Western Australia Iron Ore

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Mining Area C

Hydrological Impact Assessment and Water Management Summary

Contents

Note to Reader:

This document sets out the BHP Billiton Iron Ore assessment of groundwater and surface water related impacts associated with Mining Area C activities to support the EMP Rev 6.

1 Introduction

A hydrological change assessment for Mining Area C was completed as part of the broader environmental impact assessment to establish the range of potential changes in surface and groundwater conditions which may result in an unacceptable impact to the dependent or supporting environments.

The continued development of below water table mining operations and the interception of surface water flow volumes formed the basis for assessment of the potential threatening processes. The indicative mine schedule used in the assessment reflected the Mining Area C life of mine schedule.

The assessment also recognises the temporal and spatial variance in water balance outcomes and cumulative effects from other mining activities, and predicts changes to hydrological condition which could eventuate owing to a range of possible mine schedules, development sequences and mine closure strategies.

The assessment considered the following hydrological change aspects at key water dependent receptors (Coondewanna Flats, Weeli Wolli Springs and Ben's Oasis) and also the water resource:

- Groundwater level
- Groundwater quality
- Surface water flow volume and persistence
- Surface water quality

The assessment was completed in context to the broader adaptive management approach for the upper Weeli Wolli catchment which focuses on the key water dependent receptors, including the water resource and importantly considers impact in relation to outcome based thresholds which have been already adopted for the key assets. The approach allows for the progressive development of scientific knowledge and therefore sets precautionary thresholds and objectives which reflect this level of technical knowledge, including the application of preventative and mitigating controls.

As many preventative controls are already in place to mitigate impacts under the existing Mining Area C Life of Project Environmental Management Plan (EMP Revision 5a) (BHP Billiton Iron Ore 2014) and the Mining Area C Closure Plan (BHP Billiton Iron Ore 2014a), the outcomes and impact predictions do recognise some of these controls, such as a water supply being sourced from proactive dewatering areas and managed aquifer recharge (MAR) to offset the potential impacts from groundwater abstraction activities.

2 Regional water management approach

The strategic approach to site water management is currently outlined in the EMP Revision 5a (BHP Billiton Iron Ore 2014).

To meet our commitments and obligations, a regional water management strategy (with underlying catchment plans) has been developed to provide a regionally consistent methodology for identifying and managing water related environmental and community risks, considering:

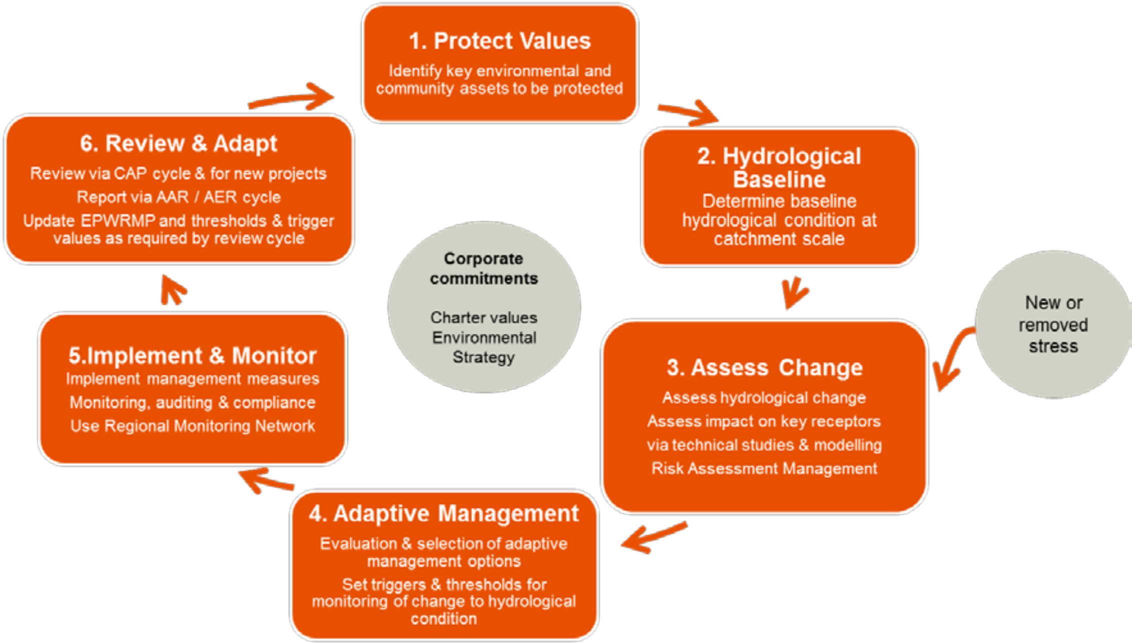
- Hydrological changes (baseline, current and future conditions of groundwater, soil moisture and surface water) resulting from BHP Billiton Iron Ore dewatering operations.
- Receiving receptors (water resources, environment, social and third-party operations), identified value and hydrological dependency (groundwater, soil moisture and/or surface water).
- Potential impacts (predicted and actual) attributable to BHP Billiton Iron Ore mining activities.
- Required risk-based adaptive management techniques that are feasible (tested and practicable) to mitigate potential impacts to acceptable levels during operations and closure.

The regional water management approach iteratively collates the key findings of eco-hydrogeological technical studies to inform the required adaptive management to enable achievement of outcome-based objectives. The adaptive management is risk based and is expected to proactively counteract, mitigate or manage potential impacts (both predicted and actual) to an acceptable level.

The approach addresses the overall water catchment management area and the specific BHP Billiton Iron Ore operations within the catchment (Central Pilbara, Mining Area C Hub). It applies catchment scale water management principles, allows for future approval processes and will simplify and provide transparency on water management criteria, risks, controls and water licences.

The regional water management approach requires that specific regulatory commitments are linked to outcome-based objectives and adaptive management methods for significant receptors if impacted by BHP Billiton Iron Ore operations. The BHP Billiton Iron Ore adaptive management process for water in the Pilbara is detailed in Figure 1.

Figure 1 – *A strategic and adaptive management approach has been implemented for water resources within the Pilbara, focusing on key environmental and community assets, sets acceptable change and objectives, and outlines practicable mitigating controls which are proportional and attributable to our impact and appropriate for the level of technical knowledge.*



3 Impact assessment references

This document summarises various work programs completed to support environmental approvals for Mining Area C and recent technical assessments carried out to improve the level of water and ecological knowledge. The reports completed as part of the assessment are referenced as follows:

1. Conceptual hydrogeology –

   Hydrogeological Assessment for Mining Area C (RPS 2014a).

2. Surface water change assessment –
   - Mining Area C Environmental Management Plan Revison 6 Surface Water Assessment, (RPS 2014).
3. Predicted water levels and groundwater change assessment –
   - Hydrogeological Assessment for Mining Area C (RPS 2014a).
   - Coondewanna Flats Eco-Hydrology Review and Conceptual Model (AQ2, 2015).

4 A summary of water effecting activities and threatening processes

The indicative project scope and mine plan schedule is summarised in the proposed EMP Revision 6 (BHP Billiton Iron Ore 2015) and assumes mining continues until 2054. The following water effecting activities have been assessed as part of the hydrological change assessment and presented in Figure 2:

Dewatering - Dewatering is a key mining activity to access below water table ore and includes the A, B, C, D, E, F, F West, P1 East, P1 West, P2, P3, P4, P5, P6, R and Brockman Detrital deposits. The lowering of groundwater levels during mine dewatering activities results in a propagation of drawdown and the modification of the hydrological conditions away from the orebody aquifers and more regionally towards the key receptors of Coondewanna Flats, Weeli Wolli Spring and Ben's Oasis.

Water Supply Drawdowns - A water supply borefield will be required once mine dewatering volumes fall below water demand volumes. Water supplies for Mining Area C will continue to be delivered from dewatering and proactive dewatering activities. The Camp Hill borefield located 15 km west of Mining Area C has been assessed and was included in the groundwater model as one of the potential options for a future source of mine water to meet processing, construction and dust suppression demand. Pumping the Camp Hill borefield could lower groundwater levels in the Mining Area C vicinity and potentially impact groundwater dependent ecosystems.

Reduced Surface Water Availability - Surface water flow and runoff will be intercepted and diverted to prevent inflow and inundation of the open pits, and to prevent flooding of infrastructure. Proposed pit and overburden storage area (OSA) developments have the potential to impact surface water resources have the potential to impact surface water resources by:

1. changing local surface water flow patterns,
2. affecting surface water runoff volumes and quality,
3. increasing the risk of erosion and sedimentation, or
4. introducing contamination to the subsurface from chemicals.

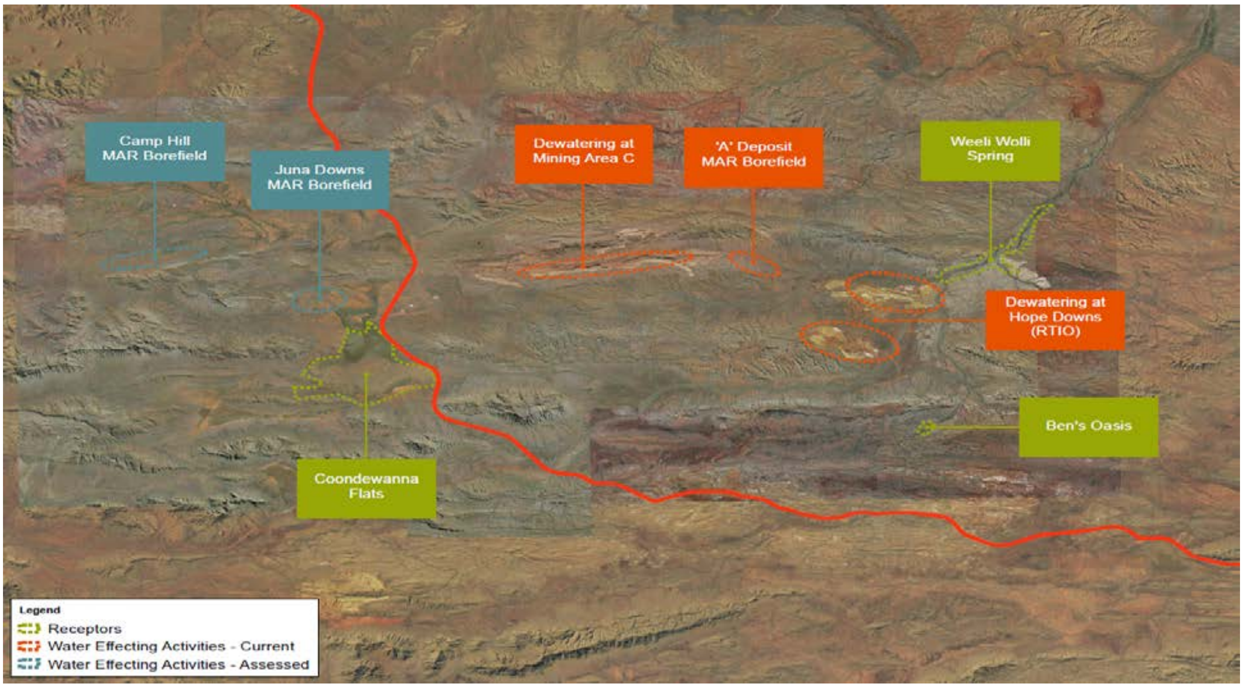
Surface water ultimately flows towards Weeli Wolli Creek and supports Coondewanna Flats.

Management of surplus water - The discharge of surplus mine water will occur during periods when the mine water demand is less than the dewatering rate. The release and discharge of surplus mine dewatering can alter groundwater levels, impact riparian tree health and change water quality. MAR (through infiltration and injection) is the existing method of surplus management and for the purpose of this assessment is assessed as aquifer injection at Camp Hill borefield. The ongoing MAR trial at Mining Area C (currently located at A Deposit) appears to be a feasible alternative to mitigating drawdown at a key receptor.

The storage and handling of waste products - The inappropriate handling and management of soluble waste materials has the potential to alter surface and groundwater quality.

Pit void - The backfilling of pit voids to above the recovered standing water level (nominally 5 m above the groundwater level) is proposed as part of the mine closure strategy and is therefore not considered to be a water effecting activity. Once dewatering ceases and backfilling occurs, the recovery of the water level to pre-mining levels is slower than the rate of drawdown and in some instances may take centuries.

Figure 2 – Water effecting activities associated with the proposed EMP Rev 6.



5 A description of the assets of value

The water dependent receptors which could potentially be impacted from changes in hydrological conditions associated with the proposed EMP Revision 6 development have been established based on depth to groundwater monitoring, surface water flow and inundation mapping and vegetation mapping over multiple years. The primary water dependent assets identified are:

1. The Water Resource (surface and groundwater)
2. Coondewanna Flats (including Lake Robinson)
3. Weeli Wolli Spring
4. Ben's Oasis

The locations of the assets are presented on Figure 2 and a detailed description of the environmental receptors and hydrological dependency is detailed in the Strategic Environmental Approval (SEA) Ecohydrological Change Assessment report (BHP Billiton Iron Ore, 2015).

5.1 Water resources

The hydrogeology and water resources of the cental pilbara region are summarised in the SEA Ecohydrological Change Assessment report (BHP Billiton Iron Ore, 2015). Three primary water resource aquifers exist within the Upper Weeli Wolli catchment including 1) the orebody aquifer developed through mineralisation of the banded iron formation, 2) the Wittenoom dolomite which is located within the topographic low areas and 3) the overlying alluvial tertiary detrital. The aquifer yields, permeability and storage volumes vary laterally and vertically through each aquifer unit and the hydraulic connection between the systems is considered to be variable and constrained by structural controls, mineralisation and vertical permeabilities.

Recharge primarily occurs in the Coondewanna Flats area and discharge is dominated through outflow at Weeli Wolli springs. The natural water balance for the Upper Weeli Wolli catchment is estimated to be made up of inflows and outflows of around 12.4 ML/d. Of the total volume abstracted as part of the proposed mining activities between 50% and 70% is predicted to be from aquifer storage and the remainder from rainfall recharge.

5.2 Coondewanna Flats description

Coondewanna Flats is a Priority Ecological Community (PEC) (Onshore Environmental, 2015) located about 18 km south west of BHP Billiton Iron Ore's Mining Area C operations. The Great Northern Highway passes to the east of the Coondewanna Flats boundary and Rio Tinto's West Angelas to Cape Lambert rail line passes to the west. Lake Robinson is an ephemeral shallow lake which forms within Coondewanna flats during the wet season.

Coondewanna Flats is an internally-draining surface water feature and has a catchment area of approximately 866 km^2. The flats occur within an intermontane area bound by hills of Mt Robinson and The Governor to the east and south, and Packsaddle and Mount Meharry to the north and west.

Surface water flows towards the flats from the north, west and south. Surface water runoff accumulates on the flats before being lost to evaporation or infiltrating into the Tertiary detrital, where it replenishes soil water in the unsaturated zone and potentially contributes to groundwater recharge. Lake Robinson occurs within a topographic low at the north-eastern extent of the flats and is one of the terminus areas for catchment runoff. It supports distinct *Eucalyptus victrix* woodland vegetation communities. The surrounding flats are characterised by poorly-defined drainages with Mulga woodland vegetation and occasional scattered Eucalypts.

The depth to groundwater beneath the Coondewanna Flats is about 20 m bgl (AQ2, 2015) suggesting that interaction between the groundwater system and terrestrial ecosystems is unlikely. Ongoing studies on the hydrology and vegetation water use have found that vegetation communities are likely to be dependent on the surface water regime of the flats.

Environmental values

Coondewanna Flats (including Lake Robinson) includes several vegetation communities with ecological value and is listed by the Department of Parks and Wildlife (DPaW) as a Priority Ecological Community

(PEC) (Onshore Environmental 2015). The Coolibah-lignum flats: *Eucalyptus victrix* over *Muehlenbeckia* community is described by DPaW as:

> Woodland or forest of *Eucalyptus victrix* (Coolibah) over thicket of *Muehlenbeckia florulenta* (lignum) on red clays in run-on zones. Associated species include *Eriachne benthamii, Themeda triandra, Aristida latifolia, Eulalia aurea* and *Acacia aneura*. A series of sub-types have been identified:
>
> - Coolibah woodlands over lignum (*Muehlenbeckia florulenta*) over swamp wandiree (Lake Robinson is the only known occurrence) (Priority 1);
> - Coolibah and mulga (*Acacia aneura*) woodland over lignum and tussock grasses on clay plains (Coondewanna Flats and Wanna Munna Flats) (Priority 3); and
> - Coolibah woodland over lignum and silky browntop (*Eulalia aurea*) (two occurrences known on Mt Bruce Flats) (Priority 1).

Ecohydrological conceptualisation

- Surface water runoff from surrounding catchments is attenuated in the internally-draining, low-relief landscape of the flats. It principally accumulates in the Lake Robinson area but extends more widely across the flats during large flooding events.
- Anecdotal evidence indicates that surface water flow into Coondewanna Flats occurs every three in four years and is an important process for replenishing soil moisture in the unsaturated profile.
- Beneath the flats, an unconfined calcrete aquifer is present at a depth of 20 to 30 m bgl. It is overlain by largely unsaturated Tertiary detrital and underlain by low to high permeability dolomite of the Wittenoom Formation. This dolomite forms part of a regional groundwater flow system that ultimately reaches Weeli Wolli Spring.
- Groundwater recharge is associated with the infiltration of ponded surface water runoff in Lake Robinson. Recharge events are estimated to occur once in every four years. RPS (2014a) estimated that annual average recharge rate is about 10 ML/d over the broader Coondewanna Flats area. The Coondewanna Flats is considered an important groundwater recharge area for Upper Weeli Wolli catchment, supporting 75% of the catchment recharge.
- Groundwater discharge occurs as outflow to the South Flank and Mining Area C Valleys, which hydraulically connect the Coondewanna and Weeli Wolli Spring catchments.

Ecosystem components

- *E. victrix* on Coondewanna Flats rely on stored soil moisture to meet their water requirements, which is replenished by surface water inflow. Studies indicate these trees are able to obtain soil moisture for prolonged periods from horizons within the unsaturated zone above the watertable (Astron, 2014). The *E. victrix* woodlands at Coondewanna Flats are considered unlikely to rely on groundwater.
- The surface water dynamics of Coondewanna Flats are likely to influence bud-set, flowering, seed production and seedling recruitment of the *E. victrix*. However, further investigations are necessary to understand the relationship between flooding regimes and the reproductive cycle of the woodland trees.
- Mulga is a shallow-rooted species with xerophytic adaptations to drought stress. Water use requirements of the Mulga communities on the flats are most likely met by soil water in surface layers (up to 5 mbgl), which is replenished by rainfall and runoff.
- The Lake Robinson waterbody is ephemeral but may persist for several months.

Investigations into water requirements for Coondewanna Flats priority communities are ongoing. Interim findings (AQ2, 2015) suggest that Mulga and Muehlenbeckia are vadophytic and may not rely on groundwater to meet plant water requirements owing to deep water levels (>15 m) and seasonal surface water inundation. Coolibah trees most likely rely on the soil water reservoir to meet plant water needs but may have facultative dependence on groundwater during extended dry periods of below rainfall form a period of >9 years. It is likely that the hydrological environment at Coondewanna Flats plays a key role in supporting these vegetation communities via soil moisture replenishment by periodic infiltration and inundation in some places, of surface water drawdown into the unsaturated zone or potentially through fluctuation and periodic rise of the regional water table following recharge events.

Whilst these investigations are ongoing, a precautionary approach will be implemented in the management of groundwater and for the purpose of this assessment, the vegetation will be assumed to be partly dependent upon groundwater resources and that a change in water level and hydrological conditions outside of existing thresholds will require investigation and potentially mitigation.

As required by Condition 5 of Ministerial Statement 491, the Mining Area C Life of Project EMP Revision 5a (BHP Billiton Iron Ore 2014a) outlines two water level investigation triggers for Coondewanna Flats. The first is a reduction in water level below 663.75 mRL at monitoring bore GWB0039M (BH39) and the second is a rate of change in water level of greater than 0.5 m reduction per year, also at GWB0039M. These measures are inherently precautionary and have been committed to as triggers for further investigation. The proposed Life of Project EMP Revision 6 will adopt these triggers and continue the precautionary management measures.

5.3 Weeli Wolli Spring

Weeli Wolli Spring is located approximately 14 km east of Mining Area C and comprises an area where surface water and groundwater flows discharge from the Upper Weeli Wolli Creek catchment. The spring occurs where groundwater flow is constrained through a gorge in Wildflower Range. The creek and surrounding floodplain area support permanent pools and riparian woodlands.

A shallow groundwater system with extensive areas of calcrete is present up-gradient of the spring. Downstream of the Weeli Wolli gorge, the creek flows via a narrow channel past the confluence with Marillana Creek and ultimately into the Fortescue River Valley.

The spring's natural function is currently being impacted from Hope Downs operations and is maintained through artificial discharge through a series of spigots.

Environmental values

The Weeli Wolli Spring area is recognised as having multiple ecological values that collectively contribute to its DPaW listing as a Priority 1 Ecological Community. The community is described by DPaW as:

> Fringing forest or tall woodland of Silver Cadjeput (*Melaleuca argentea*) and River Red Gum (*Eucalyptus camaldulensis*) over trees of Coolibah (*Eucalyptus vitrix*) and a dense shrub layer dominated by wattles, in particular Pilbara Jam (*Acacia citrinoviridis*).

There are several species of conservation interest including one named after the spring (*Stylidium weeliwolli*). This area supports the true phreatophyte *Melaleuca argentea* which is highly sensitive to groundwater drawdown (Onshore Environmental 2015). *Eucalyptus camaldulensis* and *E. victrix* are considered to be facultative phreatophyte species.

An unusual and diverse aquatic fauna assemblage occurs in a series of permanent pools up gradient of the spring associated with the shallow groundwater system. The permanent discharge from Weeli Wolli Spring is an uncommon habitat for the Pilbara and may function as a refuge for mesic-adapted fauna.A relatively high diversity of stygofauna is associated with the calcrete and alluvial aquifer system.

The creek valley at Weeli Wolli Spring supports a diverse bird assemblage (over 60 species) and very rich microbat assemblage including the Ghost bat (*Macroderma gigas*), a State listed species. The permanent pools provide a water source and foraging habitat for microbats.

In 2014, the Weeli Wolli Spring PEC was considered by the DPaW to also include Ben's Oasis, an area located about 20 km further upstream and south of Weeli Wolli Spring. Ben's Oasis is a name that is locally used by BHP Billiton Iron Ore. At this location, the vegetation is concentrated along a relatively narrow creek channel adjacent to some surface water pools. There is very little documented information about the geology, hydrology and ecology of Ben's Oasis.

Surface and groundwater systems

Surface flow at Weeli Wolli Spring is a combination of spring baseflow supported by groundwater discharge, as well as seasonal surface water inflows.

On average, the area experiences two surface water flow events each year. Local infiltration of the surface water results in recharge to the shallow groundwater system.

The groundwater system comprises an unconfined aquifer sequence including calcrete and detritals. Groundwater is shallow being less than 10 mbgl and becoming shallower towards the spring. As the aquifer thins and narrows towards Weeli Wolli Spring, groundwater flow is concentrated and discharged over near-surface basement as baseflow.

The water balance (AQ2, 2015) identifies that groundwater throughflow from the upstream catchment is about 10 ML/day. Additional recharge of approximately 2.5 ML/d occurs within Weeli Wolli Spring area. Discharge occurs as spring baseflow (7.2 ML/day), evapotranspiration (1.5 ML/day) and groundwater throughflow in the shallow aquifer (3.6 ML/day).

Ecosystem components

The Weeli Wolli Spring area hosts a PEC comprising groundwater-dependent vegetation, permanent pools supporting a range of fauna, and a diverse stygofauna community. There is up to 30 m of saturated calcrete that provides the main stygofauna habitat.

A number of permanent pools upgradient from Weeli Wolli Spring (sustained by the shallow groundwater regime) provide aquatic habitat, and a permanent water source for terrestrial fauna and avifauna.

No information is available regarding groundwater levels or seasonal variation at Ben's Oasis. At present, there is insufficient information to formulate a conceptual ecohydrological model for Ben's Oasis.

6 A description of the predicted water balance range

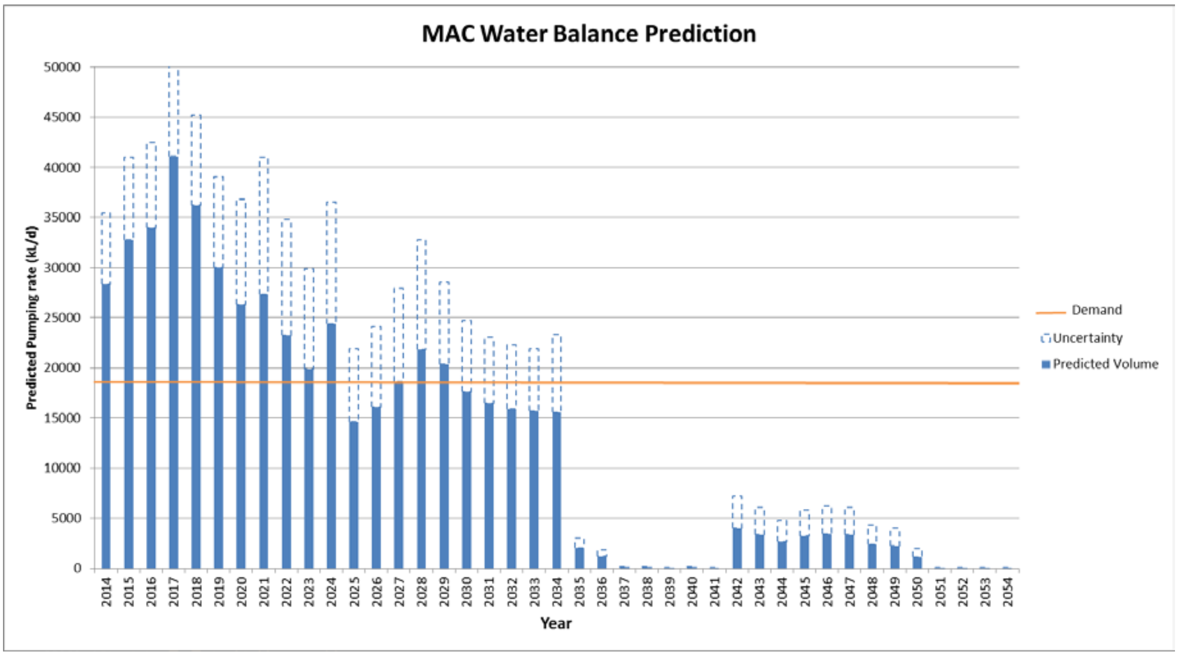
6.1 Dewatering volumes and profile

Dewatering is the key water activity which influences the water balance and the also extent of potential groundwater impacts.

Dewatering at Mining Area C operations is likely to be required until 2034 and the maximum dewatering rate is predicted to be around 40 ML/d during 2017. The annual predicted dewatering rate is presented in Figure 3. The dewatering rate is dependent upon the rate of below water table mining, the mining sequence and the deposit being mined at any one time (a maximum of 5 pits mined below water table at the same time), plus the cumulative effects from Hope Downs. It is recognised that the indicative mine schedule could change and as a result the maximum dewatering rates and periods of dewatering may vary accordingly.

To evaluate this uncertainty and the resulting temporal variance in water levels, volumes and potential impacts, an adaptive management approach has been adopted under Condition 5 of Ministerial Statement 491 and outlined within the Life of Project EMP (BHP Billiton Iron Ore 2014). The approach considers a range of potential water balance scenarios and associated drawdowns based on a mid and high case mine production plans and dewatering rates, and sets outcome based thresholds at the key receptors. These conditions are supported by practicable and feasible mitigation measures which can be implemented to address the range of predicted hydrological changes.

Figure 3 - The predicted mine water balance for the proposed EMP Revision 6.



6.2 Water demands

Future water supplies for Mining Area C are required for either 1) production demands or 2) potable. The projected daily annual averaged production water demand is estimated to peak at 17.4 ML/d from 2017 and remains at this volume until closure in 2054. Daily peak demands could be as high as 25 ML/d and as low as <2 ML/d during rain periods. Potable demands are estimated to be considerably less at around 2 ML/d.

Production water supplies will be delivered from dewatering activities. Once dewatering rates drop below the water demand volumes and future mine dewatering areas are proactively used as a water supply (2034), an alternative water supply will be developed. For the purpose of the impact assessment, the Camp Hill borefield option has been evaluated. Other supply alternatives, such as the transfer of water from a future or existing mining area are not part of this impact assessment.

6.3 Surplus water management

Surplus water will continue be managed in accordance with the Department of Water, Use of Mine Dewatering Surplus (2013). Up until 2034, dewatering rates are expected to be either equal to or greater than water demands resulting in a net water surplus of up to 24 ML/d, but typically less than 12 ML/d. During this time, there are periods of up to nine years where the entire water supplies can be matched by proactive dewatering of future below water table mining areas. Surplus volumes will vary daily depending upon daily water demand requirements and the surplus option will need a peak capacity of around 30 ML/d for short periods (days to weeks).

For the purpose of the assessment, surplus water is managed through MAR to meet BHP Billiton Iron Ore's sustainability objectives and minimise impacts to the water resource. The surplus volumes will be returned to the aquifer in three areas including the existing A Deposit MAR borefield (until 2017), an infiltration pond, plus the proposed Camp Hill borefield area. Some of the surplus water which will be injected to the aquifer at Camp Hill will be subsequently abstracted once dewatering rates fall below demand requirements. Further investigations may identify other preferred options for the future location of the MAR borefield, for example, Juna Downs (Figure 2).

Surplus water volumes up to 15 ML/d may be required to mitigate potential impacts to a key environmental receptor (Coondewanna Flats) from changes to hydrological conditions resulting from excessive groundwater drawdown coupled with periods of prolonged low rainfall.

Other surplus water management options, such as the discharge to creeks or drainage lines have not been assessed but could be considered appropriate once other more sustainable water management options have been exhausted and the potential impacts can be managed.

6.4 Surface water diversion

The upper portions of some small ephemeral creeks would be intercepted by the proposed P2, P5 and P6 pits and by proposed modifications to existing pits. Natural runoff loss from the interception of these upper creeks plus loss from the OSA and the operational footprint for Mining Area C catchment is estimated at a maximum 50%. This overall net reduction to the primary drainage areas of Weeli Wolli creek and Coondewanna has been assessed to determine whether the loss is significant. The potential impacts from runoff sedimentation and changes to water quality resulting from water waste rock interaction are addressed as part of the assessment.

6.5 Pit voids management

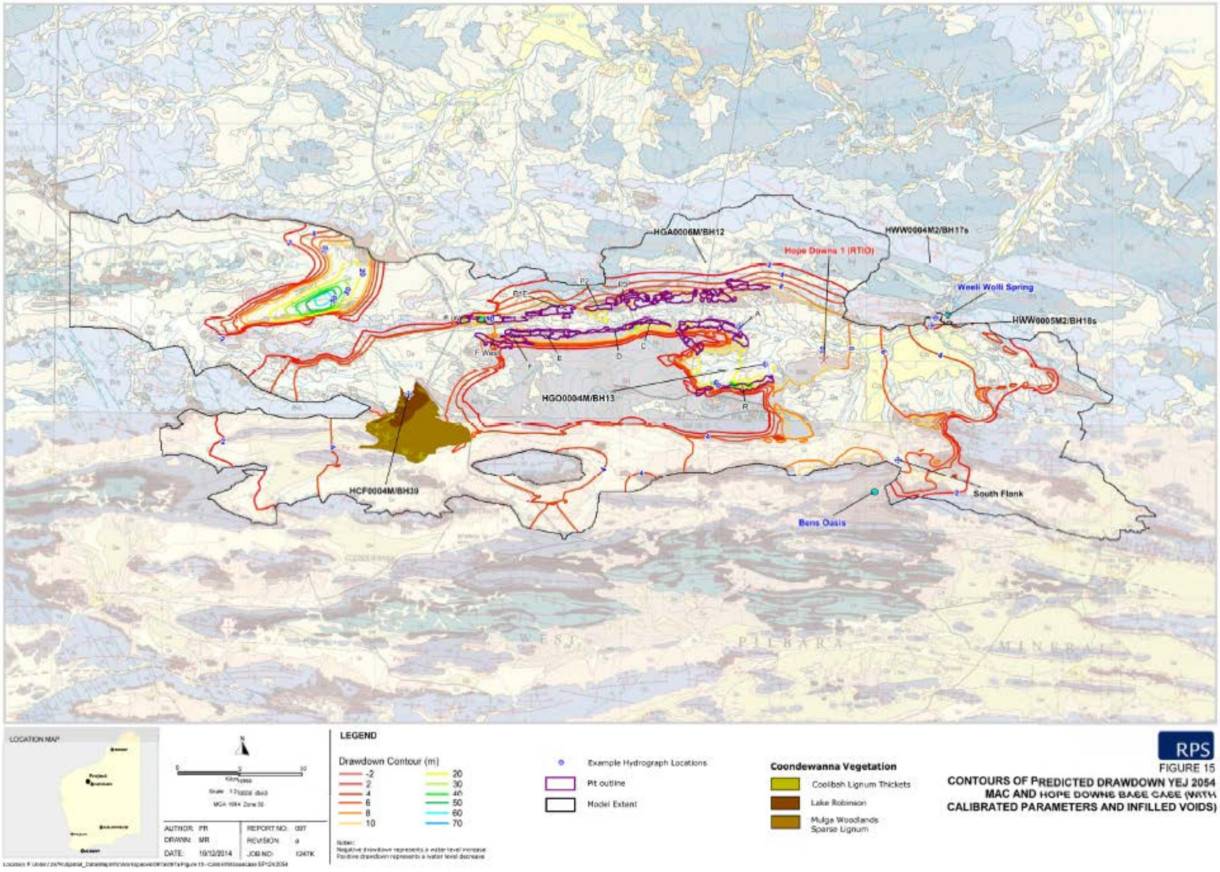
Pits below water table will be backfilled during operations as part of a waste management program and also post operations to a level which prevents impacts to water quality and allows for aquifer recovery at the key receptors. The approach removes the water quality risk. The proposed approach to waste management and pit void backfilling is documented in the Mining Area C Closure Plan (BHP Billiton Iron Ore, 2014a).

7 Change assessment methodology

Changes in Groundwater levels - To predict the range of possible changes in hydrological conditions resulting from groundwater abstraction during operations and post closure, a number of regional numerical groundwater models have been developed which simulate existing and past abstraction and predict temporal and spatial hydrological changes (RPS, 2014a). The models are regional in extent, covering the entire upper Weeli Wolli catchment and the key environmental receptors of Coondewanna, Weeli Wolli and Ben’s Oasis (extrapolated) plus the sub regional water resource aquifers such as the Wittenoom dolomite. The model area is presented in Figure 4.

The models represent an updated conceptualisation of the hydrogeology (RPS, 2014a) and simulate Mining Area C dewatering activities, surplus injection as MAR and water supply borefield abstractions referenced within the proposed EMP Revision 6 scope. Cumulative effects from Hope Downs groundwater activities and Mining Area C MAR at Camp Hill have also been included.

Figure 4 – Predicted change in groundwater levels resulting from the proposed abstraction and injection activities (end of operations).



Multiple numerical models were considered necessary to predict the range of change as the groundwater system is complex and covers a large area, and some of the major influences on these outcomes are open to multiple interpretations. To counter this inherent uncertainty, two alternate models were developed, each based on materially different hydrogeological conceptualisations; one conservative with respect to the ease of drawdown propagation towards Coondewanna Flats and the other less so. The models utilised different parameter combinations but were calibrated to the same diverse set of observations, including groundwater levels, flows at Weeli Wolli Spring and the catchment analytical water balance.

The primary variations in the conceptualisation between the numerical models are related to:

- Recharge volumes at Coondewanna,
- Hydraulic connectivity within the Wittenoom dolomite and the Tertiary Detritals between the dewatering operations and the key receptors, and
- Division of east-west groundwater flow from Coondewanna Flats to Weeli Wolli Spring via the north or south flank valleys.

The various models generate different magnitudes and rates of groundwater drawdown within the regional water resource and importantly at Coondewanna Flats. These predictions were subsequently assessed as part of the potential for groundwater dependent ecosystem and supporting environmental impact and considered in context to the previously established outcome based thresholds for the key receptors (BHP Billiton Iron Ore, 2014).

The benefit of this approach is that the models provide an assessment of the potential range of predictive outcomes considering both technical and mine development uncertainty, particularly with regards to the propagation of drawdown from Mining Area C to Coondewanna Flats (which, along with mine closure, represents the objective with the most uncertainty).

The approach is consistent with BHP Billiton Iron Ore's overarching regional adaptive management approach and is appropriately precautionary, whereby it provides a spectrum of hydrological conditions considering the range of uncertainty to establish whether the groundwater system can be managed using practicable and tested mitigation options. The models are furthermore used to establish whether the range of probable hydrological conditions can be maintained within the outcome based thresholds established for the key receptors during operations or post closure.

Changes to Surface Water flow Volumes – An analytical approach was used to estimate the potential loss or gain of water volumes owing to landform changes and diversions. The volumes were based on a percentage of catchment area loss. In some instances there was a small catchment gain owing to the change to drainage lines near catchment divides. The percentage of change was then compared in relation to the overall catchment flow change and assessed as to whether this was significant. Changes in runoff volumes were then assumed to be directly proportional to the percent change in catchment area. For example, a 1% reduction in catchment area is assumed to result in a 1% reduction in runoff volume.

Changes to Water quality – A preliminary Acid and Metalliferous Drainage (AMD) Risk Assessment has been completed for Mining Area C to support the proposed Life of Project EMP Revision 6 scope (Klohn Crippen Berger 2014) which, in part, assessed potential changes to local water quality.

It is possible for AMD to report to groundwater and surface water from overburden storage areas and backfilled pits, if potentially acid forming (PAF) material is left unmanaged; while it is unlikely for AMD to migrate from pit lakes or pit voids. The expected likelihood of water quality degradation is even lower because PAF material management measures are routinely applied.

There is a potential for leachate or runoff from waste rock stored in OSAs to be somewhat saline, and short-term pulses of salinity in contact waters are possible.

Within pit voids that extend partially below the post-closure water table, initial deterioration of water quality may occur due to leaching of wall rock in the dewatering cone and, if pits are backfilled, reaction of backfilled materials not in geochemical equilibrium with groundwater.

7.1 Regional water resource impacts

Introduction

The impact to water resources in the Upper Weeli Wolli catchment area form the proposed Mining Area C mining activity are predicted to be most significant in the groundwater aquifers and surface water flow system in the vicinity of the dewatering activities and within the mine footprint. Cumulative impacts are predicted to be most significant in the lower Weeli Wolli catchment due to the combined effect of Mining Area C and Hope Downs water management activities in this area and the recovery of the groundwater system throughout the catchment is likely to take decades to centuries. Predicting the cumulative impacts is highly uncertain, relying on a number of significant assumptions associated with the future water management strategy at Hope Downs.

Surface water flow is an important contribution of stream flow and groundwater recharge in the Coondewanna Flats and Weeli Wolli Spring areas. Runoff assessments indicate that the extent of surface water interference to the natural system from the proposed Mining Area C activities will be minimal due to the diversion of creeks and channel flow. The loss of surface water volume from the system owing Mining Area C water effecting activities occurs immediately in the mine footprint area which is located in the upper catchment some 7 to 14 km from the primary recharge features and key surface water dependent ecosystems such as Coondewanna Flats and Weeli Wolli Creek, respectively.

Changes to Surface Water flow Volumes – Impacts to the surface water flow volume and quality is not expected to be significant owing to the continued use of preventative controls such as creek diversion and sedimentation ponds. The subsequent downstream impacts to aquifer recharge and riparian vegetation in the areas of Weeli Wolli and Coondewanna are considered to be insignificant and within natural variance.

The volume of surface water intercepted by mining activities is estimated to be around 740 ML/a from the total catchment flow for the Upper Weeli Wolli catchment area. The interception and effective removal of surface water from which would ultimately discharge or infiltrate into the Weeli Wolli Spring region is around 4.2% of the total volumes and is considered to be insignificant in comparison to the disruption which has occurred owing to mining in the lower catchment. For Coondewanna, the volume of surface water flow may increase slightly to 0.3% owing to changes in landform runoff in the vicinity of the surface water catchment divide, which effectively increases the capture area.

Changes in Regional Groundwater Levels – The analysis of the predictions of the various numerical groundwater models (RPS, 2014a) indicates that groundwater within the entire catchment area will be affected to some extent from the cumulative mine related activities from both Mining Area C and Hope Downs. It is predicted that with pit backfill (at both Mining Area C and Hope Downs), the groundwater systems could recover within 1 m of the pre-mining water levels within around 300 years.

Although groundwater drawdown and changes to the water resource attributed to Mining Area C activities could extend >10 km west and east of from the mine, the resulting impacts to the groundwater resource and groundwater dependent ecosystem are considered to be manageable. However it is recognised that the aquifer water levels will be lowered by up to 100 m and in part drained immediately in the vicinity of the mines during and for the recovery period following dewatering activities.

The regional groundwater drawdown response to Mining Area C pumping is predicted to propagate out from the Marra Mamba orebodies in an east-west direction following the higher transmissivity Wittenoom dolomite and detrital aquifers. The extent of drawdown associated with Brockman dewatering is considered to be less significant owing to low permeability rocks (shale and banded iron formation (BIF)) constraining the drawdown extent.

This water level change is predicted to extend preferentially towards Coondewanna Flats, with a smaller, and much later, change predicted at Weeli Wolli Spring. The extent of drawdown from Mining Area C to Ben's Oasis is considered unlikely owing to geological controls, catchment boundary features and distance from Mining Area C.

Groundwater levels are expected to rise and fall in the vicinity of the Camp Hill borefield as the system is used for surplus MAR and subsequently as a water supply borefield. The draw up is predicted to be up to 40 m. Operational borefield management and design will ensure that water levels remain >10 m from the ground surface during surplus injection. Aquifer abstraction at volumes of up to 17 ML/d is expected to see a localised drawdown of 70 m in the vicinity of the abstraction bores to around 2 m at a distance of 8 km to the northwest. The aquifer drawdown effects are predicted to be isolated from the mine dewatering area of influence owing to the ridge of low permeability BIF and shale separating the pumping centres.

Changes in Water Quality – Geochemical testing and AMD risk assessments (Klohn Crippen Berger, 2014) have identified that the potential for impacts to water quality are considered to be low, primarily owing to the low proportion of acid generating material, the high proportion of acid consuming material and the planned backfill and waste management program during and at the end of mining.

The application of sedimentation ponds which will be installed at the margins of the mining area will reduce the likelihood of a degradation of surface water resources and impacts to flora and fauna.

Waste management and the storage of chemicals will continue to be considered in context to the existing standard management practices and therefore is unlikely to have a discernable impact to water quality.

7.2 Impacts to Coondewanna Flats

Impacts to Coondewanna Flats PEC owing to changes in hydrological conditions associated with mining activities at Mining Area C (or even the broader cumulative effects of Hope Downs) will be controlled with preventative water management activities and any residual impact risk managed using the mitigation measures outlined in the Life of Project EMP and Mine Closure Plan.

The changes to hydrological conditions at Coondewanna are primarily expected to be associated with falling groundwater levels as a result of dewatering the eastern deposits (E Deposit), and to a lesser extent through the cumulative effects of dewatering the Marra Mamba deposits (A and C), the Packsaddle Range deposits and the Hope Downs deposits. Changes in surface water volumes are not considered to impact the PEC values as outlined above.

The range of numerical groundwater modelling results predict that water levels could fall by between 6 and 9.5 m at the northern edge of Coondewanna Flats by 2036 and at which point water levels begin to recover. The rate of change is estimated to be around 0.3 to 0.4 m/year. The rate and extent of drawdown appears to be dependent upon the hydraulic connection (transmissivity of the dolomite) between the mine and Coondewanna. Although variances to the mine sequence and dewatering schedule appear to affect the response timeframe and rate of decline, the ultimate magnitude of drawdown appears to be relatively similar and within model error, and therefore generally independent upon the order of mines and short term pumping variances.

As outlined in Section 5.2, Coondewanna is unlikely to be dependent upon groundwater and therefore the magnitude and rate of change in hydrological conditions outlined above are unlikely to result in an impact to the PEC. However, a longer monitoring data set (of the soil and groundwater hydrological conditions) would be required to demonstrate that the vegetation assemblages do not become partly dependent upon groundwater or even the overlying capillary fringe during significant drought periods where below average rainfall extends for >9 years (AQ2, 2015). As a result, a precautionary management approach will continue to be adopted for Coondewanna and monitoring and investigation thresholds will continue to be applied. These thresholds and any requirement to implement mitigation measures will be evaluated annually as outlined in the Life of Project EMP.

7.3 Impacts to Weeli Wolli Spring and Stygobionts

The extent of groundwater change and surface water interception from Mining Area C activities at Weeli Wolli Spring and the groundwater dependent environment will be monitored and managed using the mitigation measures outlined within the existing Life of Project EMP.

Surface water flow interception which contributes to Weeli Wolli creek flow will be around 4.2% and considered to be within predictive error and insignificant in terms of change or impact.

The predicted groundwater drawdown resulting from Mining Area C only abstraction activities until 2054 extends to the east and reduces water levels in the lower catchment aquifer (alluvials, dolomite and calcrete aquifers) by 2 to 4 m. The proportion of drawdown beneath the spring complex attributable to Mining Area C dewatering activities is predicted to be around 1.5 m by 2050.

Cumulative groundwater drawdown from the combined Mining Area C and Hope Downs dewatering activities shows much greater impacts, whereby water levels are significantly reduced in the lower catchment spring area. This drawdown, which reaches a maximum of approximately 6 m, is associated predominantly with abstraction from Hope Downs. The timing and success of Hope Downs closure plans to recover groundwater levels will also influence the water level and potential for a continued impact at Weeli Wolli Spring.

8 Regional Cumulative Effects

As highlighted above, the predictive groundwater models have also included the activities of other mining operators within the Upper Weeli Wolli catchment.

The predicted further downstream impacts outside the Weeli Wolli upper catchment (lower Weeli Wolli catchment and ultimately the Fortescue Marsh) from the Mining Area C operation are considered to be manageable.

Changes to the groundwater and surface water discharge volumes and contributing flows to the downstream and adjoining catchment discharge points from Mining Area C activities are estimated to be up to <1% and 4.2%, respectively and typically will continue to be masked by the extent of water affecting activities from mining operations between Weeli Wolli Spring and Fortescue Marsh.

9 Management Options

The existing Life of Project EMP Revision 5a outlines the range of water management alternatives and hydrological thresholds which are currently being applied as a part of the adaptive management controls to mitigate and prevent impacts from the proposed mining activities to the key receptors, such as the water resource, Weeli Wolli Spring and Coondewanna Flats. The proposed Mining Area C EMP Revision 6 and associated Mine Closure Plan define the following practicable and feasible water management options to manage impacts:

1. Proactive dewatering volumes will continue to be used as a process supply when dewatering rates fall below water demand requirements. The predicted water balance indicates that this is likely to

occur at various stages between 2024 and 2035. The activity will see dewatering water being preferentially abstracted and used over a stand-alone water supply borefield, ultimately reducing the long term drawdown on the water resources.

2. Consistent with the Department of Water Mine Water Management Guidelines (DoW, 2013), and where practicable and feasible, surplus groundwater will continue to be preferentially returned to the aquifer through MAR. The practice will be used to reduce the extent and duration of groundwater drawdown and mitigate the impact to water resources. However, it is recognised that there are practicable and aquifer limitations with MAR and some surface water discharge maybe explored at a later date.
3. Surplus water is planned to be introduced into the proposed Camp Hill borefield from about 2018 onwards, effectively storing water into the dolomite and alluvial aquifers. Subsequently, the MAR borefield will be reversed and the borefield will be pumped as a water supply (approximated to be post 2035). Although Camp Hill has been assessed as part of the numerical modelling, other locations may prove to be more feasible.
4. Surface water will continue to be diverted around the mining footprint to the extent practicable to minimise the loss of surface water flow in the natural drainage systems. Sediment ponds will continue to be installed at the margins of the deposit (east and west) to retain runoff and settle sediment prior to discharge into natural drainage features which ultimately flow into Coondewanna Flats and Weeli Wolli Spring PECs.
5. Backfilling of below water table mine voids.

In addition to preventative controls, a number of mitigating controls have been tested and proposed to prevent impacts to the key receptors, including:

Coondewanna Flats - The change in hydrological conditions at Coondewanna Flats is predicted to be between 6 and 9.5 m by the end of mining activities in 2054. The net change or rate of change in water levels is considered unlikely to result in an impact to the PEC (AQ2, 2015). However, as outlined previously, a precautionary approach to impact management will be applied using hydrological change thresholds until ecological thresholds can be established. The hydrological thresholds are outlined in the Life of Project EMP (Revision 5a). In the event that water levels fall below the investigation thresholds, a review will be completed of the hydrology and potential impacts and the finding discussed with the various Regulators. If following the review the risk of impact is considered likely, mitigation controls will be implemented.

The mitigating controls proposed in the Life of Project EMP include infiltration and injection of water into the aquifer between the aquifer stress (dewatering) and the receptor margins to maintain hydraulic heads at Coondewanna Flats. Infiltration rates at Coondewanna of up to 15 ML/d until 2041 may be required to offset the drawdown from mine dewatering activities.

Weeli Wolli Spring - Mitigating controls and hydrological thresholds or triggers to address Mining Area C's proportion of impacts to Weeli Wolli Spring have not been considered in the Life of Project EMP. Over the next 20 years Hope Downs will predominantly continue to impact the spring and any long term effects from Mining Area C are considered to be comparatively small and ultimately will depend upon the success of Hope Downs closure. However, the potential impacts will be reviewed and where necessary controls implemented as more monitoring data is made available.

The range of preventative and mitigating measures suitable to prevent impacts at Weeli Wolli Spring during the later stages of Mining Area C mining and into closure are outlined in the Life of Project EMP. The hydrological changes resulting from Mining Area C will be reviewed annually as part of the groundwater operating strategy (GWOS) and annual aquifer review (AAR) reporting and adaptive management process. The findings from the annual review will inform the routine updates of the Mine Closure Plan (nominally every 5 years).

10 References

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