Post-Closure Groundwater Impact Assessment for the Underground Mining Operation at Olympic Dam

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Extended Abstract

1. Introduction

The current BHP Billiton Olympic Dam (OD) operation comprises underground workings (tunnels, stopes) and a number of surface facilities including the TSF and processing plant. Mined out stopes in the underground workings are backfilled using cement aggregate fill which includes a portion of process tailings. Current life-of-mine plans indicate that the underground operation will continue for at least another 45 years. At the end of mine life, dewatering will cease, and the underground workings will re-flood. An assessment of the potential impacts that the Olympic Dam underground operation could have on the regional hydrogeology and groundwater quality in the intermediate and long term is required to support development of closure plans for the mine site.

During the period 2007 to 2011, OD considered the option of developing a large-scale open pit mine operation. Groundwater modelling and TSF source term assessments were conducted (SWS, 2010; SRK 2010) to support the environmental impact assessment of that proposed development (BHP Billiton 2009; 2011). The current assessment utilised material from these previous assessments where possible; however, modifications were necessary, in particular to the groundwater model, to reflect the change from an open pit to an underground operation.

The assessment for planned life-of-mine underground workings included:

(i) Prediction of groundwater behaviour post-closure, e.g. times required to re-flood underground workings and possible long-term groundwater flow paths and fluxes.

(ii) Development of appropriate source terms for contaminant sources that may impact groundwater quality. The two primary source terms identified were the tailings storage facility (TSF) and the underground workings.

2. Groundwater Modelling

The groundwater model developed for the open pit case (developed using a FEFLOW modelling platform – BHP Billiton, 2009; SWS, 2010) was modified to represent the underground workings. Modifications to the model comprised replacement of the open pit void with backfilled stopes and open voids representing development workings, shafts and raise bores. Changes to the model were effected by adapting the model grid and increasing number of layers in the vicinity of the mine workings. The modified model, following verification using monitored groundwater behaviour during operations to-date, was used to predict future groundwater behaviour.

The model predicted that during the life of mine:

- Groundwater drawdown, at local and regional scale, in the Andamooka Limestone and the bedrock hydrogeological units would extend to distances of between 4 and 10 km away from the mine;
- Groundwater mounding would occur within the Andamooka aquifer under the footprint of the TSF and could extend several kilometres beyond the site.

Post-closure, the model predicted that:

- The groundwater mound under the TSF would dissipate within decades of cessation of tailings deposition.
- The underground mine would take several centuries to re-flood after mining (and dewatering) ceases. After re-flooding, groundwater would flow preferentially through the submerged stopes, tunnels, and shafts due to their high hydraulic conductivity when compared to the surrounding bedrock. The major proportion of the groundwater flowing into the underground workings from the basement rock sequence would discharge to the overlying Andamooka Limestone aquifer via raise bores.

- Once within the Andamooka Limestone formation, flow paths for groundwater leaving the site would be northwards and then eastwards toward Lake Torrens. Flow is calculated to be very slow; particle tracking indicated that solutes would remain within the mining lease boundary throughout the 10,000 year timescale modelled.

The groundwater modelling assumed simplified representations of the groundwater system. Model input parameters were based on measured data wherever possible. Where data were unavailable, parameters were based on expert judgement or published information for analogous systems. As more data become available, it will be possible to reduce uncertainty with respect to model parameterisation, and increase confidence in long-term predictions.

3. Source Term Assessment

3.1 Tailing Storage Facility

A TSF-related source term was developed as part of the EIS studies (SRK, 2010), and is currently being re-assessed as part of the evaluation of alternate processing options being considered by OD.

TSF seepage, after percolating downwards through unsaturated soils and sediments, is expected to reach the Andamooka Limestone aquifer. Field evidence for the existing TSF indicates that percolates are neutralized effectively within the underlying soils and sediments, and that most metals and trace elements are being attenuated, either within the tailings or immediately below the TSF. A comparison between solute concentrations in the mound beneath the existing TSF and background concentrations in the Andamooka limestone aquifer indicate that only a limited number of solutes are marginally elevated above background concentrations – SO4, Cu, Se, U (as U3O8) (Table 1). The water quality within the present-day mound underlying the TSF is considered a reasonable analogue for the water quality that would occur throughout operations.

Table 1. Selected groundwater monitoring results within the Andamooka Limestone aquifer

Parameter	Mound below TSF	Baseline groundwater
pH	6.8	7.1
Cl	12000	11000
SO_4	5100	3600
Al	0.03	0.05
Ca	950	890
Fe	0.2	0.43
Mg	1000	610
Na	7700	5800
As	0.005	0.003
Co	0.007	0.004
Cu	0.034	0.019
Mn	0.52	0.74
Ni	0.014	0.015
Pb	0.004	0.003
Se	0.05	0.01
U_3O_8	0.10	0.034
Zn	0.042	0.033

Post-closure, percolation rates would be dictated by infiltration from incident rainfall. Considering the highly evaporative environment, and the proposed closure measures that will be implemented (e.g. emplacement of covers on the TSF), percolation rates are expected to decrease substantially and, as predicted by the hydrogeological modelling, the mound beneath the TSF would dissipate and the water quality is expected to revert to background levels over time.

3.2 Underground workings

The primary components that would be expected to contribute to the underground source term comprise: (i) exposed wall rocks of the underground workings that will have oxidised due to exposure to oxygen during operations; and, (ii) the cement-amended tailings backfill. Conceptual models were developed to describe the geochemical evolution of both these components.

The wall rock source term was developed on the basis that reactive, sulfidic materials would be exposed to oxidation during operations whilst the underground workings are actively ventilated. The wall rocks would undergo blast damage during mining which would increase exposure of reactive surfaces to oxidation. Soluble oxidation reaction products would accumulate within the wall rocks and could be released on contact with water during re-flooding. Oxidation and solute accumulation rates were estimated from laboratory scale kinetic testing conducted on relevant rock types as part of the Environmental Impact Statement assessment (BHP Billiton, 2009). The laboratory-scale rates were scaled to allow for relative exposure of reactive surface area within the underground workings and exposure time.

The cement-amended backfill contains approximately 57% limestone gravel, 21 % tailings and 8 % cementitious material (fly-ash and Portland cement) with water making up the balance. The cementitious materials present are expected to cause mildly to highly alkaline conditions upon inundation of the backfill. As the cement cures, a range of phases are expected to form including hydroxides, calcium aluminium silicate hydrates, gypsum. Dissolved concentrations in backfill porewater are expected to be similar to, or lower than, those in neutralised raffinate. This expectation is based on the premise that the solubility of many elements is low under alkaline conditions, and that strong attenuation within the backfill could be expected (incorporation of contaminants within newly formed phases combined with sorption onto backfill mineral surfaces).

4 Groundwater Impact Assessment

The hydrogeological modelling indicated that hydrogeological impacts would be within acceptable bounds within the near vicinity of the mine workings. Groundwater drawdown at potential environmental and third party boreholes would be less than 4 m.

There is a strong similarity between the water quality estimated for the neutralised percolate from the TSF and the water quality that would result for the combined underground workings source terms. Furthermore, flow from the underground workings would be significantly lower than from the TSF, and proportionately, the underground workings represent a minor source of solute release.

Overall, in the long term (within the time frames considered herein), impacts on baseline groundwater quality at the mine lease boundary are not expected to occur.

5 References

BHP Billiton, 2009. Olympic Dam Expansion – Draft Environmental Impact Statement

BHP Billiton, 2011. Olympic Dam Expansion – Supplementary Environmental Impact Statement (SEIS).

Schlumberger Water Services (SWS), 2010. Updates to Stuart Shelf Regional Groundwater Flow Model. Appendix F4 of the SEIS report.

SRK, 2010. TSF Supplemental Geochemical Investigations. Appendix F5 of the SEIS report.