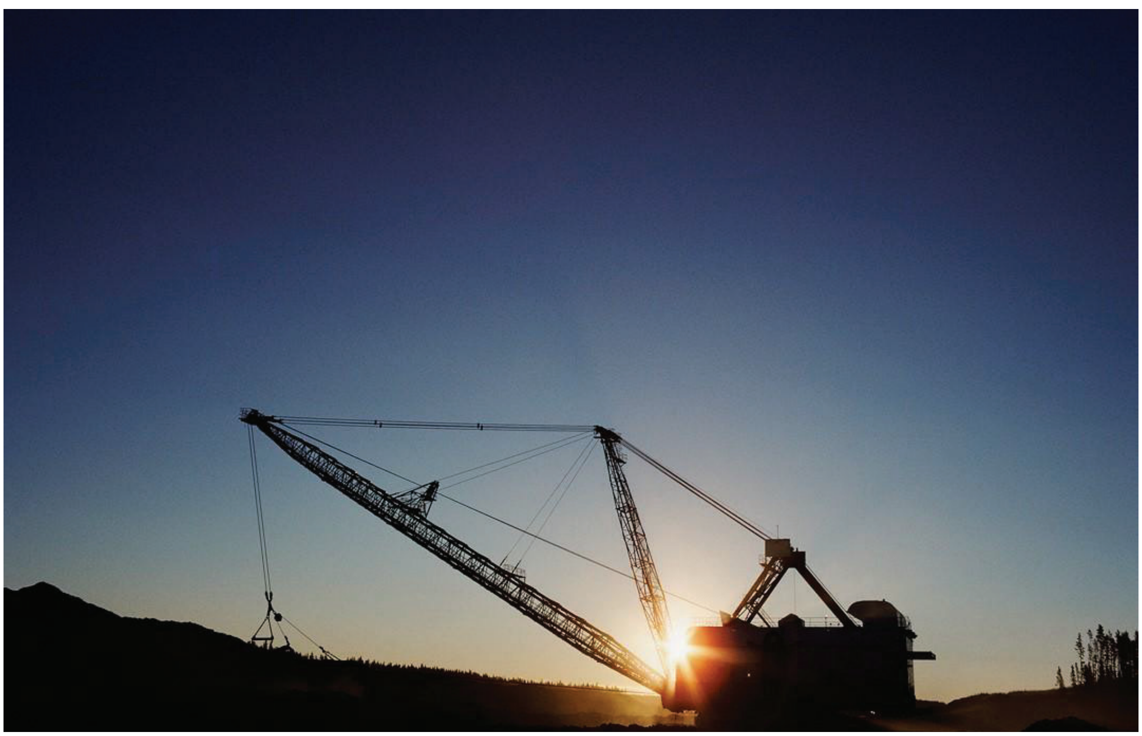
HANSEN BAILEY

BENGALLA MINE MODIFICATION 4

SURFACE WATER IMPACT ASSESSMENT

DECEMBER 2017



Question today
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Bengalla Mine Modification 4
Surface Water Impact Assessment

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E	6/12/2017	Revised dam names
F	7/12/2017	Clarifications
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1 INTRODUCTION

Bengalla Mining Company Pty Limited (BMC) operates the Bengalla Mine (Bengalla) in the Upper Hunter Valley of NSW. Bengalla is situated approximately 130 km north-west of Newcastle and 4 km west of the township of Muswellbrook.

BMC holds Development Consent SSD-5170 (as modified) under Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act) for the Continuation of Bengalla Mine. SSD-5170 enables BMC to continue open cut coal mining at a production rate of up to 15 million tonnes per annum (Mtpa) of run of mine (ROM) coal until 2039.

SSD-5170 has been modified three times. Modification 1 (MOD 1) granted under Section 96(2) of the EP&A Act on 16 December 2015 authorises the alteration to various water management infrastructure and relocation of an explosives storage facility. Modification 2 (MOD 2) granted under Section 96(2) of the EP&A Act on 1 July 2016 authorises the alteration of the approved Main Overburden Emplacement Area (OEA) to improve visual amenity and establish a new access road. Modification 3 (MOD 3) granted under Section 96(2) of the EP&A Act on 23 December 2016 authorises minor changes to the approved location of an explosives facility, reload facility, Hunter River pipeline and topsoil stockpiles.

BMC is now seeking approval from the NSW Minister for Planning for Modification 4 (MOD 4) to SSD-5170 under Section 96(2) of the EP&A Act to facilitate the following:

— Changes to the approved water management system to reflect operations at Bengalla Mine (Bengalla) including the proposed Dry Creek East Dam (mine water storage dam) and proposed enlargement of the approved Future Staged Discharge Dam (ED1) to approximately 700 ML capacity;

— Temporary storage of approximately 2,500m^3 of excess material from the construction of ED1;

— Increase in the capacity and additional locations of temporary Run Of Mine (ROM) coal stockpiles:

— Increase the capacity of temporary ROM coal stockpiles to 1,215,000 t from the approved 350,000 t;

— Additional storage locations for temporary emplacement of coal processing reject material, prior to permanent emplacement

— Temporary clay emplacement within the Main OEA or to the west of this for later use in the reinstatement of Dry Creek

All of MOD 4 activities are within the approved Project Disturbance Boundary. No changes are being sought to the method, extent or intensity of mining or mining equipment fleet.

WSP Australia Pty Limited has been engaged by Hansen Bailey Pty Limited to prepare a revised Surface Water Impact Assessment (SWIA) to support the Statement of Environmental Effects (SEE) for MOD 4. This report presents the assessment methodology, assumptions and findings, and is structured as follows:

— Section 1 provides background information on Bengalla.

— Section 2 provides a brief overview of the national and state regulatory framework relating to surface water resources.

— Section 3 describes the existing surface water environment.

— Section 4 describes the existing, approved and proposed water management systems for Bengalla.

— Section 5 provides details of the site water balance for MOD 4, including modelling methodology, assumptions, results and relevant water licencing.

— Section 6 provides an assessment of potential surface water impacts of MOD 4.

— Section 7 outlines mitigation and management measures for MOD 4.

— Section 8 summarises the findings of the assessment.

2 REGULATORY FRAMEWORK

2.1 REGULATORY DOCUMENTS

Key regulatory documents and guidelines relevant to this assessment include:

— Protection of the Environment Operations Act 1997.

— Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002 and Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Amendment Regulation 2016.

— Water Management Act 2000 (and associated Water Sharing Plans).

— *Managing Urban Stormwater: Soils and Construction - Volume 1* (Landcom, 2004) ('Blue Book') and *Managing Urban Stormwater: Soils and Construction - Volume 2E Mines and Quarries* (Department of Environment and Climate Change (DECC), 2008).

2.1.1 PROTECTION OF THE ENVIRONMENT OPERATIONS ACT 1997

Bengalla holds Environment Protection Licence (EPL) 6538 under the Protection of the Environment Operations Act 1997 (POEO Act). EPL 6538 includes a licensed discharge point to allow for release of water from the Existing Staged Discharge Dam (SDD) to the Hunter River. The discharge volume and concentration limits are provided in Table 2.1.

Table 2.1 EPL 6538 discharge conditions

PARAMETER	LIMIT
pH	6.5 - 9.5
TSS	120 mg/L
Volume	200 ML/day

EPL 6538 was recently varied in December 2016 to change the location of the licensed discharge point, and associated surface water monitoring points, following completion of the Dry Creek diversion works. The old discharge point to Dry Creek was located at the Existing SDD. The new discharge point is located within the Western Diversion Levee, with discharge water now being pumped from the Existing SDD to the discharge point via a pipeline. This location may be amended again in the future as operations move westward via an EPL 6538 amendments.

2.1.2 WATER MANAGEMENT ACT 2000

Under the Water Management Act 2000, BMC must hold Water Access Licences (WAL) with sufficient water allocation to account for the water Bengalla takes from a water source. A summary of surface water entitlements held by BMC for exclusive use by Bengalla is provided in Table 2.2.

Table 2.2 Surface water entitlements held by BMC for Bengalla

WATER SOURCE	ENTITLEMENT
Hunter Regulated River Water Source (Management Zone 1A)	1,449 high security units 1,376 general security units
Hunter Unregulated and Alluvial Water Source - Muswellbrook Water Source	109 ML (harvestable right)

HUNTER REGULATED RIVER WATER SOURCE

BMC holds WALs with sufficient share component totalling 6,017 units, comprising 1,455 high security units and 4,562 general security units from the Hunter Regulated River Water Source under the Water Sharing Plan (WSP) for the Hunter Regulated River Water Source 2016. Bengalla currently has exclusive rights for the use of at least 2,826 units (comprising 1,449 high security units and 1,376 general security units) under these WALs. The remaining units of the WALs (comprising 5 high security units and 3,186 general security units) are currently subject to temporary use by licensees of BMC owned land for agricultural purposes (BMC, 2017).

HUNTER UNREGULATED AND ALLUVIAL WATER SOURCE

The WSP for the Hunter Unregulated and Alluvial Water Sources 2009 applies to the Muswellbrook Water Source, including Dry Creek and its tributaries. A WAL is not required to take and use water by means of harvestable rights dams in accordance with the applicable harvestable rights order under the Water Management Act 2000. Harvestable rights may be available to account (wholly or partially) for the take of water from a water source.

2.1.3 PROTECTION OF THE ENVIRONMENT OPERATIONS (HUNTER RIVER SALINITY TRADING SCHEME) REGULATION 2002 AND AMENDMENT REGULATION 2016

The Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002 (the HRSTS) operates in the Hunter River catchment.

The central idea of the HRSTS is to only discharge salty water when there is lots of low salt, fresh water in the river (NSW DEC, 2016). The Hunter River is broken into three sectors for the purposes of the HRSTS: the upper, middle and lower sectors. Bengalla is located within the upper sector. Monitoring points along the Hunter River are used to measure whether the river is in ‘low’, ‘high’ or ‘flood’ flow. When the river is in ‘low’ flow, no discharge is allowed. When the river is in ‘high’ flow, limited discharge is allowed controlled by a system of salt discharge credits. The amount of discharge allowed depends on the ambient salinity in the river, so it can change daily. The total allowable discharge (TAD) is calculated so that the salt concentration does not exceed 900 µS/cm in the middle and lower sectors of the river or exceed 600 µS/cm in the upper sector. When the river is in ‘flood’, unlimited discharge is allowed as long as the salt concentration does not exceed 900 µS/cm. Members of the HRSTS coordinate their discharges so that this goal is achieved (NSW DEC, 2016).

There is a total of 1000 salt discharge credits in the HRSTS, with different licence holders having different numbers of credits. Licence holders can only discharge salt into the river in proportion to the credits they hold: 1 credit allows a discharge of 0.1% of the TAD (NSW DEC, 2016).

The NSW Environment Protection Authority (EPA) has recently completed a review of the HRSTS. The Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Amendment Regulation 2016 implements the recommendations of the review and commenced on 16 March 2017. The primary change contained in the Amendment Regulation is an increase to the flood flow thresholds to significantly lower the risk that salinity targets could be exceeded by simultaneous, full capacity discharges by all participants during ‘flood’ flows. The new ‘flood’ flow thresholds will not impact the total amount of salt that can be discharged by participants or the frequency, size and duration of discharge opportunities under the Scheme. However, the new thresholds will change the number of discharge opportunities that are classified as ‘high flow’ versus ‘flood flow’ and there may be slightly more discharges being classified as ‘high flow’. Participants will need to ensure that they hold sufficient credits in order to discharge their desired quantity of saline water into these ‘high flow’ discharge opportunities (NSW EPA, 2016).

The amended HRSTS flow thresholds are summarised in Table 2.3. The ‘flood’ flow threshold increased from >4,000 to >6,500 ML/day in the upper sector, from >6,000 to >16,500 ML/day in the middle sector, and from >10,000 to >28,500 ML/day in the lower sector.

Table 2.3 Amended flow thresholds for HRSTS

FLOW CATEGORY	FLOW RATE (ML/DAY)		
	UPPER SECTOR	MIDDLE SECTOR	LOWER SECTOR
Low flow (no discharge)	0 to 1,000	0 to 1,800	0 to 2,000
High flow (discharge with credits)	1,000 to 6,500	1,800 to 16,500	2,000 to 28,500
Flood flow (discharge unrestricted by credits)	> 6,500	> 16,500	> 28,500

Bengalla participates in the HRSTS. BMC's EPL 6538 stipulates the concentration and volume limits at the licensed discharge point applicable to HRSTS releases (refer to Section 2.1.1 Table 2.1).

2.1.4 MANAGING URBAN STORMWATER: SOILS AND CONSTRUCTION

The *Managing Urban Stormwater: Soils and Construction* publications provide guidelines for erosion and sediment control during construction and other land disturbance activities.

Managing Urban Stormwater: Soils and Construction - Volume 1 (Landcom, 2004) ('Blue Book') provides general guidelines for the design, construction and implementation of measures to improve stormwater management, primarily erosion and sediment control, during the construction-phase of urban development. *Managing Urban Stormwater: Soils and Construction - Volume 2E Mines and Quarries* (DECC, 2008) provides supplementary guidelines, principles and recommended minimum design standards for erosion and sediment control at mines and quarries.

Erosion and sediment controls for Bengalla will be designed, installed and maintained in accordance with the guidelines *Managing Urban Stormwater: Soils and Construction - Volume 1* (Landcom, 2004) ('Blue Book') and *Managing Urban Stormwater: Soils and Construction - Volume 2E Mines and Quarries* (DECC, 2008).

3 EXISTING SURFACE WATER ENVIRONMENT

3.1 REGIONAL AND LOCAL DRAINAGE NETWORKS

Bengalla is located adjacent to the Hunter River floodplain and is entirely encompassed by the Hunter River catchment. Upstream of Muswellbrook the Hunter River has a catchment area of approximately 4,200 km². From Muswellbrook, the Hunter River continues to meander for approximately 35 km in a generally south-west direction before turning easterly after it is joined by the Goulburn River near Denman and then continuing toward Newcastle.

The western parts of the Bengalla mining area drain to Dry Creek, which is an ephemeral tributary of the Hunter River that runs through the mine site capturing runoff from an area of about 18 km². The Dry Creek catchment has mostly been cleared for agriculture and is dominated by grasslands, although some areas of scattered woodland remain. Dry Creek has been temporally diverted to allow mining operations as per the development consent SSD-5170 (as modified). The Dry Creek Diversion works were completed in December 2016.

3.2 CLIMATE DATA

Daily rainfall and evaporation data for the site for the 114-year period between 1893 and 2006 was obtained from the Bureau of Meteorology (BOM) Data Drill service. This is the period that rainfall data overlaps with the available streamflow data (refer Section 3.4). The Data Drill accesses grids of data derived by interpolating the BOM's station records. The data in the Data Drill are all synthetic and there are no original meteorological station data left in the calculated grid fields (BOM, 2006).

The Data Drill is considered superior to individual BOM station records and site meteorological station data for long-term water balance modelling purposes because it draws on a greater dataset, both spatially and in time. The Data Drill is also considered superior for modelling purposes as it does not contain gaps.

The rainfall records from the two rainfall stations closest to Bengalla with the longest period of record (Muswellbrook (BOM Station No. 61053) and Aberdeen (BOM Station No. 61000)) were obtained and average monthly rainfall compared to that from the Data Drill. The evaporation record from Scone SCS (BoM Station No 61089) was also obtained as this is the closest station where evaporation is recorded and a similar comparison made with the Data Drill. This comparison is shown below in

Table 3.1.

Summary statistics for the Data Drill rainfall data are provided in Table 3.2.

Table 3.1 Mean monthly rainfall and evaporation

MONTH	MEAN MONTHLY RAINFALL (mm)			MEAN MONTHLY EVAPORATION (mm)	
	MUSWELLBROOK (61053) (125 YEARS DATA)	ABERDEEN (61000) (113 YEARS DATA)	DATA DRILL * (114 YEARS DATA)	SCONE SCS (61089) (66 YEARS DATA)	DATA DRILL (128 YEARS DATA)
January	69.6	73.5	71.4	220	214
February	66.9	62.2	62.6	174	169
March	52.8	51.6	53.8	155	150
April	43.5	40.2	42.3	105	106
May	41.5	41.5	40.4	68	72
June	51.3	44.5	44.6	48	53
July	44.2	40.6	39.9	59	61
August	38.6	36.5	36.3	84	88
September	40.7	39.1	38.0	117	118
October	48.6	49.3	49.3	158	157
November	56.1	50.9	49.7	183	184
December	67.0	66.1	61.7	223	217
Total	620.7	596.0	589.8	1,594	1,583

*Notes: * Data Drill for coordinates -32.25S, 150.85E (decimal degrees)*

Table 3.2 Summary statistics for modelled rainfall data (Data Drill – 1893 to 2006)

STATISTIC	ANNUAL RAINFALL (mm/YR)
Minimum	285
5^{th} percentile (dry)	348
10^{th} percentile	373
50^{th} percentile (median)	591
90^{th} percentile	766
95^{th} percentile (wet)	815
99^{th} percentile	940
Maximum	1225
Standard deviation	154

3.3 RAINFALL RUNOFF

The volume of surface water runoff from mine site catchments has been estimated using the Australian Water Balance Model (AWBM) rainfall-runoff model (Boughton, 1993) that is incorporated in the OPSIM water balance model.

The AWBM is a partial area saturation overland flow model. The use of partial areas divides the catchment into regions (contributing areas) that produce runoff during a rainfall-runoff event and those that do not. These contributing areas vary within a catchment according to antecedent catchment conditions and allow for the spatial variability of surface storage in a catchment. The use of the partial area saturation overland flow approach is simple and provides a good representation of the physical processes occurring in most Australian catchments (Boughton, 1993). This is because daily infiltration capacity is rarely exceeded, and the major source of runoff is from saturated areas. Figure 3.1 shows a schematic layout of the AWBM.

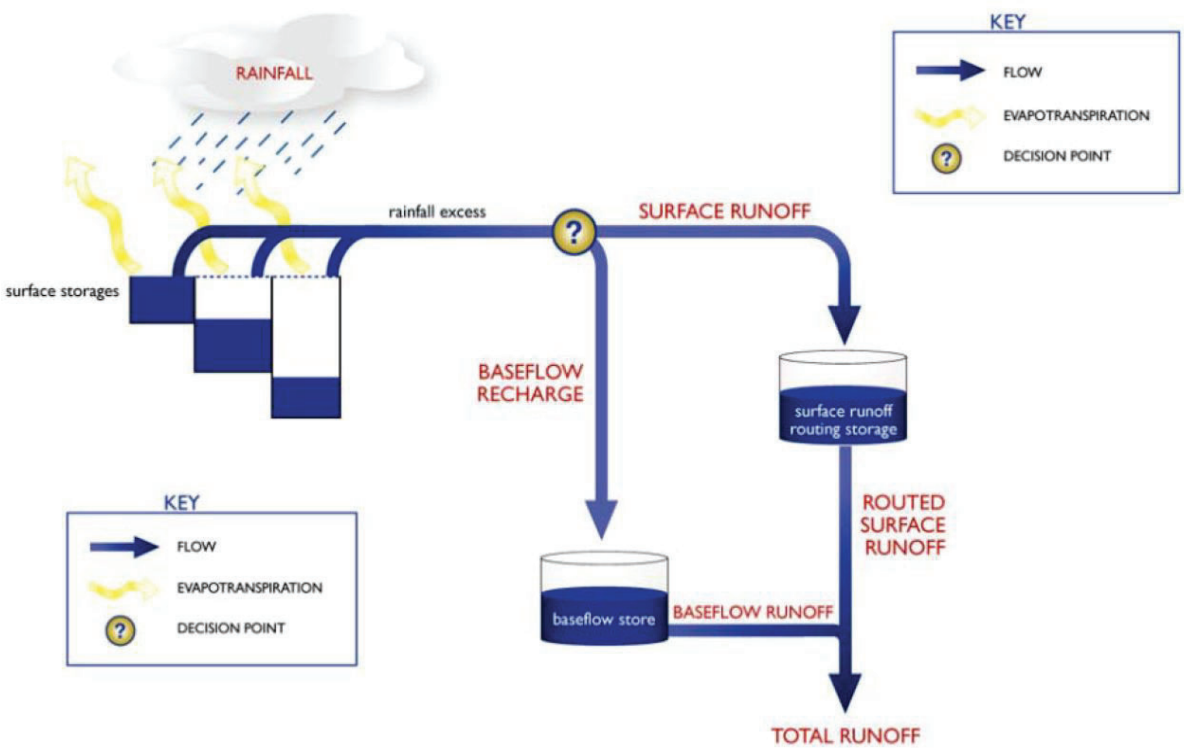

Figure 3.1 Schematic layout of the AWBM rainfall-runoff model (CRC for Catchment Hydrology Australia, 2004)

To implement the AWBM in a given catchment, a set of nine parameters must be defined as summarised in

Table 3.3. These parameters define the generalised model for a particular catchment. The parameters are usually derived for a gauged catchment by a process of calibration where the recorded streamflows are compared with calculated streamflows. The parameters are adjusted to produce the best match between the means and standard deviations of the daily streamflows, to match the difference in peak flow discharges.

Table 3.3 Description of AWBM parameters

PARAMETER	DESCRIPTION
A1, A2, A3	Partial areas represented by surface storages
C1, C2, C3	Surface storage capacities
Ks	Daily surface flow recession constant
BFI	Baseflow index
Kbase	Daily baseflow recession constant

AWBM parameters for Bengalla have been obtained from the Bengalla Continuation of Mining Project Environmental Impact Statement (EIS) SWIA (WRM, 2013) and are summarised in Table 3.4. Verification of the water balance model and adopted AWBM parameters was undertaken for the period January 2010 to December 2011 as part of the EIS SWIA. No further calibration or verification has been undertaken of the adopted AWBM parameters. Average long term volumetric runoff coefficients estimated from the AWBM are also summarised in Table 3.4. The volumetric runoff coefficient is the ratio of the volume of runoff to the volume of rainfall. Rainfall losses include interception by vegetation, evaporation from the land surface, depression storage on the land surface and infiltration into the soil.

Table 3.4 Adopted AWBM parameters for mine site catchments

LAND USE	AWBM PARAMETERS								
	BFI	K_{BASE}	A1	A2	A3	C1 (mm)	C2 (mm)	C3 (mm)	VOLUMETRIC RUNOFF COEFFICIENT
Undisturbed area	0.134	0.433	0.433	5.7	57.8	115.7	0.933	0.39	12.4%
Rehabilitated spoil	0.134	0.433	0.433	5.7	57.8	115.7	0.933	0.39	12.4%
Industrial	0.134	0.433	0.433	2.6	26.7	53.3	0	0	21.8%
Open cut pit	0.2	0.6	0.2	5	70	90	0	0	15.7%
Active spoil	0.136	0.27	0.594	50	100	500	0	0.103	2.7%

Source: EIS SWIA (WRM, 2013)

3.4 STREAMFLOW

The streamflow record for the Hunter River at Muswellbrook Bridge (Station No 210002) was obtained from the NSW Government Department of Primary Industries Water (DPI Water) 'real-time data' website. The Muswellbrook Bridge gauge has been in operation since 1913 and is still operating, however, there is more than 30 years of missing data over this period of record. The catchment area for the Hunter River at Muswellbrook Bridge is approximately 4,220 km^2.

Historical streamflow timeseries for the Hunter River at Muswellbrook Bridge (Station No 210002) for the full period of record from 1913 to 2017 is provided in Figure 3.2 and a low flow frequency analysis is provided in Figure 3.3. A flow duration curve for the full period of record from 1913 to 2017 is provided in Figure 3.4. The flow duration curve shows the percentage of time that flow in the Hunter River equals or exceeds a specific value based on the historical record. The Hunter River catchment was modified in 1988 with completion of upgrade works to Glenbawn Dam, and the daily flow duration curve for the period 1988 to 2017 is also provided in Figure 3.4 as this curve is more representative of the catchment in its current developed condition.

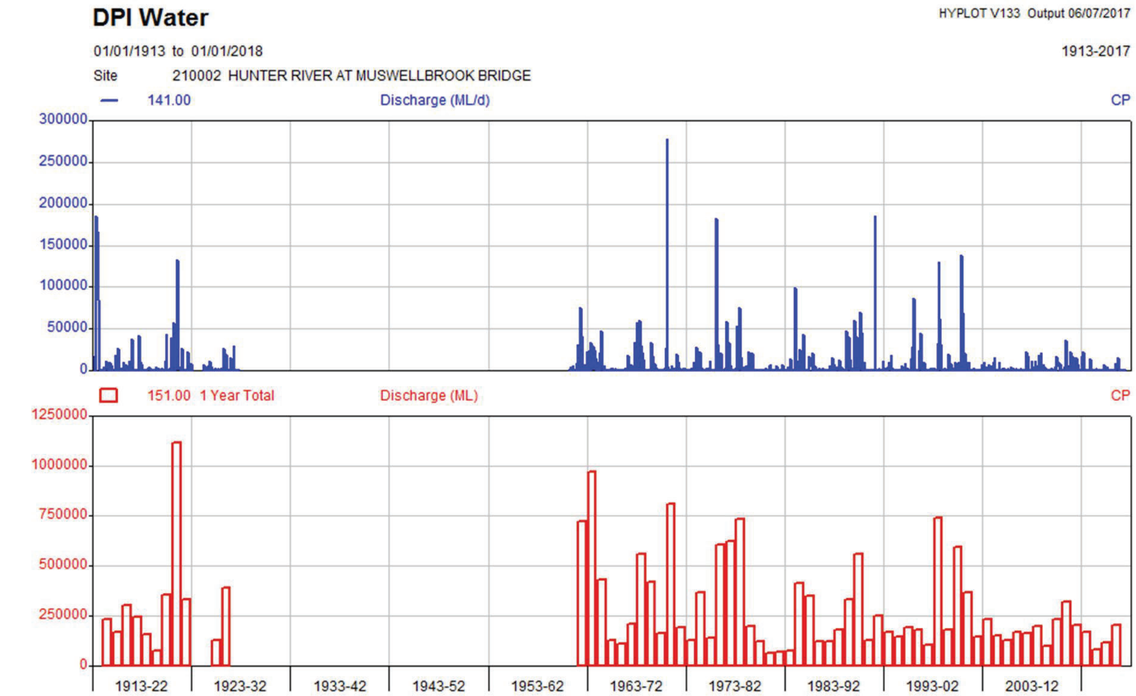

Figure 3.2 Streamflow timeseries for Hunter River at Muswellbrook Bridge (Station No 210002) for 1913 to 2017 (Source: DPI Water 'real-time data' website)

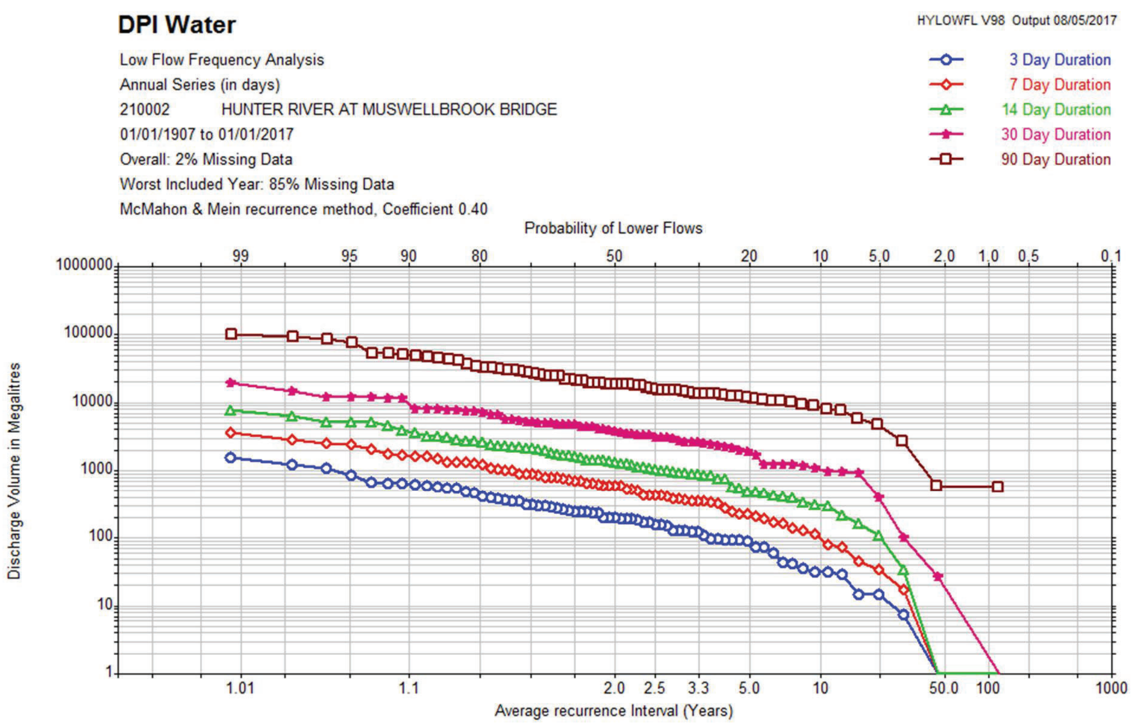

Figure 3.3 Low flow frequency analysis for Hunter River at Muswellbrook Bridge (Station No 210002) for 1913 to 2017 (Source: DPI Water 'real-time data' website)

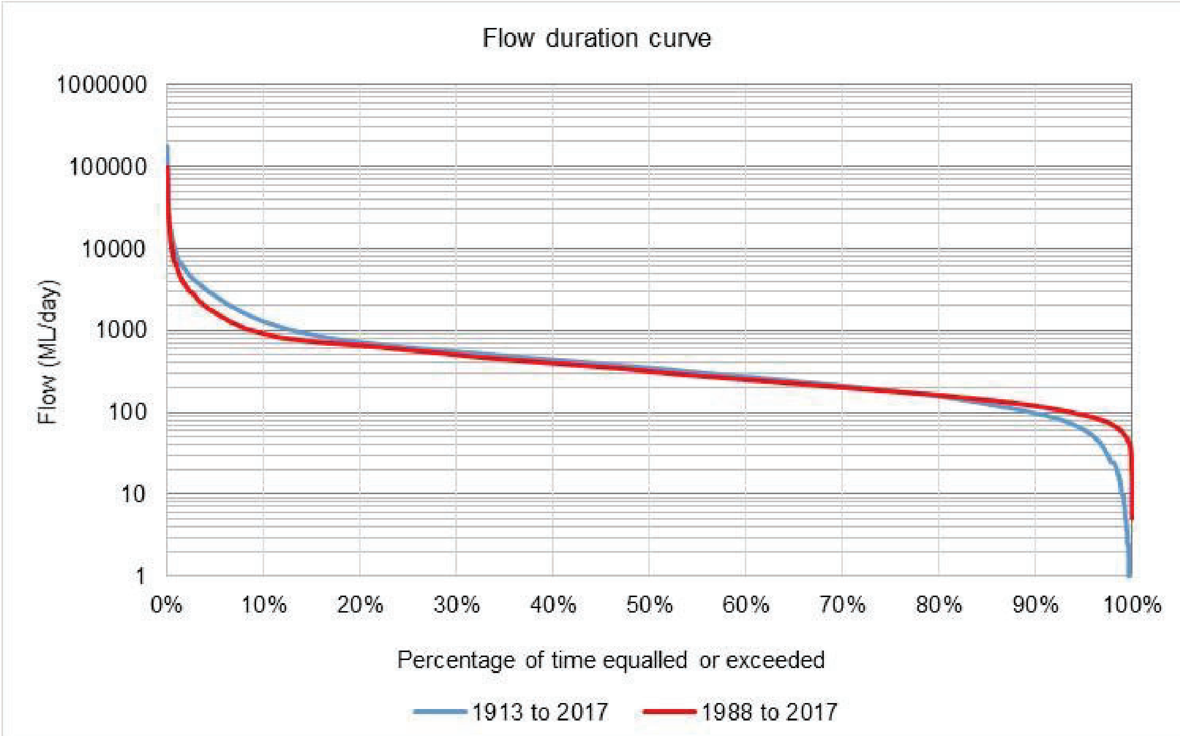

Figure 3.4 Flow duration curve for Hunter River at Muswellbrook Bridge (Station No 210002)

The flow duration analysis for the period 1988 to 2017 shows that flows less than 10 ML/day can be expected 0.01% of time. The minimum flow recorded from 1988 to 2017 was 5.1 ML/day. The flow duration curve for the full period of record from 1913 to 2017 shows that flows less than 10 ML/day can be expected 1.1% of time. Comparison of the two flow duration curves indicates that Glenbawn Dam has increased the frequency of low flows and decreased the frequency of high flows.

For the purposes of water balance modelling, simulated streamflow data for the Hunter River was obtained from DPI Water's Integrated Quantity and Quality Model (IQQM) for the period 1/1/1900 to 30/6/2007 for use in the EIS SWIA (WRM, 2013). The IQQM simulated streamflow data is based on the catchment in its developed condition (with assumed demands for power generation and irrigated crop areas etc) and does not contain data gaps. As such the IQQM simulated data was considered superior to historical streamflow data for the purposes of water balance modelling. Simulated data is not available beyond 30/6/2007.

4 WATER MANAGEMENT

4.1 EXISTING WATER MANAGEMENT STRATEGY

Bengalla's existing water management strategy is described in the Bengalla WMP (BMC, 2017). The following definitions are used for the various water types:

— Clean water - Water pumped from the Hunter River into the Existing Raw Water Dam or runoff from a catchment that is undisturbed by mining and associated activities. Includes runoff from fully rehabilitated mined out areas where the rehabilitation area has been relinquished.

— Mine water - Water that accumulates within, or drains from, active mining and infrastructure areas and any other areas where runoff may have or has come into contact with coal or carbonaceous material.

— Sediment water - Runoff from areas disturbed by mining and associated activities that has not come into contact with coal or carbonaceous material. Includes water from non-relinquished rehabilitation areas.

— Contaminated water - Associated with water used by the vehicle washbay and bathhouse that is captured and processed in the hydrocarbon separation system and waste water treatment plant (WWTP) respectively to enable its transfer and reuse in the mine water system.

Water management at Bengalla is based on the following key principles:

— Minimise the use of clean water from external sources.

— Where possible, divert clean water away from areas disturbed by mining and associated activities.

— Collect sediment water in catch drains and direct to sediment traps and settling dams, and where required reuse as Bengalla water supply.

— Collect runoff from industrial areas (mine water) in catch drains.

— Transfer of open cut pit water (mine water) to storage dams for reuse as Bengalla water supply.

— Minimal offsite discharge of surplus mine water.

4.1.1 CLEAN WATER MANAGEMENT

Dams, pipelines and associated drainage structures redirect clean water away from disturbed areas. A series of temporary drains divert clean water around the disturbance area to the downstream waterway.

4.1.2 MINE WATER MANAGEMENT

Mine water is used onsite or discharged to the Hunter River in accordance with EPL 6538 and the HRSTS. Water stored in the Existing Washery Dam is used for mine site demands, excluding the vehicle wash down, fire suppression and drinking and shower purposes, as a priority over raw water. The pit is utilised for mine water storage, as required. The EPL 6538 licensed discharge point for mine water is located on the Western Diversion Levee, with discharge water being pumped from the Existing SDD to the discharge point via a pipeline.

4.1.3 SEDIMENT WATER MANAGEMENT

Sediment water is detained within the Bengalla water management system. Sediment dams transfer water to the mine water management system, with overflows from sediment dams to natural watercourses only occurring during large rain events or prolonged wet periods.

New sediment dams are designed in accordance with the guidelines *Managing Urban Stormwater: Soils and Construction - Volume 1* (Landcom, 2004) ('Blue Book') and *Managing Urban Stormwater: Soils and Construction - Volume 2E Mines and Quarries* (Department of Environment and Climate Change, 2008). Sediment dams are generally 'wet basins' designed for 'Type D/F' soils.

Following the relinquishment of established rehabilitation areas it is anticipated that relevant sediment dams will be removed from the mine water management system and clean runoff from rehabilitated areas will be released to the environment.

4.1.4 CONTAMINATED WATER MANAGEMENT

Contaminated water at Bengalla is generated by the bathhouse and vehicle wash bay. Contaminated water from the bathhouse is processed through the WWTP which then directs the water into the process water circuit for reuse in the mine water system. Contaminated water from the vehicle wash bay is processed through a hydrocarbon separation system which directs waste oil into a waste oil tank and the water component into the facilities sump. The water from the facilities sump overflows into the East & West Facilities dams for reuse in the Bengalla water management system.

4.2 EXISTING WATER MANAGEMENT SYSTEM

Bengalla's existing water management system is described in the Bengalla WMP (BMC, 2017). The main components of the existing Bengalla water management system (as at June 2017) include:

— The Existing Washery Dam supplies process water to the coal handling and preparation plant (CHPP) and truck fill stations. The Existing Washery Dam is also used as a transfer dam, receiving excess mine water which then overflows to the Existing SDD.

— Water supply infrastructure includes the Hunter River intake and pipeline and the Existing Raw Water Dam which acts as a storage dam for raw water pumped to site.

— The Bengalla WWTP treats effluent and directs it into the Bengalla mine water management system for reuse.

— The East & West Facilities dams capture CHPP return water, contaminated water from the WWTP and vehicle wash, mine water runoff and mine water transferred from the Wantana West Dam and ROM North Dam. Water from the East & West Facilities Dams is transferred to the Existing Washery Dam.

— The South Loop Road Dam and Endwall Dam receive mine water from the pit.

— CW1 (located north of Wybong Road) intercepts runoff from the Dry Creek catchment upstream of Bengalla.

— The Northern Diversion Levees divert clean water from the upper Dry Creek catchment into CW1.

— The Western Diversion Levee, constructed west of Dry Creek and south of Wybong Road, diverts clean water around active mining and into Dry Creek south of the existing Mine Access Road.

— The EPL 6538 licensed discharge point for mine water is located on the Western Diversion Levee, with discharge water being pumped from the Existing SDD to the discharge point via a pipeline. Discharges are undertaken in accordance with conditions of the HRSTS and EPL 6538.

— Sediment traps, drainage channels and sediment dams collect and treat sediment water runoff from overburden, non-relinquished rehabilitation and hardstand areas.

— Various other minor sediment and mine water dams.

A schematic of the existing Bengalla water management system is provided in Figure 4-1.

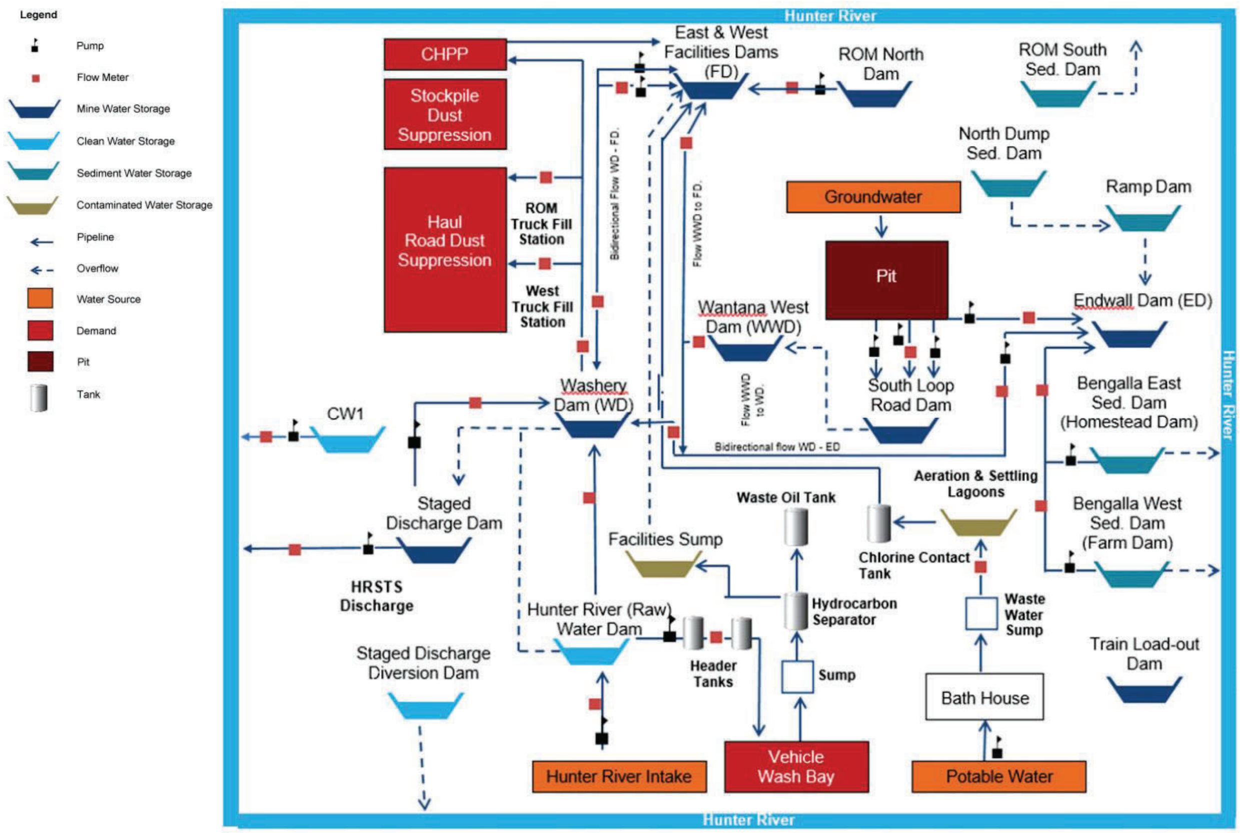

Figure 4-1 Bengalla existing water management system schematic (March 2017) (Source: BMC, 2017)

4.3 APPROVED OPERATIONS

To facilitate ongoing mining operations at Bengalla, a number of changes to the original Bengalla water management system have been approved as part of the Bengalla Continuation of Mining Project (as modified). Key changes include:

BENGALLA CONTINUATION OF MINING PROJECT

— Increased water demands associated with increased production rates, including CHPP water use, stockpile and haul road dust suppression and vehicle wash down.

— Mining operations continuing west through some existing facilities. Some storages will be relocated as this occurs. The Existing Raw Water Dam, Existing Washery Dam and Existing SDD will be relocated. The approved capacity of Future SDD (ED1) is 300 ML.

— The diversion of Dry Creek via dams and pipe work with a later permanent alignment of Dry Creek through rehabilitation areas when overburden areas are suitably advanced.

— Construction of various mine water dams, diversion drains, levees, sediment dams and associated drainage works, as required.

MOD 1

— Utilisation of the Satellite Pit as a temporary mine water catchment dam.

— Relocation of the SDD and HRSTS release point.

— Construction of clean water diversion levees in locations other than those already approved.

— Revised locations for the Future Raw Water Dam and Future Washery Dam.

The performance of the approved Bengalla water management system is described in the Bengalla MOD 1 SEE SWIA (WRM, 2015). The overall health of the water management system is reflected in the modelled stored inventory in the open cut pits. The median (50th percentile) inventories of the Main Pit and Satellite Pit show that the pits are generally maintained dry with no long term build up. The 90th percentile inventory in the Main Pit and Satellite Pit reaches 240 ML and 450 ML respectively. The 99th percentile inventory in the Satellite Pit reaches approximately 1,250 ML (WRM, 2015).

MOD 2

MOD 2 did not include significant changes to the Bengalla water management system. Water balance modelling was not undertaken for MOD 2.

MOD 3

MOD 3 did not include significant changes to the Bengalla water management system. Water balance modelling was not undertaken for MOD 3.

4.4 PROPOSED WATER MANAGEMENT SYSTEM

The proposed MOD 4 water management system includes:

— Enlargement of the Future ED1 to approximately 700 ML in order to provide additional out-of-pit mine water storage onsite and to reduce the volume stored in-pit during wet conditions. This is 400 ML above the approved capacity of 300 ML. There are no changes proposed to the approved location or general operating philosophy of ED1.

— Provision of the proposed approximately 93 ML capacity Dry Creek East Dam.

  — Dry Creek East Dam will initially be a mine water dam (Year 4) and will operate as a midway point between the open cut pit and ED1. Dry Creek East Dam will replace the existing function of Wantana West Dam as a staging point for pit dewatering. Pumped flows from the Main Pit and Satellite Pit will be received via the South Loop Road Dam which will overflow into the Dry Creek East Dam. From the Dry Creek East Dam mine water will be pumped onto the Future Washery Dam for reuse onsite or release from ED1 under the HRSTS. Pumped flows from the Endwall Dam and Wantana West Dam sediment dams will also report to Dry Creek East Dam.

  — Dry Creek East Dam will be converted to a sediment dam (by Year 8) and will capture and treat runoff from a local overburden catchment as well as continuing to receive pumped inflows from other sediment dams. As a sediment dam, Dry Creek East Dam will pump to the Future Washery Dam and Dry Creek East Dam will overflow to the natural watercourse only during large rain events or prolonged wet conditions. When Dry Creek East Dam no longer operates as a mine water dam, pit dewatering will be to the Future Washery Dam. The dewatering pipeline route may include a small staging dam to facilitate efficient pumping.

  — Dry Creek East Dam will be considered a clean water dam when the overburden catchments reporting to it are fully rehabilitated and relinquished and will release to natural watercourses.

— Relocation of the approved Temporary OEA Sediment Dam within the Main OEA. The approved Temporary OEA Sediment Dam was located to the east of the Main OEA ridgeline and overflowed to Bengalla East Sediment Dam. The approved strategy also directed runoff from overburden areas west of the ridgeline to Ramp Dam (and onto Endwall Dam). The proposed approximately 58 ML Temporary OEA Sediment Dam is located to the west of the ridgeline and captures runoff from areas west of the ridgeline. The proposed Temporary OEA Sediment Dam overflows to the open cut pit and pumps to the proposed Dry Creek East Dam.

— Runoff from the proposed ROM stockpile and Temporary Rejects Cells will be captured in the mine water management system. In Year 4, these areas drain to the Satellite Pit and the East & West Facilities dams. In Year 24, these areas drain to the Main Pit and the East & West Facilities dams.

The proposed water management system layouts for the Year 4, 8, 15 and 24 mine stage 'snapshots' are shown in Figure 4-2 to Figure 4-5. The proposed water management system schematics, showing the connectivity between water storages, sources and demands, for the Year 4, 8, 15 and 24 mine stage 'snapshots' are shown in Figure 4-6 to Figure 4-9.

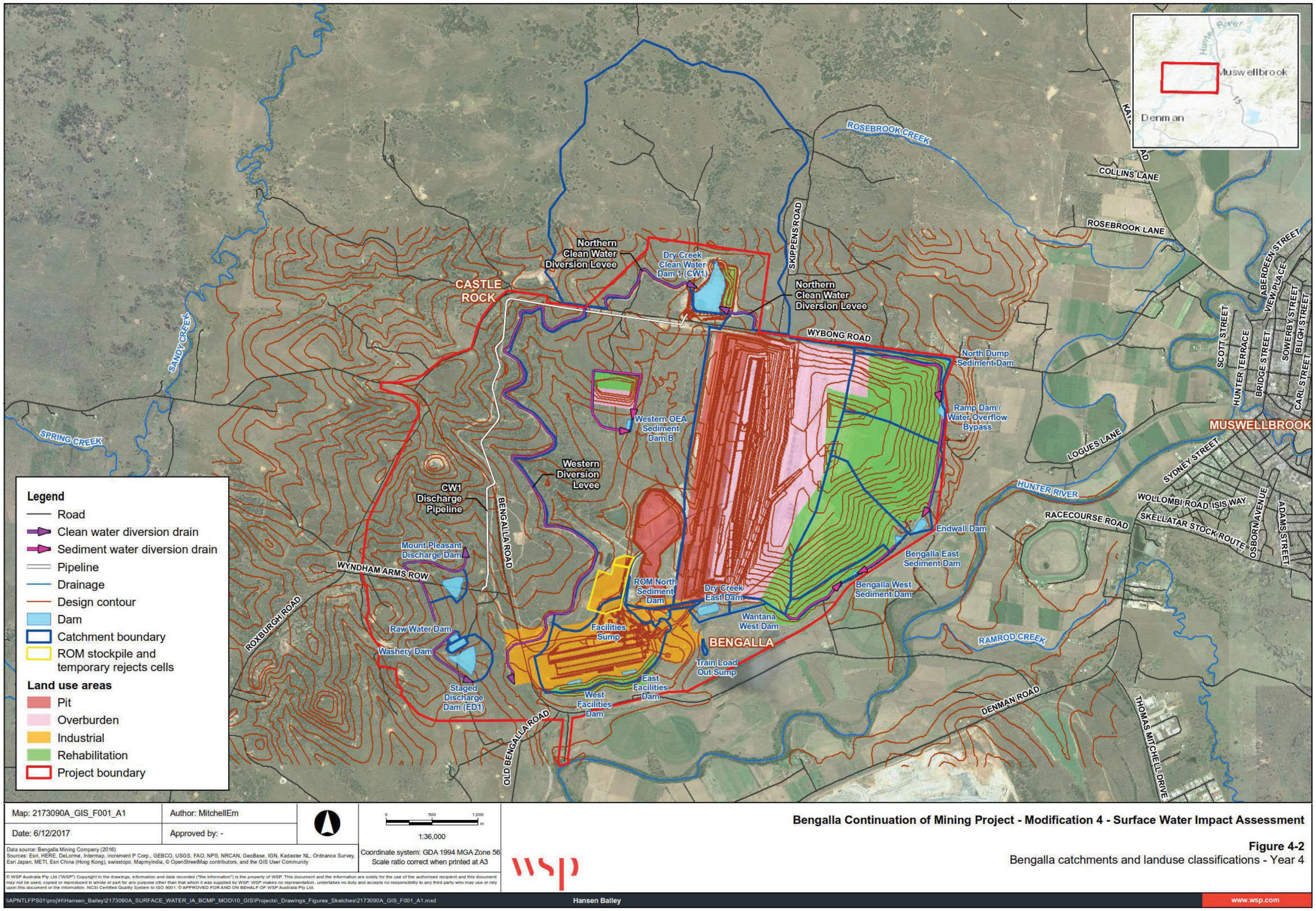

Figure 4-2 Bengalla catchments and landuse classifications – Year 4

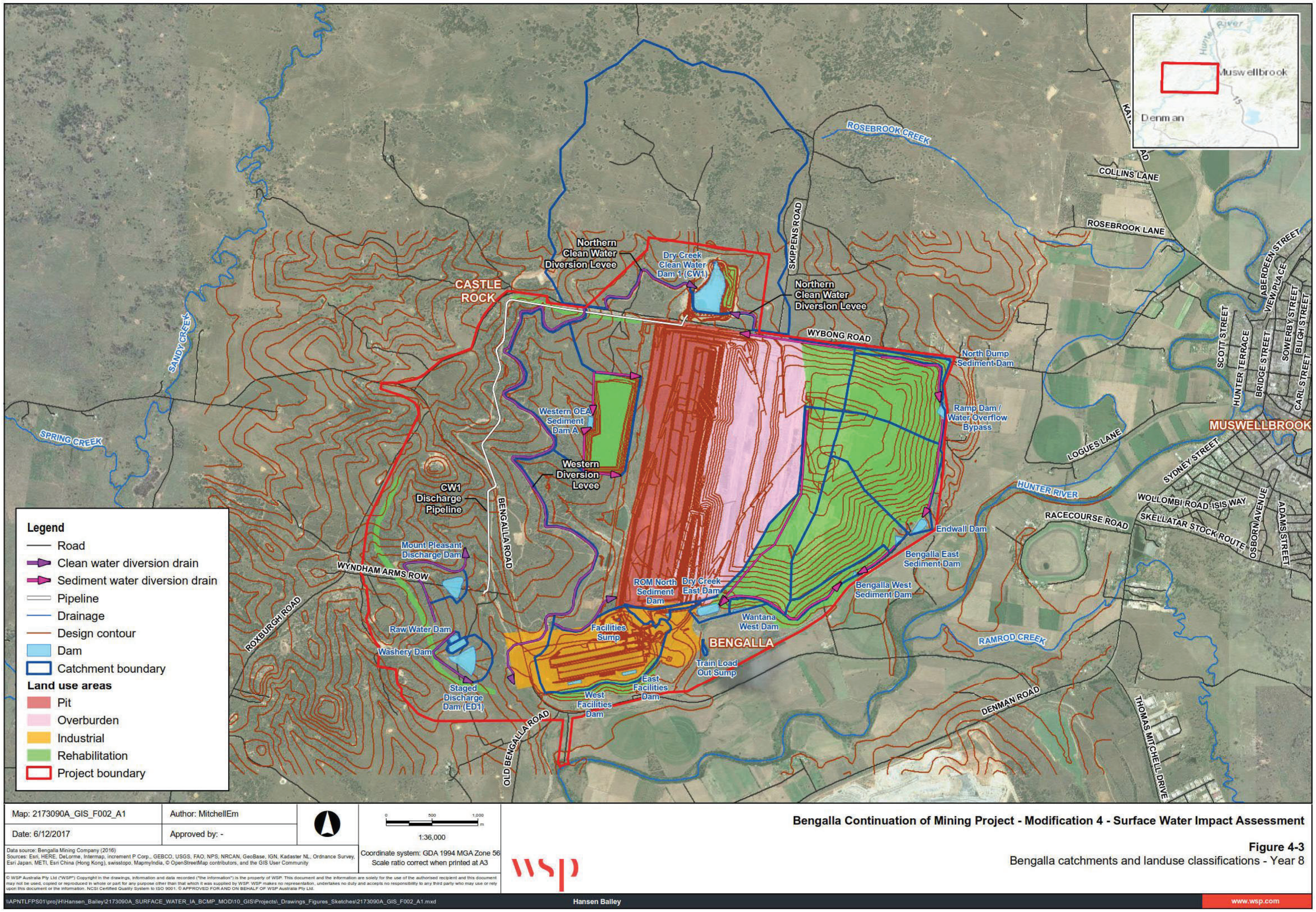

Figure 4-3 Bengalla catchments and landuse classifications – Year 8

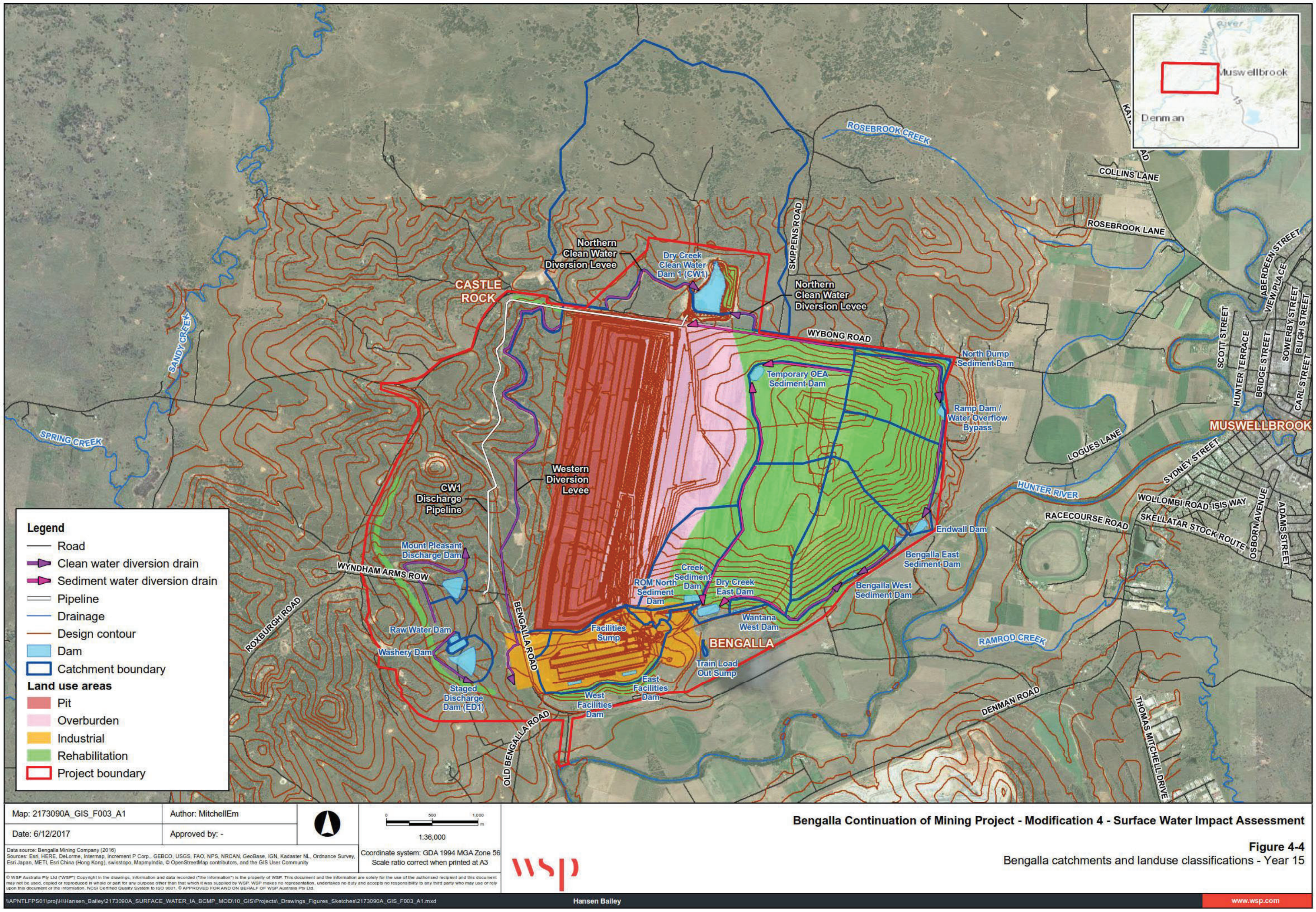

Figure 4-4 Bengalla catchments and landuse classifications – Year 15

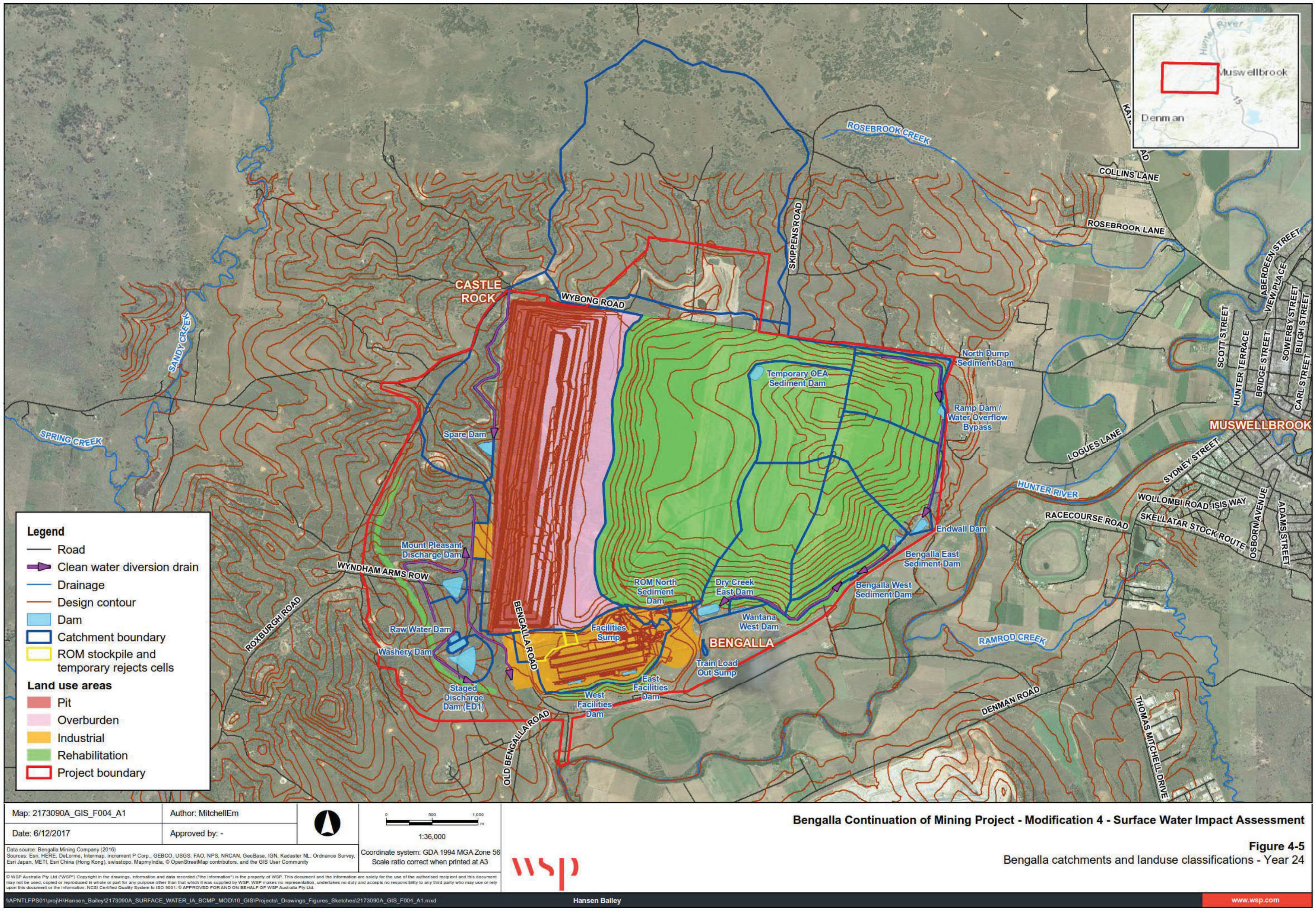

Figure 4-5 Bengalla catchments and landuse classifications – Year 24

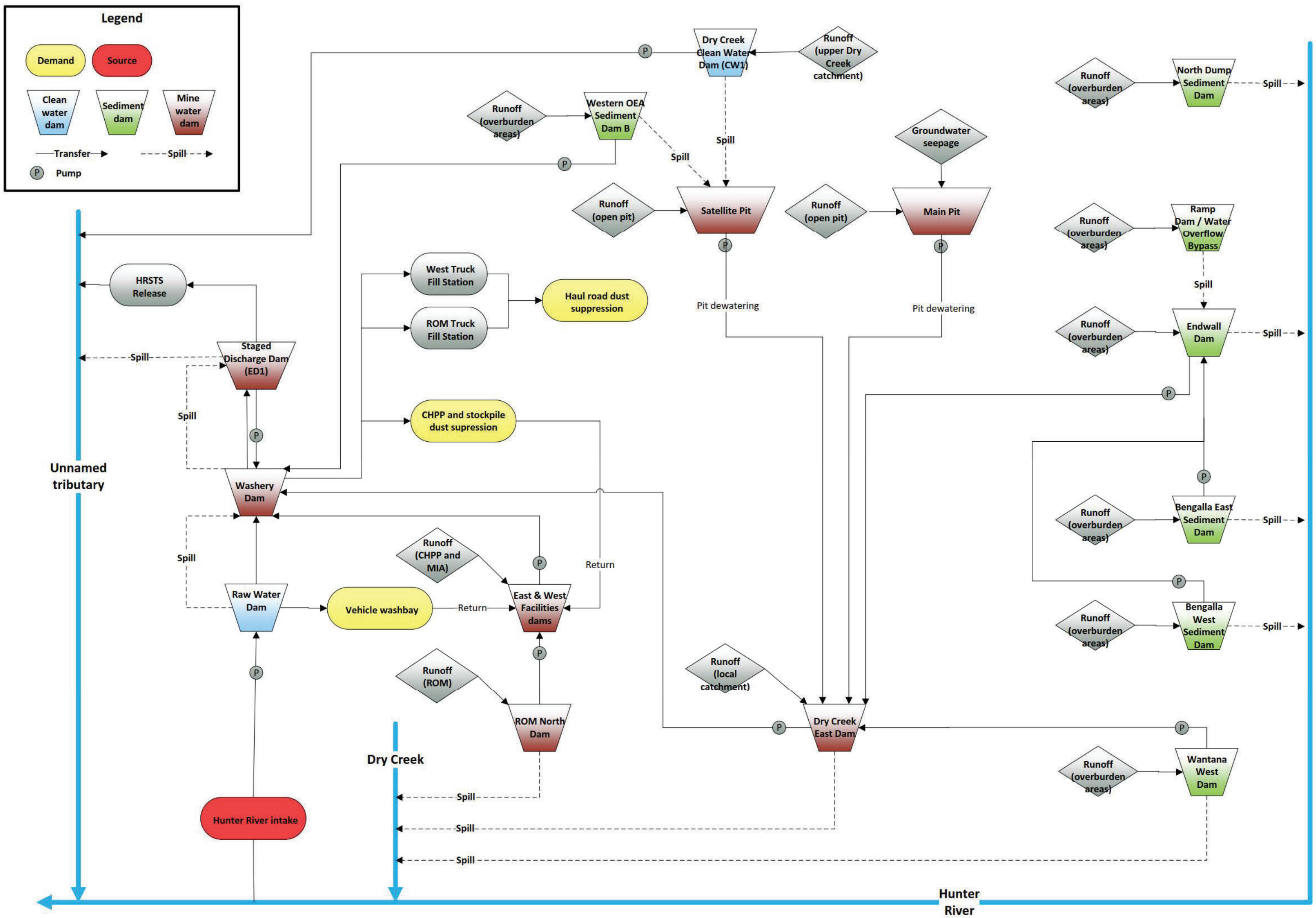

Figure 4-6 Bengalla proposed water management system schematic – Year 4

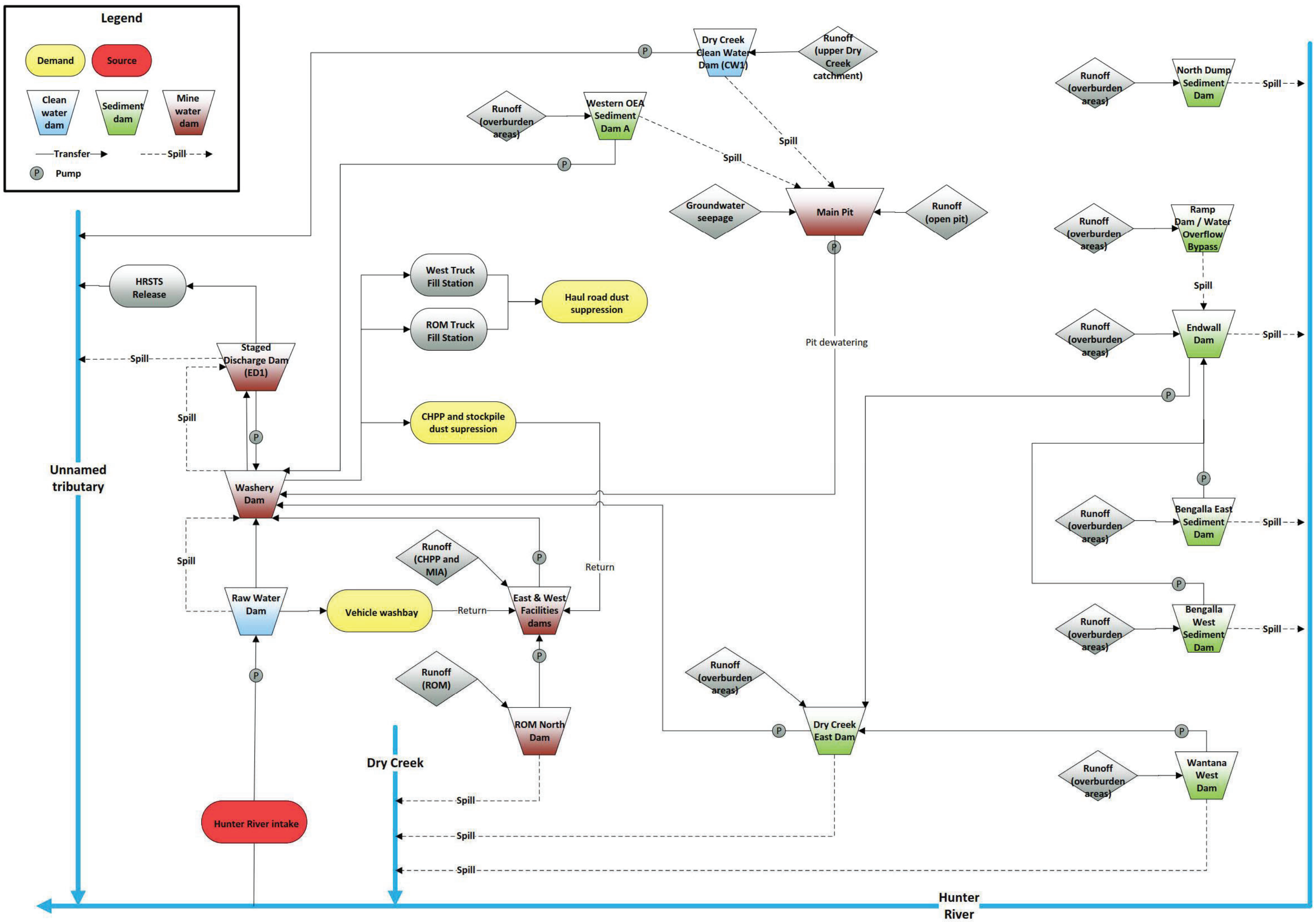

Figure 4-7 Bengalla proposed water management system schematic – Year 8

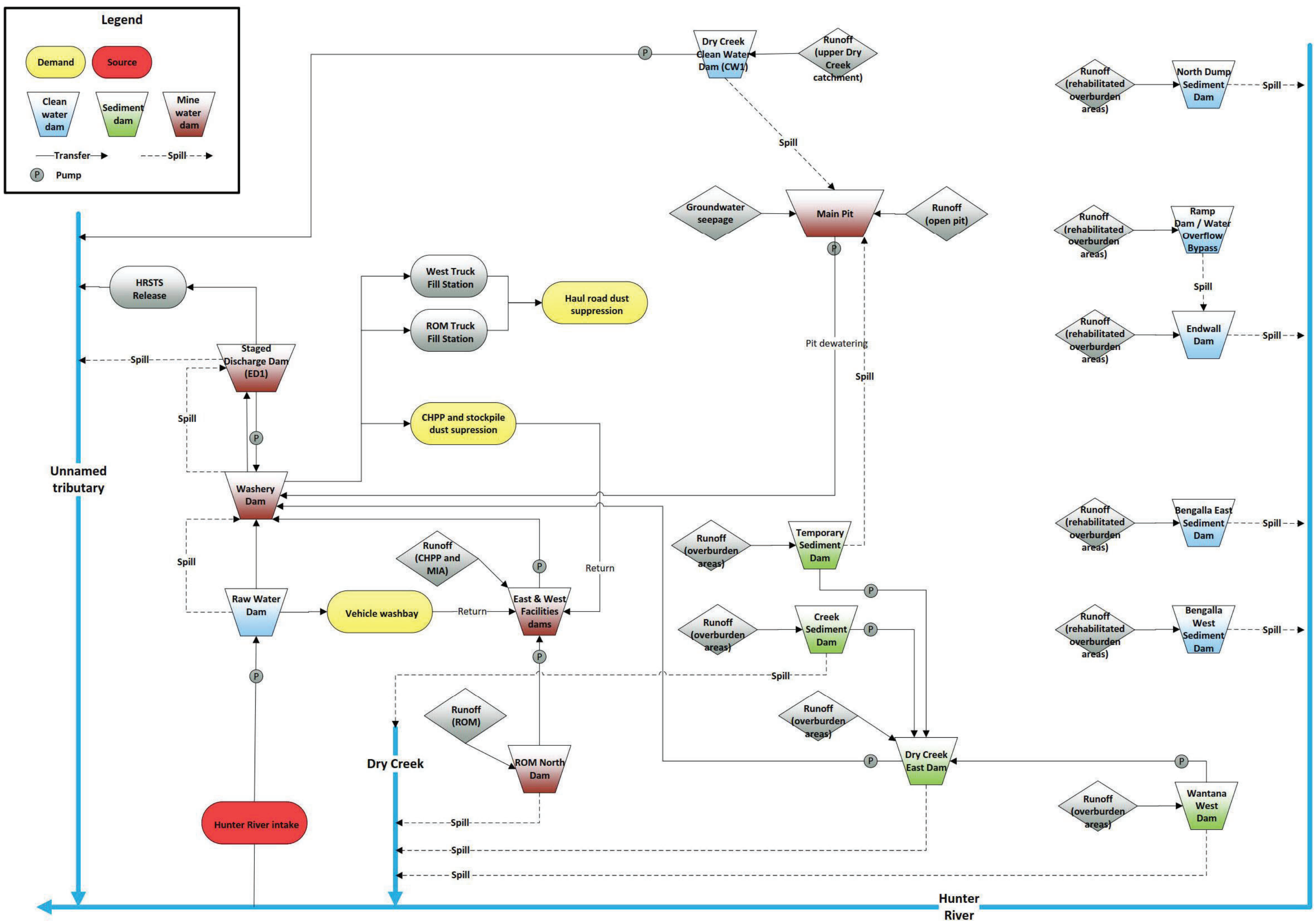

Figure 4-8 Bengalla proposed water management system schematic – Year 15

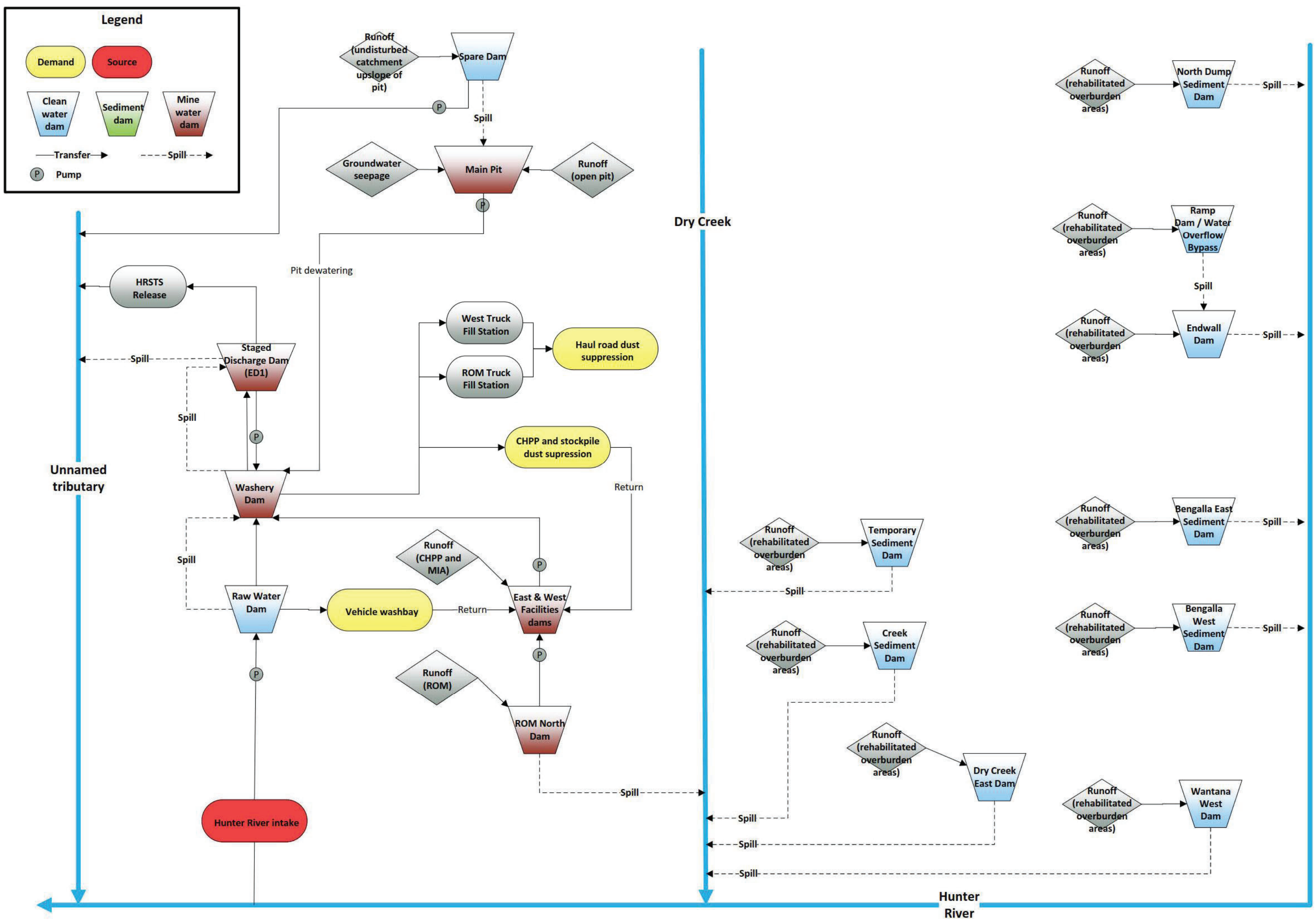

Figure 4-9 Bengalla proposed water management system schematic – Year 24

4.5 WATER MANAGEMENT STRUCTURES

Existing, approved and proposed water storages are summarised in Table 4.1. The timing of proposed water structures is provided in Table 4.2. By Year 4, the Existing Raw Water Dam, Existing Washery Dam and Existing SDD will all be relocated, and Endwall Dam and Wantana West Dam will be converted from mine water dams to sediment dams.

Table 4.1 Bengalla existing, approved and proposed water management structures – description

DAM	EXISTING CAPACITY (ML)	APPROVED CAPACITY (ML)	MOD 4 PROPOSED CAPACITY (ML)	PURPOSE	COMMENTS
Existing Staged Discharge Dam (SDD)	280	280	NA (to be replaced by ED1)	Mine water	Staging capacity for wet weather conditions. Licensed release point for mine water under the HRSTS. Accepts water from the Bengalla water management system.
Future ED1	NA	300	700	Mine water	
Existing Washery Dam	25	25	NA (to be replaced by Future Washery Dam)	Mine water	Supply dam for the CHPP and dust suppression water for the water truck fill points. The Existing Washery Dam overflows to the SDD. The Future Washery Dam will overflow to the Future ED1.
Future Washery Dam	NA	25	25	Mine water	
Existing Raw Water Dam	5	5	NA (to be replaced by Future Raw Water Dam)	Clean water	Storage dam for clean water extracted from the Hunter River, supplies the Existing Washery Dam, vehicle wash and fire suppression system. Overflows to the Washery Dam.
Future Raw Water Dam	NA	5	5	Clean water	
East & West Facilities dams	158 with short term capacity up to 208	158 (comprises 24 ML + 24 ML and nominal 110 ML for 'Additional Facilities Dam' if required)	158 with short term capacity up to 208	Mine water	Accepts mine water runoff from the CHPP stockpile and main infrastructure area and process water from dewatering of coal reject material. Accepts pumped mine water inflow from North ROM dam and contaminated water from the WWTP and vehicle wash.
ROM North Dam	13.6	51 (includes nominal 50 ML for 'Additional ROM Dam' if required)	51 (modelled as 13.6 as this is existing)	Mine water	Captures mine water runoff from the ROM and ROM haul road.
ROM South Dam	0.5		0.5	Sediment water	Captures sediment water runoff from the ROM visual bund.

DAM	EXISTING CAPACITY (ML)	APPROVED CAPACITY (ML)	MOD 4 PROPOSED CAPACITY (ML)	PURPOSE	COMMENTS
Endwall Dam	80	80	80	To be converted to sediment dam by approximately Year 4 (currently mine water dam)	Currently accepts mine water pumped from the pit. Also receives sediment water from rehabilitation area, Bengalla East and Bengalla West Sediment Dams.
West Wantana Dam	16	16	16	To be converted to sediment dam by approximately Year 4 (currently mine water dam, pit dewatering function to be replaced by Dry Creek East Dam)	Captures sediment water runoff from disturbed areas associated with Wantana Extension.
Bengalla East Sediment Dam (Homestead Dam)	23.7	43 (nominal)	43 (modelled as 23.7 as this is existing)	Sediment water	Captures sediment water runoff from the OEA un-relinquished rehabilitation area.
Bengalla West Sediment Dam (Farm Dam)	5	5 (assigned to East Wantana Sediment Dam)	5	Sediment water	Captures sediment water runoff from the OEA un-relinquished rehabilitation area.
Ramp Dam (bypassed by open drain)	16	16	16	Sediment water	Previously accepted sediment water runoff from the OEA rehabilitation area and overflow from the North Dump Sediment Dam. Now bypassed.
Dry Creek Clean Water Dam 1 (CW1)	900	900	900	Clean water	Captures runoff from the Dry Creek catchment upstream of Bengalla.
Train Load Out Sump	0.5	0.5	0.5	Mine water	Accepts mine water runoff from the train load out facility.
Facilities Sump	0.5	0.5	0.5	Contaminated water	Accepts contaminated water from the truck and light vehicle wash bay.

DAM	EXISTING CAPACITY (ML)	APPROVED CAPACITY (ML)	MOD 4 PROPOSED CAPACITY (ML)	PURPOSE	COMMENTS
North Dump Sediment Dam	0.5	0.5	0.5	Sediment water	Accepts sediment water runoff from the rehabilitation on the northern emplacement area.
Dry Creek East Dam	NA	NA	93	Mine water	Replaces the function of West Wantana Dam - accepts mine water overflow from the South Loop Road Dam -
Western OEA Sediment Dam A	NA	26 (nominal)	83 (nominal*, sized using 'Blue Book' for Year 8 catchment)	Sediment water	Captures runoff from Western OEA.
Western OEA Sediment Dam B	NA	17 (nominal)	16 (nominal*, sized using 'Blue Book' for Year 4 catchment)	Sediment water	Captures runoff from Western OEA.
Creek Sediment Dam	NA	36 (nominal)	270 (nominal*, sized using 'Blue Book' for Year 24 Dry Creek reinstatement catchment)	Sediment water	Captures runoff from disturbed areas during rehabilitation of Dry Creek.
Spare Dam	NA	100 (nominal)	100 (nominal**)	Clean water	Captures clean surface water from upstream catchment.
South Loop Road Dam	0.5	0.5	NA (to be replaced by proposed new Dry Creek East Dam)	Mine water	Currently accepts mine water pumped from the pit. Overflows to the Wantana West Dam. Will overflow to the proposed new Dry Creek East Dam.
Temporary OEA Sediment Dam	NA	Shown in EIS and MOD 1 but not sized	58* (sized using 'Blue Book' for Year 15 catchment)	Sediment water	Capture sediment water runoff from overburden areas.
Main pit	NA	NA	NA	Mine water	Open cut pit
Satellite pit	NA	NA	NA	Mine water	Open cut pit

*Notes: * Dam sizing is nominal. To be confirmed during detailed design. To be sized using 'Blue Book'. Storage capacity may be provided in more than one sediment dam located within the OEA.*

*** Spare Dam sizing is nominal. To be confirmed during detailed design.*

Table 4.2 Bengalla proposed water management structures - period of operation

STORAGE	TYPE OF WATER STORAGE	REPRESENTATIVE MINE STAGE			
		YEAR 4	YEAR 8	YEAR 15	YEAR 24
Future ED1	Mine water	X	X	X	X
Future Washery Dam	Mine water	X	X	X	X
Future Raw Water Dam	Clean water	X	X	X	X
East & West Facilities dams	Mine water	X	X	X	X
ROM North Dam	Mine water	X	X	X	X
ROM South Dam	Sediment water	X	X	X	X
Endwall Dam	Sediment dam	X	X	-	-
	Clean water	-	-	X	X
West Wantana Dam	Sediment dam	X	X	X	-
	Clean water	-	-	-	X
Bengalla East Sediment Dam (Homestead Dam)	Sediment Dam	X	X	-	-
	Clean water	-	-	X	X
Bengalla West Sediment Dam (Farm Dam)	Sediment Dam	X	X	-	-
	Clean water	-	-	X	X
Ramp Dam	Sediment dam	X	X	-	-
	Clean water	-	-	X	X
Dry Creek Clean Water Dam 1 (CW1)	Clean water	X	X	X	-
Train Load Out Sump	Mine water	X	X	X	X
Facilities Sump	Contaminated water	X	X	X	X
North Dump Sediment Dam	Sediment Dam	X	X	-	-
	Clean water	-	-	X	X
Dry Creek East Dam	Mine water	X	-	-	-
	Sediment water	-	X	X	-
	Clean water	-	-	-	X
Western OEA Sediment Dam A	Sediment water	-	X	-	-
Western OEA Sediment Dam B	Sediment water	X	-	-	-
Creek Sediment Dam	Sediment water	-	-	X	-
Spare Dam	Clean water	-	-	-	X
Temporary OEA Sediment Dam	Sediment water	-	-	X	-
	Clean water	-	-	-	X
Main pit	Mine water	X	X	X	X
Satellite pit	Mine water	X	-	-	-

Legend: Shading 'x' – storage active for 'snapshot' mine stage, No shading – storage not active for 'snapshot' mine stage

5 MINE WATER BALANCE

5.1 MODELLING APPROACH

Water balance models for the Bengalla water management system were developed for the EIS SWIA (WRM, 2013) and MOD 1 SEE SWIA (WRM, 2015) using OPSIM software, a widely used platform for mine site water balance studies. The MOD 1 model has been used as the basis of water balance modelling for MOD 4 and has been revised to include MOD 4.

The OPSIM model was used to calculate the volume of water in storages at the end of each day by taking into account daily rainfall-runoff inflow, groundwater inflow, evaporation from the storage, water usage, pumping between storages in the form of a pumping policy, controlled releases and storage overflow. The OPSIM model also included a high-level salt balance to calculate the concentration of salt in storages at the end of each day in order to simulate controlled releases to the Hunter River under the HRSTS.

The OPSIM model was run at a daily time step using the ‘forecast period simulation’ mode. The ‘forecast period simulation’ runs the model over the 22 year mine life considered (i.e. 1 January 2018 to 31 December 2039) for multiple climate sequences (or realizations) developed by stepping through the available climate and streamflow data from 1893 to 2006. This is the period that concurrent streamflow and climate data are available. The first realization starts on 1 January 1893, the second realization on 1 January 1894 etc. The model was simulated for 93 realizations. The model parameters (catchment areas, storage facilities, demands, groundwater inflows and operating rules etc.) are varied in the model between the Year 4, 8, 14 and 24 mine stage ‘snapshots’. This takes into account the dynamic nature of the mine plan and water management system. The results for all of the realisations are retained and are analysed using percentile analysis. The assumed timing for the mine stage ‘snapshots’ in the model is summarised Table 5.1.

Table 5.1 Assumed timing for mine stage ‘snapshots’ in OPSIM model

MINE STAGE ‘SNAPSHOT’	PERIOD APPLIED IN OPSIM MODEL	PERIOD (YEARS)
Year 4	Year 3 to Year 7 (1 January 2018 to 31 December 2022)	5
Year 8	Year 8 to Year 14 (1 January 2023 to 31 December 2029)	7
Year 15	Year 15 to Year 23 (1 January 2030 to 31 December 2038)	9
Year 24	Year 24 (1 January 2039 to 31 December 2039)	1

The water balance model operating rules have been refined to reflect recent changes to the HRSTS flow thresholds made under the HRSTS Amendment Regulation 2016. The onsite operating rules generally prioritise pumping of mine water and sediment dam water to the Future Washery Dam (and onto ED1) over pit dewatering, to better reflect the existing operational Bengalla water management system.

5.2 MODEL ASSUMPTIONS

The following key assumptions were made in the water balance analysis:

— The mine conditions (catchment areas, storage facilities, demands, groundwater inflows and operating rules etc) will change continuously over the life of the mine. The changes to mine conditions occurring between snapshots have not been considered. However, the Year 4, 8, 15 and 24 mine stage ‘snapshots’ are considered to reasonably represent the conditions over the approved life of the mine.

- A pumping policy based on the existing and proposed infrastructure has been included in the water balance model. Pump rates modelled are average daily rates, assuming operation of the pumps at an average rate for 24 hours per day. Pump rates have been provided by BMC and have been updated since the EIS.
- Annual estimates of demands have been distributed uniformly to obtain daily average demands for the water balance model. The exception is dust suppression demands which are estimated in the model on a daily basis based on rainfall.
- It is assumed that water cannot be pumped out of sediment dams below the 'sediment zone' volume. Sediment has not been modelled.
- It is assumed that the overburden emplacement areas will be progressively rehabilitated. Once the entire catchment of any overburden sediment dam is rehabilitated and relinquished, pumping to the mine water management system will cease and runoff from relinquished areas will be released directly to the natural watercourse via a sediment dam. The assumed timing of the release of sediment dams is provided in Table 4.2.
- Annual estimates of groundwater inflows to the pit have been distributed uniformly to obtain daily inflow rates for the water balance model. All groundwater inflows are assumed to inflow to the Main Pit.
- The Hunter River and Dry Creek watercourses have not been modelled in detail. Modelling of the Hunter River is limited to the flow and salinity time series provided by the DPI Water IQQM model for the duration 1893 to 2006.
- While the model assesses the performance of the system under historical climatic events assuming they will reoccur in the future at the same magnitude and in the same sequence, it neither takes into account changes in climate conditions, nor incorporates the potential impacts of global climate change.
- AWBM rainfall-runoff model parameters for mine site catchments have been sourced from the EIS SWIA (WRM, 2013). Verification of the water balance model and adopted AWBM parameters was undertaken for the period January 2010 to December 2011 as part of the EIS SWIA (WRM, 2013). No further calibration or verification of the AWBM parameters has been undertaken.
- Salinity concentrations for runoff from mine site catchments have been sourced from the EIS SWIA (WRM, 2013). No calibration or verification of the salinity parameters has been undertaken.
- It is assumed that raw water will be available from the Hunter River as required to meet demands. It has been assumed that adequate water allocations or alternative water sources are available to makeup the external water requirement (the model essentially assumes an infinite source of external water).
- It is assumed that controlled releases from ED1 will be made in accordance with the conditions of the HRSTS. Release rates were determined in the water balance model based on the salinity of water stored in SDD along with salinity and streamflow rates in the Hunter River. It was assumed that 3.5% of the TAD could be used by BMC based on the number of credits held by BMC at the commencement of the HRSTS (35 credits). It was assumed that TAD opportunities could be 100% utilised. Refer to Section 5.3.5.3 for details of the HRSTS.
- It is assumed that all runoff within the water management system drains to a storage, and that the diversion drains capture all runoff from their local catchments with no bypass.
- The ROM South Dam, Train Load Out Sump and Facilities Sump have not been included in the model.
- Starting volumes at the commencement of the water balance model simulation have been assumed based on recorded site data on 11 November 2016.

5.3 MODEL DATA

5.3.1 STORAGE CHARACTERISTICS

A summary of existing, approved and proposed water storages capacities is provided in Table 4.1. The assumed period of operation of the proposed water management structures for the mine stage 'snapshots' is summarised in Table 4.2. The assumed period of operation in Table 4.2 indicates if a dam will be present for a specified 'snapshot' in time. The actual timing for commissioning / decommissioning of dams will depend on the mine progression and may occur in between mine stage 'snapshots'.

Stage-storage relationships have been used in the water balance model to calculate the volume of evaporation from dams and the volume of direct rainfall on dams. The stage-storage relationships for existing dams were assumed based on data provided by BMC based on bathymetry and survey undertaken in 2016. Stage-storage relationships for proposed dams were assumed based on data from the EIS model (WRM, 2013) or from assumed storage characteristics. Stage-storage relationships for proposed sediment dams were based on 1V:3H side slopes and a storage depth of 3 m.

Storage volumes for the commencement of the water balance model simulation were based on recorded site data for 11 November 2016 as summarised in Table 5.2. Storages not listed in Table 5.2 are assumed empty.

Table 5.2 Assumed initial model storage volumes (as recorded 11 November 2016)

DAM	STARTING VOLUME (ML)	COMMENTS
Existing Raw Water Dam	5.0	Assigned to Future Raw Water Dam
Existing SDD	143.8	Assigned to ED1
Existing Washery Dam	22.8	Assigned to Future Washery Dam
East & West Facilities dams	114.4	
Endwall Dam	20.5	
West Wantana Dam	5.6	

5.3.2 CATCHMENT AND LANDUSE BREAKDOWN

Catchment boundaries for the water management system were generally delineated using the mine plans and reasonable assumptions about the likely destination of runoff. Catchment boundaries are shown on the conceptual water management system plans provided in Figure 4-2 to Figure 4-5.

The catchment boundaries for the East & West Facilities dams have been based on the existing footprint of the MIA and CHPP areas, with the exception of Year 24 where the catchment has been extended to the west to include the proposed ROM stockpile and Temporary Rejects Cells.

A summary of modelled catchment areas is provided in Table 5.3 and a more detailed breakdown of catchment area land uses is provided in Appendix A.

Table 5.3 Modelled catchment areas

DAM	CATCHMENT AREA (HA)			
	YEAR 4	YEAR 8	YEAR 15	YEAR 24
Bengalla East Sediment Dam (Homestead Dam)	94.1	94.1	94.1	94.1
Bengalla West Sediment Dam (Farm Dam)	17.3	17.3	17.3	17.3
CW1	631.0	631.0	631.0	-
Dry Creek East Dam	9.0	98.1	135.4	135.4
East & West Facility dams	95.3	91.5	91.0	102.2
Endwall Dam	96.9	96.9	96.9	96.9
North Dump Sediment Dam	7.8	7.8	7.8	7.8
Pit	432.0	744.6	797.8	487.4
Ramp Dam (bypassed)	75.3	75.3	75.3	75.3
ED1	19.5	19.5	19.5	19.5
Future Raw Water Dam	1.2	1.2	1.2	1.2
Future Washery Dam	2.0	2.0	2.0	2.0
ROM North Dam	7.6	7.6	7.6	6.1
Train Load Out Sump	0.4	0.4	0.4	0.4
Wantana West Dam	4.4	4.4	4.4	4.4
Satellite Pit	515.9	-	-	-
Western OEA Sediment Dam B	27.8	-	-	-
Western OEA Sediment Dam A	-	145.8	-	-
Temporary OEA Sediment Dam	-	-	101.4	101.4
Creek Sediment Dam	-	-	72.8	-
Spare Dam	-	-	-	96.4
Future Dry Creek (includes former CW1 catchment and rehabilitated areas)	-	-	-	1,147.1
Total	2,037.4	2,037.4	2,155.6	2,394.6

Legend: Shading – catchment not active for 'snapshot' mine stage, No shading – catchment not active for 'snapshot' mine stage

5.3.3 WATER QUALITY

Salt generation rates for water inputs have been sourced from the EIS SWIA (WRM, 2013) and are summarised in Table 5.4. These rates are based on analysis of the site monitoring data.

Table 5.4 Water quality salt generation rates adopted in model

MINE STAGE 'SNAPSHOT'	SALT GENERATION RATE (µS/CM)
Natural / dirty water	240
Rehabilitated spoil	500
Industrial	1,700
Open cut mine	5,000
Active spoil	1,000
Groundwater	1,300
Hunter River intake	550

Source: EIS SWIA (WRM, 2013)

5.3.4 WATER INPUTS

5.3.4.1 SURFACE WATER RUNOFF

The AWBM rainfall-runoff model (using the historical daily rainfall and monthly evapotranspiration data) is incorporated in the OPSIM model to generate a daily time series of runoff from mine site catchments. The AWBM rainfall-runoff model and parameters are described in Section 3.3.

5.3.4.2 DIRECT RAINFALL

Direct rainfall on dams were determined based on assumed dam stage-storage relationships. Stage-storage relationships are discussed in Section 5.3.1.

5.3.4.3 GROUNDWATER SEEPAGE

Groundwater inflow estimates for the mining pits were sourced from Figure 11.6 of the Bengalla Continuation of Mining Project Groundwater Impact Assessment (AGE, 2013). Pumpable pit seepage estimates for the 'snapshot' mine stages considered are summarised in Table 5.5 and are defined as the total volume of groundwater seepage minus losses due to evaporation. The AGE (2013) report indicates that groundwater ingress is from the Permian coal measures.

Table 5.5 Groundwater seepage estimates

MINE STAGE 'SNAPSHOT'	PUMPABLE PIT SEEPAGE (ML/DAY)
Year 4	0.07
Year 8	0
Year 15	0.04
Year 24	0

Source: Bengalla Continuation of Mining Project Groundwater Impact Assessment (AGE, 2013)

5.3.4.4 EXTERNALLY SOURCED WATER

Raw water will be imported from external sources to meet demands during a water deficit and to provide a source of high-quality water. Fire suppression and vehicle wash down demands will be sourced from the Future Raw Water Dam. The Future Raw Water Dam will supply makeup water to the Future Washery Dam for use in the CHPP and for dust suppression (when there is an onsite water deficit). When there is a mine water deficit onsite, a minimum stored volume will be maintained in the Future Washery Dam by pumping water from the Future Raw Water Dam (Hunter River water).

BMC hold Water Access Licences (WALs) with sufficient share component totalling 6,017 units (comprising 1,455 high security units and 4,562 general security units) to account for the maximum predicted take for the life of Bengalla based on predicted demands from the Hunter Regulated River Water Source (Management Zone 1A). BMC maintains exclusive rights for the dedicated use of at least 3,309 units (comprising 1,449 high security units and 1,860 general security units) under the WALs. The remaining units of the WALs (comprising 5 high security units and 2,702 general security units) are currently subject to use by licensees of BMC owned land for agricultural purposes.The 1,449 units of high security water entitlements are equivalent to a maximum total of 1,449 ML/year assuming 100% allocation of high security water entitlements. Note that lower allocations of high security entitlements can be expected during dry periods, with little or no allocation of general security entitlements possible during drought periods.

5.3.5 WATER OUTPUTS

5.3.5.1 DEMANDS

CHPP DEMANDS

CHPP demands have been sourced from the EIS SWIA (WRM, 2013). A net CHPP demand of 1,164 ML/yr was assumed based on a ROM throughput of 15 Mtpa modelled for all ‘snapshot’ mine stages considered. The net CHPP demand is based on the average plant usage of 77.6 L/ROM tonne (wet) which is based on recorded net water usage at Bengalla during the 2011 calendar year.

STOCKPILE DUST SUPPRESSION DEMANDS

Stockpile dust suppression demands have been sourced from the EIS SWIA (WRM, 2013). A demand of 150 ML/yr has been assumed for all ‘snapshot’ mine stages considered. The dust suppression demand is based on usage rates provided by BMC. One hundred percent evaporative loss of stockpile dust suppression demands has been assumed.

Stockpile dust suppression demands will be sourced from the Future Washery Dam.

HAUL ROAD DUST SUPPRESSION

Haul road dust suppression demands have been sourced from the EIS SWIA (WRM, 2013). Dust suppression rates are based on a dry day haul road watering rate of 3.1 mm/day. The rate has been reduced on rain days. The haul road areas are based on haul road lengths calculated from the mine plans and an assumed width of 25 m.

Haul road dust suppression demand estimates are summarised in Table 5.6. One hundred percent evaporative loss of haul road dust suppression demands has been assumed.

Table 5.6 Haul road dust suppression demand estimates

MINE STAGE 'SNAPSHOT'	HAUL ROAD WATERING AREA (HA)	MAXIMUM DAILY DUST SUPPRESSION (KL/DAY)*	AVERAGE YEARLY DUST SUPPRESSION (ML/YR)**
Year 4	47.1	1,478	457
Year 8	45.0	1,414	437
Year 15	54.3	1,706	527
Year 24	52.5	1,648	509

Notes:

** For a non-rain day.*

*** Based on long term average including rain days*

Source: EIS SWIA (WRM, 2013)

VEHICLE WASH DOWN

Vehicle wash down demands have been sourced from the EIS SWIA (WRM, 2013) and is 132 ML/year.

Vehicle wash down demands will be sourced from the Future Raw Water Dam.

DEMAND SUMMARY

Assumed demands are summarised in Table 5.7. Dust suppression demands in Table 5.7 are based on average climate conditions and are therefore likely to be higher during dry conditions.

Table 5.7 Average demand summary

YEAR	ROM COAL (Mtpa)	DEMAND (ML/YR)				
		CHPP DEMAND (NET)	STOCKPILE DUST SUPPRESSION	HAUL ROAD DUST SUPPRESSION (AVERAGE CLIMATE)	VEHICLE WASH DOWN (NET)	TOTAL
Year 4	15.0	1,164	150	457	132	1,903
Year 8	15.0	1,164	150	437	132	1,883
Year 15	15.0	1,164	150	527	132	1,973
Year 24	15.0	1,164	150	509	132	1,955

Demand sources are summarised in Table 5.8. Where demands are listed as being sourced from the Future Washery Dam in Table 5.8 they will be sourced from mine water as a priority. When there is a mine water deficit onsite, a minimum stored volume will be maintained in Washery Dam by pumping water from the Future Raw Water Dam (Hunter River water).

Table 5.8 Demand sources

DEMAND	SOURCE	WATER CLASSIFICATION
CHPP	Future Washery Dam	Mine water (as a priority over raw water)
Stockpile dust suppression	Future Washery Dam	Mine water (as a priority over raw water)
Haul road dust suppression	Future Washery Dam	Mine water (as a priority over raw water)
Vehicle wash down	Future Raw Water Dam	Raw water (Hunter River water)

5.3.5.2 OTHER LOSSES

EVAPORATION

Average monthly evaporation estimates were based on historical climate data sourced from the BOM station Scone SCS (BOM station No. 61089). A reduction factor of 0.7 has been applied to the open cut pit to account for reduced evaporation rates.

Evaporative surface area for dams has been determined based on assumed dam stage-storage relationships. Stage-storage relationships are discussed in Section 5.3.1.

SEEPAGE

Water balance modelling has assumed no seepage loss. This assumption is intended to be conservative from the perspective of containment performance but may not be conservative for other outcomes of operational simulation modelling (such as water supply reliability).

5.3.5.3 HRSTS CONTROLLED RELEASES

Controlled releases of mine water stored in ED1 will be made in accordance with the conditions of the HRSTS and EPL 6538. Release rates will depend on stored water quality in ED1 along with streamflow and salinity conditions in the Hunter River.

Release rules (Rule 1 and Rule 2) for inclusion in the OPSIM water balance model are generally based on the rules adopted for the EIS SWIA (WRM, 2013). A maximum daily release of 200 ML has been assumed in accordance with EPL 6538 and the HRSTS conditions. The release rules have been updated to reflect recent changes to the flood flow thresholds made under the HRSTS Amendment Regulation 2016. The 'flood' threshold for the upper sector was increased from 4,000 ML/day to 6,500 ML/day.

The release rules have also been updated to more accurately reflect credit limitations during 'high' flow periods. The EIS SWIA (WRM, 2013) and MOD 1 SEE SWIA (WRM, 2015) models assumed that 100% of the TAD could be used by Bengalla, and no salt discharge credit limit was applied during 'high' flow periods. In reality, during 'high' flow periods the TAD would be proportioned amongst the different license holders participating in the HRSTS based on the number of credits held. A limit of 35 credits has now been assumed for Bengalla based on the number of credits held by Bengalla at the commencement of the HRSTS (i.e. 3.5% of the available 1000 credits).

Modelled release rules are summarised in Table 5.9 and Table 5.10.

Table 5.9 Modelled controlled release rules from ED1 to Hunter River under HRSTS – Rule 1

RULE 1 – VOLUME LIMIT RATING			
HUNTER RIVER FLOW CLASSIFICATION (FOR UPPER SECTOR)	HUNTER RIVER STREAMFLOW (ML/DAY)	MAXIMUM RELEASE RATE (ML/DAY)	APPLY RULE 2?
Low	< 1,000 ML/day	0	No
High	1,000 to 6,500 ML/day *	200	Yes
Flood	> 6,500 ML/day *	200	No

*Notes: * Flood flow threshold changed from 4,000 to 6,500 ML/day under The Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Amendment Regulation 2016*

Table 5.10 Modelled controlled release rules from ED1 to Hunter River under HRSTS – Rule 2

Rule 2 – Salinity limit rating			
METHOD	CR (µS/CM)	K VALUE	COMMENT
Absolute Increase (K + Cr)	0	600	If the EC of Hunter River is zero, the concentration in the Hunter River can increase by up to 600 µS/cm as a result of discharge from all HRSTS license holders. Bengalla is allocated 3.5% of total discharges (i.e. 35 credits at 0.1% per credit)
Absolute Increase (K + Cr)	600	0	If the EC of Hunter River is 600 µS/cm, the concentration in the Hunter River can increase by zero mg/L as a result of discharge from all HRSTS license holders. Bengalla is allocated 3.5% of total discharges (i.e. 35 credits at 0.1% per credit)

Where Cr = concentration at the reference node (i.e. the Hunter River) and K = concentration increase (linearly interpolated). Setting K = 600 for Cr = 0 µS/cm, and K = 0 for Cr = 600 µS/cm allows transfer so long as receiving water quality does not increase by more than 600 µS/cm for an initial receiving water concentration of 0 µS/cm, pro-rating to an increase of no more than 0 µS/cm for an initial receiving water concentration of 600 µS/cm. OPSIM linearly interpolates data between adjacent rows.

Source: Modified from EIS SWIA (WRM, 2013).

The estimated TAD under the HRSTS was calculated at a daily time step as the mass of salt that could be added to the Hunter River to achieve the target salinity (i.e. the same target salinity set by 'Rule 2' in OPSIM). The Hunter River salinity time series referenced by 'Rule 2' in the model was artificially modified so that during high flow periods other license holders were responsible for a salinity increase equivalent to 96.5% of the TAD and only 3.5% of the TAD was available for use by Bengalla.

The OPSIM water balance model operating rules assumed that water would not be discharged from ED1 if the stored water inventory in ED1 was less than 200 ML. This operating rule was applied to retain some water for reuse onsite.

5.3.6 WATER TRANSFER RATES

Modelled transfer rates are summarised in Table 5.11.

Table 5.11 Modelled transfer rates

PUMP, CHANNEL OR PIPELINE CONNECTION			DESIGN PEAK FLOW RATE (L/s)	COMMENT
TO	FROM	MINE STAGE 'SNAPSHOT'		
East & West Facilities dams	Rom North Dam	Years 4, 8, 15, 24	110	
Endwall Dam	Bengalla East Sediment Dam	Years 4 and 8	100	
	Bengalla West Sediment Dam	Years 4 and 8	100	
Dry Creek East Dam	Endwall Dam	Years 4 and 8	105	
	Wantana West Dam	Years 4, 8 and 15	105	
	Main Pit	Year 4	300	3 x 100 L/s pumps
	Satellite Pit	Year 4	200	2 x 100 L/s pumps
	Creek Sediment Dam	Year 15	105	
	Temporary OEA Sediment Dam	Year 15	40	
Future Washery Dam	East & West Facilities dams	Years 4, 8, 15, 24	300	
	Dry Creek East Dam	Years 4, 8, 15	400	
	Main Pit	Year 8, 15 and 24	300	3 x 100 L/s pumps
	ED1	Years 4, 8, 15, 24	120	
	Future Raw Water Dam	Years 4, 8, 15, 24	200	
	Western OEA Sediment Dam B	Year 4	40	
	Western OEA Sediment Dam A	Year 8	40	
Future Raw Water Dam	Hunter River	Years 4, 8, 15, 24	110	Sourced from Hunter River as required
ED1	Future Washery Dam	Years 4, 8, 15, 24	200	Gravity fed
Dry Creek	Spare Dam	Year 24	125	

5.3.7 OPERATIONAL RULES

Modelled operating rules are summarised in Table 5.12.

Table 5.12 Modelled operating rules

FUNCTION	ITEM	OPERATIONAL CONTROL RULES
Raw water input	Hunter River raw water supply	Annual allocation of water up to 1,449 ML/yr supplied to Future Raw Water Dam from Hunter River. Maximum daily intake of 9.5 ML/d from Hunter River.
Groundwater seepage input	Groundwater seepage	Incoming groundwater seepage into Main Pit varies per year of mine life. Refer to Section 5.3.4.3 and Table 5.5 for further details.
Site demands	CHPP	Supplied from Future Washery Dam. Refer to Section 5.3.5.1 for demand rates. Net demand modelled. 100% loss from demand.
	Stockpile dust suppression	Supplied from Future Washery Dam. Refer to Section 5.3.5.1 for demand rates. 100% loss from demand.
	Haul road dust suppression	Supplied from Future Washery Dam (via truck fill stations). Refer to Section 5.3.5.1 for demand rates. 100% loss from demand.
	Vehicle wash and fire suppression	Supplied from Future Raw Water Dam. Refer to Section 5.3.5.1 for demand rates. Net demand modelled. 100% loss from demand.
Operational pits	Main Pit (open cut pit)	Receives groundwater inflow. Refer Table 5.5 for inflow rates. Dewaters using a three-staged pumping system at the following rates: — Pit Water Volume > 0 ML: 100 L/s — Pit Water Volume > 80 ML: 200 L/s — Pit Water Volume > 200 ML: 300 L/s Dewaters to Dry Creek East Dam in Year 4. Dewaters to Future Washery Dam in Years 8, 15 and 24.
	Satellite Pit	Dewaters using a two-staged pumping system at the following rates: — Pit Water Volume > 0 ML: 100 L/s — Pit Water Volume > 4 ML: 200 L/s Dewaters to Dry Creek East Dam in Year 4. Satellite Pit not active in Years 8, 15 and 24.

FUNCTION	ITEM	OPERATIONAL CONTROL RULES
Storage dams	Future Raw Water Dam	Draws water from Hunter River up to raw water annual allocation limit as required. Supplies water to Future Washery Dam when required. Supplies vehicle wash and fire suppression.
	Future Washery Dam	Supplies water to CHPP, Stockpile Dust Suppression and Haul Road Dust Suppression when required. Transfers water to ED1 at 200 L/s when water volume is above 8 ML. Maintains minimum 7.5 ML of water from the following sources in order of priority: Year 4: — East & West Facilities dams — Dry Creek East Dam (receives pit dewatering), Western OEA Sediment Dam B — ED1 — Future Raw Water Dam Year 8, 15 and 24: — East & West Facilities dams — Dry Creek East Dam, Western OEA Sediment Dam A — Main Pit — ED1 — Future Raw Water Dam Water sourced from Future Raw Water in the event of a mine water deficit onsite. Overland transfer to ED1.
	ED1	Licenced release location for mine water discharge to Hunter River under HRSTS guidelines. Releases water to Hunter River when stored volume exceeds 200 ML and conditions of HRSTS discharge are met. Cannot be pumped-out below 70 ML to account for nominal 35 ML 'sediment zone' volume and nominal 35 ML emergency supply. Receives transfers from Future Washery Dam. Pumping to ED1 ceases when stored volume exceeds 660 ML. Spillway to Dry Creek / Hunter River.
	East & West Facilities dams	Operated to keep water levels at a minimum to prevent spills to Hunter River. Pumped to Future Washery Dam. Spillway to Hunter River.

FUNCTION	ITEM	OPERATIONAL CONTROL RULES
	ROM North Dam	Operated to keep water levels at a minimum to prevent spills to Hunter River. Pumped to East & West Facilities dams. Spillway to Hunter River.
	West Wantana Dam	Operated to keep water levels at a minimum to prevent spills to Hunter River. Pumped to Dry Creek East Dam. Cannot be pumped-out below 'sediment zone' volume. Spillway to Dry Creek.
	Ramp Dam	Spillway to Endwall Dam.
	Endwall Dam	Operated to keep water levels at a minimum to prevent spills to Hunter River. Pumped to Dry Creek East Dam. Cannot be pumped-out below 'sediment zone' volume. Spillway to Dry Creek.
	Dry Creek East Dam	Operated to keep water levels at a minimum to prevent spills to Hunter River. Pumped to Future Washery Dam. Cannot be pumped-out below 'sediment zone' volume. Pumping to Dry Creek East Dam in Year 4 ceases when stored volume exceeds 82 ML. Spillway to Dry Creek.
	Western OEA Sediment Dam B	Operated to keep water levels at a minimum to prevent spills. Pumped to Future Washery Dam. Cannot be pumped-out below 'sediment zone' volume. Spillway to Satellite Pit.
	Western OEA Sediment Dam A	Operated to keep water levels at a minimum to prevent spills. Pumped to Future Washery Dam. Cannot be pumped-out below 'sediment zone' volume. Spillway to Main Pit.
	Bengalla East Sedimentation Dam	Operated to keep water levels at a minimum to prevent spills to Hunter River. Pumped to Endwall Dam. Cannot be pumped-out below 'sediment zone' volume. Spillway to Hunter River.
	Bengalla West Sedimentation Dam	Operated to keep water levels at a minimum to prevent spills to Hunter River. Pumped to Endwall Dam. Cannot be pumped-out below 'sediment zone' volume. Spillway to Hunter River.
	Temporary OEA Sediment Dam	Operated to keep water levels at a minimum to prevent spills to Main Pit. Pumped to Dry Creek East Dam. Cannot be pumped-out below 'sediment zone' volume. Spillway to Main Pit.

FUNCTION	ITEM	OPERATIONAL CONTROL RULES
	Creek Sediment Dam	Operated to keep water levels at a minimum to prevent spills to Dry Creek. Pumped to Dry Creek East Dam. Cannot be pumped-out below 'sediment zone' volume. Spillway to Dry Creek.
	CW1	Pumps to Dry Creek to maintain empty. Spillway to Main Pit.
	Spare Dam	Pumps to Dry Creek to maintain empty. Spillway to Main Pit.
Site discharges	Hunter River Salinity Trading Scheme controlled discharge (HRSTS)	Controlled discharge from ED1 to meet the requirements of the HRSTS. Maximum daily discharge 200 ML/day. Discharge only to occur if stored volume in ED1 > 200 ML. Refer to Section 5.3.5.3 for further details.

5.4 MODEL RESULTS

The water balance model simulates the performance of the proposed mine water management system against a range of historical climate conditions. Results have been provided as a statistical predictive tool on potential performance over the mine lifetime. This forecast is based on 93 realisations of different climate data applied over the 22-year modelled life of the mine from 1 January 2018 to 31st December 2039. A range of percentile values have been provided as part of the results. The 50th percentile results reflect the median results for the site. The 1st percentile represents the value which has been exceeded by only 1% of realisations and the 99th percentile represents the value which has been exceeded in 99% of realisations.

5.4.1 EXTERNAL WATER SUPPLY REQUIREMENTS

The predicted annual volume of raw water sourced from external supplies is summarised in Table 5.13 and Figure 5.1. Demands are also provided in Table 5.13.

Table 5.13 Annual external raw water requirement based on water balance simulation

MINE STAGE 'SNAPSHOT'	DEMAND (NET) (ML/YR)	RAW WATER REQUIREMENT (ML/YR)				
		1ST %ILE RESULT	5TH %ILE RESULT	10TH %ILE RESULT	50TH %ILE RESULT	90TH %ILE RESULT
Year 4	1,903	1,726	1,688	1,658	**1,293**	847
Year 8	1,883	1,731	1,715	1,664	**1,252**	880
Year 15	1,973	1,814	1,794	1,761	**1,411**	1,033
Year 24	1,955	1,833	1,819	1,806	**1,589**	1,354
Maximum result over life of project	1,955	1,833	1,819	1,806	**1,589**	1,354

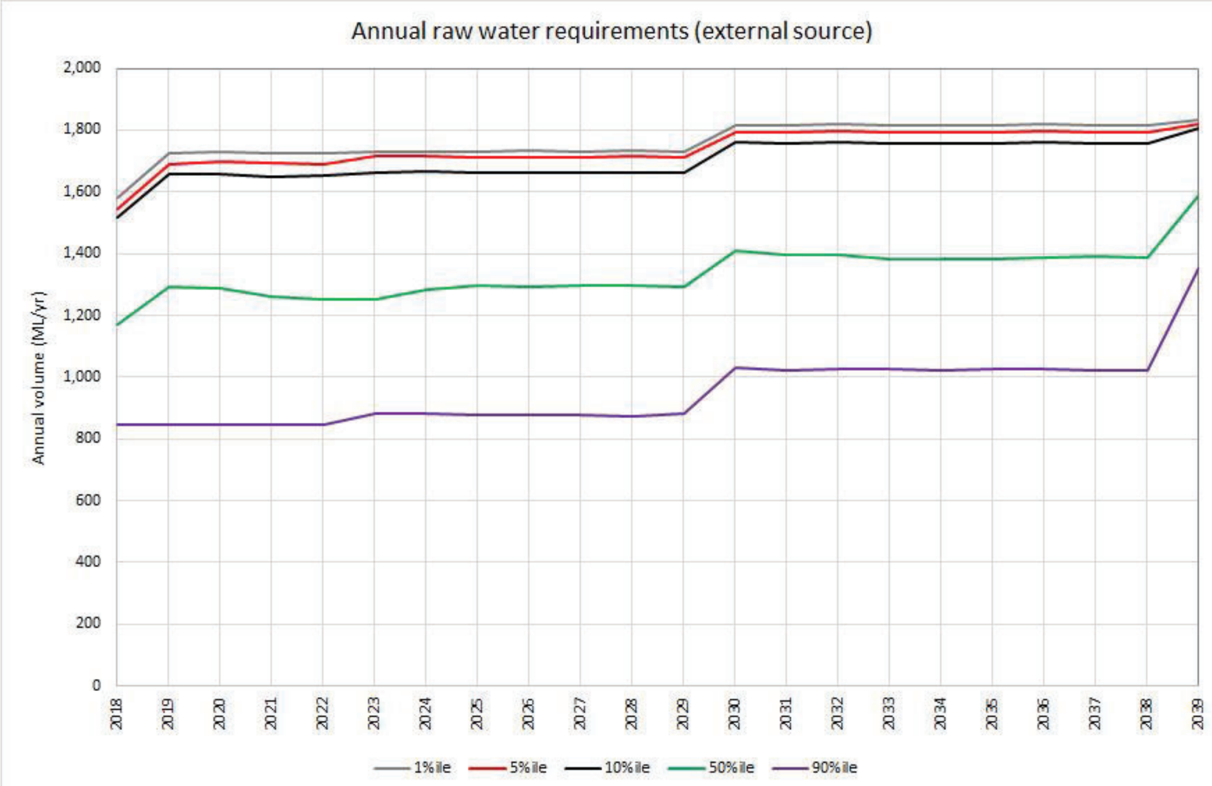

Figure 5.1 Annual timeseries of predicted annual requirement for raw water based on water balance simulation

The predicted raw water requirement from external sources varies significantly depending on the stage of mining and climate conditions. The 50th percentile (representative of average climatic conditions) annual requirement for raw water from external sources ranges from 1,252 ML/yr in Year 8 to 1,589 ML/yr in Year 24. The 1st percentile result (representative of very dry conditions) annual requirement from external sources ranges from 1,726 ML/yr in Year 4 to 1,833 ML/yr in Year 24. There is always a requirement of at least 132 ML/yr from external sources to meet vehicle wash down demands as high quality water is required. The demand from external sources is higher in the later years of the project as less water is available from mine site catchments in these years as runoff from relinquished rehabilitated areas is released to the creek system.

The requirement for raw water is below the available High Security entitlement for the 90th percentile (wet climatic conditions) for all snapshot years and the 50th percentile (average climatic conditions) for snapshot years 4, 8 and 15. For snapshot year 24, the 50th percentile raw water requirement is 1,589 ML/yr. This is 140 ML higher than the available High Security entitlement supply of 1,449 ML/yr under the Hunter Regulated River Water Source WSP (assuming 100% allocation of high security water entitlements). The 1st, 5th and 10th percentile requirements for raw water are also above the available High Security entitlement across all mine stage snapshots. However, BMC also hold general security water entitlements under the Hunter Regulated River WSP.

BMC hold Water Access Licences (WALs) with sufficient share component totalling 6,017 units (comprising 1,455 high security units and 4,562 general security units) to account for the maximum predicted take for the life of Bengalla based on predicted demands from the Hunter Regulated River Water Source (Management Zone 1A). This is based on a conservative assessment of 90% of the allocation of the high security units being available plus a minimum 35% allocation of the general security units held for exclusive use by BMC. BMC maintains exclusive rights for the dedicated use of at least 3,309 units (comprising 1,449 high security units and 1,860 general security units) under the

WALs. The remaining units of the WALs (comprising 5 high security units and 2,702 general security units) are currently subject to use by licensees of BMC owned land for agricultural purposes.

5.4.2 PERFORMANCE OF WATER STORAGE FACILITIES

OPEN CUT PITS

Predicted maximum stored volumes in the open cut pits are summarised in Table 5.14. Daily time series plots of stored volumes in the Main Pit and Satellite Pit are provided in Figure 5.2 and Figure 5.3 respectively. The pits are maintained dry for the 90th percentile and 50th percentile result (very dry to average climatic conditions) however, water may be stored in-pit for the 10th to 1st percentile result (relatively wet to very wet conditions).

The predicted 10th percentile result maximum volume stored in the Main Pit and Satellite Pit over the life of the project are 60 ML and 35 ML respectively. The predicted 1st percentile result maximum volume stored in the Main Pit and Satellite Pit over the life of the project are 727 ML and 554 ML respectively. Stored volumes in-pit are greatest in Year 4 when pit catchment areas are greatest. Stored volumes in-pit decrease in Year 24 when runoff from relinquished rehabilitated areas is released to natural watercourses.

Table 5.14 Maximum stored volume in-pit based on water balance simulation

MINE STAGE 'SNAPSHOT'	STORED VOLUME (ML)				
	1ST %ILE RESULT	5TH %ILE RESULT	10TH %ILE RESULT	50TH %ILE RESULT	90TH %ILE RESULT
MAIN PIT					
Year 4	264	91	0	0	0
Year 8	674	209	43	0	0
Year 15	716	135	49	0	0
Year 24	312	49	7	0	0
Maximum result over life of project	727	209	60	0	0
SATELLITE PIT					
Year 4	468	133	34	0	0
Maximum result over life of project	554	134	35	0	0

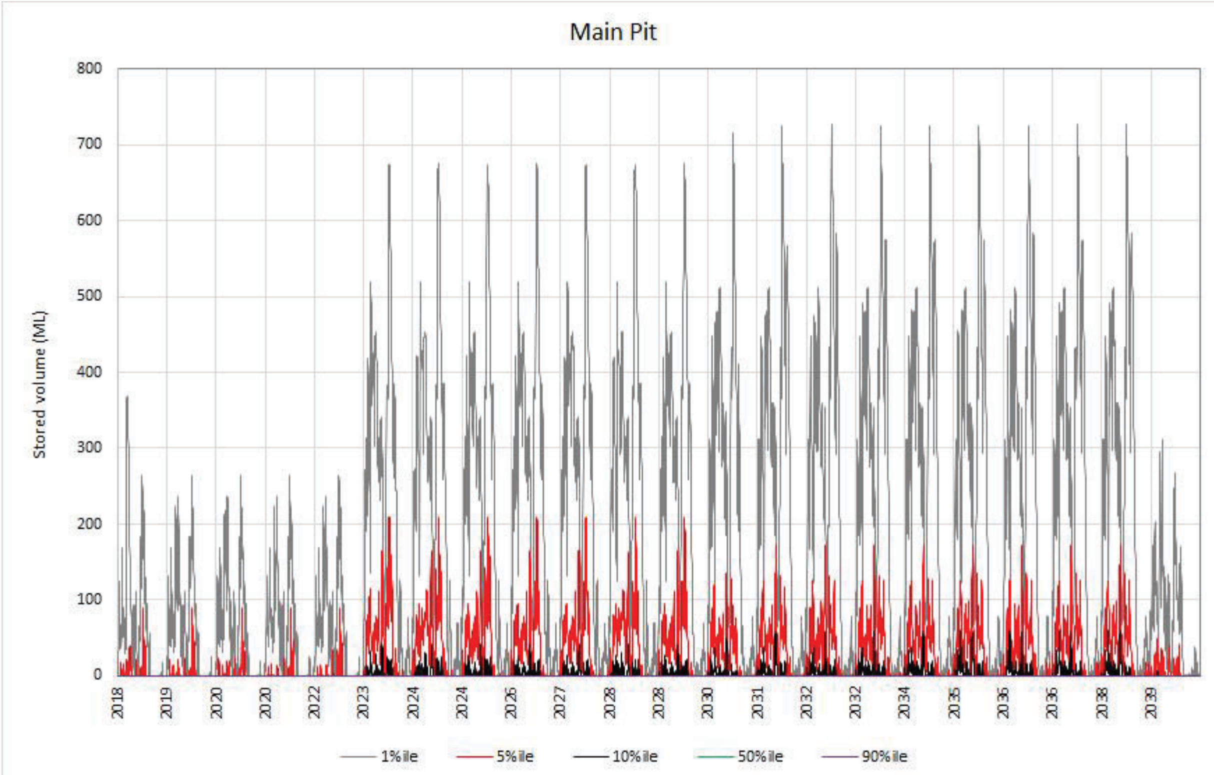

Figure 5.2 Daily timeseries of predicted stored volume in Main Pit based on water balance simulation

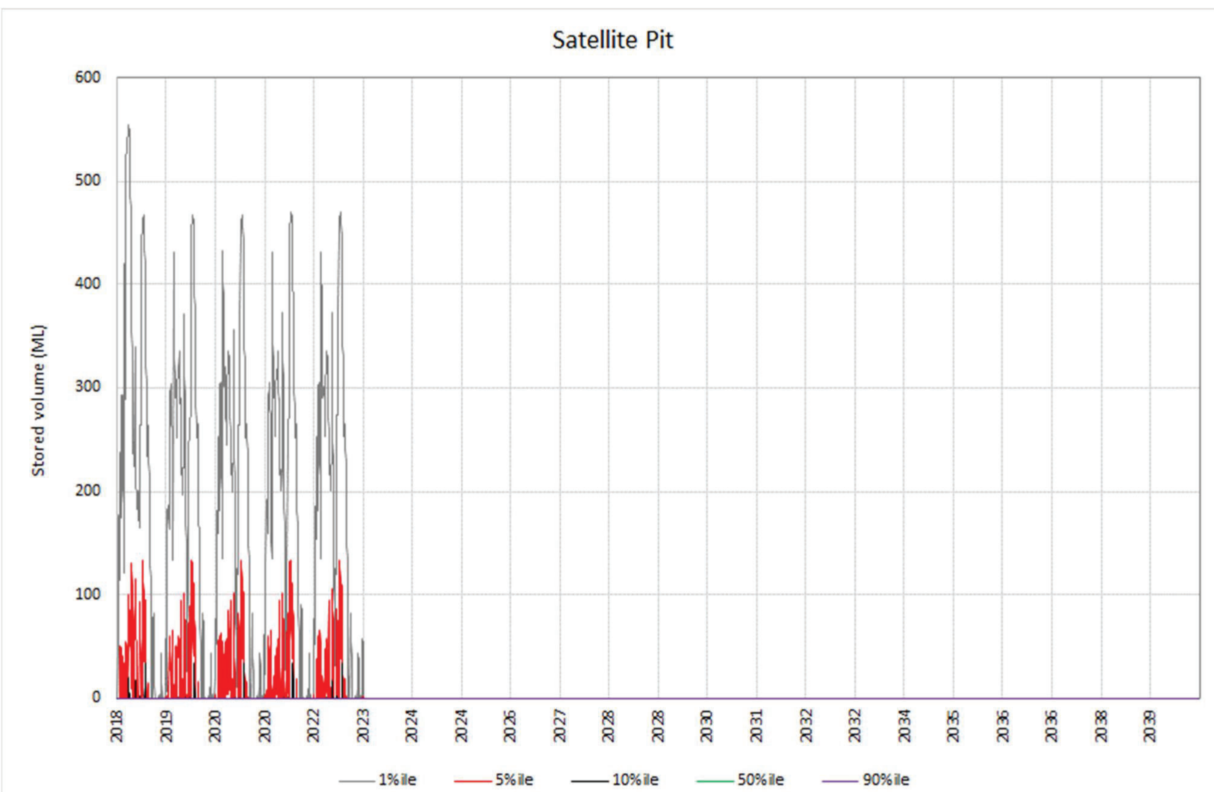

Figure 5.3 Daily timeseries of predicted stored volume in Satellite Pit based on water balance simulation

5.4.3 UNCONTROLLED OFFSITE RELEASES

MINE WATER DAMS

Water balance modelling for the simulated water balance realizations predict that there are no uncontrolled overflows from mine water dams. Modelling predicts:

— There are no uncontrolled overflows of mine water from ED1.

— There are no uncontrolled overflows of mine water from Dry Creek East Dam in Year 4 prior to its conversion to a sediment dam.

— There are no uncontrolled overflows of mine water offsite from the East & West Facilities dams. Spills are contained within the CHPP and MIA bunded area.

— There are no uncontrolled overflows of mine water from the ROM North Dam.

SEDIMENT DAMS

Water balance modelling for the simulated water balance realizations predict that uncontrolled overflows occur from sediment dams. Sediment dams typically have up to a 10% annual risk of overflow to natural watercourses a result of large rainfall events or prolonged wet conditions.

5.4.4 CONTROLLED OFFSITE RELEASES UNDER HRSTS

The predicted annual volume of controlled releases to the Hunter River from Bengalla under the HRSTS is summarised in Table 5.15 and Figure 5.4. Annual HRSTS releases of up to 1,747 ML/yr are predicted for the 1st percentile results. However, the model predicts no release for the 50th percentile except in 2018 with a release of 42 ML/yr. HRSTS releases are lower in Years 15 and 24 when runoff from relinquished rehabilitated areas is released to natural watercourses.

Table 5.15 Annual HRSTS controlled release based on water balance simulation

MINE STAGE 'SNAPSHOT'	HRSTS RELEASE (ML/YR)				
	1ST %ILE RESULT	5TH %ILE RESULT	10TH %ILE RESULT	50TH %ILE RESULT	90TH %ILE RESULT
Year 4	1,742	828	644	0	0
Year 8	1,612	772	632	0	0
Year 15	1,467	687	479	0	0
Year 24	701	259	166	0	0
Maximum result over life of project	1,747	921	662	42	0

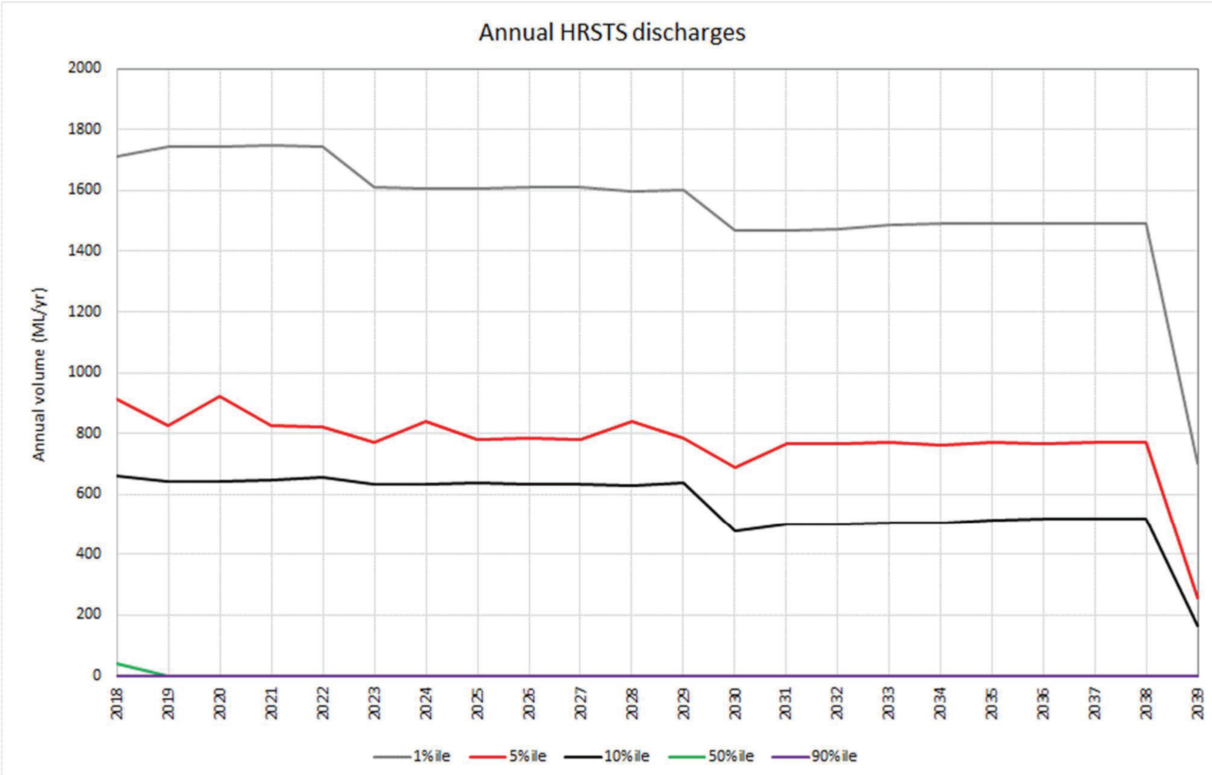

Figure 5.4 Annual timeseries of predicted annual HRSTS controlled releases based on water balance simulation

6 IMPACT ASSESSMENT

6.1 POTENTIAL IMPACTS

Potential impacts of MOD 4 on surface water resources are discussed in the following sections and include:

— Reduction to the volume of water stored in-pit during prolonged wet periods because of an increase in the out-of-pit mine water storage capacity onsite.

— Marginal changes to the volume of water released under the HRSTS resulting from the provision of additional out-of-pit mine water storage onsite and increase in the volume of sediment dam water retained onsite for reuse.

— Marginal changes to the volume of Hunter River raw water required to meet site demands because of an increase in the out-of-pit mine water storage onsite and increase in the volume of sediment dam water retained onsite for reuse.

— Marginal reduction of catchment area draining to the Hunter River due to increase of footprint of ED1 and addition of the proposed new Dry Creek East dam.

— Erosion and sedimentation impacts associated with construction of the enlarged ED1 and new Dry Creek East dam.

6.2 PIT AVAILABILITY

MOD 4 will increase the out-of-pit mine water storage capacity onsite and will result in a reduction in the volume of mine water stored in-pit during wet periods. The MOD 4 storage capacity of the enlarged ED1 is 700 ML, which is 400 ML greater than the approved capacity of 300 ML.

A comparison of the predicted maximum volume of water stored in-pit over the life of the project for the approved and MOD 4 scenarios is provided in Table 6.1. The 50th percentile result shows that the pits are generally maintained dry under average climatic conditions for both the approved and MOD 4 scenarios. The 10th percentile result, representative of relatively wet conditions, for the Satellite Pit reduces from 450 ML for the approved scenario to 35 ML for the MOD 4 scenario. The 10th percentile result for the Main Pit reduces from 240 ML for the approved scenario to 60 ML for the MOD 4 scenario.

Table 6.1 Comparison of predicted maximum in-pit storage volumes over life of project – approved versus MOD 4 scenarios

	MAXIMUM IN-PIT STORED VOLUME (ML)			
	SATELLITE PIT		MAIN PIT	
	APPROVED (MOD 1)	PROPOSED (MOD 4)	APPROVED (MOD 1)	PROPOSED (MOD 4)
50th percentile result (average climatic conditions)	0	0	0	0
10th percentile result (wet conditions)	450	35	240	60

6.3 CONTROLLED OFFSITE RELEASES UNDER HRSTS

MOD 4, along with recent amendments to the HRSTS flow thresholds, will result in minor changes to controlled offsite releases from Bengalla under the HRSTS. The additional out-of-pit storage capacity provided in the enlarged ED1 will allow Bengalla to store additional mine water, including sediment water, onsite for reuse. The recent amendments to the HRSTS flow thresholds will increase the number of release opportunities that are classified as 'high' flow (discharge with credits) versus 'flood' flow (discharge unrestricted by credits).

A comparison of the predicted HRSTS controlled releases for the approved and MOD 4 scenarios is provided in Table 6.2. The 50th percentile result, representative of average climatic conditions, increases from 0 ML/yr for the approved scenario to 42 ML/yr for the MOD 4 scenario. The 10th percentile result, representative of relatively wet conditions, reduces from 750 ML/yr for the approved scenario to 662 ML/yr for the MOD 4 scenario. The 1st percentile result, representative of very wet conditions, increases from 1,550 ML/yr for the approved scenario to 1,747 ML/yr for the MOD 4 scenario.

Table 6.2 Comparison of predicted maximum annual HRSTS controlled releases over the life of project – approved versus MOD 4 scenarios

	MAXIMUM ANNUAL HRSTS CONTROLLED RELEASE (ML/YR)	
	APPROVED (MOD 1)	PROPOSED (MOD 4)
50th percentile result (average climatic conditions)	0	42
10th percentile result (wet conditions)	750	662
1st percentile result (very wet conditions)	1,550	1,747

6.4 UNCONTROLLED OFFSITE RELEASES

For the currently approved scenario, no uncontrolled overflows were predicted from mine water dams except for the East & West Facilities dams which were predicted to have less than a 1% annual risk of overflow. For the MOD 4 scenario, no uncontrolled overflows are predicted from mine water dams. The reduction in overflow risk from the East & West Facilities dams can be attributed to the additional out-of-pit storage capacity provided in the enlarged ED1. This allows additional water to be pumped out of the East & West Facilities dams during wet periods. The reduction in overflow risk can also be attributed to an increase in the proposed pump rate from the East & West Facilities dams to the Washery Dam and an emergency short term storage capacity within excavated drains leading to the dams.

Uncontrolled overflows are predicted from sediment dams for both the approved and MOD 4 scenarios. For the MOD 4 scenario sediment dams have up to a 10% annual risk of overflow to natural watercourses as a result of large rain events or prolonged wet conditions.

6.5 EXTERNAL WATER SUPPLY REQUIREMENTS

MOD 4, along with recent amendments to the HRSTS flow thresholds, will not result in a change to the mine site water demands but will result in minor changes to the volume of mine water, including sediment dam water, that is stored onsite for reuse.

A comparison of the predicted Hunter River raw water requirement over the life of Bengalla for the approved and MOD 4 scenarios is provided in Table 6.3. The 50th percentile result, representative of average climatic conditions, shows that the raw water requirement increases from 1,530 ML/yr for the approved scenario to 1,589 ML/yr for the MOD 4 scenario. The 1st percentile result, representative of very dry conditions, decreases from 1,920 ML/yr for the approved scenario to 1,833 ML/yr for the MOD 4 scenario. This decrease may be attributed to the additional out-of-pit storage capacity, provided in the enlarged ED1, which will allow Bengalla to store additional water onsite for reuse.

Table 6.3 Comparison of predicted maximum annual external water requirements over life of project – approved versus MOD 4 scenarios

	MAXIMUM ANNUAL EXTERNAL WATER REQUIREMENT (ML/YR)	
	APPROVED (MOD 1)	PROPOSED (MOD 4)
50th percentile result (average climatic conditions)	1,530	1,589
1st percentile result (very dry conditions)	1,920	1,833

6.6 LOSS OF CATCHMENT AREA

MOD 4 will not result in significant changes to the Bengalla water management system catchment area. There are no changes proposed to the approved mine landforms. There will be a negligible increase in catchment area associated with the increased dam footprints for the enlarged ED1 and the proposed Dry Creek East Dam.

6.7 WATER QUALITY

MOD 4 will not result in significant changes to water quality in the Hunter River and Dry Creek. For the MOD 4 scenario, water balance modelling predicts that there will be no uncontrolled mine water dam overflows. Controlled releases of mine water to the Hunter River will continue to be undertaken in accordance with the conditions of the HRSTS and EPL 6538. Uncontrolled overflows will occur from sediment dams during large rainfall events or prolonged wet periods. Sediment dams typically have a 10% annual risk of overflow.

Runoff from the proposed ROM stockpile and Temporary Rejects Cells will be captured in the mine water management system.

6.8 FLOODING

MOD 4 will not result in changes to the Hunter River floodplain. The enlarged ED1 and the proposed Dry Creek East Dam are both located outside of the 100 year average recurrence interval (ARI) flood envelopes for the Hunter River and Dry Creek.

6.9 CONSTRUCTION ACTIVITIES

Erosion and sediment controls will be implemented during the construction of the proposed enlarged ED1 and proposed Dry Creek East Dam generally as stipulated in the Bengalla WMP (BMC, 2017). With the implementation of these temporary controls, construction activities are not expected to significantly impact surface water quality.

7 MITIGATION AND MANAGEMENT

7.1 WATER MANAGEMENT PLAN

The approved Bengalla WMP (BMC, 2017) has been prepared in accordance with the requirements of SSD-5170 (as modified). The WMP describes the existing approved water management infrastructure and procedures in place at Bengalla, including:

— Water managed being clean water, sediment water, mine water and contaminated water management.

— Site water balance.

— Water monitoring program.

— Water impact trigger levels and management actions.

— Erosion and sediment controls.

The existing Bengalla WMP (BMC, 2017) will be reviewed and revised to reflect MOD 4, to the satisfaction of the relevant regulatory agencies.

The proposed water management system for MOD 4 is in line with the existing key principles for water management at Bengalla. The proposed water management system, including layout plans and schematics showing the connectivity between water supplies, demands and storages for the Year 4, 15, 8 and 24 mine stage 'snapshots', is described in Section 4. The proposed site water balance is described in Section 5.

7.2 EROSION AND SEDIMENT CONTROLS

Erosion and sediment controls are outlined in the existing Bengalla WMP (BMC, 2017). Erosion and sediment controls will be implemented during the construction, operation and rehabilitation phases of the project, including construction of the proposed enlarged ED1 and the proposed Dry Creek East Dam.

Erosion and sediment controls will be designed, installed and maintained in accordance with the guidelines *Managing Urban Stormwater: Soils and Construction - Volume 1* (Landcom, 2004) ('Blue Book') and *Managing Urban Stormwater: Soils and Construction - Volume 2E Mines and Quarries* (Department of Environment and Climate Change, 2008).

7.3 DRY CREEK EAST DAM ENGINEERING DESIGN

Dry Creek East Dam is proposed to be located in an area bounded by the south haul road, an embankment that was constructed by BMC for an overland conveyor, Dry Creek and the West Wantana Dam. The overland conveyor was removed from the embankment when the ROM dump hopper was relocated from the east end of the site to a location adjacent to the CHPP. The dam design takes into account the internal powerlines present in the vicinity of the Dry Creek East Dam.

Figure 6.1 of the Bengalla Continuation of Mining Project Groundwater Impact Assessment (AGE, 2013) includes the estimated extent of quaternary alluvium on the Hunter River floodplain. Part of the footprint of the Dry Creek East Dam extends onto the area estimated to include quaternary alluvium. One test pit that was part of geotechnical engineering investigations at the proposed dam site indicated 200 mm of alluvial material present below the topsoil. Neighbouring testpits that were part of the same investigation did not encounter alluvial material.

The impoundment area of the proposed Dry Creek East Dam comprises excavated storage below the existing surface level and volume above ground contained by an earthfill embankment. To prevent potential interaction between mine water and the alluvium the excavated storage area will be lined with approximately 600 mm of compacted clay liner, formed either of approximately 300 mm or material treated in situ and overlain by another approximately 300 mm of clay or approximately 600 mm of material placed in two layers.

8 SUMMARY OF FINDINGS

Water balance modelling has been undertaken to assess the potential surface water impacts of MOD 4. Modelling has been undertaken for the life of mine using long-term historical daily climate data and is based on the Year 4, 8, 15 and 24 mine stage 'snapshots'. The results of the mine water balance for the simulated water balance realizations indicate the following:

— MOD 4 will result in a reduction in the volume of mine water stored in-pit during prolonged wet periods. The 50th percentile result, representative of average climatic conditions, shows that the pits are generally maintained dry with no long term build up. The 10th percentile volume stored in the Satellite Pit and Main Pit reaches 35 ML and 60 ML, respectively.

— Raw water from the Hunter River is required to meet site demands, with the requirement for raw water varying depending on the stage of mining and climate conditions. The 50th percentile, representative of median climatic conditions, external water requirement ranges from 1,252 ML/yr in Year 8 to 1,589 ML/yr in Year 24. BMC hold WALs for the Hunter Regulated River Water Source under the Hunter Regulated River WSP. Bengalla currently has exclusive rights for the use of 1,449 high security units and 1,860 general security units under these WALs. Demand from the Hunter River Regulated Water Source is predicted to slightly decrease as a consequence of MOD 4.

— No uncontrolled offsite overflows from mine water dams are predicted.

— Uncontrolled offsite overflows are predicted to occur from sediment dams (up to a 10% annual risk of overflow) as a result of large rainfall events or prolonged wet conditions.

— Controlled releases under the HRSTS will need to occur during wet climatic conditions. Controlled releases of mine water from ED1 will be undertaken in accordance with the conditions of the HRSTS and EPL 6538. The 50th percentile release, representative of average climatic conditions, is 42 ML/yr.

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— WRM Water & Environment (2015), Bengalla Modification, Surface Water Impact Assessment, Appendix D.

APPENDIX A

CATCHMENT AND LANDUSE BREAKDOWN

Table A1 Catchment areas and landuse breakdown – Year 4

CATCHMENT	CATCHMENT AREA (HA)					
	REHABILITATION	INDUSTRIAL	ACTIVE SPOIL	OPEN CUT PIT	UNDISTURBED	TOTAL
Bengalla East Sediment Dam	91.5	0.0	0.0	0.0	2.6	94.1
Bengalla West Sediment Dam	16.2	0.0	0.0	0.0	1.1	17.3
CW1	4.9	0.0	0.0	0.0	626.0	631.0
Dry Creek East Dam	0.0	0.2	0.4	0.6	7.8	9.0
East & West Facility dams	11.0	82.9	0.0	0.0	1.4	95.3
Endwall Dam	90.9	0.0	0.0	0.0	6.0	96.9
North Dump Sediment Dam	5.5	0.0	0.2	0.0	2.1	7.8
Pit	36.7	0.8	252.8	115.8	25.8	432.0
Ramp Dam (bypassed)	64.9	0.0	8.6	0.0	1.8	75.3
ED1	0.0	0.0	0.0	0.0	19.5	19.5
Future Raw Water Dam	0.0	0.0	0.0	0.0	1.2	1.2
Future Washery Dam	0.0	0.0	0.0	0.0	2.0	2.0
ROM North Dam	0.0	7.4	0.0	0.0	0.2	7.6
Train Load Out Sump	0.0	0.0	0.0	0.0	0.4	0.4
Wantana West Dam	0.3	0.0	0.8	0.0	3.2	4.4
Satellite Pit	0.0	21.5	0.0	41.2	453.1	515.9
Western OEA Sediment Dam B	8.9	0.0	8.8	0.0	10.1	27.8
Western OEA Sediment Dam A	0.0	0.0	0.0	0.0	0.0	0.0
Temporary OEA Sediment Dam	0.0	0.0	0.0	0.0	0.0	0.0
Creek Sediment Dam	0.0	0.0	0.0	0.0	0.0	0.0
Spare Dam	0.0	0.0	0.0	0.0	0.0	0.0
Total	330.9	112.9	271.6	157.6	1,164.4	2,037.4

Table A2 Catchment areas and landuse breakdown – Year 8

CATCHMENT	CATCHMENT AREA (HA)					
	REHABILITATION	INDUSTRIAL	ACTIVE SPOIL	OPEN CUT PIT	UNDISTURBED	TOTAL
Bengalla East Sediment Dam	91.9	0.0	0.0	0.0	2.2	94.1

Bengalla West Sediment Dam	17.3	0.0	0.0	0.0	0.0	17.3
CW1	4.9	0.0	0.0	0.0	626.0	631.0
Dry Creek East Dam	95.3	0.4	0.8	0.0	1.6	98.1
East & West Facility dams	5.8	85.3	0.0	0.0	0.3	91.5
Endwall Dam	91.7	0.0	0.0	0.0	5.2	96.9
North Dump Sediment Dam	7.7	0.0	0.0	0.0	0.1	7.8
Pit	36.1	3.4	294.8	184.0	226.3	744.6
Ramp Dam (bypassed)	73.5	0.0	0.0	0.0	1.7	75.3
ED1	0.3	0.0	0.0	0.0	19.2	19.5
Future Raw Water Dam	0.0	0.0	0.0	0.0	1.2	1.2
Future Washery Dam	0.0	0.0	0.0	0.0	2.0	2.0
ROM North Dam	0.0	7.3	0.3	0.0	0.0	7.6
Train Load Out Sump	0.0	0.1	0.0	0.0	0.3	0.4
Wantana West Dam	3.3	0.0	0.0	0.0	1.0	4.4
Satellite Pit	0.0	0.0	0.0	0.0	0.0	0.0
Western OEA Sediment Dam B	0.0	0.0	0.0	0.0	0.0	0.0
Western OEA Sediment Dam A	51.5	0.0	0.0	0.0	94.4	145.8
Temporary OEA Sediment Dam	0.0	0.0	0.0	0.0	0.0	0.0
Creek Sediment Dam	0.0	0.0	0.0	0.0	0.0	0.0
Spare Dam	0.0	0.0	0.0	0.0	0.0	0.0
Total	479.2	96.5	295.9	184.0	981.7	2,037.4

Table A3 Catchment areas and landuse breakdown – Year 15

CATCHMENT	CATCHMENT AREA (HA)					
	REHABILITATION	INDUSTRIAL	ACTIVE SPOIL	OPEN CUT PIT	UNDISTURBED	TOTAL
Bengalla East Sediment Dam	91.9	0.0	0.0	0.0	2.2	94.1
Bengalla West Sediment Dam	17.3	0.0	0.0	0.0	0.0	17.3
CW1	4.9	0.0	0.0	0.0	626.0	631.0

Dry Creek East Dam	129.5	0.5	0.0	0.0	5.4	135.4
East & West Facility dams	5.7	85.4	0.0	0.0	0.0	91.0
Endwall Dam	91.7	0.0	0.0	0.0	5.2	96.9
North Dump Sediment Dam	7.6	0.0	0.0	0.0	0.1	7.8
Pit	60.0	1.6	301.7	251.3	183.1	797.8
Ramp Dam (bypassed)	75.3	0.0	0.0	0.0	0.0	75.3
ED1	0.2	0.0	0.0	0.0	19.2	19.5
Future Raw Water Dam	0.0	0.0	0.0	0.0	1.2	1.2
Future Washery Dam	0.0	0.0	0.0	0.0	2.0	2.0
ROM North Dam	0.0	7.4	0.0	0.0	0.2	7.6
Train Load Out Sump	0.0	0.1	0.0	0.0	0.3	0.4
Wantana West Dam	3.3	0.0	0.0	0.0	1.0	4.4
Satellite Pit	0.0	0.0	0.0	0.0	0.0	0.0
Western OEA Sediment Dam B	0.0	0.0	0.0	0.0	0.0	0.0
Western OEA Sediment Dam A	0.0	0.0	0.0	0.0	0.0	0.0
Temporary OEA Sediment Dam	101.4	0.0	0.0	0.0	0.0	101.4
Creek Sediment Dam	49.0	2.7	21.2	0.0	0.0	72.8
Spare Dam	0.0	0.0	0.0	0.0	0.0	0.0
Total	638.0	97.7	322.8	251.3	845.9	2,155.6

Table A4 Catchment areas and landuse breakdown – Year 24

CATCHMENT	CATCHMENT AREA (HA)					
	REHABILITATION	INDUSTRIAL	ACTIVE SPOIL	OPEN CUT PIT	UNDISTURBED	TOTAL
Bengalla East Sediment Dam	91.4	0.0	0.0	0.0	2.6	94.1
Bengalla West Sediment Dam	16.8	0.0	0.0	0.0	0.5	17.3
Dry Creek East Dam	129.5	0.5	0.0	0.0	5.4	135.4
East & West Facility dams	6.5	95.7	0.0	0.0	0.0	102.2
Endwall Dam	89.7	0.0	0.0	0.0	7.2	96.9
North Dump Sediment Dam	7.6	0.0	0.0	0.0	0.1	7.8
Pit	0.6	9.2	259.1	181.2	37.3	487.4
Ramp Dam (bypassed)	75.1	0.0	0.0	0.0	0.2	75.3
ED1	0.3	0.0	0.0	0.0	19.1	19.5

Future Raw Water Dam	0.0	0.0	0.0	0.0	1.2	1.2
Future Washery Dam	0.0	0.0	0.0	0.0	2.0	2.0
ROM North Dam	0.0	6.1	0.0	0.0	0.0	6.1
Train Load Out Sump	0.0	0.1	0.0	0.0	0.3	0.4
Wantana West Dam	3.1	0.0	0.0	0.0	1.3	4.4
Satellite Pit	0.0	0.0	0.0	0.0	0.0	0.0
Western OEA Sediment Dam B	0.0	0.0	0.0	0.0	0.0	0.0
Western OEA Sediment Dam A	0.0	0.0	0.0	0.0	0.0	0.0
Temporary OEA Sediment Dam	101.4	0.0	0.0	0.0	0.0	101.4
Creek Sediment Dam	0.0	0.0	0.0	0.0	0.0	0.0
Spare Dam	0.0	0.0	0.0	0.0	96.4	96.4
Subtotal	522.0	100.6	259.1	181.2	173.6	1,247.6
Former CW1 (to reinstated Dry Creek)	0.0	0.0	0.0	0.0	642.7	642.7
Dry Creek (reinstated)	474.3	1.9	0.7	0.0	27.5	504.4
Total	996.4	102.5	259.8	181.2	843.6	2,394.6