run-off would occur only for events with a return period of 1 in 20 years or more.

Even for the short duration events (0.083 hours), an event with a 1-in-20-year return period would yield the equivalent of about 8 mm, which is likely to be attenuated in the local surface undulations of the LGS so that actual run-off would be minimal. However, events with a return period greater than 1 in 50 years and of two-hour duration (yielding about 46 mm) would be expected to generate run-off from the LGS.

The modelling shown in Appendix E1 of the Supplementary EIS also predicted the water quality from such run-off; the pH is predicted to be neutral (pH 6.5 to 8.5), and hence no acidic run-off is expected.

The RSF would consist of class B (potentially reactive rock), class C (benign rock) and class D (acid neutralising rock) material, as shown in Figure 5.16 of the Draft EIS. While there is potential for run-off to be generated from the class B materials prior to this material being encapsulated, this material is less reactive that class A material (i.e. low-grade ore). Since any run-off from the LGS is predicted to be of neutral pH, any run-off generated from the RSF would also be expected to be of neutral pH.

With regard to hydrocarbon contamination, this would be minimised by the normal maintenance regime for the haul truck fleet. In the event of hydrocarbon spillage, the size and extent of the RSF and LGS are such that run-off to the environment beyond the proposed disturbance footprints would be highly unlikely.

RSF run-off into clay pans

A number of clay pans occur in the vicinity of the rock storage facility (RSF) and these were identified on Figure 15.3 of the Draft EIS. Many are in the proposed footprint of the RSF, but others would continue to provide habitat for biota outside the RSF footprint.

Run-on areas in the Olympic Dam area include shallow claypans, canegrass swamps and other areas where water accumulates. Biota develop or emerge after rain events to colonise these areas. These species includes the trilling frog (*Neobatrachus centralis*), which has been shown to be abundant in the Olympic Dam area (Read 1999). After a rainfall event, the trilling frogs emerge from underground burrows and lay eggs in ephemeral waterbodies, including those in the natural landforms, such as clay pans and swales. Other biota reported to utilise these temporary waterbodies include shield shrimp (*Triops australensis*), clam shrimp, caddis fly larvae and algae.

In order to explore potential effects of run-off from the RSF, further work was carried out to model the solute loads and volumes of stormwater run-off (see Appendix E1 of the Supplementary EIS). The model generated predicted concentrations of 22 metals and a number of anions in the run-off after rainfall events of five minutes (0.083 hours) and two hour duration for one, two, five, 10, 20, 50 and 100 year return periods. As noted in Section 11.3.1 above, it is the lower rainfall intensities that generate the highest solute concentrations (because of the lower dilutions), and therefore the investigated events and durations represent the worst-case conditions for potential toxicity to biota.

The predicted concentrations of the metals were compared with the ecotoxicity data for Australian biota as compiled by Markich and others (2002) and Warne and others (2009). Copper, lead, uranium and zinc exceeded the minimum concentration that elicited a detrimental response for at least one species of green algae, aquatic flowering plants and a number of invertebrate animals.

While no metal ecotoxicity data are available for *Neobatrachus centralis*, toxicity of metals including copper appears to vary between frog species and life stage. Kaplan and Yoh (1961) reported that concentrations of 0.4–4 mg Cu/L had no effect on the viability of the North American adult *Rana pipiens*. These concentrations are up to 33 times higher than those predicted for run-off from the RSF.

Bridges and others (2002) reported $LC_{50\ (96\ hours)}$ for the North American species *Rana sphenocephala* and *Bufo boreas* tadpoles of 0.23 and 0.12 mg Cu/L respectively. These values are of the same order of magnitude as the predicted concentration of 0.12 mg Cu/L in RSF run-off after a five-minute rainfall event.

Landé and Guttman (1973) studied the effect of Cu on *Rana pipiens* tadpoles, and reported an $LC_{50\ (72\ hours)}$ of 0.15 mg/L, which is close to the predicted concentration in run-off after a five-minute rainfall event. Furthermore, inhibition of the tadpoles' growth rate was observed at concentrations of 0.06 and 0.16 mg Cu/L. A reduction in growth rate could be significant in *Neobatrachus centralis*, since tadpoles desiccate and die if they do not metamorphose before ephemeral pools dry up (Read 1999).

Although the predicted concentrations of some metals exceed levels reported to be toxic to a wide range of biota, including algae, invertebrates and fish, a key factor is the amount of stormwater that may run-off from the RSF. The assessment presented in Appendix E1 estimates likely amounts of run-off from the RSF for storm durations ranging from five minutes (0.083 hours) to 72 hours, and with return periods of up to 1 in 500 years for four types of materials that represent the potentially exposed materials.

The capacity to generate run-off depends on the hydraulic conductivity of the exposed material. Two of the materials with high hydraulic conductivity are not expected to produce run-off except in extremely intense storms of limited duration (i.e. five minutes to one hour) that would occur only infrequently (1-in-500-year return period). Two other materials with lesser hydraulic conductivity would generate run-off that could reach the clay pans at the toe of the RSF.

Given the predicted concentrations of metals in run-off, BHP Billiton would adopt a precautionary approach, and apply control measures to protect the ecosystems. As noted above, the management measure to be applied would be an engineered structure, about 1 m high, constructed to contain stormwater for a 1-in-100-year event in the sub-catchments intersected by the ultimate footprint of the RSF.

RSF dust into clay pans

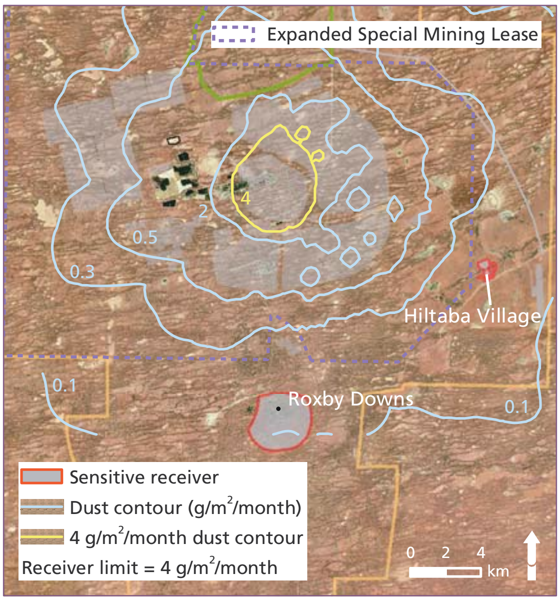
Two factors would contribute to the effect of dust deposition in swales and clay pans on resident biota such as frogs, shield shrimp and clam shrimp. These are:

- the amount of dust depositing in the swales and clay pans
- the leachability or solubility of metals in the dust.

Amount of dust depositing in swales and clay pans
Controlling dust emissions from the operation would reduce the amount of dust available for leaching. Section 13.3.4 of the Draft EIS outlined project design elements that would be implemented to reduce dust emissions. These include:

- suppressing dust on unsealed haul roads and unsealed access roads using saline water or a suitable chemical dust suppressant
- providing a 500 m separation between the toe of the RSF and Arid Recovery to minimise direct and indirect impacts from dust
- using an enclosed conveyor system with baghouses at transfer points, and intermediate storage bins to minimise dust emissions.

The predicted extent of the area at or above the maximum deposition limit of 4 g/m²/month was shown in Figure 13.18d of the Draft EIS (updated and reproduced here as Figure 11.7). This indicates that this area would include only the open pit mine, part of the RSF and part of the mineral processing area. The area is not predicted to impact Arid Recovery or significant areas beyond the proposed disturbance footprints.



Annual average dust deposition rate

Figure 11.7 Predicted dust deposition rate (g/m²/month)

Leachability or solubility of metals in the dust
The low solubility of the metals will limit their impact.

Section 2.2 of the Draft EIS described the characteristics of the mineralised material. The predominant minerals would be bornite-chalcocite and chalcopyrite, which are sulphide minerals (Cu_5FeS_4, CuS_2 and $CuFeS_2$ respectively). Heavy metals (such as copper and iron) sulphides are insoluble in water, although they can be solubilised under acidic conditions after they have been oxidised. Surface waters, such as that likely to accumulate in clay pans and swales, are neutral to slightly alkaline (pH 6.76 to 9.3) as shown in Tables 11.1 and 11.2 of the Draft EIS, and so the metals present in the sulphidic minerals are unlikely to be solubilised even after they have been oxidised.

In addition, solubility is not the only determinant of toxicity. Bioavailability depends on speciation of the metal (ionic form and presence in solid or liquid phase). Copper (Cu) is likely to pose the greatest toxicity issue in any metals leached from dust (Markich et al. 2002; Warne et al. 2009). Given the low solubility of the metal minerals in the dust, very little Cu is likely to dissolve. The soils in the clay pans have high levels of clay minerals to which Cu ions strongly adsorb (Kalis 2006), thereby removing them from the liquid or bioavailable phase.

The measures to suppress dust generation, together with the low solubility of minerals that would contribute metals to the dust, and the likely adsorption of metals that will take the metals out of the bioavailable compartment, suggest that dust is unlikely to present an ecotoxicological hazard to animals resident in the swales and clay pans.

11.4 ACCUMULATION OF WATER IN THE OPEN PIT

11.4.1 MODELLING

Issue:
Further clarification was sought on the adequacy of the long-term, steady-state conditions of the pit lake modelling.

Submission: 2

Response:

The outcomes of the pit lake modelling presented in the Draft EIS (Section 11.5.4) were obtained after running the model for a simulation period of 3,000 years. The modelling included a 'base-case' scenario, reflecting the most likely situation of water inflows and evaporation, and a range of sensitivity analyses where inflows were increased above the most likely conditions and evaporation was reduced, thereby assessing worst-case conditions. Under all scenarios, the modelling demonstrated there was no likelihood the lake in the open pit would spill over the top of the pit or would rise to a level that would result in reversal of groundwater gradients. Appendix J2 of the Draft EIS detailed the pit lake modelling and stated that hydrologic steady state conditions are not likely to be realised for at least 3,000 years and the pit lake is expected to equilibrate at a quasi-steady state elevation of between –310 mAHD and –690 mAHD (noting that the pit floor would be approximately –1,000 mAHD).

The pit lake model and report were reviewed by internationally recognised expert Dr Jan Vermaak of Golder Associates Pty Ltd. Commenting on the timeframe of the model run, Dr Vermaak said, 'The long-term (3,000-year) forecasts of pit lake levels and water quality exceed normal industry practice, and projections over this timeframe should be viewed with caution. However, we agree with the author's approach of considering both 100-year climate projections based on model simulations by the CSIRO and climate conditions over the last 10,000 years as a basis of understanding the range of variability that has previously occurred.' (The model report and full peer review report were presented in the Draft EIS as Appendix J2).

The model run of 3,000 years is therefore considered adequate for the purpose of an EIS.

11.4.2 PIT LAKE

Issue:

Clarification was requested on the pit lake that would form in the open pit post-closure, specifically the:

- pit lake filling or overflowing the open pit post-closure
- potential to affect local aquifers
- adequacy of the inclusion of climate change in the pit lake assessment
- water quality of the pit lake
- mineralogy and dissolution capacity of potential radionuclides in the pit lake
- potential uses for the water
- potential for the water to affect fauna that enters the open pit.

Submissions: 1, 13, 40, 44, 57, 88, 136 and 257

Response:

Depth of the pit lake post-closure

As described in Sections 11.5.4 and 23.8.1 of the Draft EIS, modelling of water into the 1 km-deep pit shows that a lake, about 100 m deep, would form about 100 to 200 years post-closure. The lake would ultimately reach a depth of about 350 m about 3,000 years post-closure (refer Appendix J2 of the Draft EIS for details), which is about 650 m below the natural ground surface. Therefore, the modelling indicated there is no potential for the pit to overflow, even under extreme climate change scenarios.

Potential to impact on local aquifers

Section 5.2.1 of Appendix J2 of the Draft EIS detailed the assessment of the implications of the pit lake on local aquifers. The water balance indicated that the deepest aquifer, the Corraberra Sandstone aquifer, which is located no deeper than 200 m below ground level, would be at least 450 m above the elevation of the ultimate pit lake water surface at 650 m below ground level.

Over the long term, the salinity of the pit lake is likely to be much higher than that of the aquifer, and in order to compare pressure heads a freshwater equivalent head was calculated. The assessment demonstrated that the pressure head in the Corraberra Sandstone aquifer would be at least 140 m greater than in the pit lake.

The modelling therefore indicated that the pit lake would act as a permanent groundwater sink and would drain the regional groundwater system indefinitely, with no potential for the water in the pit to recharge to the groundwater system and thus reverse groundwater gradients, even under extreme climate change scenarios. It is noted that while the open pit would drain the aquifer indefinitely, groundwater drawdown would reach a state of equilibrium, as shown in Figures 12.14 and 12.15 of the Draft EIS and updated in Section 12.2 of the Supplementary EIS, due to aquifer recharge.

Adequacy of the inclusion of climate change in the pit lake assessment

Appendix J2 of the Draft EIS explained that the sensitivity analysis performed on input parameters included consideration of climate change and extreme storm events. The variation in rainfall could be –30% up to +50%, considering both natural variation and anthropogenic influences. This represents the upper and lower bounds of short-term (100-year) model predictions and long-term (10,000-year) palaeo-climatic investigations. Climate change scenarios were investigated for the water balance over this range.

With climate change projections suggesting less frequent, but more intense, rainfall events in the future, Sections 2.3.5 and 5.2.3.2 of Appendix J2 of the Draft EIS detailed the assessment of extreme rainfall events through additional model runs. The extreme rainfall event considered the effect of a probable maximum precipitation (PMP) event on the pit water levels with a corresponding PMP of 420 mm. The effect of a PMP event on the water balance was assessed by introducing the event into the model during the lake filling and quasi-steady state stages. The assessment showed that an extreme event would result in a change of water level of a maximum 10 m. A variation of this amount is within the bounds of long-term water level fluctuations and demonstrates that the pit lake would not be sensitive to specific extreme storm events.

The pit lake model and report was reviewed by internationally recognised expert Dr Jan Vermaak of Golder Associates Pty Ltd. With respect to the climate change projections of the model, Dr Vermaak said:

> ...we (Golder Associates Pty Ltd) agree with the author's approach of considering both 100-year climate projections based on model simulations by the CSIRO and climate conditions over the last 10,000 years as a basis of understanding the range of variability that has previously occurred.

(The model report and full peer review report were presented in the Draft EIS as Appendix J2).

As such, the climate change predictions used for the model are considered adequate for the purpose of an EIS.

Water quality of the pit lake that would form in the open pit

Considerable attention was given to this issue in the assessment and presentation of the surface water chapter of the Draft EIS (refer in particular to Sections 11.5.4 and 11.6; Tables 11.3 and 11.4; and Appendix J2).

As detailed in Sections 11.5.4 and concluded in Section 11.6, a saline to hyper-saline lake would form in the pit void with salinities ranging from 25,900 mg/L (100 years post-closure) to 247,000 mg/L (3,000 years post-closure) due primarily to groundwater inflow, pit wall run-off and rainfall. Any potential contaminants in groundwater inflow to the pit would be sourced from seepage from the TSF and RSF. The TSF and RSF geochemistry and modelling of the movement of the seepage from the facilities were summarised in Chapter 12 and reported in detail in Appendix K4, K5 and K6 of the Draft EIS (see also Sections 12.3 and 12.4 of the Supplementary EIS for further discussion).

Section 12.6.2 of the Draft EIS explained that particle tracking of the remaining groundwater solutes was carried out to predict the movement of seepage from the TSF and RSF when it reached the groundwater. By the end of mining, seepage would not be likely to have travelled more than 100 m from the TSF or the RSF. The maximum distance that solutes could move away from the facilities would occur between 100 and 500 years post-closure, before the effect of the drawdown from the open pit dominated and regional groundwater flowed towards the pit. Simulation of seepage movement in groundwater showed that, in the longer term, drawdown caused by the open pit would effectively capture contaminants that entered the groundwater system from the TSF and RSF.

As concluded in Section 12.7 of the Draft EIS, the potential for acid generation from the RSF is low. In addition, the neutralising base layer of the RSF and the naturally occurring calcareous clays and Andamooka Limestone beneath the TSF and RSF are expected to attenuate most metals. Section 12.6.2 of the Draft EIS outlined that, although most contaminants are removed by these attenuating processes, selenium and uranium (albeit much reduced from the concentrations in the tailings percolate) remain elevated above background levels beneath the TSF. *In situ* reactions of the seepage with the carbonate minerals in the soils, clays and Andamooka Limestone also lead to bicarbonate concentrations exceeding background levels which eventually would be captured in the pit. Sections 12.3.1 and 12.4.1 of the Supplementary EIS present the findings of further geochemical studies undertaken since the publication of the Draft EIS, with these additional studies confirming the attenuation capacity of the sediments that underlie the TSF and RSF.

The modelling presented as Appendix J2 of the Draft EIS showed that the water in the pit lake would be near-neutral (i.e. pH 7.8 eventually reducing to 7.3) and therefore this would not be an 'acidic lake'. The salinity and concentration of metals in the lake would gradually increase through evapoconcentration, and a permanent salt crust is predicted to form on the surface of the lake about 3,000 years post-closure, essentially isolating the water underneath.

Mineralogy and dissolution capacity of all potential radionuclides in the pit lake

The Pit Lake Limnological and Geochemical Assessment (refer Appendix J2 of the Draft EIS) used a modelling approach to estimate pit lake chemistry at various time intervals (50, 100, 200, 500, 1,000, 2,000 and 3,000 years post-closure). It is noted, as stated in Appendix J2 of the Draft EIS by internationally recognised expert Dr Jan Vermaak of Golder Associates Pty Ltd, that the projections of water quality and pit lake levels at 3,000 years 'exceed normal industry practice and projections over this timeframe should be viewed with caution'.

The model used Monte Carlo techniques to generate probabilistic values to provide guidance about the likely spread of values over the time range studied. Values at 3,000 years are described as 'steady state' or 'quasi-steady state' and may be regarded as indicative of the final concentrations of solutes in the pit lake.

Consideration of inputs to the pit lake can provide further estimates, with water inputs from four sources considered:

- groundwater
- rainfall that falls onto the pit wall and runs into the lake
- direct incident rainfall that falls into the pit lake
- run-off from external catchments.

Groundwater input is predicted to provide the largest inflow volume (58%) and hence the largest contribution of solutes. Rainfall (16% of inflow volume) and external catchment run-off (2% of inflow volume) are likely to make minor contributions to solutes entering the pit lake. Pit wall run-off (24% of inflow volume) is predicted to incorporate components off the wall surface and thus contribute to the solutes entering the pit lake. Similarly, a proportion of the groundwater entering the pit would be evaporated as it ran down the pit walls before reaching the lake surface. However, pit wall run-off from rainfall may transport precipitated minerals that may be in solution or suspension into the lake.

Therefore, the composition of solutes in the pit lake water would be dominated by the composition of the groundwater, with some contribution from dissolved components of the pit wall rock.

Uranium is the principal radionuclide present in groundwater in the Stuart Shelf and Olympic Dam SML (refer Appendix K3 of the Draft EIS). The concentration of uranium reported in samples from this area ranged from <0.01 to 0.076 mg/L. The sum of total dissolved solids and total suspended solids in the sample with the maximum uranium concentration was 25,000 mg/L. If all the water were evaporated from inflows of this nature, the overall concentration of uranium in the resulting solid would be about 3 ppm (equivalent to 3 mg/kg). Section 26.2.4 of the Supplementary EIS provides an alternative worst-case assessment by assuming that groundwater is predominantly made up of TSF seepage. A uranium concentration between 3 and 10 ppm (37–125 Bq/kg) is comparable to the range of the concentrations of uranium naturally found in soils: for example 2–330 Bq/kg (UK) and 4–140 Bq/kg (US as compiled in UNSCEAR 2000).

Many of the input waters are supersaturated with respect to certain mineral phases, and precipitation of various minerals would begin at various times post-closure, as shown in Tables 33 and 34 of Appendix J2 of the Draft EIS. As well as precipitation, some ions are likely to adsorb to surfaces such as that provided by precipitated ferrihydrites and aluminium oxyhydroxides.

Thus, the likely chemical makeup of the pit lake at any point in time is subject to uncertainty; however, the model predicts that from about 3,000 years post-closure, uranium in solution would start to precipitate as sodium autinite.

Attachment 2 of Appendix J2 listed 61 uranium species included in the geochemical model, which illustrates the complexity of uranium chemistry and mineralogy. However, since the pit lake is predicted to reach a 'quasi-steady' state after 3,000 years, and would not affect the local aquifers, all radionuclides would be contained in the lake, with the majority present in precipitated material.

During the operational phase of the mine, the quality of water entering the pit would be monitored regularly so the results of the pit limnological modelling could be validated and/or further refined. However, the potential concentrations of radionuclides predicted for the pit lake would not present any significant risk to people or the environment.

Potential uses for the water

As shown in Table 11.3 of the Draft EIS, the predicted pit lake water quality would be saline to hyper-saline, ranging from 25,900 mg/L (100 years post-closure) to 247,000 mg/L (3,000 years post-closure). Based on guidelines of the Australian and New Zealand Environment and Conservation Council (ANZECC/ARMCANZ 2000), and the South Australian Environment Protection (Water Quality) Policy 2003 (SA EPA 2003), the pit lake water would not meet the criteria for freshwater aquatic ecosystems, drinking water, stock water or recreational use and therefore is not considered to have any beneficial use.

Potential for the water to affect fauna in the open pit

As explained in Section 23.8.1 of the Draft EIS, wildlife (particularly birds) could be attracted to the lake in the open pit post-closure. However, the lake is not expected to attract large numbers of birds because the temperature in the pit would be high (up to 10°C above ambient), and the pit lake is unlikely to support aquatic food. Nevertheless, the pit lake water is not considered to be toxic to fauna, for the following reasons, as detailed in the pit lake limnology modelling (refer Appendix J2 of the Draft EIS):

- the water would be saline to eventually hypersaline, which is generally unpalatable to fauna
- the water would be of a neutral to near-neutral pH
- the water would contain concentrations of metals (arsenic, copper, lead, uranium and zinc) below the relevant ANZECC trigger value for poultry (ANZECC 2000), with fluoride concentrations potentially slightly exceeding the ANZECC trigger value of 21 mg/L with a modelled concentration of 12.1 to 36.1 mg/L.

As noted above, during the operational phase of the mine, the quality of water entering the pit would be monitored so the results of the pit limnological modelling could be validated and/or further refined.

11.4.3 DEWATERING

Issue:

Clarification was requested on the quality and fate of water that would be produced by the dewatering undertaken around the perimeter of the open pit.

Submissions: 1 and 27

Response:

As described in Section 5.4.3 of the Draft EIS, extraction of groundwater to depressurise the open pit walls would continue for the life of the open pit mine at a rate of about 5 ML/d, but dewatering would be at its greatest (up to about 15 ML/d) up to Year 6.

The groundwater pumped during depressurisation activities would be very salty, with total dissolved solids (TDS) of around 40,000 to 200,000 mg/L (seawater has a TDS of around 35,000 mg/L). The extracted water would be used primarily for dust suppression and construction activities, although some may be desalinated at the on-site desalination plant for use in the metallurgical plant. A monitoring program using piezometer monitoring wells would be established to review the depressurisation system and optimise its performance.

The quality of the groundwater produced by dewatering around the perimeter of the open pit would not be affected by the quality of seepage from the tailings storage facility (TSF) or the rock storage facility (RSF). Section 12.6.2 of the Draft EIS explained that a majority of contaminants in the seepage from the TSF are naturally 'treated' through neutralisation by the carbonate materials in the sediments underlying the TSF and RSF. The natural attenuation leads to improved water quality before the seepage reaches the groundwater system.

Section 12.6.2 of the Draft EIS also noted that although most contaminants are removed by these processes, selenium and uranium (albeit much reduced from the concentrations in the tailings percolate) remain higher than background levels beneath the TSF. *In situ* reactions of the seepage with the carbonate minerals in the soils, clays and the Andamooka Limestone also lead to bicarbonate concentrations exceeding background levels.

Particle tracking of the remaining solutes was carried out to predict the movement of seepage from the TSF and RSF when it reaches the groundwater. By the end of mining, seepage would not be likely to have travelled more than 100 m from the TSF or the RSF. Therefore, the remaining contaminants would not exist in the groundwater extracted by the dewatering of the open pit.

The maximum distance that solutes could move away from the facilities would occur between 100 and 500 years post-closure, before the effect of the drawdown from the open pit dominated and regional groundwater flowed towards the pit. Simulation of seepage movement in groundwater shows that, in the longer term, drawdown caused by the open pit would effectively capture contaminants that entered the groundwater system from the TSF and RSF.

Issue:

Further information was requested regarding the water that would be pumped from the pit during mine operation: specifically, the fate of the pumped water; the quality of the pumped water (salinity, metals and hydrocarbons); the potential for it to affect clay pan ecology and soils; and associated management.

Submissions: 2 and 27

Response:

The primary source of water in the open pit during operation would be directly from rainfall, as groundwater as a source is removed through pit dewatering and stormwater run-off because of the design of the open pit.

Sections 5.4.3 and 11.5.1 of the Draft EIS outlined the proposed design of the open pit. The proposed design includes:

- grading of the landscape and building of a pit perimeter bund to prevent significant stormwater run-off entering the pit
- sumps and a series of mobile and primary transfer pumping stations to manage rainfall that falls directly into the pit.

As described in Section 11.5.1 and detailed in Appendix J2 of the Draft EIS, water that reached the pit floor, either directly or from the pit walls, would flow to a sump. This water would be used preferentially for dust suppression when the pit floor and haul roads were dry, and the remaining water would be available for recycling in on-site processes.

Appendix J2 of the Draft EIS assessed the rainfall entering the pit as being typically high-quality fresh rainwater with neutral pH, low salinity and low metal concentrations. Based on average recurrence interval (ARI) design rainfall intensities for Olympic Dam (refer Table 8.2 of the Draft EIS), the maximum volume of water entering the open pit when it is at its full design size (4.1 km x 3.5 km) would be 2.0 and 2.3 gigalitres for a 1-in-100-year rainfall event lasting 24 or 72 hours respectively. As soon as practicable in the planned mining operation, storage capacity by means of a pit sump would be created for this volume in the open pit, thus facilitating the capture of rainwater and allowing for recycling in on-site processes. During the early, rapid development stage of mining operations, temporary sumps would be designed to facilitate capture and management of rainfall inflows in the same manner. However, worst-case ARI predictions in these early years would require the mining operations to be pumped clear to some extent.

During periods of prolonged rainfall or extreme rainfall events (i.e. beyond a 1-in-100-year rainfall event), several contingencies are available and would be explored to determine the optimum outcome. Depending on its quality, excess pit water could be reclaimed for use as appropriate in the process plant; delivered to the existing evaporation ponds or newly proposed balance ponds; or, as outlined in the Draft EMP ID 4.4 Stormwater Discharge (refer Appendix U of the Draft EIS), stormwater from the pit could be pumped to existing natural depressions in the dune-swale landscape in the ultimate disturbance footprint of the RSF.

The likelihood of hydrocarbon contamination would be minimised by the normal maintenance regime for the haul truck fleet used in the open pit. Spillages of all process materials and products are treated seriously by BHP Billiton and systems and procedures are in place to ensure that spills are identified, reported, cleaned up and investigated to prevent recurrence. In the event of a spillage, a number of controls are available for operational personnel to contain the spill, including temporary bunds and spill kits, which operational and emergency response personnel are trained to use. Accidental spills in the open pit would be contained and remediated in the open pit.

As part of contingency management, all parts of the expanded operation would undergo hazard and operability (HAZOP) reviews to identify the potential for spills and the likelihood of spillages. A draft environmental management plan for chemical/hydrocarbon spillage was included in Appendix U of the Draft EIS. As outlined in Draft EMP ID 2.1 Chemical/Hydrocarbon Spillage, the current operation’s spill management and reporting procedure would be extended to the expanded operation.