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Surface Water Impact Assessment



BENGALLA CONTINUATION OF MINING PROJECT - SURFACE WATER IMPACT ASSESSMENT

Hansen Bailey Pty Ltd
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For and on behalf of
WRM Water & Environment Pty Ltd

A handwritten signature in black ink, appearing to read 'David Newton', written over a horizontal line.

David Newton
Director

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EXECUTIVE SUMMARY

WRM Water & Environment Pty Ltd was commissioned by Hansen Bailey, on behalf of Bengalla Mining Company Pty Ltd (BMC), to undertake a surface water impact assessment to determine potential impacts on surface water resources due to the Continuation of Bengalla Mine Project (the Project).

The Project involves the continuation of mining to the west at a rate of up to 15 Mtpa for up to 24 years. The Project will facilitate the extraction of approximately 316 Million tonnes of Run of Mine coal. The Project includes the interim diversion and realignment of Dry Creek along with the relocation of water storage infrastructure as mining progresses through existing dams.

Bengalla Mine (Bengalla) is located to the north of the Hunter River, adjacent to the Hunter River floodplain. The western portion of the site drains into an ephemeral creek known as Dry Creek, which flows south through the Project Boundary and discharges to the Hunter River main channel to the southwest of Bengalla.

BMC currently holds a high security Water Access Licence with an allocation of up to 1,449 units enabling extraction from the Hunter River, as well as a licensed discharge point, operated in accordance with the Hunter River Salinity Trading Scheme (HRSTS) and existing Environmental Protection Licence (EPL) 6538. Under current catchment conditions (since the upgrade to Glenbawn Dam in 1988), the Hunter River is perennial.

The Hunter River water quality is characterised by low salinity and moderate alkalinity. However, numerous water quality parameters exceed water quality guidelines, particularly for nutrients, zinc and pH.

The potential impacts of the Project on surface water resources include:

- Loss of catchment area draining to Dry Creek and the Hunter River due to capture of runoff within onsite storages during mining. This could potentially reduce runoff volumes to Dry Creek and the Hunter River;
- Adverse impacts on the quality of surface runoff draining from the local site catchments to Dry Creek and the Hunter River;
- Additional water demand from the Hunter River to meet increased operational water requirements for the Project;
- Adverse impacts on downstream water quality associated with possible overflows from the Mine Water Management System; and
- Impacts on the hydrology and water quality of Dry Creek and the Hunter River associated with discharges under the HRSTS.

A key component of the methodology for the surface water impact assessment has been the development of a detailed computer model of the mine water balance. The model was configured to represent the inflows to and outflows from the mine water management system as well as transfers of water between mine site storages. The mine water system was verified against observed system performance during 2010 to 2011. The mine water system model was simulated on a daily basis over the 24 year life of the Project using 90 different rainfall sequences based on recorded historical data.

The results of the water balance model indicate that additional water may be required to meet increased site demands associated with increased production rates. Groundwater inflows are predicted to be low and there is a chance that additional water above the current allocation volume will be required if extreme drought conditions are experienced.

Results of the mine water balance modelling are summarised as follows:

- Water is required from the Hunter River Intake for all years of the Project life. The maximum (99th percentile) external water requirement is approximately 2,200 ML/a between Years 5 to 24. The median (50th percentile) external water requirement is, approximately 1,500 ML/a. The 10th percentile external water requirement is approximately 1,000 ML/a.
- Maximum (99th percentile) HRSTS discharges are approximately 1,000ML/a. The median (50th percentile) annual discharge is zero for the life of the Project.
- There are no simulated uncontrolled discharges from the Mine Water system for the 99th percentile in all years of the Project life.
- The impacts of HRSTS controlled discharges from the Project on the Hunter River flow duration relationship are negligible.
- The long term volume in the final void is expected to be approximately 45,000 to 52,000 ML (64 to 71 mRL, or about 90 m below the surrounding ground level).
- The long term salinity in the final void is expected to increase initially at a rate of 5 $\mu\text{S}/\text{cm}$ per year (average over 1,000 years) and reach a stable salinity of less than 20,000 $\mu\text{S}/\text{cm}$.

BMC currently undertakes an extensive surface water monitoring program, which will continue to be implemented for the Project. Monitoring includes onsite dams (saline, sediment and clean), receiving waters (upstream and downstream Hunter River and Dry Creek), and additional monitoring of receiving waters which is undertaken during periods of controlled release under the HRSTS. Onsite dam surface water monitoring locations will be relocated as appropriate when the dams are relocated. Relocation of the discharge location and Dry Creek requires changes to the receiving water monitoring locations; however the purpose, type of analysis and frequency of the monitoring points will remain unchanged.

In summary, the Project is unlikely to have a greater impact on surface water resources than the existing mining operations.

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1 INTRODUCTION

WRM Water & Environment Pty Ltd was commissioned by Hansen Bailey, on behalf of Bengalla Mining Company Pty Ltd (BMC), to undertake a surface water impact assessment (the assessment) for the Continuation of Bengalla Mine Project (the Project). This assessment will form part of the Environmental Impact Statement (EIS) supporting an application for Development Consent under Part 4, Division 4.1 of the *Environmental Planning and Assessment Act 1979* (EP&A Act).

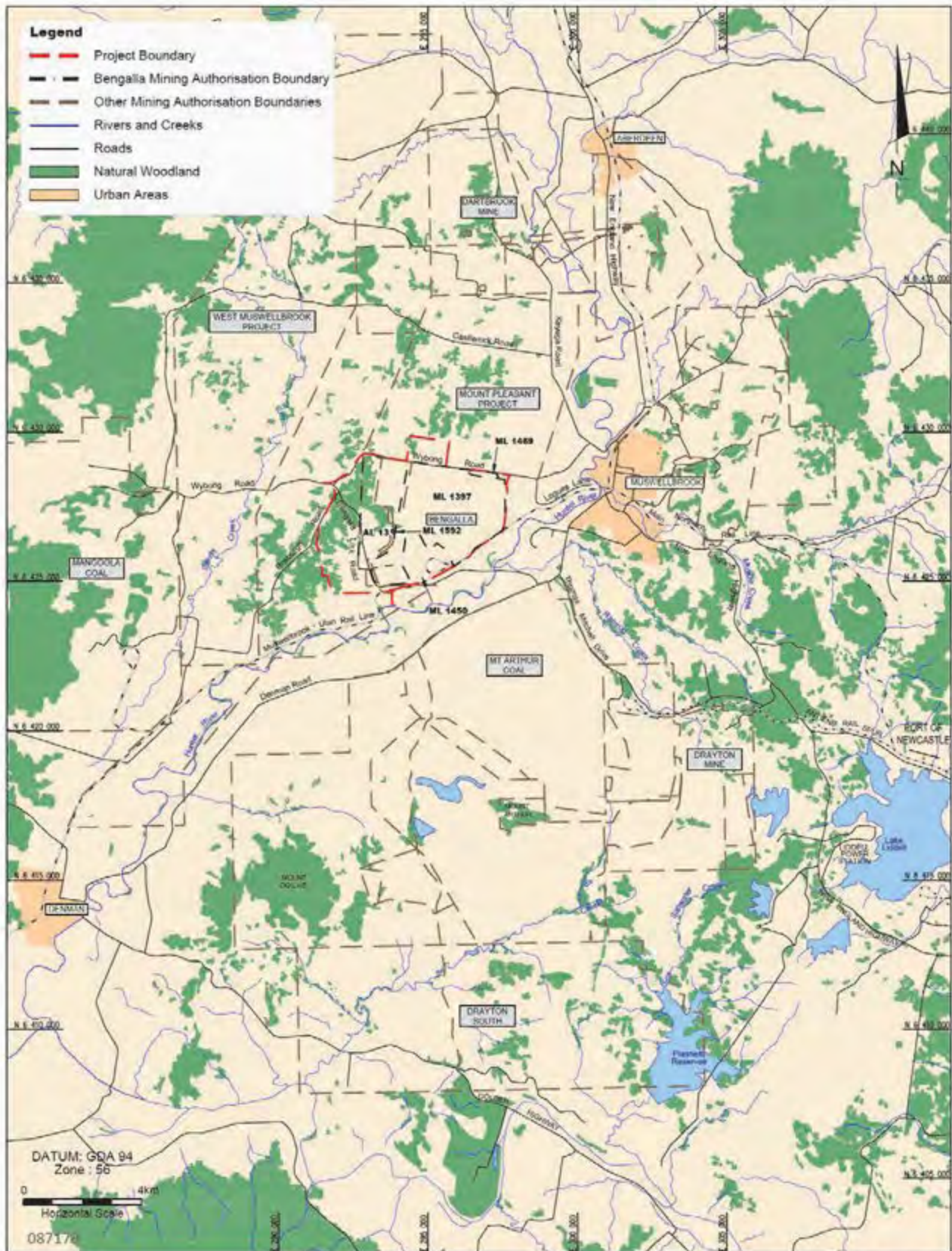
The Project involves the continuation of mining to the west at a rate of up to 15 Mtpa for up to 24 years. The Project will enable the extraction of up to an additional 316 Mt of run of mine (ROM) coal from the Whittingham Coal Measures.

The Project generally consists of the following components:

- Open cut mining towards the west at a rate of up to 15 Mtpa ROM coal for 24 years to a total of 316 Mt;
- Continued use of the existing dragline, truck fleet and excavator fleet (with progressive replacement);
- An out of pit Overburden Emplacement Area (OEA) to the west of Dry Creek which may be utilised for excess spoil material until it is intercepted by mining;
- Continued use, extension or relocation to existing infrastructure, including administration and parking facilities, in-pit facilities (including dragline shut down and erection pad), helipad, tyre laydown area, explosives and reload storage facility, core shed workshop and administration buildings, roads, reject bin, ROM Hopper, water management infrastructure, supporting power infrastructure, and ancillary infrastructure;
- Construction and use of various items of new infrastructure (including radio tower, extensions to Main Infrastructure Area (MIA), Mount Pleasant Project Staged Discharge Dam and associated water reticulation infrastructure, additional ROM coal stockpile and upgrade to the emergency ROM coal stockpile along with associated conveyor network);
- Processing, handling and transportation of coal via the (upgraded) CHPP and rail loop for export and domestic sale;
- Continued rejects and tailings co-disposal in the Eastern OEA and temporary in pit reject emplacement;
- Relocation of a 3 km section of Bengalla Link Road around Year 15 near the existing mine access road to facilitate coal extraction;
- The diversion of Dry Creek via dams and pipe work with a later permanent alignment of Dry Creek through rehabilitation areas when emplacement areas are suitably advanced;
- Relocation of water storage infrastructure as mining progresses through existing dams (including the Staged Discharge Dam, raw water dam); and
- A workforce of approximately 900 full time equivalent personnel (plus contractors) at peak production.

This report includes a further eight sections:

- Section 2 provides an overview of the regulatory framework;
- Section 3 describes the existing environment with respect to surface water resources;
- Section 4 describes the existing water management system at Bengalla and the proposed water management system;
- Section 5 provides an assessment of the potential impacts of the Project on surface water resources;
- Section 6 presents an analysis of the site water balance;
- Section 7 outlines proposed mitigation and management measures for the Project;
- Section 8 presents a summary of the conclusions of the assessment; and
- Section 9 provides a list of references.



Hansen Bailey
ENVIRONMENTAL CONSULTANTS

Figure 1.1 Regional Locality, Bengalla Mine

2 REGULATORY FRAMEWORK

2.1 REGULATORY DOCUMENTS

The following legislation, plans, policies and regulations are relevant to this assessment:

- Protection of the Environment Operations Act 1997;
- *Water Management Act 2000* and applicable Water Sharing Plans;
- State Water Management Outcomes Plan (SWMOP) and Hunter and Central Rivers Catchment Action Plan (CAP);
- Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002;
- National Water Quality Management Strategy: Australian Guidelines for Fresh and Marine Water Quality (ANZECC/ARMCANZ, 2000); and
- NSW Office of Water (NOW) Water Reporting Requirements for Mining Operations 2009.

The relevance of key legislation is briefly outlined in the following sections.

2.1.1 Protection of the Environment Operations Act 1997

Bengalla is licensed under the *Protection of the Environment Operations Act 1997*. The existing licence (EPL 6538) makes provision for release of water from the site at the outlet pipe from the Staged Discharge Dam, with concentration and volume limits shown in Table 2.1.

Table 2.1 Bengalla EPL 6538 Discharge Conditions

Item	Unit	Limit
pH	pH units	Lower: 6.5 Upper: 9.5
Total suspended solids	mg/L	120
Volume	ML/d	200

(NSW Government Office of Environment & Heritage, 2011)

2.1.2 Water Management Act 2000

Water Sharing Plans

The *Water Management Act 2000* applies to surface waters within the Project Area Boundary and the Hunter River itself through the following Water Sharing Plans:

1. **Hunter Unregulated and Alluvial Water Sources Water Sharing Plan 2009.** Surface water in Dry Creek and its tributaries is regulated under this plan. Water volumes extracted from these catchments require a water entitlement (an unregulated river access licence). The plan limits annual extraction to provide for no new growth in water entitlements.
2. **Hunter Regulated River Water Sharing Plan 2003.** All water extractions from the Hunter River will be managed under appropriate Water Access Licences (WALs). BMC holds approximately 1,449 high security units of Hunter River water shares. Water will continue to be extracted from existing licences, and there will therefore be no cumulative impact on water supplies in the Hunter River catchments caused by the changes for the Project.

Excluded Works

Dams solely for the capture, containment and recirculation of drainage and/or effluent, consistent with best management practice or required by a public authority (other than Landcom or the Superannuation Administration Corporation or any of their subsidiaries) to prevent the contamination of a water source, that are located on a minor stream are excluded works. Accordingly, these dams are not required to be the subject of water supply works approval and there is no requirement for a WAL to take water and use water from them.

2.1.3 State Water Management Outcomes Plan (SWMOP) and Hunter and Central Rivers Catchment Action Plan (CAP)

The SWMOP (established under the *Water Management Act 2000*) and CAP (established under the *Catchment Management Authorities Act 2003*) set out the broad targets and strategic directions for the state and for the catchment. Natural resources features to be protected and enhanced are identified, along with actions to achieve key outcomes. The Project is consistent with the SWMOP and CAP objectives because:

- Surface disturbance is restricted to the area of the Project Boundary. Impacts will be mitigated within the site water management system. Erosion and sediment controls will be designed and operated in accordance with '*Managing urban stormwater: soils and construction*' requirements (Landcom, 2004);
- Any extraction of water will be in accordance with licensing provisions; and
- Discharges from the site will only occur in accordance with the site EPL and where applicable, the *Hunter River Salinity Trading Scheme* (HRSTS).

2.1.4 Protection of the Environmental Operations (Hunter River Salinity Trading Scheme) Regulation 2002

The HRSTS was introduced by the NSW Government to reduce salinity levels in the Hunter River, and operates under the *Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002*.

Releases of mine water to the Hunter River can be made in compliance with the conditions of an EPL and in accordance with credits purchased under the HRSTS. The HRSTS limits the quantity of salt that may be discharged through a cap and trade system that also restricts discharge to periods of high flow.

Under the HRSTS, credit holders are permitted to discharge saline water to the Hunter River on a managed basis. The aim is to maintain river salinity levels below 600 $\mu\text{S}/\text{cm}$ at Denman and 900 $\mu\text{S}/\text{cm}$ at Singleton. This is achieved through:

- Discharge scheduling that allows discharge only at times when the river flow and salinity level are such that salt can be discharged without breaching the salinity targets; and
- Sharing the allowable discharge according to licensed holdings of tradeable salinity credits.

The discharge schedule prohibits discharges during low flow periods. Discharges are regulated in proportion to credit holdings during high flow periods and unlimited discharges are permitted during flood flow periods, subject to tributary protection limits and the overarching requirement to achieve the upper limit salinity levels at Denman and Singleton.

A total of 1,000 credits are available for allocation through the scheme. Consequently, a holding of one credit entitles the owner to discharge 0.1 per cent of the total allowable discharge for the period.

If discharge of further excess water to the Hunter River system is required, under the scheme, credits may be obtained on a day to day basis through trade between licensed users, or, for long term use, through public auction.

Under the HRSTS, the Hunter River is separated into three sectors upstream of Singleton: Upper, Middle and Lower. Bengalla lies in the Upper Section (upstream of the confluence of the Hunter River and Goulburn River). The HRSTS flow and river salinity thresholds for the Upper Sector are presented in Table 2.2.

Table 2.2 HRSTS Flow & River Salinity Thresholds, Upper Sector

Hunter R Flow Rate (ML/d)	Block Classification	River Target Salinity (EC)	Discharge Procedure
<1,000	Low	n/a	No discharges allowed
1,000 – 4,000	High	600 $\mu\text{S}/\text{cm}$	Limited discharges allowed, controlled by salt credits and Total Allowable Discharge (TAD)
>4,000	Flood	600 $\mu\text{S}/\text{cm}$	Unlimited discharges

(Protection of the Environment Operations (Hunter River Salinity Trading Scheme) Regulation 2002)

The water in the river is divided into numbered blocks. The scheme operators monitor the flow and salinity in each block, and calculate the Total Allowable Discharge (TAD) of salt to meet the salinity target. Credit holders are notified via a dedicated website of the TAD and the start and end times for each release.

BMC is currently a Licence Holder and Scheme Participant of the HRSTS, with an allocation of 35 credits which entitles BMC to discharge 3.5 percent of the TAD for a given period.

2.2 DIRECTOR-GENERAL'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS

Section 78A(8A) of the EP&A Act states that a development application for a State Significant Development must be accompanied by an EIS prepared in accordance with the *Environmental Planning & Assessment Regulation 2000* (EP&A Regulation). Clause 3 of Schedule 2 of the EP&A Regulation states that prior to the preparation of an EIA, the applicant must make a written application to the Director-General for Environmental Assessment Requirements (DGRs). A request for DGRs, supported by the Continuation of Bengalla Mine Background Document, was made by BMC on 17 February 2012. In response, DGRs for the Project were issued by the Director-General on 13 March 2012.

This assessment, which forms part of the EIS, addresses the DGRs concerning surface water. Table 2.3 lists the DGRs that are relevant to this assessment and the sections of this report where those DGRs are addressed. Table 2.4 presents environmental assessment requirements from the NSW Office of Water.

Table 2.3 Director-General's Environmental Assessment Requirements

Key Issue	Requirement	Report Section
Water Resources	- Detailed assessment of potential impacts on the quality and quantity of existing surface and ground water resources, including: - detailed modelling of potential groundwater impacts, including any potential impacts on the alluvial aquifers of the Hunter River and confirmation of the physical extent of the river's alluvium;	Groundwater Impact Assessment (AGE, 2012)
	impacts on affected licensed water users and basic landholder rights;	Section 5.10
	impacts on riparian, ecological, geo-morphological and hydrological values of watercourses, including environmental flows;	Section 5.6
	details and staging for the proposed Dry Creek re-diversion; and	Dry Creek Interim Management System & Conceptual Re-establishment Study (Parsons Brinckerhoff Australia Pty Limited, 2012)
	a flood assessment including identification of any necessary flood impact mitigation measures;	Section 5.8
	a detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume, salinity and frequency of any water discharges), water supply infrastructure and water storage structures;	Section 6
	an assessment of proposed water discharge quantities and quality/ies against receiving water quality and flow objectives;	Section 5.4 Section 5.6
	assessment of impacts of salinity from mining operations, including disposal and management of coal rejects and modified hydrogeology, a salinity budget and the evaluation of salt migration to surface and groundwater sources;	Section 6
	identification of any licensing requirements or other approvals under the Water Act 1912 and/or Water Management Act 2000;	Section 2 Section 5.10
	demonstration that water for the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan (WSP);	Section 5.2
	a description of the measures proposed to ensure the development can operate in accordance with the requirements of any relevant WSP or water source embargo;	Section 2.1.2
	a detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate surface and groundwater impacts; and	Section 6.6 Section 7.5
	compliance with the Hunter River Salinity Trading Scheme.	Section 2.1.4

Table 2.4 NSW Office of Water's Environmental Assessment Requirements

Requirement	Report Section
▪ Demonstrate compliance with the Water Management Act (2000) and Water Act 1912.	Section 2.1.2
▪ Demonstrate consistency with the rules for Water Sharing Plans	Section 2.1.2
▪ Identify relevant state and federal water management policies and guidelines	Section 2
▪ Demonstrate consistency with the following strategies: ▫ NSW Water Conservation Strategy (2000) ▫ NSW Salinity Strategy (2000)	Section 2
▪ Identify all current and proposed surface water interception and/or extraction	Section 5.10
▪ Provide details of water supply works	Section 5.2
▪ Provide details of flood works and drainage works	Section 5.8
▪ Calculation of maximum harvestable rights	Section 2.1.2
▪ Assessment of impacts on watercourses and associated riparian vegetation	Section 5.6.5
▪ Baseline monitoring data of surface water quality and quantity	Section 3.6 Section 3.4
▪ Geomorphic assessment of Dry Creek, including details of stream order, river styles and energy regimes	Dry Creek Interim Management System & Conceptual Re-establishment Study (Parsons Brinckerhoff Australia Pty Limited, 2012)
▪ Assessment of impacts on vegetation, sediment movement, channel stability, water quality and hydraulic regime	Section 5
▪ Description of measures to minimise potential environmental impacts	Section 7
▪ Details of ongoing monitoring programs for surface water quality	Section 7.6
▪ Contingency strategies to remediate, reduce or manage potential impacts	Section 7
▪ Details of critical thresholds for negligible impacts to surface water sources	Section 5.10
▪ Rehabilitation programs related to channel and riparian vegetation	Dry Creek Interim Management System & Conceptual Re-establishment Study (Parsons Brinckerhoff Australia Pty Limited, 2012)
▪ Provide details of proposed rehabilitation measures to restore water sources	Dry Creek Interim Management System & Conceptual Re-establishment Study (Parsons Brinckerhoff Australia Pty Limited, 2012)

3

EXISTING SURFACE WATER ENVIRONMENT

3.1 REGIONAL DRAINAGE NETWORK

Bengalla is located on the northern side of the Hunter River, adjacent to the Hunter River floodplain. The Hunter River has a catchment area of approximately 4,200 km² to Muswellbrook. The Hunter River main channel is about 50 to 100 m wide and 3 to 6 m deep and meanders through an alluvial floodplain about 2 km wide.

The Hunter River catchment upstream of Bengalla includes Glenbawn Dam, which commands a catchment area of about 1,300 km², approximately one-third of the total river catchment to Muswellbrook. Glenbawn Dam was commissioned in 1957 with a storage capacity of 300,000 ML with its main purpose as flood mitigation. The Dam was raised in 1988 to a total storage capacity of about 750,000 ML.

3.2 LOCAL DRAINAGE NETWORK

3.2.1 Catchment Description

The local drainage network in the vicinity of Bengalla generally consists of relatively steep gullies which drain from the surrounding hills into flat, meandering tributaries across the Hunter River floodplain. The eastern and southern limits of the Project Boundary are the Hunter River alluvial flats.

The western portion of the site drains to Dry Creek, which flows south through the Project Boundary (see Figure 3.1) and has a total catchment area of about 18 km². Dry Creek joins the Hunter River main channel to the southwest of Bengalla.

Figure 3.1 shows the local drainage characteristics in the vicinity of the site, including aerial photography and topographical information. Figure 3.2 shows photographs of the Dry Creek main channel in the Project Boundary near Wybong Road and near the Windmill Sedimentation Dams. Figure 3.3 shows photographs of the main channel of the Hunter River in the vicinity of Muswellbrook Bridge.

A desktop assessment was undertaken to identify the stream order of Dry Creek. Stream ordering followed the Strahler stream classification system where waterways are given an 'order' according to the number of additional tributaries associated with each waterway (Strahler A. N., 1952). In this report, stream order is defined by those watercourses represented on the NSW 1:25,000 topographic map series. Following this methodology, Dry Creek was determined to be a 3rd order stream.

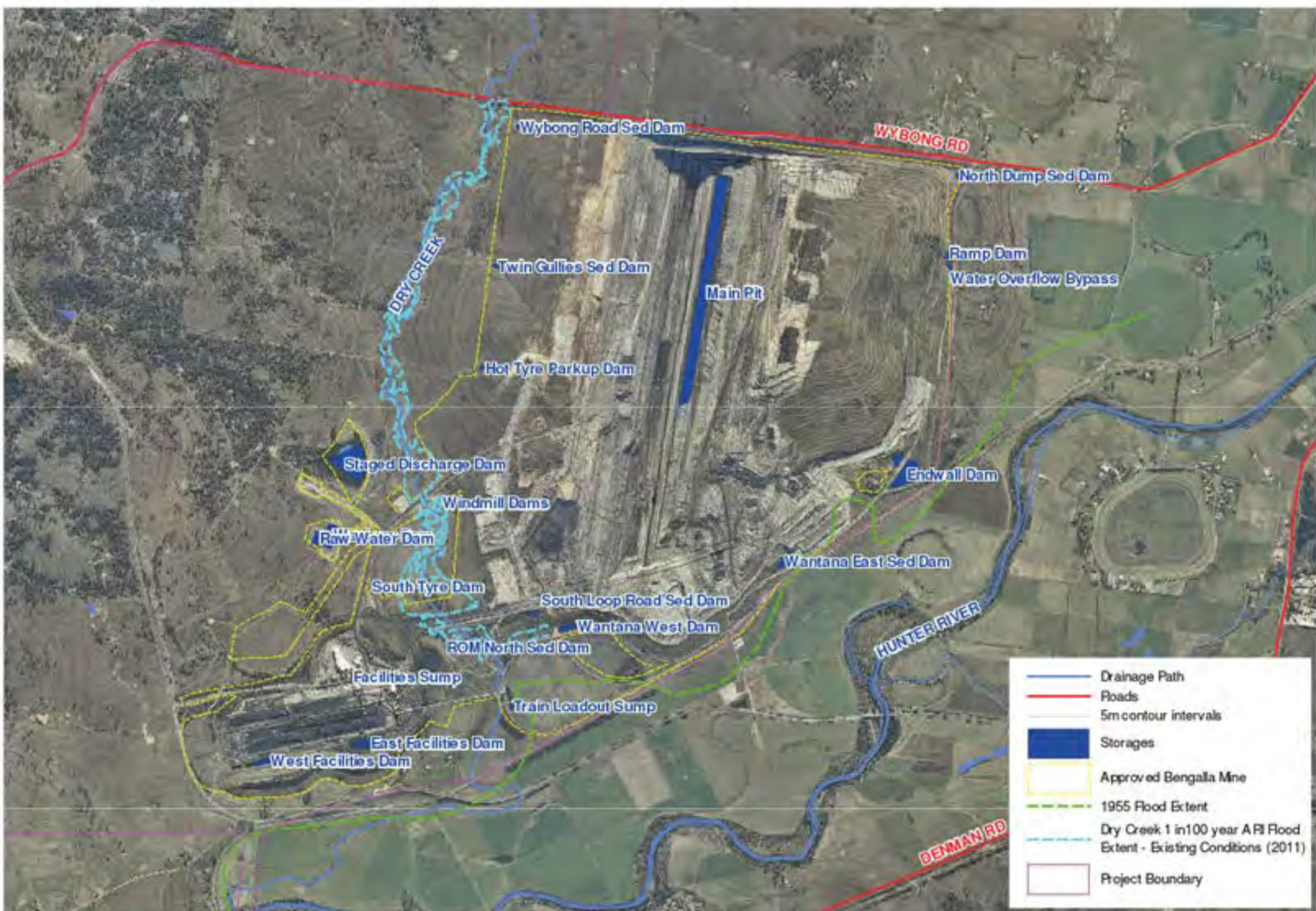


Figure 3.1 Local Drainage Characteristics



(1)



(2)



Figure 3.2 Photographs of Dry Creek Main Channel (1) near Wybong Road, facing downstream; (2) near Wybong Road, facing upstream; (3) near Windmill Sedimentation Dams, facing downstream; and (4) near Bengalla Road, facing upstream showing modified channel reach. (Parsons Brinckerhoff Australia Pty Limited, 2012).



Figure 3.3 Photographs of Hunter River Main Channel near Kayuga Bridge at Muswellbrook (1) facing downstream; and (2) facing upstream.

3.2.2 Dry Creek Geomorphological and Hydraulic Characteristics

Dry Creek within the the Project Boundary consists of a single main channel within the confines of a lower terrace floodplain. Riparian vegetation along Dry Creek in the Project Boundary is generally in poor condition and consists of scattered trees and brush. The main channel and overbank areas are grassed, which is typical of the Hunter region due to extensive clearing for agriculture. The Soil and Land Capability Assessment identified the soil characteristics adjacent to Dry Creek as consisting of primarily Deep Brown to Brown Sodosols, which has an inherently high erosion risk due to potential for localised flooding (GSS Environmental, 2013). Active bank erosion is evident at some locations. Figure 3.2 shows photographs of the Dry Creek main channel in the Project Boundary.

The channel longitudinal section through the Project Boundary is shown in Figure 3.4. Creek chainages associated with each cross section location are shown in Figure 3.5. Typical cross sections of the main channel are shown in Figure 3.6. Cross sections are shown left bank to right bank looking downstream,

The main channel of Dry Creek across the Project Boundary (downstream of Wybong Road) has the following characteristics:

- An average bed width of 7.9 m varying between 4.2 m and 14.7 m (90% confidence limits);
- A varying channel depth between approximately 0.4 m and 2.5 m, with an average of 1.1 m. Generally, the channel depth decreases downstream.
- A relatively uniform bed slope and hydraulic gradient of 1% (Figure 3.4) for the reach between Wybong Road and the haul road crossing at the infrastructure area. Downstream of the train loadout area the slope flattens to approximately 0.1% until the confluence with the Hunter River.
- The channel reach downstream of the haul road crossing (CH 4,500 to CH 6,800) has been previously modified during the development of the existing project infrastructure.
- The bank-full capacity of the Dry Creek channel in the Project Boundary is approximately 20 m³/s. Downstream of the haul road crossing the bank-full capacity is reduced due to the smaller channel depth and flatter gradient.

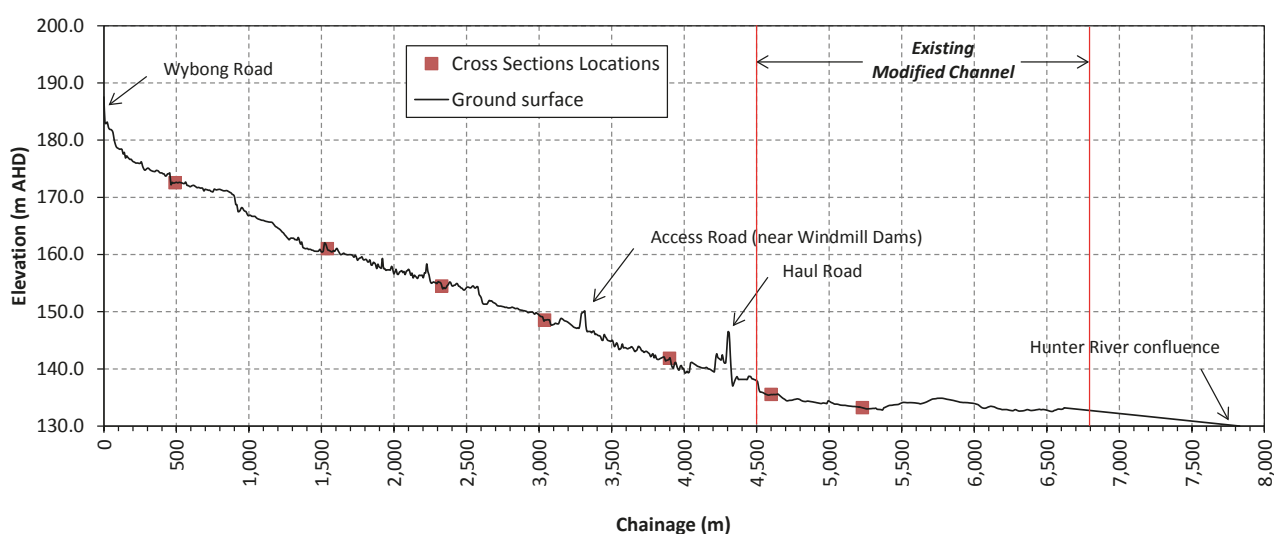


Figure 3.4 Dry Creek Long Section



Figure 3.5 Dry Creek Longitudinal Section and Cross Section Plan

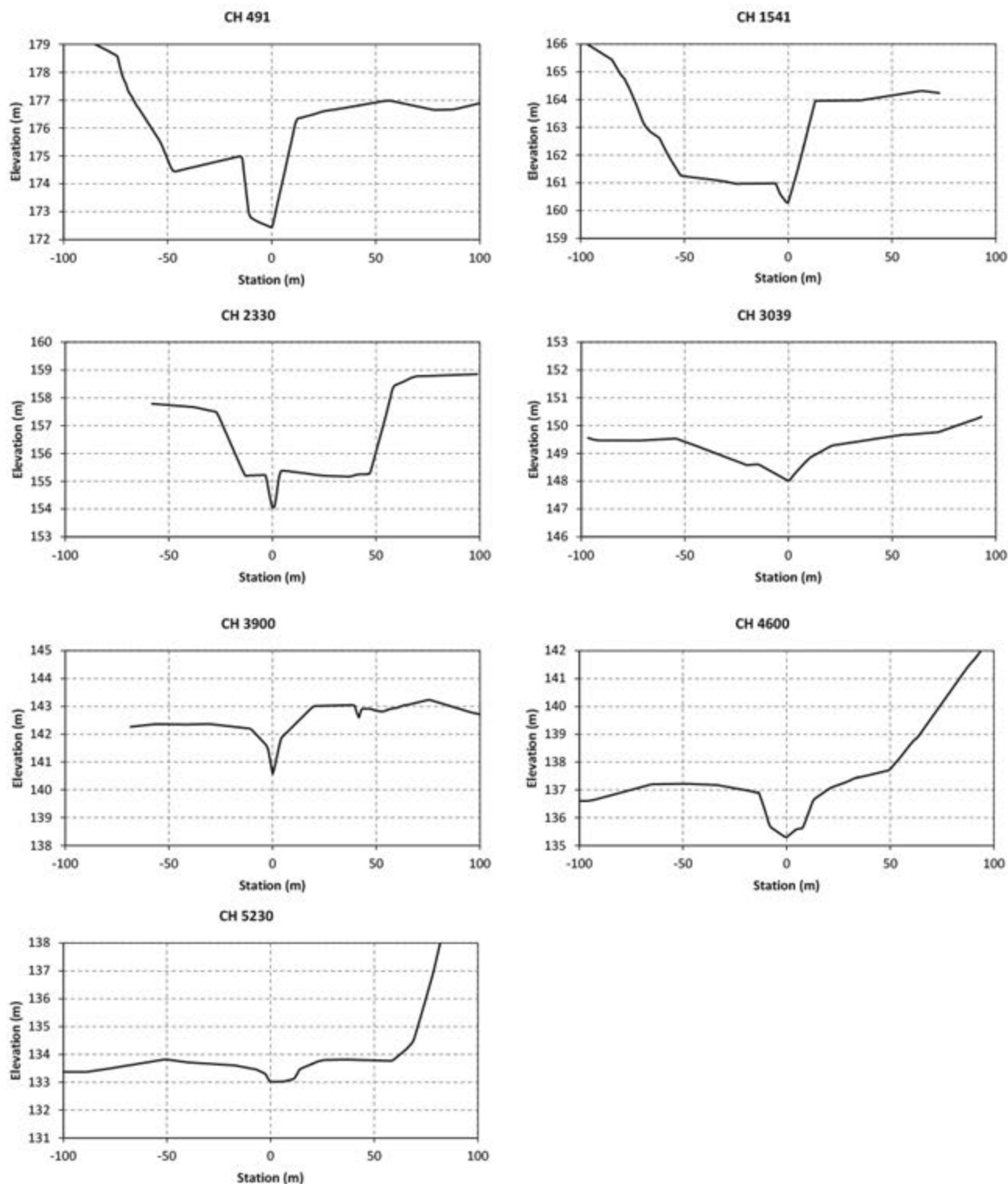


Figure 3.6 Dry Creek Cross Sections

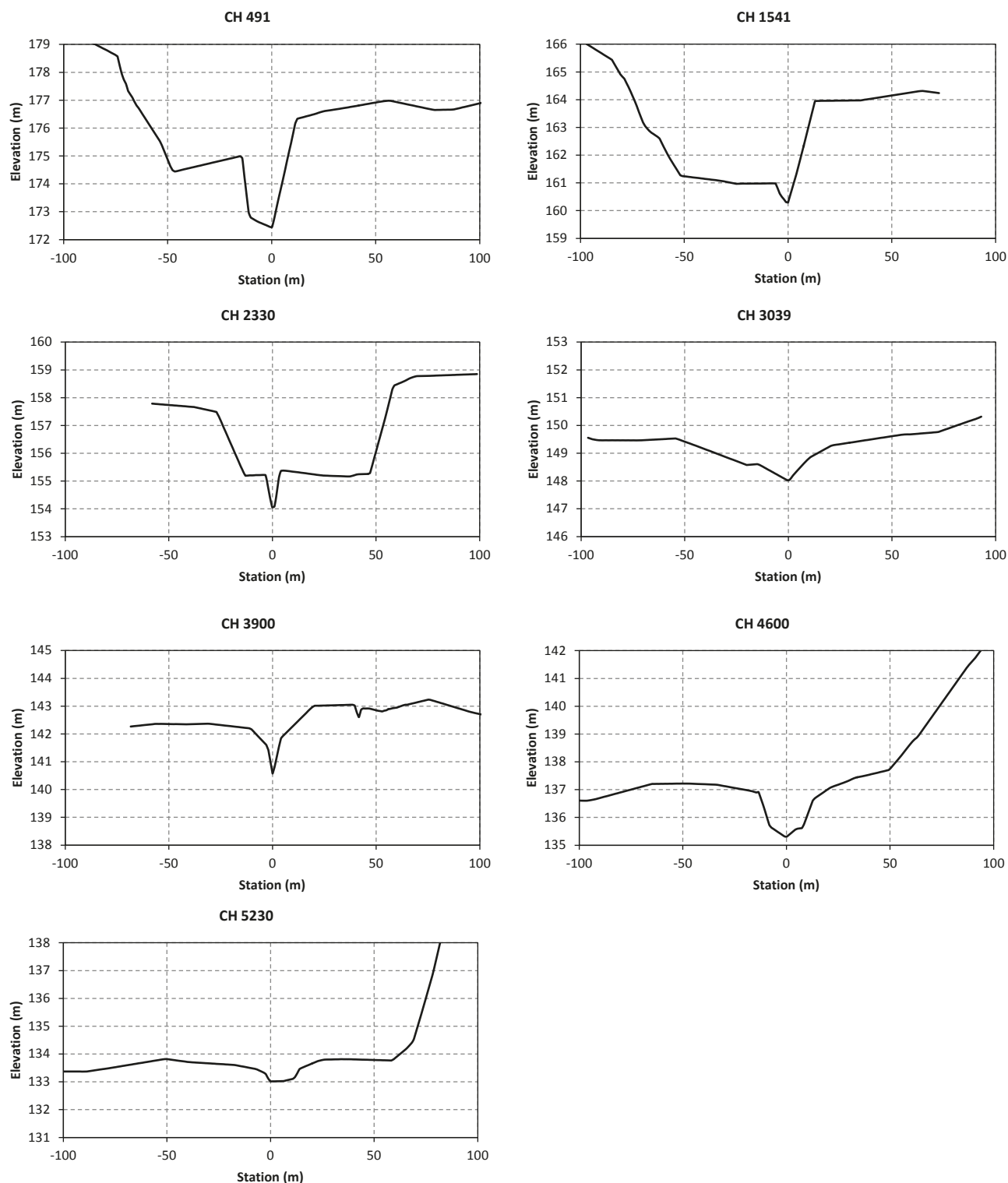


Figure 3.6 Dry Creek Cross Sections

3.3 RAINFALL AND EVAPORATION

Daily rainfalls have been recorded in Muswellbrook at Lower Hill Street (Bureau of Meteorology (BOM) Station No. 061053), about 4 km from Bengalla, since 1870. Table 3.1 shows summary details of the rainfall station. The location of the station is shown in Figure 3.8. Table 3.2 shows mean monthly rainfalls for the Lower Hill Street rainfall station. The mean annual rainfall is 618mm, with maximum monthly rainfalls occurring during the summer months.

Table 3.1 Rainfall Station Details

Station No.	Station Name	Elevation (m)	Easting	Northing	Distance from Site (km)	Opened	Closed
061053	Muswellbrook (Lower Hill St)	143	300775.31	6428670.55	4	1870	-

(Australian Government Bureau of Meteorology, 2012)

Table 3.2 also shows mean monthly evaporation (based on a Class A evaporation pan) recorded by the BOM at Scone SCS (Station No. 061089), located some 22 km to the north of Bengalla. Mean annual evaporation is 1594mm, which is more than double mean annual rainfall.

Figure 3.7 shows the annual distribution of average monthly rainfall and evaporation in the local area. Mean evaporation is similar to mean rainfall in the winter months, but substantially exceeds rainfall for the remainder of the year.

In order to extend the rainfall dataset for the water balance calculations, a synthetic rainfall dataset was also obtained for a location near the Project from the Queensland Department of Resource Management's (DERM's) Data Drill service (Jeffrey et al. 2001). The Data Drill *"accesses grids of data derived by interpolating the Bureau of Meteorology's station records. Interpolations are calculated by splining and kriging techniques. The data in the Data Drill are all synthetic; there are no original meteorological station data left in the calculated grid fields. However, the Data Drill does have the advantage of being available for any set of coordinates in Australia"* (DERM, 2012). The key advantage of adopting the Data Drill data is that it has been adjusted to remove accumulated totals over multiple days and to fill periods of missing data using rainfall from nearby stations.

A comparison of mean monthly rainfalls for Data Drill and BoM rainfall stations is presented in Table 3.2.

Table 3.2 Mean Monthly Rainfall and Evaporation

Month	Mean Monthly Rainfall (mm)		Mean Monthly Pan Evaporation (mm)
	Muswellbrook (Lower Hill St) (061053) [1870 - Present]	SILO Data Drill [1889 - Present]	Scone Scs (061089) [1965 - Present]
Jan	69.7	71.0	220
Feb	66.8	62.9	174
Mar	52.5	55.1	155
Apr	43.6	41.1	105
May	41.3	39.8	68
Jun	50.8	44.2	48
Jul	44.0	40.9	59
Aug	38.7	36.9	84
Sep	40.5	37.8	117
Oct	48.3	48.8	158
Nov	54.7	49.8	183
Dec	67.4	61.9	223
Total	618	590	1,594

(Australian Government Bureau of Meteorology, 2012)
(Jeffrey et al., 2001)

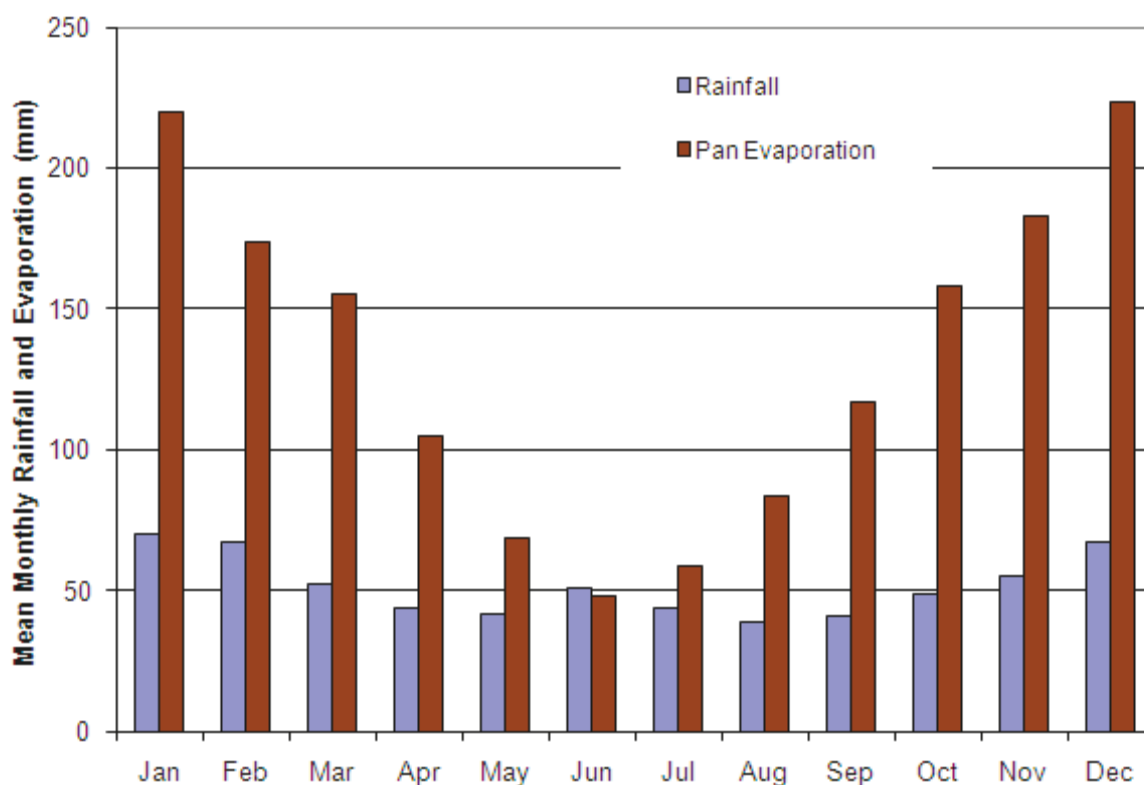


Figure 3.7 Distribution of Monthly Rainfall at Muswellbrook (Lower Hill St) and Evaporation (Scone SCS) (Australian Government Bureau of Meteorology, 2012)

3.4 STREAMFLOW

Flow and water quality data for the Hunter River was sourced from NOW at two locations shown in Figure 3.8:

- Station No. 210002 – Hunter River at Muswellbrook Bridge (approximately 13km upstream of Dry Creek confluence). The catchment area of the river to the gauge is approximately 4,220 km². Note that the recorded flow data has more than 30 years of missing data over the period of record.
- Station No. 210055 – Hunter River at Denman (22km downstream of Bengalla).
- Station No. 210001 – Hunter River at Singleton. This gauge has the longest period of recorded flows in the Hunter River from 1913 to current, with only 48 days of missing data over the entire period.

Figure 3.10 shows the recorded flow-duration relationship for the Hunter River at Muswellbrook Bridge (Station No. 210002), located about 4 km east of Bengalla, for the full period of record (1913 to 2007) and since the completion of the upgrade to Glenbawn Dam (1988 to 2007). The catchment area of the Hunter River to Muswellbrook Bridge is approximately 4,220 km². Although data is available at Muswellbrook Bridge from 1913, the recorded flow data has more than 30 years of missing data.

Under current catchment conditions (since the upgrade to Glenbawn Dam in 1988), the Hunter River is perennial, with a minimum flow rate of about 10 ML/d. The median (50th percentile) flow rate is about 380 ML/d and the 5th percentile flow rate is greater than 100 ML/d. A cursory review of the two flow-duration curves indicates that Glenbawn Dam has increased the frequency of low flows (due to regulation) and moderately reduced the frequency of high flows.

Figure 3.9 shows the historical flow rates for the Hunter River at Singleton (Station No. 210002), for the full period of record (1913 to current). The catchment area of the Hunter River to Singleton is approximately 16,400 km². The peak instantaneous flow rate of 76,600 ML/d (887 m³/s) occurred in February 1955.

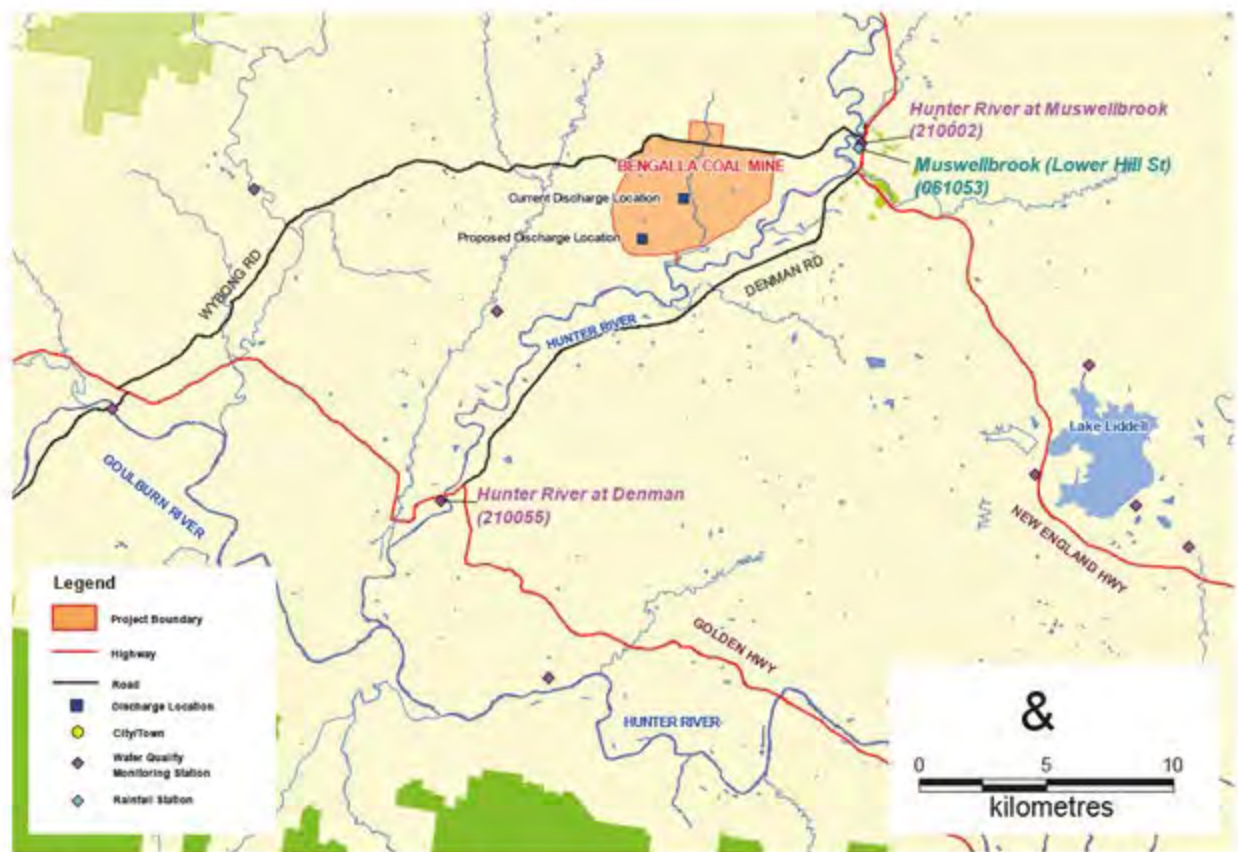


Figure 3.8 Locations of Nearby NOW Hunter River Streamflow & Water Quality Station and BOM Rainfall Monitoring Stations

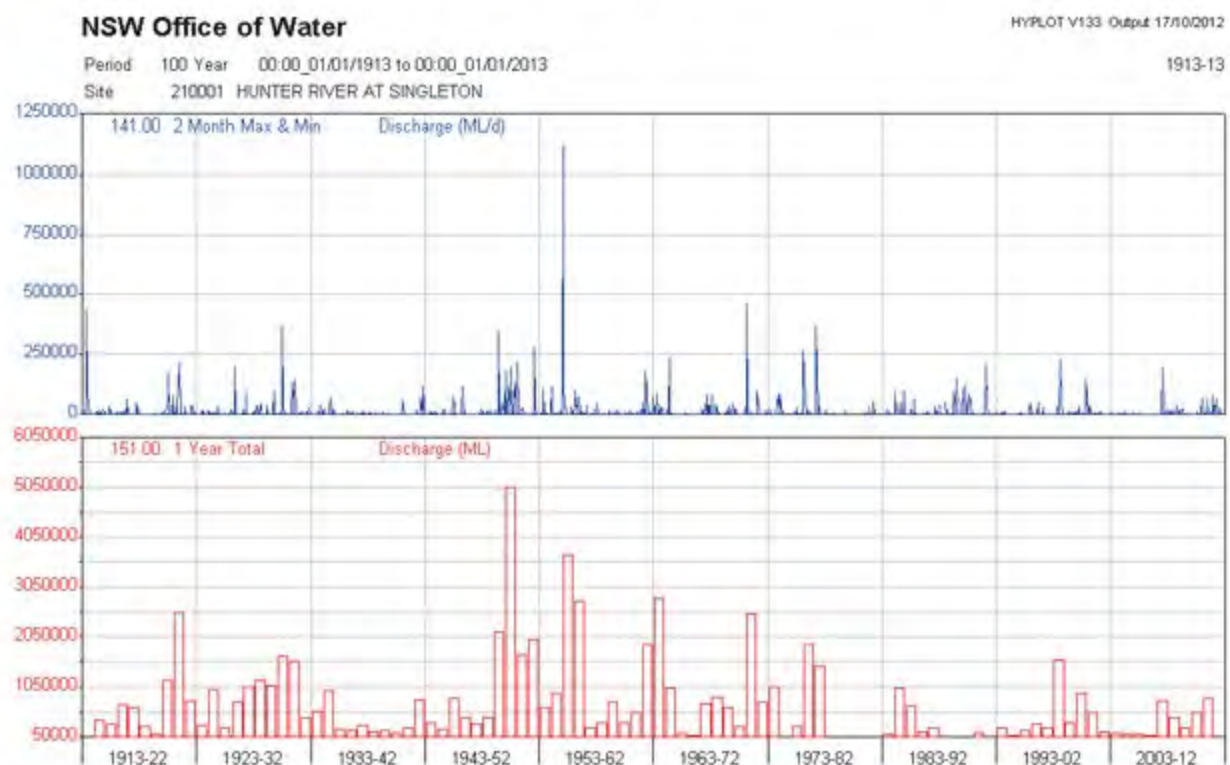


Figure 3.9 Historical Flows – Hunter River at Singleton (#210001) (New South Wales Government, 2012)

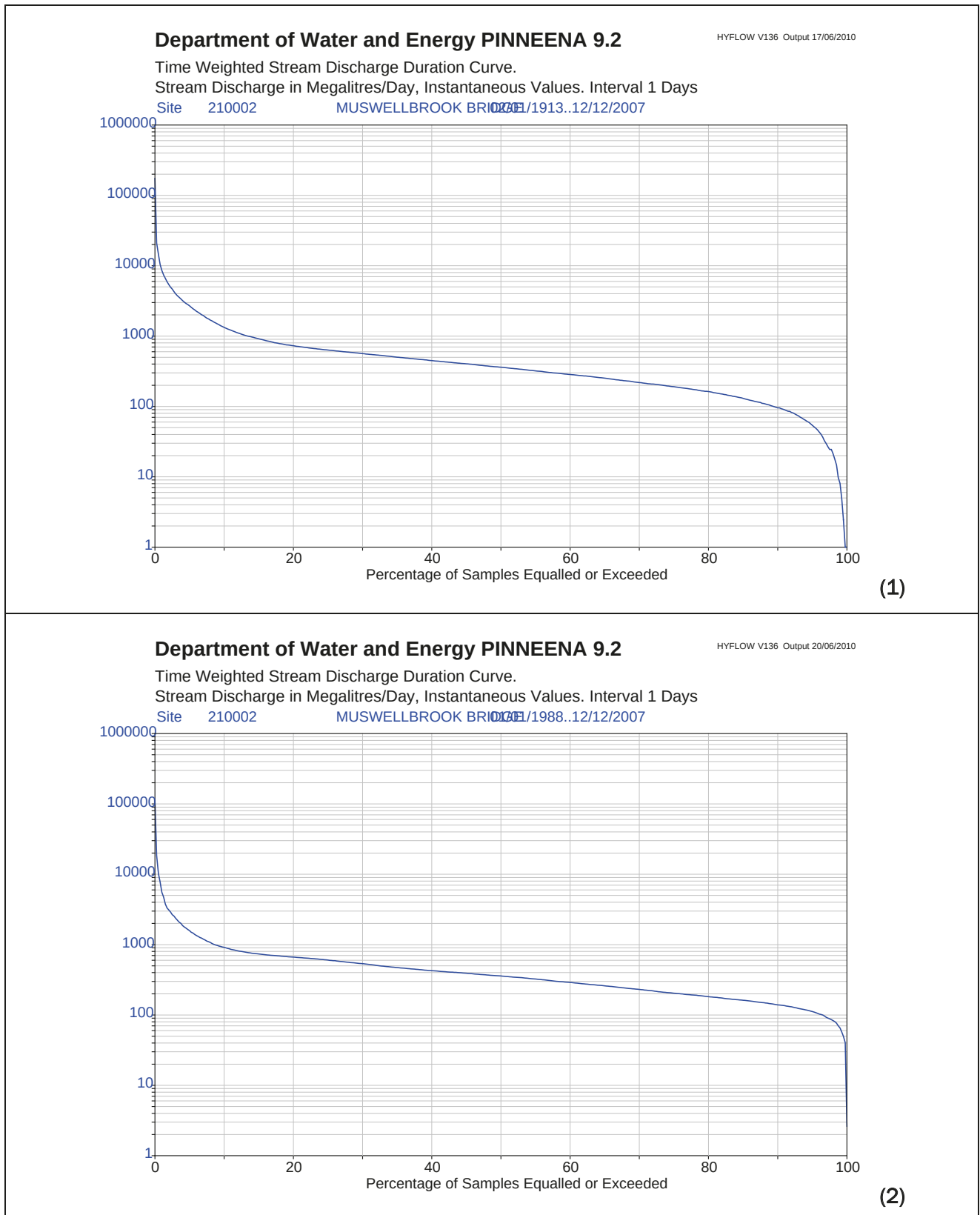


Figure 3.10 Flow-Duration Relationship for Hunter River at Muswellbrook Bridge (1) 1913-2007, (2) 1988-2007

3.5 HRSTS DISCHARGES

BMC participates in the HRSTS and is permitted to discharge from the main mine water storage (Staged Discharge Dam) during periods of 'high' or 'flood' flows in the Hunter River in accordance within the scheme rules. However, Bengalla normally operates with a net water deficit and has rarely had to discharge mine water under the HRSTS.

Historical discharges from Bengalla under the Hunter River Salinity Trading Scheme (HRSTS) are as follows:

- 2011 – 109ML;
- 2010 – 49ML;
- 2009 – 0ML;
- 2008 – 64ML;
- 2007 – 205ML; and
- 2006 – 0ML.

3.6 SURFACE WATER QUALITY

3.6.1 BMC Monitoring

Overview

Bengalla undertakes an extensive surface water monitoring program, including:

- Onsite dams – saline, sediment and clean water dams;
- Receiving waters – upstream and downstream Hunter River and Dry Creek; and
- Discharge waters – additional receiving water monitoring undertaken during periods of discharge under the HRSTS.

Sampling locations, analysis type and frequency are shown in Table 3.3.

Onsite Dams

The frequency and extent of onsite dam water sampling at Bengalla is carried out based on risk to the surrounding environment. Sampling is undertaken at 18 dams across the Bengalla site, including saline dams, sedimentation dams and general catchment dams not impacted by mining. A summary of the results of the onsite dam monitoring program are presented in Table 3.4 and full results are presented in Appendix A.

Receiving Waters

In accordance with the approved Bengalla Environmental Monitoring Program and Water Management Plan the pH, Electrical Conductivity (EC) and Total Suspended Solids (TSS) levels in the Hunter River are monitored on a monthly basis. Monitoring is conducted at three sites upstream (W01, W02 and W03) and one site downstream (W04) of Bengalla. Additional samples are also collected from these locations following rainfall events of greater than 15 millimetres over a 24 hour period.

Dry Creek is monitored daily during rainfall events for pH, Electrical Conductivity (EC) and Total Suspended Solids (TSS) levels upstream (monitoring point SW04) and downstream (monitoring point SW05) of Bengalla. The locations of surface water monitoring sites are shown in Figure 3.11. Over the period of record from 2008 to 2011, there have been only two occasions with sufficient flow in Dry Creek (not including controlled discharges under the HRSTS) for water quality sampling to be undertaken, shown in Table 3.4. A flow monitor was installed in Dry Creek in late 2012 to collect additional data. Preliminary results show that Dry Creek is alkaline, slightly brackish, with a mean Total Suspended Solids (TSS) of 185mg/L.

In periods of high or flood flows, excess water from Bengalla can also be discharged into the Hunter River under the HRSTS, where discharges are conducted strictly in accordance with BMC's Environment Protection Licence (EPL 6538). All discharge is released from the main Bengalla water storage (Staged Discharge Dam) and additional surface water monitoring of Dry Creek and the Hunter River is also undertaken at locations (EPA01, EPA02 and EPA03, see Figure 3.11) during any such discharge event.

Table 3.5 provides a summary of mean water quality parameters measured at the four Hunter River monitoring sites from 2006 to 2011. Preliminary results show that the Hunter River is alkaline, fresh, and has a mean TSS of approximately 53 mg/L.

The results of the surface water monitoring program indicate that water quality downstream of Bengalla is slightly more saline than upstream of Bengalla. Over this period approximately 427ML of water was discharged from Bengalla under the HRSTS. A number of tributaries which drain a variety of land uses, including agricultural and urban land uses, enter the Hunter River between the upstream and downstream monitoring points. The Bengalla HRSTS discharges and the non-mining land uses could also have an impact on Hunter River water quality within the monitored reach.

3.6.2 NSW Office of Water Monitoring

As discussed in Section 3.4, Hunter River water quality data has been collected since the 1970s. Locations of nearby water quality gauging stations are shown in Figure 3.8. The available data is summarised in Table 3.6 and compared to the trigger values in the Australia and New Zealand Environment Conservation Council (ANZECC) water quality guidelines. Exceedances of the ecosystem protection trigger levels have occurred for Total Nitrate, Total Phosphorous, Zinc and pH, but all other constituents are below trigger levels. The NSW Office of Water monitoring results indicate that the Hunter River is alkaline, fresh, and has a median TSS of 8 mg/L. Further details are presented in Appendix B.

Table 3.3 Bengalla Surface Water Monitoring Program

Sample Point ID	Sampling Point Description	Type of Analysis	Frequency	Min. No. of samples per year
Hunter River				
W01	Hunter River D/S of Kayuga Bridge - access off Ford Street	Basic Surface Water Analysis	Monthly and within 24 hours of a rainfall event > 15mm	12
		6 monthly Surface Water Analysis	6 monthly	2
W02	Hunter River U/S of Merriwa Railway Bridge - access via Thornbro Dairy	Basic Surface Water Analysis	Monthly and within 24 hours of a rainfall event greater than 15mm	12
W03	Hunter River U/S of Merriwa Railway Bridge - access via Logues Lane	Basic Surface Water Analysis	Monthly and within 24 hours of a rainfall event > 15mm	12
W04	Hunter River D/S of discharge point - access via White Creek Vineyard	Basic Surface Water Analysis	Monthly and within 24 hours of a rainfall event > 15mm	12
		6 monthly Surface Water Analysis	6 monthly	2
Discharge Monitoring				
EPA01	Discharge point outlet at 280ML Discharge Dam	Basic Surface Water Analysis	Twice daily during discharge (at least 6 hours apart)	Discharge dependent
EPA02	D/S of discharge point in Dry Creek - access via Lumeah Dairy road to Hunter River	Basic Surface Water Analysis	Twice daily during discharge (at least 6 hours apart)	Discharge dependent
EPA03	U/S of discharge point in Dry Creek	Basic Surface Water Analysis	Twice daily during discharge (at least 6 hours apart)	Discharge dependent
Dam Monitoring				
East Facilities Dam	South of the CHPP Infrastructure area	Basic Surface Water Analysis	Annually	1
East Windmill Dam	Dry Creek - south of Main Access Road	Basic Surface Water Analysis	Quarterly and within 25 hours of a rainfall event > 15mm	4
Endwall Dam	Adjacent to Bengalla Homestead - north side of the overland conveyor	ARD	Quarterly and within 25 hours of a rainfall event > 15mm	12
Hot Tyre Parkup Dam	D/S of the Hot Tyre Parkup - Western Side	Basic Surface Water Analysis	Annually	1
Main Access Sedimentation Dam	Dry Creek - north of Main Access Rd	Basic Surface Water Analysis	Annually	1
Main Endwall Dam	Adjacent to Bengalla Homestead - south side of the overland conveyor	Basic Surface Water Analysis		12
North Dump Sedimentation Dam	Corner of Overton and Wybong Roads	Basic Surface Water Analysis	Quarterly and within 25 hours of a rainfall event > 15mm	4

Sample Point ID	Sampling Point Description	Type of Analysis	Frequency	Min. No. of samples per year
Ramp Dam	Above in-pit crib hut facilities	Basic Surface Water Analysis	Annually	1
Raw Water Dam	Above Water Treatment Plant	Basic Surface Water Analysis	Annually	1
South Loop Rd Sediment Dam	South of southern tree screen - access from Wantana Dairy	Basic Surface Water Analysis	Annually	1
Staged Discharge Dam	Bengalla Mining Lease Staged Discharge Dam	6 monthly surface water analysis	Annually	2
Train Loadout Sump	Inside of Bengalla rail loop adjacent to Train Loadout Bin	Basic Surface Water Analysis	Annually	1
Twin Gullies Sedimentation Dam	South of Wybong Rd Dam - upstream of pocket of trees	Basic Surface Water Analysis	Annually	1
Wantana Dam	At the Wantana Dairy south of overland conveyor	Basic Surface Water Analysis	Annually	1
Washery Dam	Adjacent to Water Treatment Plant	Basic Surface Water Analysis	Annually	1
West Facilities Dam	South of the CHPP Infrastructure area	Basic Surface Water Analysis	Annually	1
West Windmill Dam	Dry Creek - south of Main Access Road	Basic Surface Water Analysis	Quarterly and within 25 hours of a rainfall event > 15mm	4
Wybong Rd Sedimentation Dam	Just south of north tree screen - immediately to the east of Dry Creek	Basic Surface Water Analysis	Annually	1
Dry Creek				
SW04	North of EPA03 in Dry Creek (294823, 6428767 MGA94, Z56)	Basic Surface Water Analysis	Daily during rainfall events >15mm/24 hours	Rainfall & flow dependent
SW05	South of EPA02 in Dry Creek (294674, 6424999, MGS94, Z56)	Basic Surface Water Analysis	Daily during rainfall events >15mm/24 hours	Rainfall & flow dependent

Basic Surface Water Analysis: ph, EC, TSS

6 monthly Surface Water Analysis: ph, EC, TSS, SO₄, Al, As, Be, B, Ca, Cd, Cl, Cr(VI), Co, Cu, F, Fe, Pb, Li, Mn, Mg, Hg, Mo, Ni, Se, V, Zn

ARD: ph, EC, TSS, Sulphate



Figure 3.11 Bengalla Receiving Waters – Surface Water Monitoring Locations

Table 3.4 Onsite Dams & Dry Creek Surface Water Quality Monitoring Results, 2007 to 2011

Parameter		W06 Endwall Dam (Sediment Dam)	W07 Main Endwall Dam	W08 East Windmill Dam	W09 West Windmill Dam	Staged Discharge Dam	SW05 Dry Creek D/S	W10 MTA Sediment Dam	W11 North Dump Sediment Dam
pH	Max	9.4	9.3	9.3	10.3	8.6	8.1	9.2	-
	Mean	8.7	8.7	8.8	8.8	8.7	8.0	8.3	-
	Min	7.6	7.2	8.0	7.9	8.9	7.9	7.0	-
	Count	83	52	37	38	4	2	7	-
EC (µS/cm)	Max	8,960	5,240	6,510	3,680	3,780	1,495	3,140	-
	Mean	2,760	2,884	2,218	2,062	2,778	1,432	1,194	-
	Min	340	620	583	854	1,970	1,369	226	-
	Count	83	52	37	38	4	2	7	-
TSS (mg/L)	Max	130,000	309	25,800	444	93	266	4,810	1,970
	Mean	1,880	64	796	76	37	185	1,013	1,970
	Min	11	8	15	6	9	104	10	1,970
	Count	83	50	36	37	4	2	5	1
SO ₄ (mg/L)	Max	818	1,030	-	-	-	-	-	-
	Mean	386	390	-	-	-	-	-	-
	Min	84	50	-	-	-	-	-	-
	Count	28	28	-	-	-	-	-	-

Table 3.5 Hunter River Mean Surface Water Quality Monitoring Results, 2006 to 2011

Year	W01 Kayuga Road Bridge			W02 Rail Bridge			W03 Racecourse			W04 Whites Creek Vineyard		
	pH	TSS (mg/L)	EC (µS/cm)	pH	TSS (mg/L)	EC (µS/cm)	pH	TSS (mg/L)	EC (µS/cm)	pH	TSS (mg/L)	EC (µS/cm)
2006 (n=17)	8.0	11	361	8.0	11	358	8.0	8	371	7.9	12	382
2007 (n=25)	7.5	86	452	7.5	127	453	7.5	105	496	7.4	65	603
2008 (n=28)	7.9	44	580	8.0	177	576	8.0	46	605	7.9	35	670
2009 (n=18)	7.9	28	515	7.9	30	505	8.0	37	534	7.9	37	577
2010 (n=22)	8.1	80	506	8.0	70	509	8.0	29	498	8.0	30	513
2011 (n=14)	8.0	42	459	8.0	56	464	8.0	34	497	7.9	70	516

n = number of samples

Table 3.6 Summary of NOW Hunter River Water Quality Data at Muswellbrook Bridge and Denman (New South Wales Office of Water, 2011)

Parameter	Unit	ANZECC Trigger Value				U/S (MUSWELLBROOK BRIDGE - 210002)			D/S (HUNTER RIVER DENMAN - 210055)		
		Irrigation	Livestock drinking	Eco-system	Recreational	Median	90%ile	count	Median	90%ile	count
flow	ML/d					286	648	480			
pH	pH	6.0 - 9.0		6.5 - 8^	6.5 - 8.5	8.1	8.5	791	8.2	8.6	48
EC (uncompensated)	µS/cm	1,000 *				430	684	44			
EC (25C)	µS/cm					440	680	990	485	691	108
Total Dissolved Solids (TDS)	mg/L		2,000*		1,000	162	191	32			
Total Suspended Solids (TSS)	mg/L					8	30.8	142	3	3	1
Calcium (Ca)	mg/L		1,000			37.0	52.6	165	37.6	43.8	12
Magnesium (Mg)	mg/L		2,000**			26.9	36.7	164	25	32.8	12
Sodium (Na)	mg/L	115			300	40.4	55.7	176	44.0	57.4	23
Potassium (K)	mg/L					1.7	2.3	162	1.4	1.8	12
Bicarbonate (HCO3)	mg/L	-				232.5	292.8	168	220.7	257.6	15
Sulphate as SO4	mg/L		1,000		400	31.3	48.4	164	30.0	43.5	11
Chloride as Cl	mg/L	175***			400	44.2	72.2	174	59.0	91.3	23
Fe (Soluble)	mg/L	0.2	-		0.3	0	0.1	113	0.01	0.02	2
Fe (Total)	mg/L					0.12	0.99	110	0.11	0.37	4
Boron (B)	mg/L	0.5	5	0.37^^	1	0	0.3	126	0	0.17	3
Manganese (Mn)	mg/L	0.2	-	1.9^^	0.1	0.05	0.07	62			
Zinc (Zn)	mg/L	2	20	0.008^^	5	0	0.037	94	0.01	0.016	2
Fluoride (F ⁻)	mg/L	1	2			0.34	0.5	139	0.33	0.44	4
Nitrite and nitrate as N	mg/L		30	0.7^^	11	0.14	0.56	297	0.17	0.40	143
Total Kjeldahl Nitrogen (TKN)	mg/L					0.4	0.8	17			
Total nitrogen (Total N)	mg/L	5		0.5^		0.48	1.00	183	0.52	0.95	183
Total phosphorus (Total P)	mg/L	0.05		0.05^		0.08	0.56	474	0.08	0.13	46

* Lowest recommended value.

** Cattle (insufficient information on other livestock).

*** Sensitive crops.

^ Lowland river (<150m altitude).

^^ 95% of species protected.

^^ Nitrate only.

4 PROPOSED WATER MANAGEMENT STRATEGY AND INFRASTRUCTURE

4.1 EXISTING WATER MANAGEMENT SYSTEM

The existing Bengalla water management system is operated in accordance with the Bengalla Water Management Plan (WMP) (Coal & Allied, 2012) and the Environmental Management System (EMS) procedures, which are approved in accordance with ISO 14001.

Surface water management at Bengalla is based on the following key principles:

- Minimise use of fresh water from external sources (Bengalla has a current allocation from the Hunter River);
- Diversion of clean surface water runoff away from areas disturbed by mining activities;
- Collection of surface water runoff from areas disturbed by mining activities in catch drains and direction to sediment traps and settling dams for control of suspended sediment prior to release from site or reuse via the mine water management system;
- Collection of runoff from industrial areas in catch drains and direction, via an oil and grease separator, to the Bengalla Waste Water Treatment Plant (WWTP) for treatment and return to storage dams for reuse as mine water supply; and
- Transfer of open cut pit water to storage dams for reuse as mine water supply.

The Bengalla water management system includes various water storages for mine water and sedimentation dams for settling of suspended sediment prior to release off site or reuse via the mine water management system. Excluding sedimentation dams, the total available storage within the mine water management system is approximately 450 ML.

The main components of the existing water-related infrastructure include:

- The Washery Dam which supplies process water to the CHPP and truck fill stations. The Washery Dam is also used as a transfer dam, receiving excess mine water which is then pumped to the Staged Discharge Dam.
- The Staged Discharge Dam is the licensed release point for saline water under the HRSTS.
- Water supply infrastructure including the Hunter River Intake and pipeline and the Raw Water Dam which acts as a storage dam for Hunter River water to site.
- The East and West Facilities Dams which capture CHPP return water and runoff from the Industrial Area.
- The Bengalla WWTP which treats sewage effluent and directs it into the process water circuit for reuse.
- The Wantana West Dam and Endwall Dam which receive pit dewatering and supply to the Washery Dam.
- Sediment traps, drainage channels and sediment dams to collect and treat runoff from spoil and hardstand areas.

- Clean water drains to divert runoff from undisturbed catchments around areas disturbed by mining/infrastructure.

Details of existing water management infrastructure, including storage sizes and locations are provided in Section 6.3.

4.2 PROPOSED WATER MANAGEMENT SYSTEM

Changes to the approved mine under the Project will result in a number of potential changes to the water management system. Key changes include:

- Increased water demands associated with increased production rates, including CHPP water use, stockpile and haul road dust suppression and vehicle washdown.
- Mining through the Staged Discharge Dam, Washery Dam and Raw Water Dam. These storages are proposed to be relocated west of their current location. The relocated dams will have a similar size and function to the existing dams.
- Mining through Dry Creek, which it is proposed to be captured north of Wybong Road in a clean water dam (CW1) and pumped south around the mining operations and released into the Dry Creek tributary to the west of the Bengalla Link Road. Once mining has progressed, the Dry Creek channel will be reinstated once stable through overburden and rehabilitated and the upstream clean water dam removed (unless further consultation and approvals are sought in this regard). Further information on the diversion of Dry Creek is detailed in the Dry Creek Interim Management System and Conceptual Re-establishment Study (Parsons Brinkerhoff Australia Pty Limited, 2012).
- Construction of sediment dams and associated drainage as required.

In addition to the above changes to the Bengalla water management system, it is proposed to construct the Mount Pleasant Project Discharge Dam to the west of the Bengalla Mining Operations to mitigate the Project's disruption of Mount Pleasant Project's approved discharge route. This dam would not form part of the Bengalla water management system, and could be used by the adjoining Mount Pleasant operation following the receipt of appropriate approvals to allow discharges from that site under the HRSTS. As such, the Mount Pleasant Project Discharge Dam is only assessed in this report in relation to erosion and sediment control required during construction.

Details of the proposed water management system layout, water demands, sediment dams, predicted groundwater inflows, and catchments and land use classifications are provided in Section 6.6.

5 IMPACT ASSESSMENT

5.1 POTENTIAL IMPACTS

The potential impacts of the Project on surface water resources include:

- Additional water demand from the Hunter River to meet increased operational water requirements for the Project;
- Loss of catchment area draining to Dry Creek and the Hunter River due to capture of runoff within onsite storages during mining. This could potentially reduce runoff volumes to Dry Creek and the Hunter River;
- Adverse impacts on the quality of surface runoff draining from the local site catchments to Dry Creek and the Hunter River;
- Adverse impacts on downstream water quality associated with possible overflows from the Mine Water Management System;
- Impacts on the hydrology and water quality of Dry Creek and the Hunter River associated with controlled discharges under the HRSTS;
- Impacts on the hydrology and flow regime of Dry Creek and the Hunter River associated with the delay in pumped clean water releases from the Dry Creek Clean Water Dam (CW1);
- Impacts on the geomorphology of Dry Creek and the Hunter River associated with the Dry Creek Relocation; and
- Interference with flood flows along Dry Creek and the Hunter River associated with changes in the respective flood plains.

An assessment of each of these potential impacts of the Project is provided in the following sections.

5.2 MINE SITE WATER REQUIREMENTS

Significant volumes of water are required on the mine site to meet operational water demands, such as dust suppression and coal processing. A key objective of the mine site water management system is to maximise reuse of onsite surface runoff and groundwater inflows. This onsite recycling of water will minimise the volume of water from external sources that is required to satisfy site demands. However, the volume of water captured on site is highly variable dependent upon climatic conditions. Hence, the required makeup water volume from external sources is likely to vary significantly from year to year.

A detailed daily water balance model has been prepared to estimate the likely variation in mine site water requirements over the life of the Project. Full details of the methodology and results of the water balance modelling are provided in Section 6.

The results of the water balance model show that:

- The maximum annual water demand for operations during the life of the mine, including coal processing and dust suppression is approximately 1,974 ML/a. The peak water requirement is greater due to evaporation losses;
- The peak water requirement is predicted to occur between Years 5 to 24, when the CHPP is at the maximum production rate of 15 Mtpa. The current Hunter River raw water allocation is 1,449 units (which equates to 1,449ML/a when 100% allocation is announced);
- The 99th percentile annual raw water requirement from an external source is approximately 2,200 ML/a during Years 5 to 24; and
- The median (50th percentile) annual raw water requirement from an external source is approximately 1,500ML/a during Years 5 to 24.

The first priority source of water to satisfy mine site water demands will be recycled mine water from the CHPP, followed by captured dirty water runoff from around the site, then clean water runoff from sediment dams around the site and lastly raw water from the Hunter River. The external water source requirement is therefore minimised by the recycling of mine site water. Since the quantity of water available from onsite sources will be dependent on rainfall, water balance modelling was undertaken to estimate the required volume of raw water from the Hunter River for a range of climatic conditions. Figure 5.1 shows the simulated raw water requirements from external sources. Note that the percentiles shown in Figure 5.1 are a statistical representation of multiple model simulations for different rainfall sequences. They do not represent model results for a single rainfall sequence.

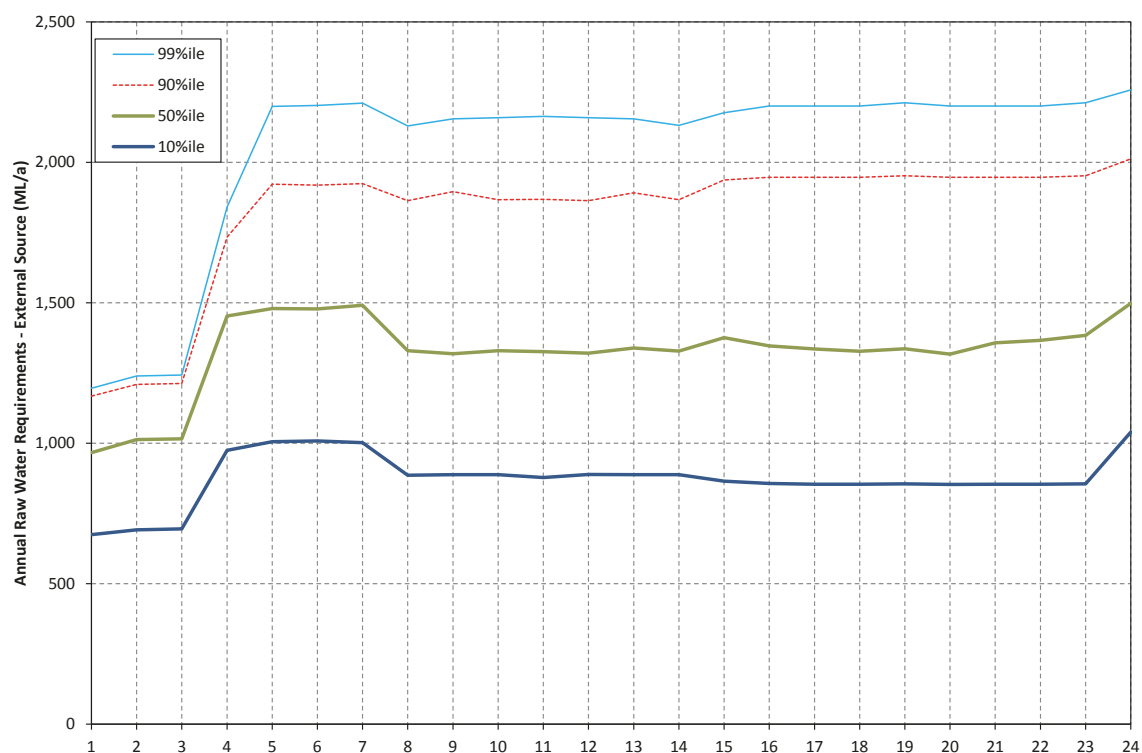


Figure 5.1 Annual Raw Water Requirements - External Source

Water required from external sources will be obtained under appropriate WALs and will be accessed in accordance with the requirements of existing Water Sharing Plans, including adherence to total daily extraction limits. This will ensure no adverse impacts on water availability for other licensed water users.

5.3 LOSS OF CATCHMENT AREA

During active mining operations, the mine water management system will capture runoff from areas that would have previously flowed to either Dry Creek or the Hunter River. The mine stage plans are shown in Figure 6.9 to Figure 6.13 for Years 1, 4, 8, 15 and 24 respectively. A breakdown of the catchment areas reporting to the mine site storages are provided in Table 6.8 to Table 6.12.

Table 5.1 shows the total catchment area captured within the mine water management system during the Project life. The maximum captured Dry Creek catchment area of 983 ha (not including the diverted catchment from upstream of Wybong Road) occurs during Year 15 of the Project representing 39% of the Dry Creek catchment to the confluence with the Hunter River. Note that sediment dams overflow to Dry Creek or the Hunter River during periods of rainfall, reducing the volume of water lost from the downstream catchment. The Dry Creek clean water catchment upstream of Wybong Road reporting to CW1, and downstream of Wybong Road reporting to the Satellite Dam, Spare Dam and Proposed Diversion Dam, is not included in the area reduction calculations as it is assumed that these clean water dams are maintained empty. Refer to Section 5.7 for further details.

Table 5.1 also shows the catchment area captured in the final landform. The final landform restores the Hunter River catchment area (excluding the Dry Creek catchment) to 100% of its pre-mining catchment area. The final landform captures 551 ha or 22% of the Dry Creek catchment to the confluence of the Hunter River. The impacts of this loss in catchment to the Hunter River on average flow volumes are presented in Section 5.6.2.

Table 5.1 Receiving Waters Catchment Area during Mining Operations

Mine Stage	Dry Creek to Hunter River Confluence		Hunter River (excluding Dry Creek) to Dry Creek Confluence	
	Area (ha)	Proportion of Pre-mining Area (%)	Area (km ²)	Proportion of Pre-mining Area (%)
Pre-Mining	2,515	100%	4,177	100%
Existing (2011)	2,242	89 %	4,172	99.9 %
Project				
Year 1	2,212	88 %	4,172	99.9 %
Year 4	2,047	81 %	4,172	99.9 %
Year 8	1,758	70 %	4,172	99.9 %
Year 15	1,532	61 %	4,172	99.9 %
Year 24	1,844	73 %	4,173	99.9 %
Final Landform	1,964	78 %	4,177	100 %

5.4 SURFACE WATER QUALITY

The Bengalla Water Management Plan has the following key objectives in relation to surface water quality of receiving waters:

- No uncontrolled offsite mine water releases;
- Controlled saline water discharges will only occur as specified under the rules of the HRSTS; and
- Runoff from disturbed sites (non-saline) will be treated for sediment before offsite release.

Potential impacts on surface water quality in the receiving waters will be managed by implementation of the following measures:

- Bengalla Site Water Management System (detailed in Section 6.6);
- Compliance with HRSTS discharge limits;
- Sediment and Erosion Control Plan (detailed in Section 7.3); and
- Surface Water Monitoring Program (detailed in Section 7.5).

The results of the water balance modelling show that no uncontrolled release of saline water occurs over the Project life. Excess saline water is released in accordance with the existing rules of the HRSTS. Downstream impacts on surface water quality are therefore considered negligible.

5.5 UNCONTROLLED OFFSITE RELEASES

A key objective for the operation of the mine water management system is to manage the risk of mine water of unsuitable quality being released to receiving waters. The results of detailed site water balance modelling show that the site water management system can be operated to ensure no uncontrolled release of saline water over the Project life. Overflows from sediment dams will occur, however this runoff water would have had no coal contact and would have been sediment treated. Further details of the site water balance model are provided in Section 6.

5.6 IMPACTS OF CONTROLLED DISCHARGES UNDER HRSTS

5.6.1 Overview

BMC is a current participant of the HRSTS, which provides the opportunity to discharge saline water without exceeding salt concentration limits in the Hunter River. Further details of the HRSTS are provided in Section 6.3.4. Under the Project, BMC will continue to be a Scheme participant. Controlled discharges are currently made from the Staged Discharge Dam, which would be mined out after approximately Year 4. A proposed relocation of the Discharge Dam (and release point) to the south-west is shown in Figure 5.3.

Historical discharges to the Hunter River are presented in Section 3.5. Figure 5.2 shows the simulated total annual controlled discharges from the Staged Discharge Dam and Bengalla Relocated Discharge Dam to Dry Creek under the HRSTS. Review of the results shows that:

- No discharges are required under the HRSTS for the 50th percentile results.
- The 90th percentile results show that up to approximately 350 ML/a are discharged under the HRSTS.
- The 99th percentile results show that up to approximately 1,000 ML/a are discharged under the HRSTS. There is a marked increase in potential discharges in Year 8 of Project life, likely associated with the large increase in catchment area reporting to the mine water system. Year 4 has a total 'disturbed' footprint of 515 ha (industrial and overburden and active pit areas), compared to 747 ha in Year 8 (refer Section 6.6.4).

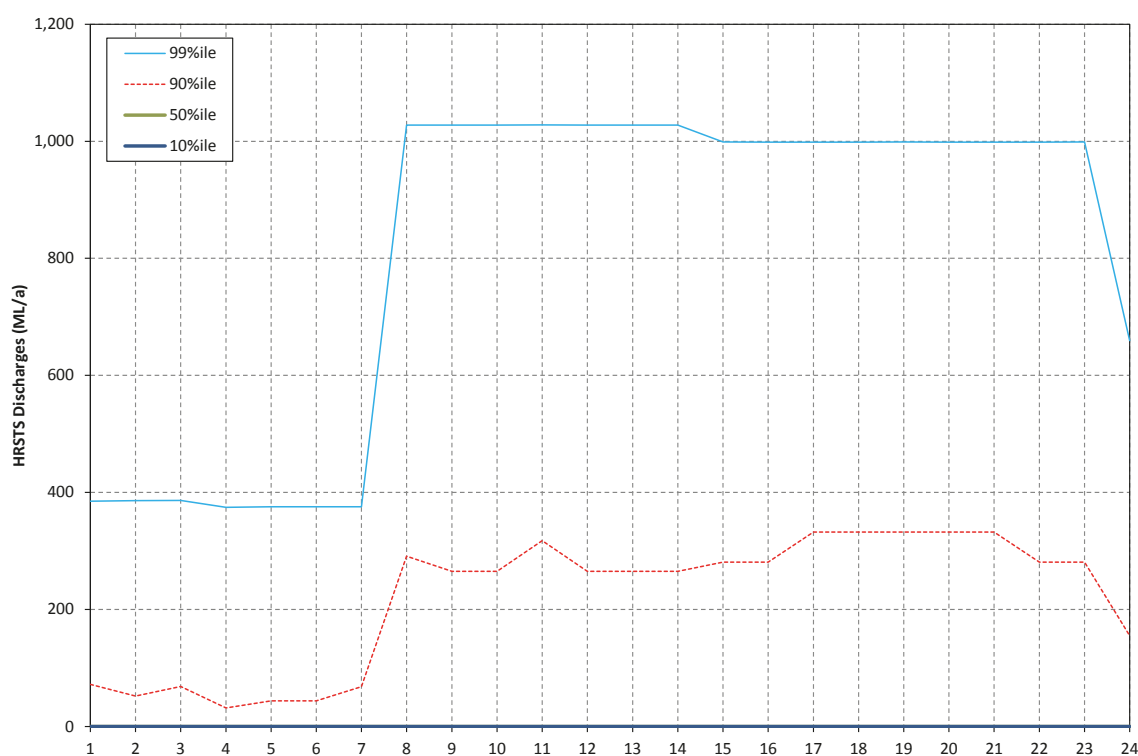


Figure 5.2 Predicted Annual HRSTS Discharges

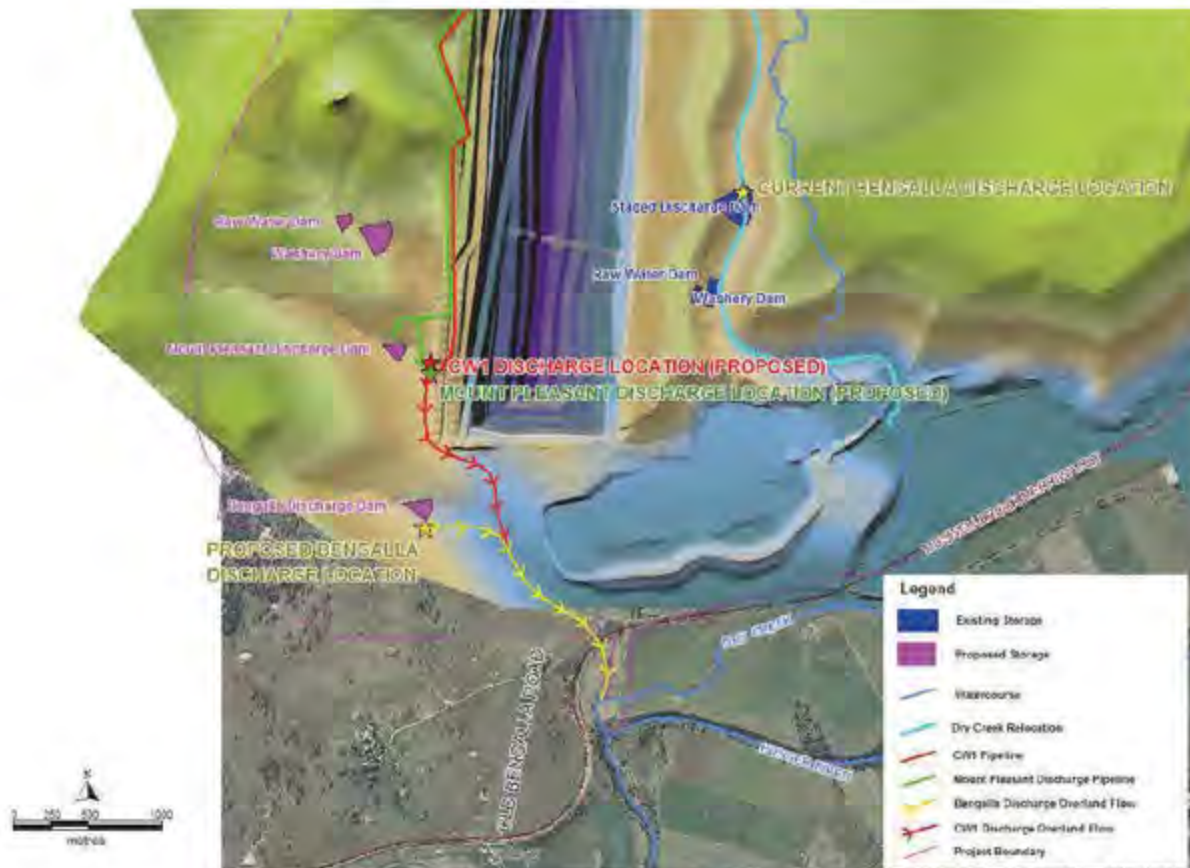


Figure 5.3 Existing and Proposed Discharge Locations

Controlled releases of saline water under the HRSTS have the following potential impacts:

- Impacts on the total flow volume in Dry Creek and the Hunter River;
- Impacts on the Dry Creek and Hunter River flow regime (frequency of high, medium and low flows);
- Impacts on stream condition, including bank erosion; and
- Water quality impacts.

These potential impacts are discussed in the following sections.

5.6.2 Hunter River Flow Volume

Table 5.2 shows the net impact of the Bengalla water management system on Hunter River flow volumes over the Project life. The average runoff captured in the system is based on the captured catchment areas (see Table 5.1), the average annual rainfall and the long term average runoff coefficient for undisturbed areas. The mine water balance simulated average controlled discharges to the Hunter River are used to estimate the average net reduction in runoff in the Hunter River. The results show that the average annual reduction in flows to the Hunter River varies between 458 and 923 ML/a during the Project, and the average annual reduction is 423 ML/a post-mining.

Figure 5.4 shows the simulated flow duration relationship for the Hunter River at Denman for the period 1893 to 2006 (NSW Office of Water IQQM Model). Review of the results indicates that the median (50th percentile) flow is 200 GL/a. The minimum flow rate is approximately 60GL/a. The maximum average net runoff reduction of 923 ML/a is less than 0.5% of the median annual flow rate in the Hunter River at Denman. The post-mining annual average reduction of 423 ML/a approximately 0.2% of the median Hunter River annual flow at Denman. Hence, in practical terms the reduction in Hunter River flow volume due to the Project is likely to be undetectable.

Table 5.2 Net Impact of Mine Water Management System on Hunter River Flow Volumes over Project Life

Mine Stage	Average Runoff Captured (ML/a)	Average Hunter River Discharges (ML/a)	Average Sedimentation Dam Overflows (off-site)	Average Net Runoff Reduction (ML/a)
Year 1	622	19	145	458
Year 4	749	19	69	661
Year 8	971	82	74	815
Year 15	1,144	85	136	923
Year 21	810	44	110	656
Post-Mining	423	0	0	423

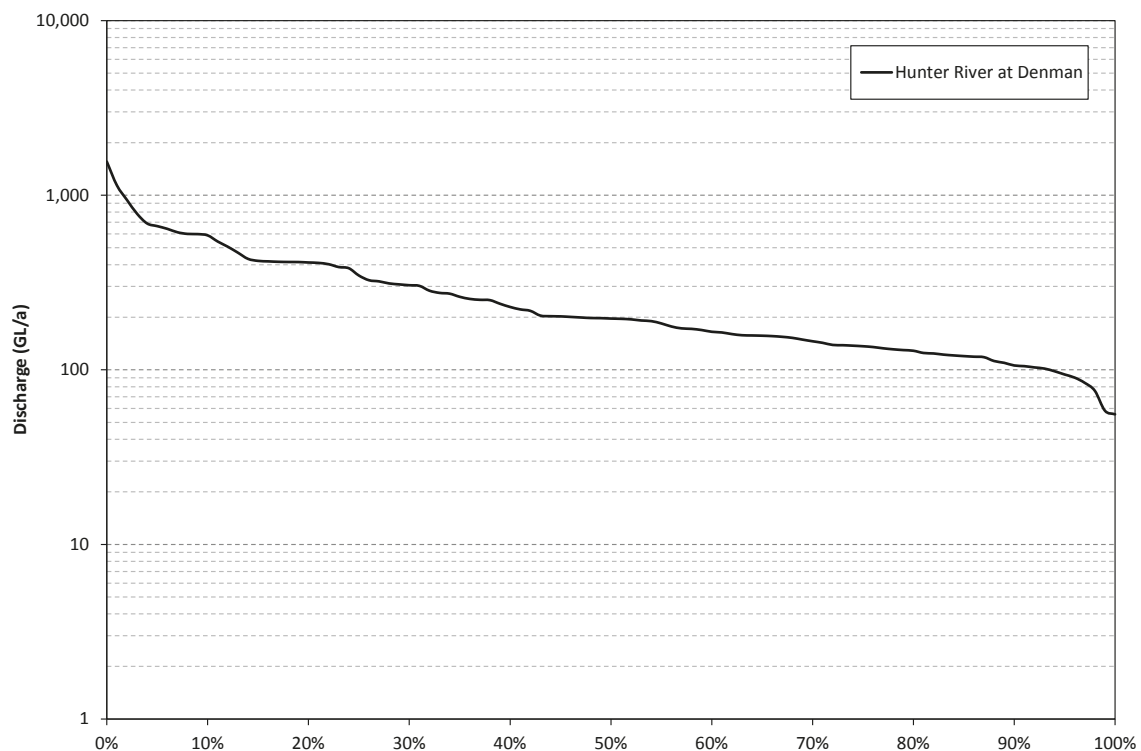


Figure 5.4 Simulated Hunter River at Denman Flow Duration Relationship, 1893 – 2006 (NSW Office of Water IQQM Model)

5.6.3 Hunter River Flow Regime

The controlled discharge of saline water to Dry Creek and the Hunter River will also affect the frequency of different flow rates. Event runoff will be captured in the mine water management system during storm events and then released at a later date.

Figure 5.5 shows the flow duration relationship for the Hunter River at Denman for the case with and without simulated discharges from the Project, for the duration of the Project. The results are presented for a 24 year climate sequence with average total Hunter River discharge. The results show that the discharge of water from Bengalla under the HRSTS will have a negligible impact on the flow duration relationship for the Hunter River.

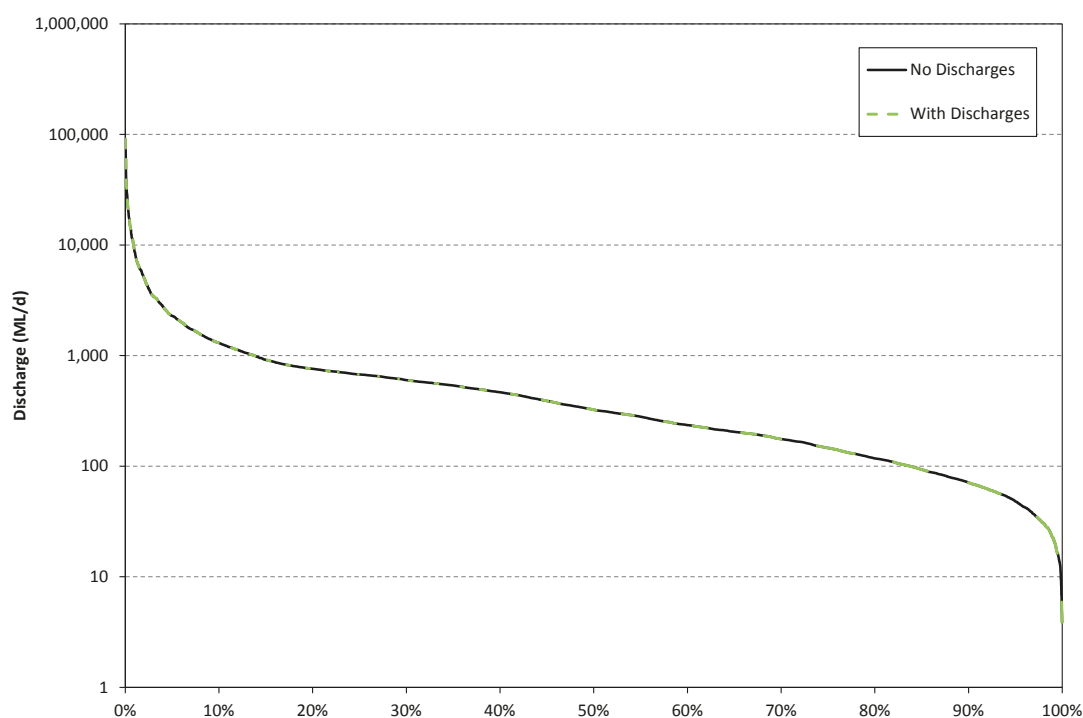


Figure 5.5 Hunter River at Denman Flow Duration Relationship, "Average" Climate Realisation

The mine water balance (see Section 6) indicates that the maximum controlled discharges occur in Years 15 to 23. Year 20 has been chosen as representative to demonstrate the worst case for impacts to the Hunter River flow regime. Figure 5.6 shows the simulated flow duration relationship for the Hunter River at Denman for the 'with discharges' and 'no discharges' cases for Year 20 only. The results indicate there are negligible impacts on the flow duration relationship for the Hunter River.

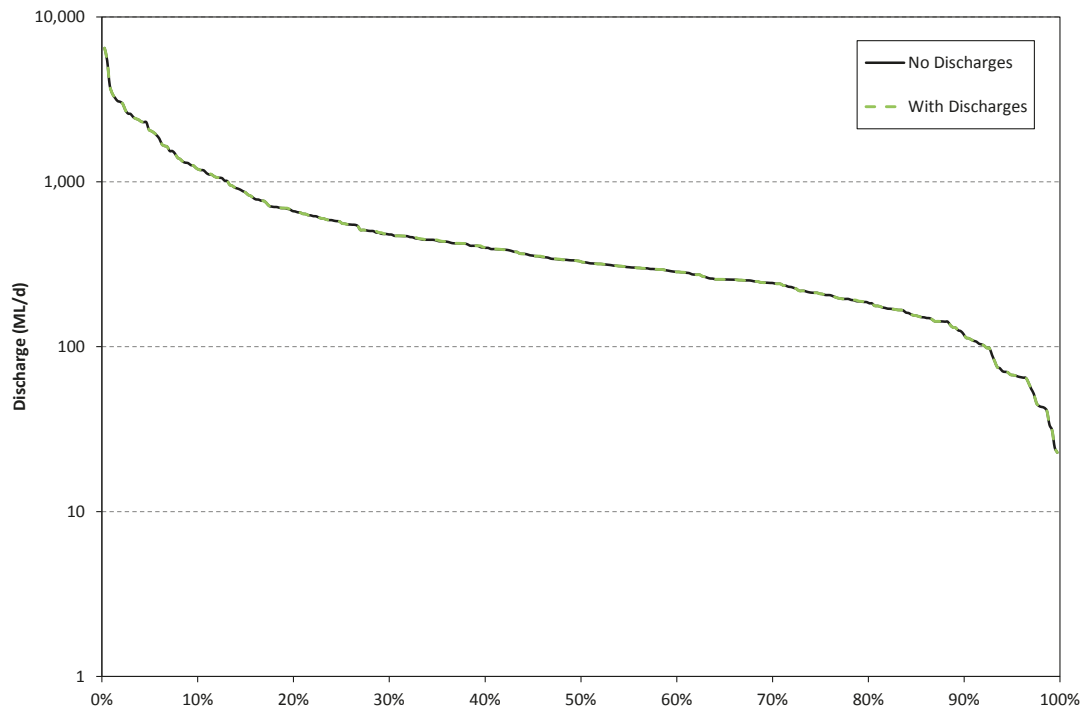


Figure 5.6 Hunter River at Denman Flow Duration Relationship (Year 20 only), "Average" Climate

5.6.4 Dry Creek Flow Regime

Figure 5.7 shows the simulated flow duration relationship for Dry Creek at the Hunter River confluence for the pre-mine, existing, Year 15 and Final Landform cases. Year 15 represents the maximum captured Dry Creek catchment area (refer Table 5.1) during the Project. The flow duration curves shown are for 'static' simulations of each mine stage over 114 years of historical climate data. Review of the results indicates that the final landform will restore the Dry Creek flow duration relationship to close to that of the Pre-Mine case.

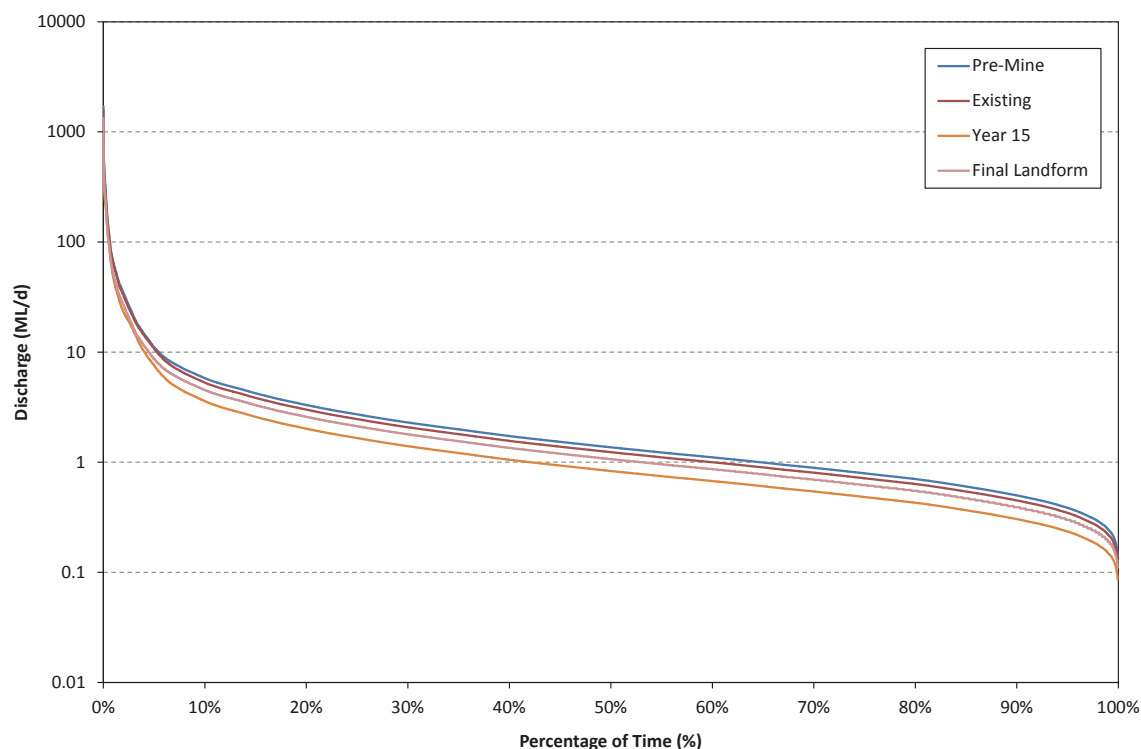


Figure 5.7 Dry Creek Flow Duration Relationship (Static Scenario Results)

5.6.5 Stream Condition

The predicted flow rate of the controlled discharge will be less than 200 ML/d (2,300 L/s), as required by EPL 6538. Simultaneous flows may occur due to releases from the Dry Creek Clean Water Diversion Dam (CW1), as well as controlled discharges from the Bengalla Discharge Dam, and potentially controlled discharges from the Mount Pleasant Project Discharge Dam. Dry Creek is an ephemeral watercourse, and hence it is possible that controlled discharges may occur at times when there is no natural flow in Dry Creek. Note that current Bengalla operations have discharged flows of this magnitude to Dry Creek in the past when required. It is not expected that discharges under the proposed Project will have an additional impact on the stream condition of Dry Creek to that already experienced under the current operations.

The Project involves mining through the current discharge location and approximately 1.8 km of Dry Creek downstream from the discharge location. The existing and relocated discharge locations are shown in Figure 5.3. The proposed discharge flow path crosses the Old Bengalla Road and the Muswellbrook-Merriwa Railway. Detailed design of the discharge location, infrastructure and creek crossings at the road and railway will be undertaken to ensure the path of water from the proposed discharge location to the confluence with Dry Creek is stable.

As specified under the rules of the HRSTS, controlled discharges may only occur when the 'high' or 'flood' flow block is passing Bengalla. Therefore, controlled releases from the Project will only occur when the Hunter River is in an increased state of flow. Based on the comparatively low controlled discharge rate, it is not expected that controlled discharges would result in adverse hydraulic impacts on the Hunter River, such as increased bed and bank erosion.

5.6.6 Water Quality Impacts

Discharges under the HRSTS are controlled by NSW EPA so that the salt concentration in the Hunter River Upper Sector (upstream of Denman) does not exceed 600 $\mu\text{S}/\text{cm}$. An important component of meeting the salinity goal is to discharge the salt load evenly throughout the discharge period to avoid short periods of elevated salinity in the Hunter River (DECCW, 2010).

Controlled discharges from the Project will continue to be released in accordance with HRSTS and EPL 6538 requirements.

5.7 IMPACTS OF CLEAN WATER RELEASES FROM CLEAN WATER DIVERSION DAMS

Over the Project life, there are four clean water diversion dams proposed:

- Dry Creek Clean Water Diversion Dam (CW1) – north of Wybong Road (refer Figure 6.9);
- Satellite Dam – highwall dam upstream of the Satellite Pit (refer Figure 6.10);
- Diversion Dam – highwall dam west of Main Pit (refer Figure 6.11); and
- Spare Dam – highwall dam west of Main pit (refer Figure 6.13).

The CW1 Dam will be constructed in Year 2 to facilitate the interim diversion of Dry Creek. The dam will remain in place until the re-establishment of Dry Creek in approximately Year 20 (unless subsequent approvals are sought). The Satellite Dam would only be in place for approximately 3 years (Years 3, 4 and 5) whilst mining of the Satellite Pit obstructs flows down Dry Creek, and before the Main Pit has progressed to mine through this area. The Diversion Dam would be in place for approximately 3 years (Years 6, 7 and 8) whilst the mining pit progresses to the west before it is mined through. To minimise impacts on downstream flow volumes, it is proposed to maintain these three clean water dams empty. The Spare Dam would be in place for approximately 9 years (Year 16 to 24).

Figure 5.3 shows the proposed discharge pipeline and discharge location of clean water from the clean water diversion dams. The Dry Creek interim management system (Parsons Brinkerhoff Australia Pty Limited, 2012) proposes a pump rate of 1,085 L/s to empty a 200 year Average Recurrence Interval (ARI), 72 hour event from CW1 in 14 days. A detailed assessment of the Dry Creek Interim Management System and Conceptual Re-establishment Study has been undertaken and is documented in a separate report (Parsons Brinckerhoff Australia Pty Limited, 2012).

5.8 FLOOD IMPACT ASSESSMENT

5.8.1 Hunter River Catchment

The February 1955 flood event was the largest on record (1913 to current) for the Hunter River adjacent to Bengalla and occurred before the commissioning of the Glenbawn Dam. The approximate flood extent in the vicinity of Bengalla for the 1955 flood event is shown in Figure 3.1. The extent of the flooding for the 1955 flood encroaches slightly into the Southern Overburden Extension Area (OEA) near Bengalla Homestead however this area has since been blocked off from the Hunter River floodplain following the recent approvals associated with DA 211/93 (as modified). The impacts of the OEA on Hunter River flooding were also previously assessed as part of the Surface Water Impact Assessment for Bengalla Development Consent Modification (WRM, 2010).

WRM (2010) has undertaken a flood frequency analysis (FFA) to obtain an estimate of the magnitude of the 1955 flood event. The FFA results show that the 1955 flood is approximately equal to the 100 year Average Recurrence Interval (ARI) design flood event. Note that due to the effects of the Glenbawn Dam, which includes 120,000 ML of flood storage, the actual 100 year ARI design flood flow rate is likely to be less than the recorded 1955 flood flow rate.

Figure 6.9 to Figure 6.13 show the 1955 flood event extent for the mine stages Year 1 to Year 24 respectively. The Project does not encroach onto the 1955 flood extent during any stage (with the exception of the existing OEA). It is therefore not expected that the Project will impact on the behaviour of flood flows in the Hunter River.

5.8.2 Dry Creek Catchment

The existing 100 year ARI flood extent for Dry Creek is shown in Figure 3.1. The Project involves the interim diversion of Dry Creek via dams and pipework with a later permanent realignment of Dry Creek through rehabilitation areas when emplacement areas are suitably advanced. A detailed impact assessment including hydraulic analysis of the Dry Creek interim management system and re-establishment has been undertaken (Parsons Brinckerhoff Australia Pty Limited, 2012). The modified Dry Creek alignment has been designed to ensure a stable drainage system for post-mining conditions.

5.9 GEOMORPHIC IMPACTS

5.9.1 Dry Creek

Details of the relocation of Dry Creek are described in the Dry Creek Interim Management System and Conceptual Re-establishment Study (Parsons Brinckerhoff Australia Pty Limited, 2013). The following design criteria were adopted for the re-established Dry Creek (Parsons Brinckerhoff Australia Pty Ltd, 2013):

- A low flow channel with a 2 year ARI capacity;
- A larger high flow channel with a 100 year ARI capacity;
- Channel cross section and roughness that allows opportunity for environmental enhancement;
- Horizontal and vertical alignment that minimizes velocities and erosion potential and allows opportunity for environmental enhancement; and
- A stable channel that will resist erosion and scour under flood events up to and including the 50 year ARI flood event.

A typical channel cross section is shown in Figure 5.8, and a comparison of the longitudinal sections of the Dry Creek existing alignment and the re-established alignment is shown in Figure 5.9. Design characteristics are summarised as follows:

- Base width: 8 m
- Low flow channel depth: 0.77 m
- Low flow channel side slopes: 1(v):4(h)
- High flow channel side slopes: 1(v):10(h)
- Channel longitudinal bed slope: (varies)
- CH 0 to CH 3,000, average ~ 0.5%
- CH 3,000 to 4,500, average ~ 2%

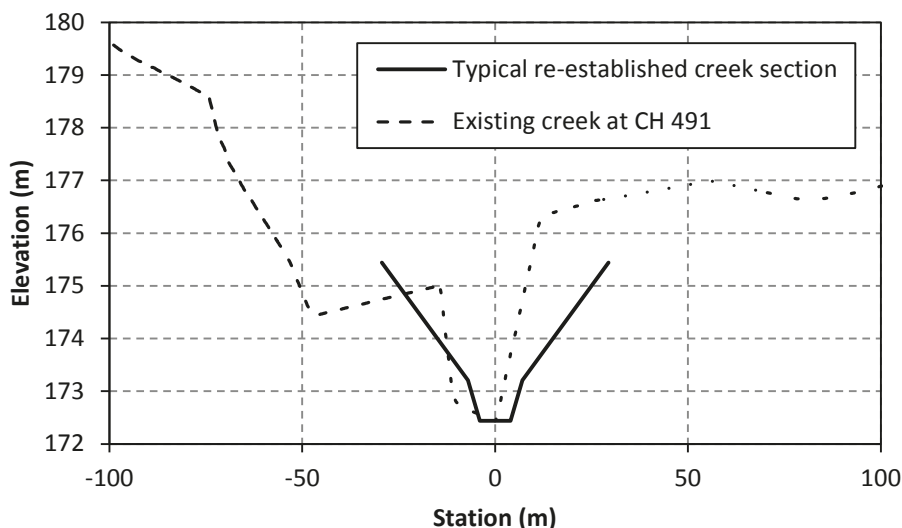


Figure 5.8 Re-established Dry Creek Typical Cross Section

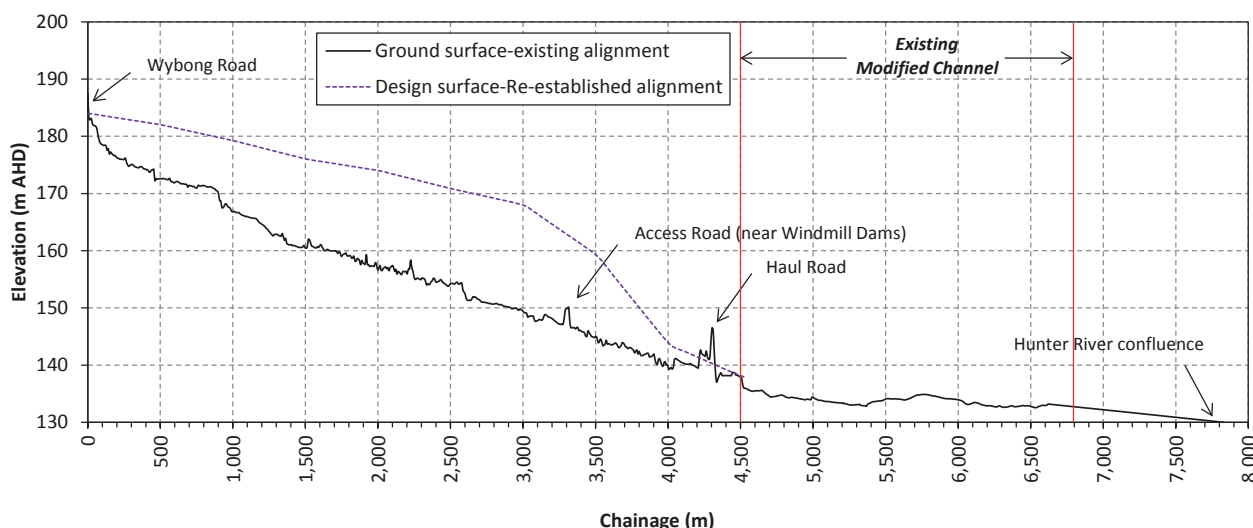


Figure 5.9 Existing and Re-established Dry Creek Longitudinal Section

The channel geometry is similar to the existing Dry Creek channel (refer Section 3.2.2), with the exception of the channel slope which is flatter for the majority of the re-established reach, with a short reach of increased slope towards the downstream end. It is likely that the re-established creek will be more efficient at conveying flow than the existing creek. To offset the effect of increased flow efficiency a longer stream length has been introduced (Parsons Brinkerhoff Australia Pty Limited, 2013).

5.9.2 Hunter River

Geomorphic impacts on the Hunter River are expected to be negligible due to the comparative size of the Dry Creek catchment (~18 km²) and the Hunter River catchment (~4,200 km² to Muswellbrook). The Dry Creek catchment area and design flood flows are unchanged from existing conditions and therefore the re-established creek does not result in increased peak flows from the catchment (Parsons Brinkerhoff Australia Pty Ltd, 2013).

5.10 WATER ALLOCATIONS

The water management system for the Project has been designed to minimise the capture of clean runoff wherever possible. Clean water diversion dams are proposed to capture clean water runoff that would have drained into the open cut mining areas. Water collected in these dams will be pumped to the CW1 release location, (refer Figure 5.3) for release into Dry Creek. The remaining dams are solely for the capture, containment and recirculation of mine affected water consistent with best management practice to prevent the contamination of a water source. These types of dams are “excluded works” and are exempt from the requirement for water supply works approvals and Water Access Licences. Therefore the water captured in these dams is not subject to licensing.

Water balance modelling of the clean water diversion dams indicates that the frequency and volume of overflows from the highwall dams is very low. Therefore, these dams are effective at diverting clean water around the open cut. On this basis, a WAL may only be required for the residual catchment between the highwall of the mining areas and the proposed clean water diversion dams. It has been assumed that collection of water from the clean catchment draining to the Washery Dam, Raw Water Dam, Staged Discharge Dam and Bengalla Relocated Discharge Dam (all of which generally store mine affected water with the exception of the Raw Water Dam) may require a WAL. Figure 5.10 shows the clean water catchment areas requiring a WAL for runoff capture.

Table 5.3 shows the estimated average volume of water captured within the water management system over the life of the Project. Runoff volumes have been separated into mine affected catchments draining to sediment/mine water dams, clean water runoff draining to diversion dams and clean water runoff draining to mine water dams.

The intercepted average and maximum annual runoff has been estimated using average and maximum annual rainfalls at Muswellbrook (Station No. 061053) of 618mm and 1,225mm respectively. A volumetric runoff coefficient of 0.113 has been used based on the runoff coefficient utilised for harvestable rights calculations at Bengalla (10% of runoff = 0.07 ML/ha = 7 mm runoff. 100% of runoff = 70 mm. 70mm/618 mm average annual rainfall = 11.3%).

The total surface water entitlement for the unregulated river water source is 107,439 units (ML/a). The Muswellbrook Water Source, in which the Project is located, is a component of the unregulated river water source and has an entitlement of 636 units (ML/a). The predicted average annual impact (20 ML/a) on the total share component for the Muswellbrook Water Source under the Hunter Unregulated and Alluvial Water Sources Water Sharing Plan is approximately 3% on an annual average basis for the Project life.

The total surface water entitlement (general and high security access licences) for the Hunter Regulated River water source is 151,792 units (ML/a). The Project is located in Management Zone 1, which has an entitlement of 85,413 units (ML/a).

Table 5.3 Surface Water Allocations

Water Type	Water Sharing Plan	Water Source	CHPP Throughput (Mtpa)	Predicted Annual Take (ML/a)		Predicted Annual Impact on Water Source (%)		BMC Current Licences	Licence Allocation Required (ML/a)	
				Average	Maximum	Average	Maximum		Average	Maximum
Surface Water	Hunter Regulated River	Hunter Regulated River	9.5	1,120	1,449	1.3%	1.7%	1,449 units	0	0
			10.7	1,220	1,680	1.4%	2.0%		0	231
			13.0	1,374	2,000	1.6%	2.3%		0	551
			15.0	1,500	2,257	1.8%	2.6%		51	808
	Hunter Unregulated and Alluvial	Muswellbrook	n/a	20	39	3%	6%	0	20	39

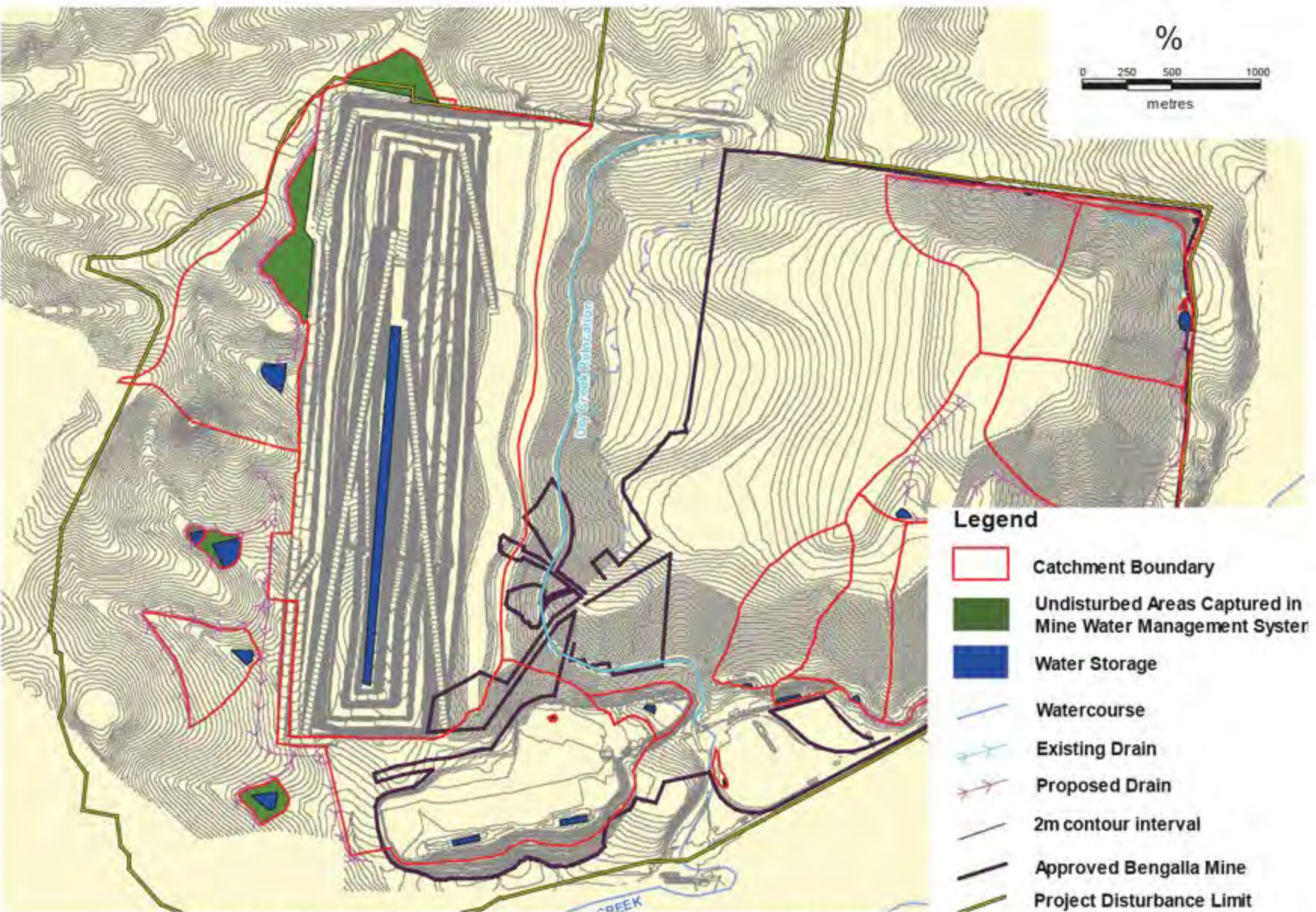


Figure 5.10 Clean Catchment Areas Requiring Water Allocation Licence for Runoff Capture

6 MINE WATER BALANCE

6.1 OVERVIEW

The computer based OPSIM model was used to simulate the site water balance for the Project. The model simulates the operations of all major components of the proposed water management system, including:

- Climatic variability – rainfall and evaporation;
- Catchment runoff;
- Controlled discharges (under the HRSTS) and uncontrolled overflows;
- Groundwater inflows; and
- Site water usage (CHPP, haul road dust suppression and stockpile dust suppression, vehicle wash).

6.2 SIMULATION METHODOLOGY

The water balance model has been run for two types of simulation methodologies: ‘static’ and ‘forecast’.

The static water balance results are based on a long-term simulation (114 Years) with the model configuration fixed to a particular stage of mine development. These results provide an indication of the relative magnitude of inflows and outflows at that particular stage of mining.

The forecast water balance results are generated by running multiple climate sequences through the model and taking a statistical representation of the results for the different climate cases modelled. These results more accurately reflect the actual performance of the system because they take into account the dynamic nature of the mine staging, groundwater inflows, CHPP throughputs. In these runs the model configuration changes over time, to reflect the changes due to mine development.

The forecast water balance model has been run on a daily timestep for a 24 year period, corresponding to the period of operation of the Project. The model was run for multiple climate sequences, each referred to as a “realisation”. Each realisation is based on a 24 year sequence extracted from the historical rainfall data. The first of 95 realisations is based on rainfall data from 1893 to 1917. The second is based on data from 1894 to 1918, and so on. This approach provides the widest possible range of climate scenarios covering the full range of climatic conditions represented in the historical rainfall record.

The model configuration changes over the 24 year Project life, reflecting changes in the water management system over time. The different stages of the mine life are linked in the model to reflect variations over time such as catchments, ROM coal production and groundwater inflows. Five different representative stages of mine life were modelled (Years 1, 4, 8, 15 and 24). Although the catchment areas will continuously change as the Project progresses, the adopted

approach of modelling discrete stages will provide a reasonable representation of conditions over the 24 year period.

The operational rules and physical layout for each representative stage of mine progression are applied to a range of years given in Table 6.1.

Table 6.1 Application of Representative Mine Stage to Full Mine Life

Representative Mine Stage	Applied Range of Mine Life	Period (years)
Year 1	Year 1 – Year 3	3
Year 4	Year 4 – Year 7	4
Year 8	Year 8 – Year 14	7
Year 15	Year 15 – Year 23	9
Year 24	Year 24	1

6.3 EXISTING WATER MANAGEMENT SYSTEM

6.3.1 Overview

The existing Bengalla water management system is operated in accordance with the Bengalla Water Management Plan (WMP) (Hansen Bailey, 2012) and the Environmental Management System (EMS) procedures, which are certified to ISO 14001.

Surface water management at Bengalla is based on the following key strategies:

- Minimal use of fresh water from the Hunter River;
- Diversion of clean surface water runoff away from areas disturbed by mining activities;
- Collection of surface water runoff from areas disturbed by mining activities in catch drains and direction to sediment traps and settling dams for control of suspended sediment prior to release from site or reuse via the mine water management system;
- Collection of runoff from industrial areas in catch drains and direction, via an oil and grease separator, to the Bengalla Waste Water Treatment Plant (WWTP) for treatment and return to storage dams for reuse as mine water supply; and
- Transfer of open cut pit water to storage dams for reuse as mine water supply.

6.3.2 Real Time Environmental Management System (RTEMS)

The BMC water management system is operated with a Real Time Environmental Management System (RTEMS). The system is fully automated and utilises real time monitoring of water storage, quality and usage across the site, including alarms and safeguards to detect potential releases, leaks or water-related incidents.

6.3.3 Hunter River Water Use

BMC is permitted under Water Supply Works Approval 20WA201594 and associated Water Access Licence Number WAL001106 (previously 20SL060388) to withdraw a maximum of 1,449 units (1,449 ML for years of 100% allocation) of fresh water each year from the Hunter River. Fresh water withdrawn from the Hunter River is primarily used in coal processing, dust suppression and within the bathhouse. This additional Hunter River water is only used when necessary to remedy a water deficit on-site after all alternative mine water sources have been utilised.

Historical draw from the Hunter River is reported in the Bengalla Annual Reviews as follows:

- 2011 – 448ML;
- 2010 – 497 ML;
- 2009 – 601 ML;
- 2008 – 474 ML;
- 2007 – 526 ML; and
- 2006 – 860ML.

6.3.4 Hunter River Salinity Trading Scheme

The BMC water management system was designed to minimise the use of fresh water from the Hunter River. This is achieved through maximising the recycling of CHPP process water by dewatering rejects and utilising secondary quality water where possible across the site. Wherever possible, saline mine water and treated sewage water are used for coal processing and dust suppression. Any required discharge events from the mine water management system are managed under the guidelines of the HRSTS. Historical discharges under the HRSTS are described in Section 3.5.

6.3.5 Mine Water Storages

The Bengalla water management system includes various water storages for mine water and sedimentation dams for settling of suspended sediment prior to release off site or reuse via the mine water management system. Summary details of water storages at Bengalla are provided in Table 6.2 with the locations of storages shown in Figure 6.2. Excluding sedimentation dams, the total available storage within the mine water management system is approximately 450 ML.

A schematic of the current (2011) mine water management system is presented in Figure 6.1.

Table 6.2 Bengalla Water Management Structures - Existing

Dam	Capacity	Classification
Raw Water Dam	5	Clean water
Washery Dam	25	Mine water
Endwall Dam	80	Mine water
Ramp Dam	16	Mine water
East Facilities Dam	24	Mine water
West Facilities Dam	24	Mine water
Staged Discharge Dam	280	Mine water
Train Loadout Sump	0.5	Mine water
Facilities Sump	0.5	Mine water
Windmill Sedimentation Dams	3	Sediment Dam
Wybong Road Sedimentation Dam	0.4	Sediment Dam
Twin Gullies Sedimentation Dam	32	Sediment Dam
North Dump Sedimentation Dam	0.5	Sediment Dam
Water Overflow Bypass	10	Sediment Dam
Hot Tyre Parkup Dam	0.2	Mine water
South Loop Road Sedimentation Dam	0.5	Sediment Dam
ROM North & South Sedimentation Dams	1	Sediment Dam
West Wantana Dam	16	Mine water
East Wantana Sedimentation Dam	5	Sediment Dam

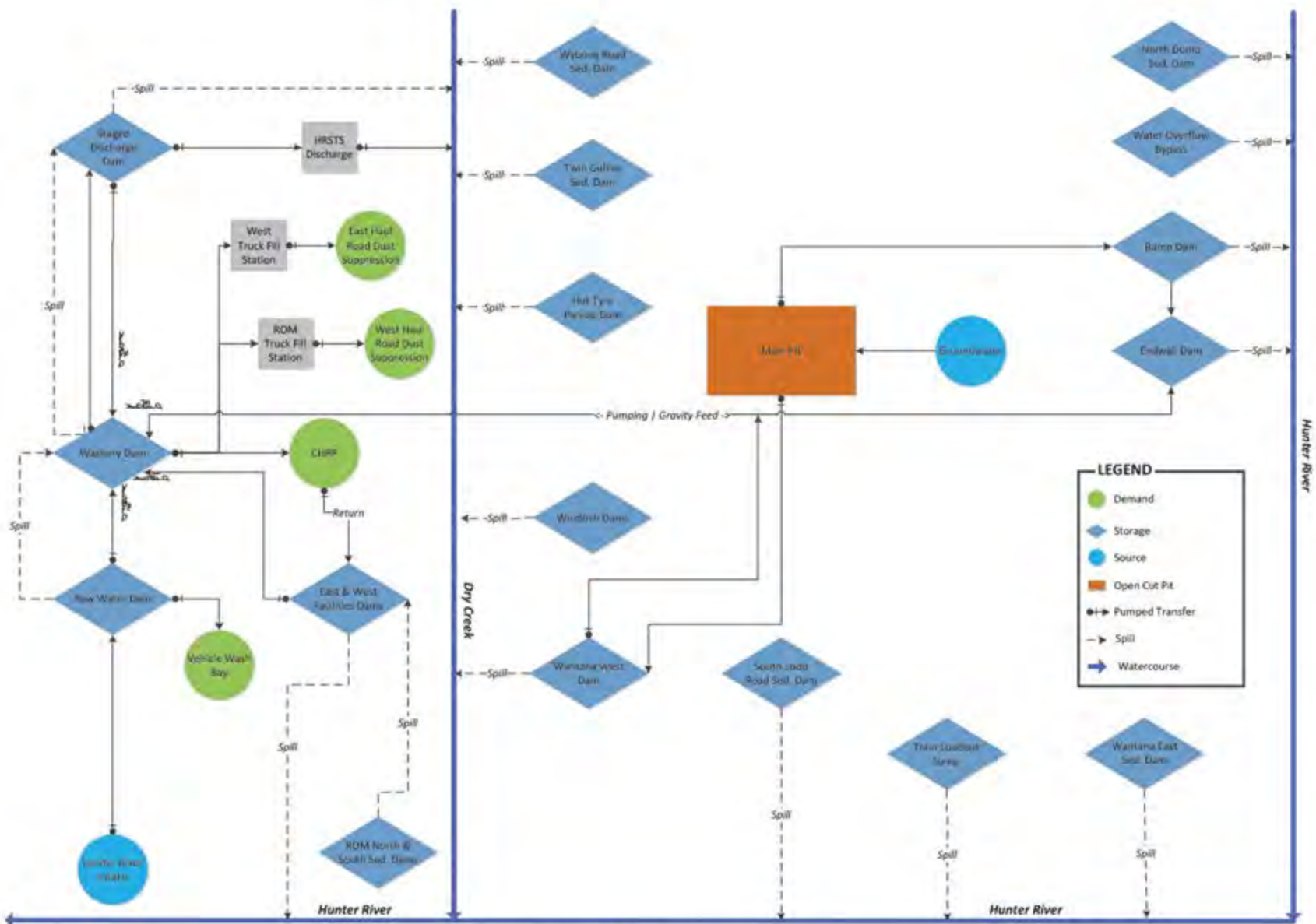


Figure 6.1 Bengalla Water Management Schematic - 2011

6.4 SIMULATION OF RAINFALL RUNOFF

The OPSIM model uses the Australian Water Balance Model (AWBM) (Boughton WC, 1993) model to estimate runoff from rainfall. The AWBM is a saturated overland flow model which allows for variable source areas of surface runoff.

The AWBM uses a group of connected conceptual storages (three surface water storages and one ground water storage) to represent a catchment. Water in the conceptual storages is replenished by rainfall and is reduced by evaporation. Simulated surface runoff occurs when the storages fill and overflow.

The model uses daily rainfalls and estimates of catchment evapotranspiration to calculate daily values of runoff using a daily water balance of soil moisture. The model has a baseflow component which simulates the recharge and discharge of a shallow subsurface store. Runoff depth calculated by the AWBM model is converted into runoff volume by multiplying the contributing catchment area.

The model parameters define the storage depths (C1, C2 and C3), the proportion of the catchment draining to each of the storages (A1, A2 and A3), and the rate of flux between them (K_b and BFI) (Boughton, 2003). Catchments across the site have been characterised into the following land use types, adopted from previous surface water investigations (PB, 2009):

- Undisturbed
- Rehabilitated Spoil
- Industrial
- Open cut pit
- Active spoil

The model parameters are shown in Table 6.3.

Table 6.3 Adopted Rainfall-Runoff Parameters – AWBM Model

Parameter	Undisturbed	Rehabilitated Spoil	Industrial	Open Cut Pit*	Active Spoil
A1	0.134	0.134	0.134	0.2	0.136
A2	0.433	0.433	0.433	0.6	0.27
A3	0.433	0.433	0.433	0.2	0.594
C1	5.7	5.7	2.6	5	50
C2	57.8	57.8	26.7	70	100
C3	115.7	115.7	53.3	90	500
C_{avg}	76	76	35	61	331
K_b	0.993	0.933	1	1	1
BFI	0.39	0.39	0	0	0.103
Long-term Volumetric Runoff Coefficient	12.4%	12.4%	21.8%	15.7%	2.7%

* Note – Illogical values assumed to be a typographical error, have reversed storage capacities.

Existing catchment areas directed to the various onsite storages at Bengalla are presented in Figure 6.2, based on survey information dated July 2011 and aerial photography dated June 2012.

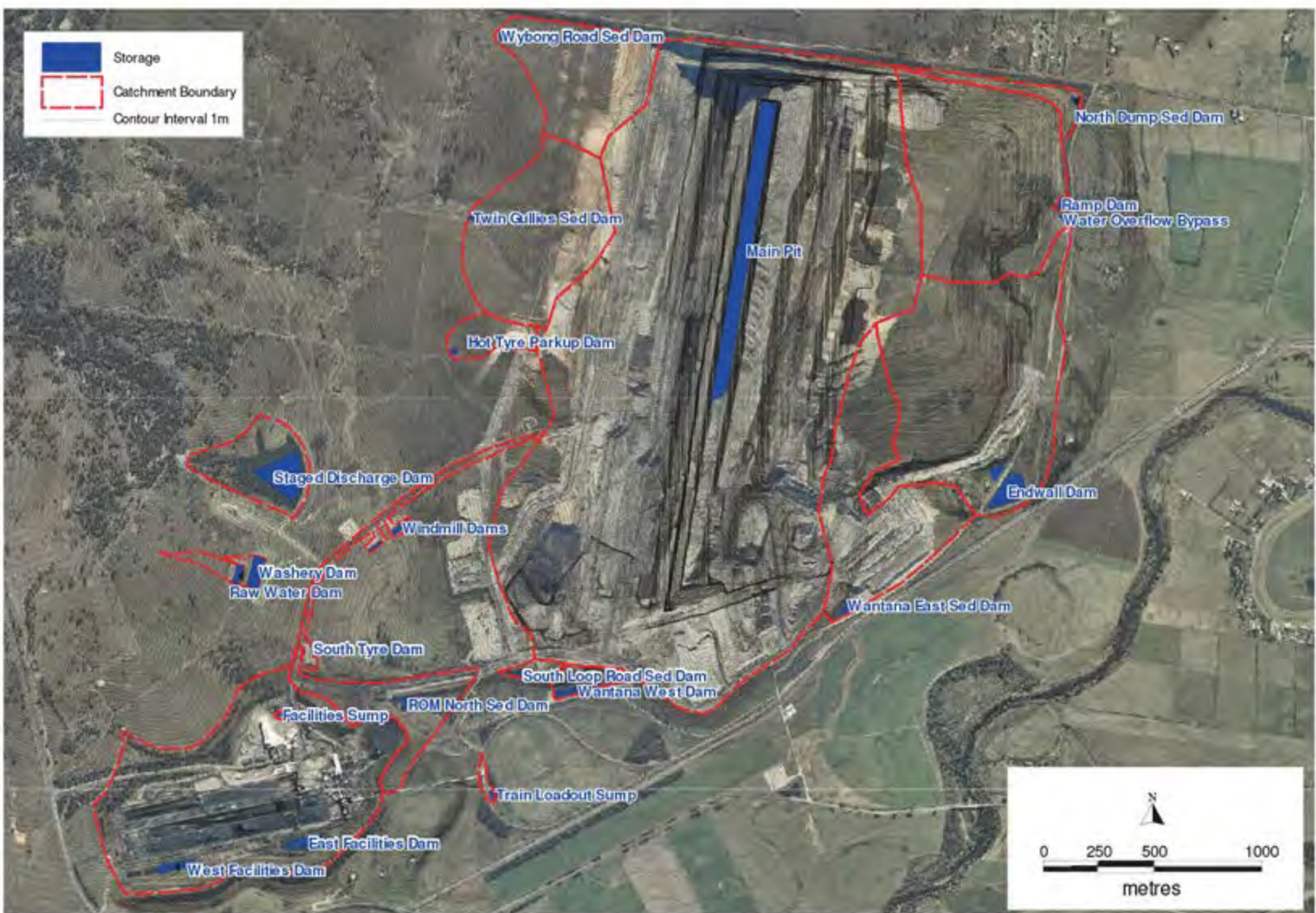


Figure 6.2 Bengalla Catchments - 2011

6.5 WATER BALANCE MODEL VERIFICATION

A verification of the Bengalla OPSIM model was undertaken over the period January 2010 to December 2011. Metered data was input directly into the model for the following flows:

- Hunter River Intake;
- Hunter River Discharges (under HRSTS);
- Haul road dust suppression (annual average); and
- CHPP throughput (annual average).

The verification was run with the following rainfall datasets for comparison purposes: Bengalla MET station, Data Drill rainfall (see Section 3.3) and the BOM station Muswellbrook Lower Hill Street #061053.

Catchments were based on survey dated July 2011, and land use classifications based on aerial photography dated January 2011.

Verification was undertaken as total site inventory of recorded volumes in the mine water storages across Bengalla. Results are presented in Figure 6.3. Review of the verification results indicates the model gives a good agreement with recorded inventories for 2010, and overestimates the site inventory for 2011. At this stage there is not enough information to suggest the rainfall runoff parameters require updating. The model is considered to provide a reasonable estimate of the overall site water balance at Bengalla.

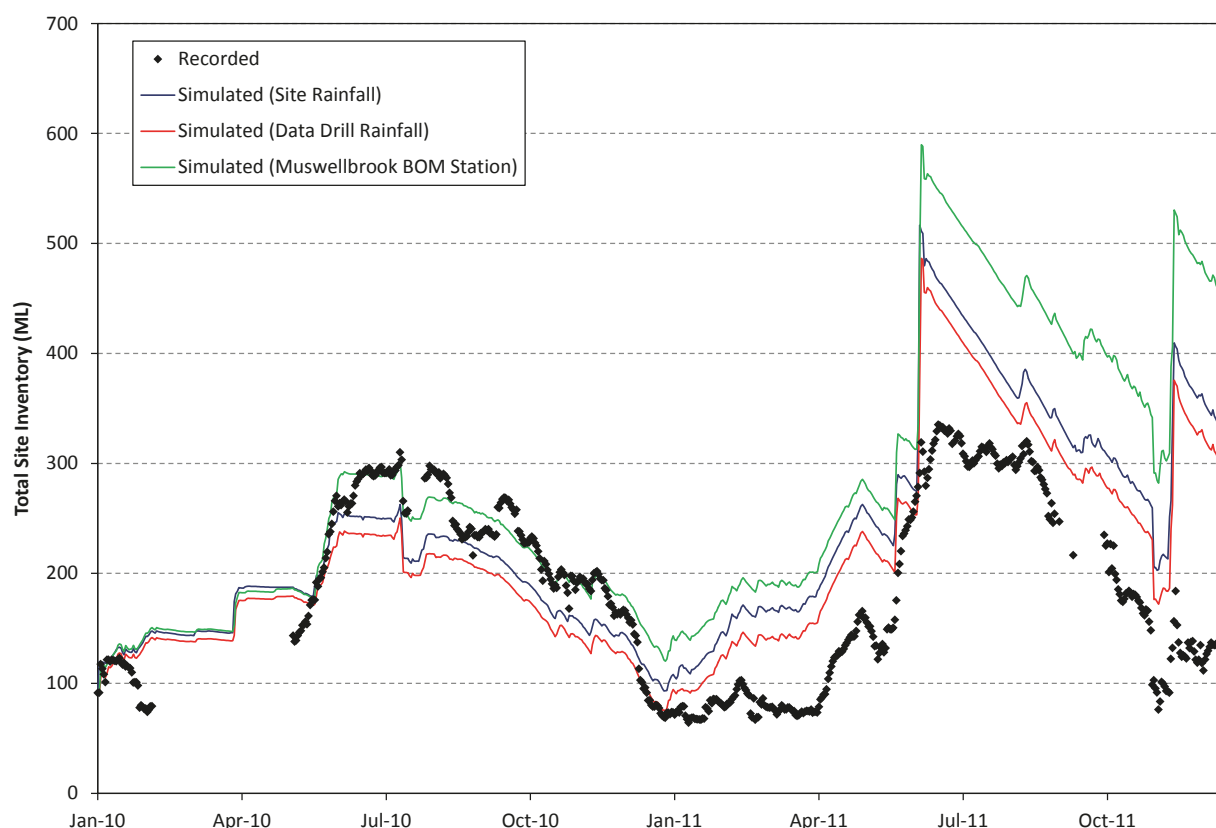


Figure 6.3 Bengalla OPSIM Verification – Total Stored Inventory, Simulated vs. Recorded (ML)

Table 6.4 shows a summary of the simulated water balance for Bengalla for the 2010/11 verification model, using the Data Drill rainfall. The following observations can be made:

Outflows

- Total water demand ranges between 700 and 820 ML/a.
- Total evaporation loss from storages ranges between approximately 115 and 170 ML/a.
- HRSTS discharges range between 40 and 110 ML/a.

Inflows

- Rainfall and runoff yield contributes between approximately 310 and 810 ML/a.
- Net groundwater inflows to open cut pits contributes approximately 50 ML/a.
- Raw water from the Hunter River Intake was approximately 500 ML/a.

Table 6.4 2010/11 Verification Model Water Balance

	2010	2011
Parameters		
CHPP Throughput (Mtpa)	5.36	5.37
Water Inputs (ML/a)		
Rainfall/Runoff Yield		
<i>Mine Water System</i>	293	779
<i>Clean Water System</i>	3	5
<i>Sedimentation System</i>	10	27
Total	306	810
Groundwater Inflows	51	51
Hunter River Intake	497	489
Gross Water Inputs	854	1,351
Water Outputs (ML/a)		
Evaporation from Storages		
<i>Mine Water System</i>	110	164
<i>Clean Water System</i>	4	4
<i>Sedimentation System</i>	1	1
Total	115	169
Dam Overflows (off-site)		
<i>Mine Water System</i>	0	0
<i>Clean Water System</i>	0	0
<i>Sedimentation System</i>	9	34
Total	9	34
HRSTS Discharges	49	109
CHPP Demand (Loss)	310	300
Stockpile Dust Suppression	115	115
Haul Road Dust Suppression	229	360
Vehicle Wash	43	43
Gross Water Outputs	869	1,129
Water Balance (ML/a)		
Change in Storage Volumes	-15	221
Gross Water Balance (deficit)	0	0

6.6 PROPOSED WATER MANAGEMENT SYSTEM

6.6.1 Water Management System Layout

The changes to the approved mine under the Project will result in a number of potential changes to the water management system layout. The revised proposed water management system is shown in the schematics in Figure 6.4 to Figure 6.8 at each of the mine stages utilised for this assessment (Year 1, 4, 8, 15 and 24). The mine stage plan layouts are presented in Figure 6.9 to Figure 6.13.

The water management system will evolve as the mine develops, simulated as follows:

- Year 1: Construction of the Bengalla North Sediment Dam, Wantana Central Sediment Dam and Bengalla East Sediment Dam. Main Pit has advanced so that dewatering is directed to Wantana West Dam only. Endwall Dam is no longer a pit water transfer dam, and now acts as a sediment dam for rehabilitated overburden runoff. Overburden emplacement has commenced at the Western OEA and runoff is collected via the Western OEA Sediment Dam B.
- Year 4: The Satellite Pit is active and dewateres to Wantana West Dam. The Bengalla Relocated Discharge Dam and Mount Pleasant Discharge Dam have been constructed to allow discharges to Dry Creek (downstream of the Satellite Pit). CW1 is operational on Dry Creek north of Wybong Road with clean water diverted to the discharge point as presented in Figure 5.3. Similarly, the Satellite Dam is constructed on Dry Creek north of the Satellite Pit with clean water diverted to the CW1 release point. The infrastructure area has been upgraded, including an additional stockpile capacity.
- Year 8: Satellite Pit has been mined through (including the Satellite Dam). The Western OEA is being mined through and runoff is collected via the Western OEA Sediment Dam A. Main Pit has progressed, mining out the Staged Discharge Dam and requiring relocation of the Washery Dam. Pit dewatering is transferred directly to the relocated Washery Dam (no longer to the Wantana West Dam). The Wantana West Dam now acts as a sediment dam for rehabilitated overburden runoff. The Proposed Diversion Dam collects clean water from the west of the pit highwall, which is dewatered to Dry Creek at the discharge point as presented in Figure 5.3.
- Year 15: Main Pit has progressed requiring relocation of the Raw Water Dam. The southern end of the Dry Creek relocation has commenced, including a temporary sediment dam (Creek Sediment Dam) to capture the runoff before rehabilitation occurs. The Western OEA has been mined through.
- Year 24: The Dry Creek relocation has been completed and the Dry Creek Clean Water Dam (CW1) and the Creek Sediment Dam are removed. The area to the east of the relocated Dry Creek is now completely rehabilitated. The Spare Dam collects clean water from the west of the pit highwall, which is dewatered to Dry Creek at the discharge point as presented in Figure 5.3.

Extension of the infrastructure area and stockpile area will require additional runoff capture capacity to ensure no uncontrolled overflows from the mine water system. The additional infrastructure area requires 100ML of additional water storage to capture surface runoff (assumed to be captured in the East & West Facilities Dams for modelling purposes), and the stockpile area extension requires 50ML of additional storage (assumed to be captured in the ROM Sediment Dams for modelling purposes). This additional storage would be accommodated by enlarging the existing dams or alternatively, subject to detailed design considerations, accommodated within new dams within the Project Disturbance Boundary.

6.6.2 Proposed Mine Water Storages

A number of storages are proposed as part of the Project water management system, including:

- the relocated discharge dam, raw water dam and washery dam;
- new sediment dams for treatment of runoff from future disturbed areas;
- additional storage capacity required for the infrastructure expansion area and additional stockpile areas;
- The Dry Creek Clean Water Dam (CW1) proposed as part of the Dry Creek diversion; and
- The highwall clean water diversion dams: Satellite Dam, Diversion Dam and Spare Dam.

Summary details of the capacity and classification of the proposed storages are shown in Table 6.5. The locations of these dams are shown in Figure 6.9 to Figure 6.13.

Table 6.5 Bengalla Water Management Structures - Proposed

Dam	Capacity	Classification
Bengalla Relocated Discharge Dam	300	Mine water
Additional Facilities Dam	100	Mine water
Additional Stockpile Area Dam	50	Mine water
Dry Creek Clean Water Dam (CW1)	900	Clean water
Bengalla East Sedimentation Dam*	43	Sediment Dam
Bengalla North Sedimentation Dam*	106	Sediment Dam
Wantana Central Sedimentation Dam*	22	Sediment Dam
Spare Dam	100**	Clean water
Western OEA Sedimentation Dam A*	26	Sediment Dam
Western OEA Sedimentation Dam B	17	Sediment Dam
Relocated Washery Dam	25	Mine water
Relocated Raw Water Dam	5	Clean water
Creek Sedimentation Dam*	36	Sediment Dam
Satellite Dam	500**	Clean water
Diversion Dam	400**	Clean water

Notes: * Refer Section 6.6.7 for further information on Sediment Dam sizing.
 ** Nominal. To be confirmed as part of detailed design.

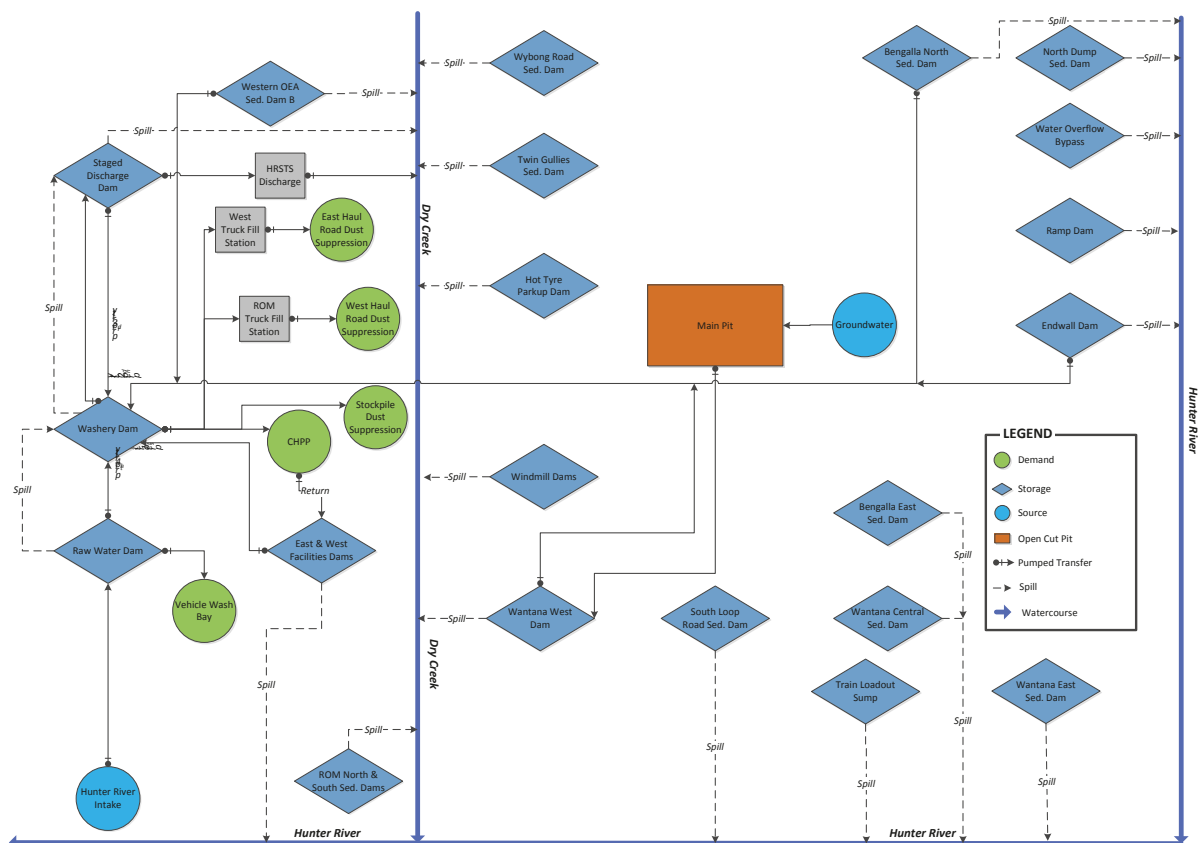


Figure 6.4 Bengalla Water Management System Schematic - Year 1

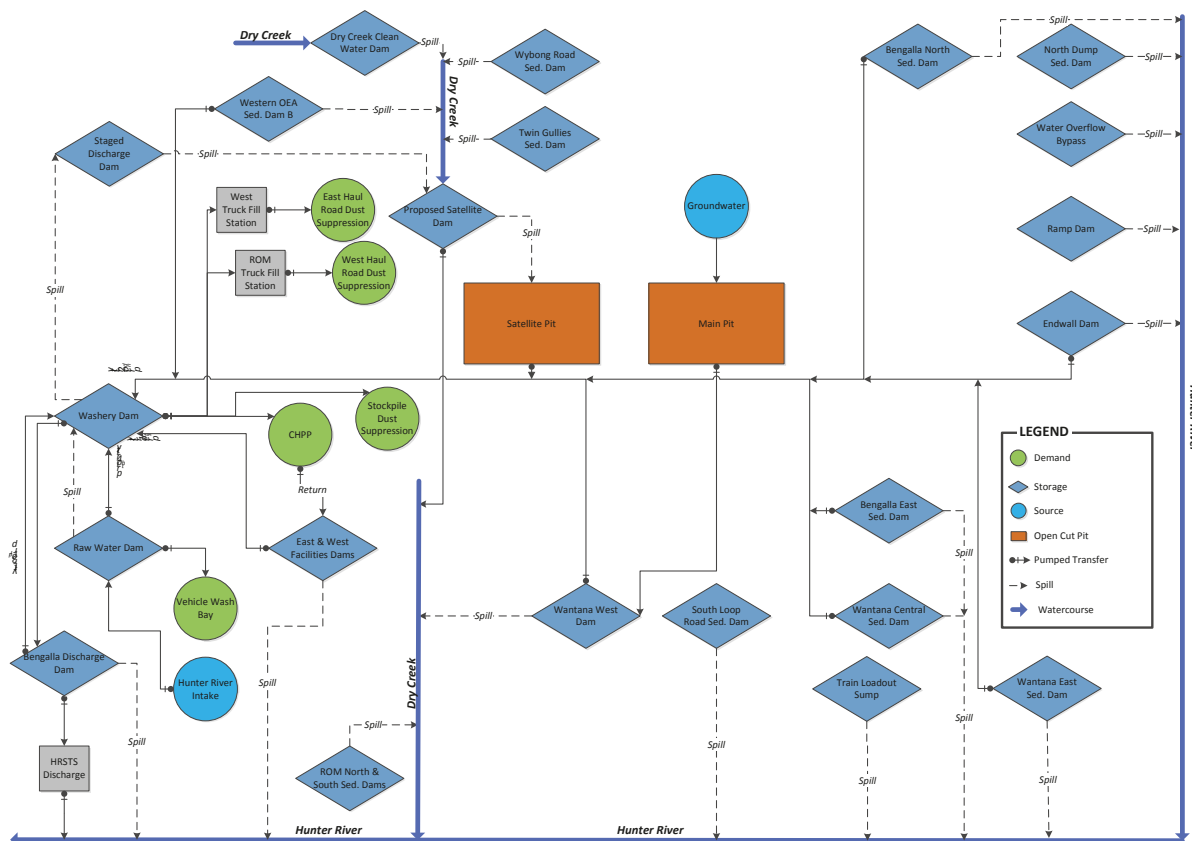


Figure 6.5 Bengalla Water Management System Schematic - Year 4

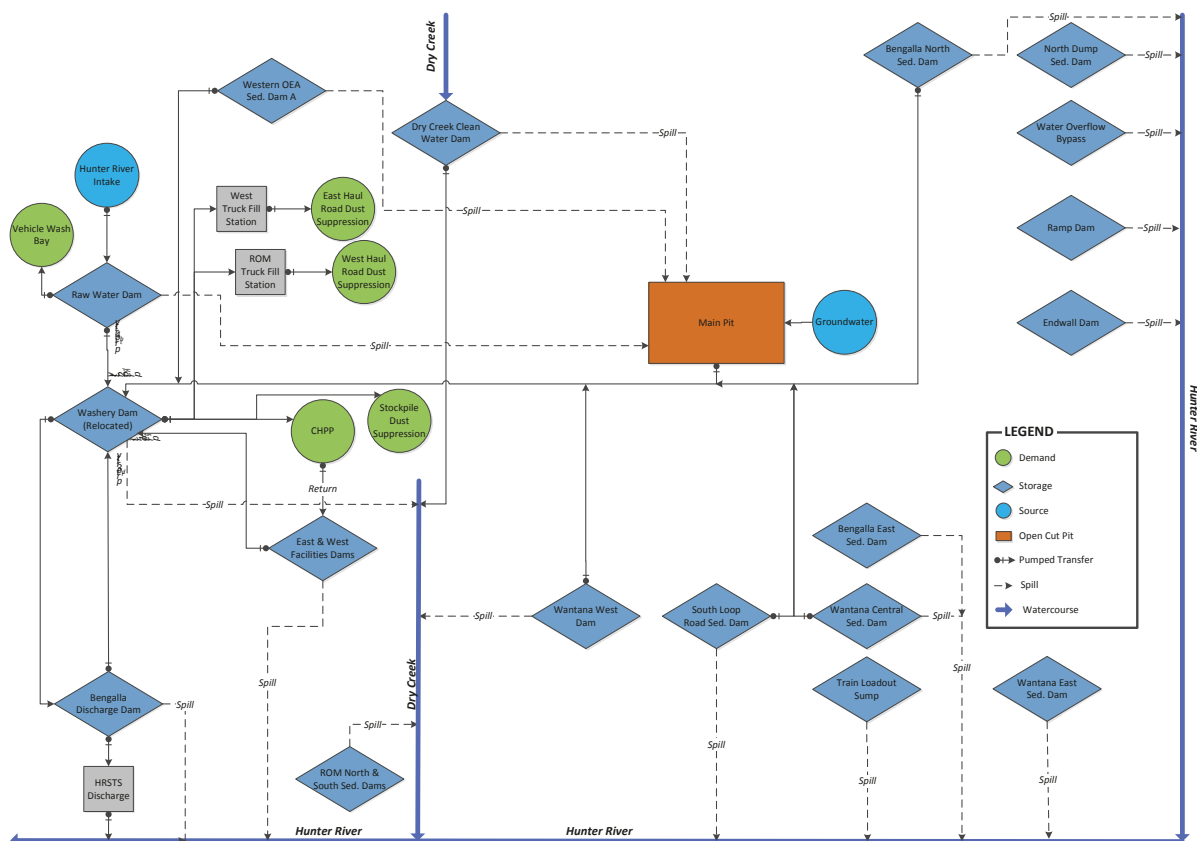


Figure 6.6 Bengalla Water Management System Schematic – Year 8

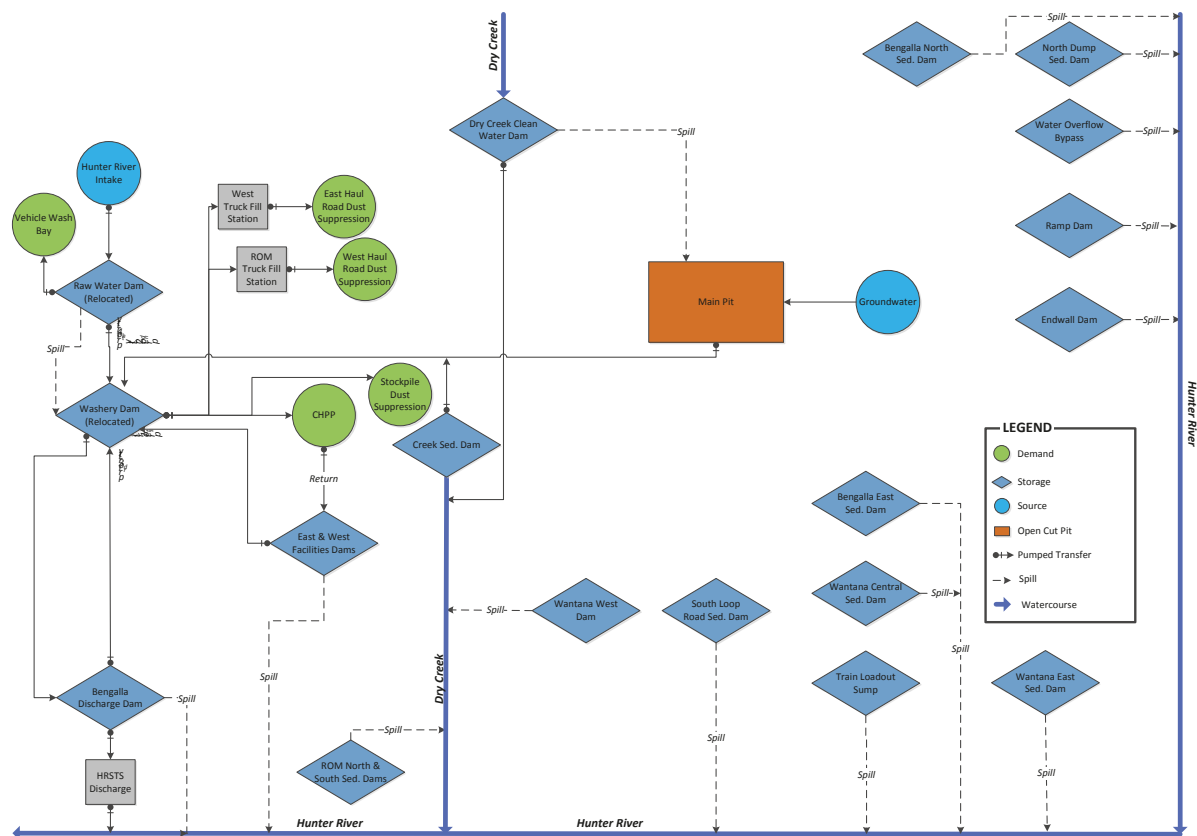


Figure 6.7 Bengalla Water Management System Schematic – Year 15

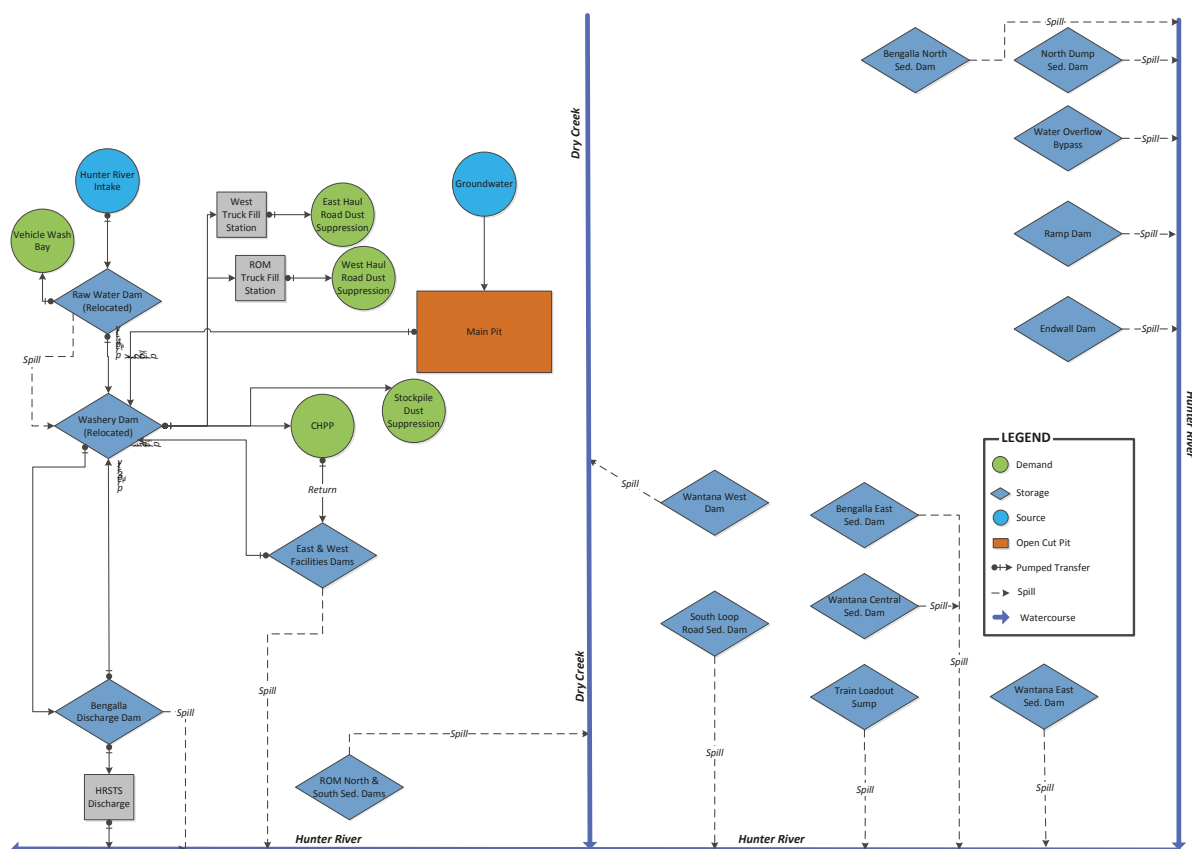


Figure 6.8 Bengalla Water Management System Schematic – Year 24

6.6.3 Groundwater Inflows

Adopted groundwater inflows are shown in Table 6.6 (AGE, 2012). The inflows have been corrected for evaporation so that they reflect the ‘pumpable’ seepage inflows from groundwater to the open cut pit(s), and averaged over the modelled period of the mine stage. The volume of ‘pumpable’ inflows is the total volume of seepage minus losses due to evaporation. The volume of pumpable inflows will be zero where the evaporation rate exceeds the seepage rate.

Table 6.6 Groundwater Inflows to Open Cut Pit (AGE, 2012)

Mine Stage	‘Pumpable’ Groundwater Inflows	
	ML/d	ML/a
Year 1	0.544	199
Year 4	0.038	14
Year 8	0	0
Year 15	0.008	3
Year 24	0	0

6.6.4 Catchments and Land Use Classifications

The changes in the physical layout are represented in the mine stage plans given in Figure 6.9 to Figure 6.13 for Years 1, 4, 8, 15 and 24 respectively. Catchment areas (separated by the different land use types) reporting to the mine site storages are provided in Table 6.8 to Table 6.12.

6.6.5 Water Quality

Water quality as salinity (electrical conductivity) is modelled in the water balance as a catchment salts generation rate. Salts generation rates for the various land use types are based on analysis of the site water dams water quality monitoring (refer Section 3.6.1). Table 6.7 shows the salts generation rates adopted in the water balance model. Table 6.7 also shows the adopted open cut pit groundwater inflow salt concentration, based on groundwater quality monitoring results.

Table 6.7 Adopted Water Quality Salts Generation Rates

Land Use	Salt Generation Rate ($\mu\text{S}/\text{cm}$)	Basis
Undisturbed	240	Average of Twin Gullies Sedimentation Dam and Wantana Sedimentation Dam (August 2009)
Rehabilitated Spoil	500	Lower envelope of Endwall Dam & Endwall Sedimentation Dam (January 2007 to July 2011)
Industrial	1,700	Average EC of East & West Windmill Dams (January 2007 to July 2011)
Open Cut Pit	5,000	Upper envelope of Endwall Dam & Endwall Sedimentation Dam (January 2010 to July 2011)
Active Spoil	1,000	Average EC of MTA Pit Sedimentation Dam (December 2008 to March 2009)
Groundwater	1,300	Average EC of alluvial aquifer monitoring (May 1999 to June 2011)
Hunter River Intake	550	Average EC of Hunter River at W04 (2006 to 2011)



Figure 6.9 Bengalla Catchments & Land Use Classifications – Year 1

Table 6.8 Year 1 Catchment and Land Use Classifications (ha)

Storage	Undisturbed	Rehabilitation	Industrial	Overburden	Active Pit	Total
Bengalla East Sedimentation Dam		38.4				38.4
Bengalla North Sedimentation Dam		39.3		4.5		43.8
East & West Facilities Dams	1.8	39.6	47.8			89.3
Endwall Dam		95.2				95.2
Facilities Sump			0.1			0.1
Hot Tyre Parkup Dam	4.3		1.6			5.9
Main Pit	6.9		24.9	226.8	26.7	285.3
North Dump Sedimentation Dam		4.8				4.8
Ramp Dam		0.2				0.2
Raw Water Dam	2.0					2.0
ROM North Sedimentation Dam	7.9	0.7	3.5			12.2
South Loop Road Sedimentation Dam		0.7	1.0			1.6
South Tyre Dam			1.2			1.2
Staged Discharge Dam	12.0					12.0
Train Loadout Sump	0.7		0.1			0.8
Twin Gullies Sedimentation Dam	19.0		10.2			29.2
Wantana Central Sedimentation Dam		9.1				9.1
Wantana East Sedimentation Dam		62.6				62.6
Wantana West Dam		3.6				3.6
Washery Dam	1.5					1.5
Water Overflow Bypass		69.6				69.6
Western OEA Sedimentation Dam B	16.1			9.7		25.9
Windmill Sedimentation Dams			5.2			5.2
Wybong Rd Sedimentation Dam	7.1		6.0			13.1
Total	79.3	364	102	241	27	812.3

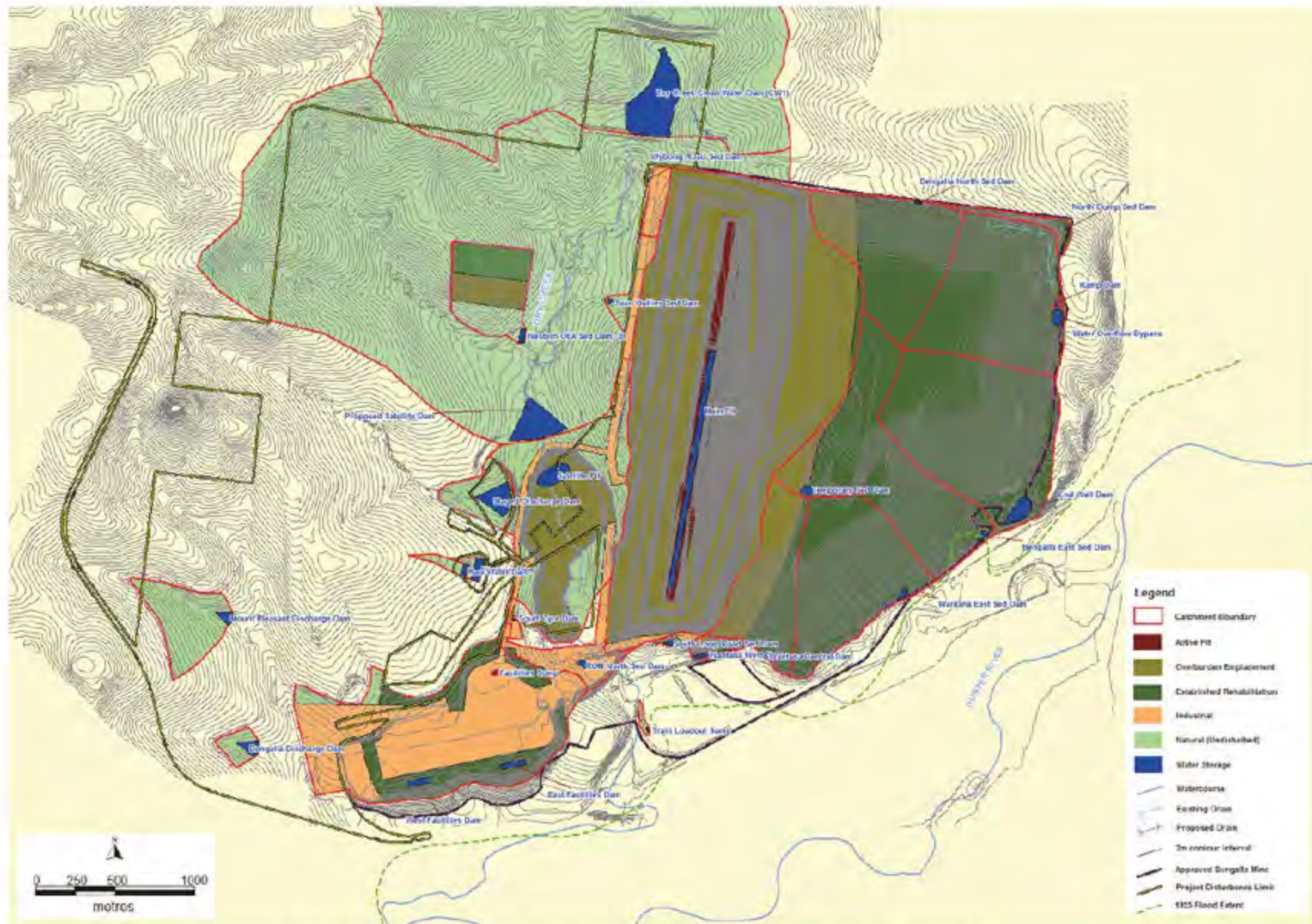


Figure 6.10 Bengalla Catchments & Land Use Classifications – Year 4

Table 6.9 Year 4 Catchments and Land Use Classifications (ha)

Storage	Undisturbed	Rehabilitation	Industrial	Overburden	Active Pit	Total
Bengalla Relocated Discharge Dam	4.2					4.2
Bengalla East Sedimentation Dam		68.6		6.6		75.2
Bengalla North Sedimentation Dam		43.6		9.9		53.5
Dry Creek Clean Water Dam (CW1)	646.9					646.9
East & West Facilities Dams	4.1	33.7	78.8			116.6
Endwall Dam		87.5				87.5
Facilities Sump			0.1			0.1
Main Pit		1.8	2.0	272.4	31.7	307.9
North Dump Sedimentation Dam		4.8				4.8
Ramp Dam		0.2				0.2
Raw Water Dam	2.0					2.0
ROM North Sedimentation Dam		0.7	13.5			14.2
Satellite Dam	407.7					407.7
Satellite Pit	31.3		13.1	41.1		85.5
South Loop Road Sedimentation Dam		0.7	1.0			1.6
South Tyre Dam			1.2			1.2
Staged Discharge Dam	12.0					12.0
Train Loadout Sump	0.7		0.1			0.8
Twin Gullies Sedimentation Dam	2.2		5.7			7.8
Wantana Central Sedimentation Dam		14.9		21.8		36.7
Wantana East Sedimentation Dam		59.4				59.4
Wantana West Dam		0.9		2.6		3.6
Washery Dam	1.5					1.5
Water Overflow Bypass		69.6				69.6
Western OEA Sedimentation Dam B	7.8	9.7		8.3		25.9
Wybong Road Sedimentation Dam	0.4		5.0			5.4
Total	1,121	396.1	120	362.8	32	2,032

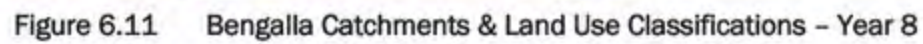


Table 6.10 Year 8 Catchments and Land Use Classifications (ha)

Storage	Undisturbed	Rehabilitation	Industrial	Overburden	Active Pit	Total
Bengalla Relocated Discharge Dam	4.2					4.2
Bengalla East Sedimentation Dam		68.6		7.5		76.1
Bengalla North Sedimentation Dam		43.6		15.8		59.4
Diversion Dam (Clean Water)	366.6					366.4
Dry Creek Clean Water Dam (CW1)	646.9					646.9
East & West Facilities Dam	17.2	28.5	88.0	0.1		133.8
Endwall Dam		87.5				87.5
Facilities Sump			0.1			0.1
Main Pit	88.0	1.9	67.5	435.4	55.8	648.7
North Dump Sedimentation Dam		4.8				4.8
Ramp Dam		0.2				0.2
Raw Water Dam	2.0					2.0
ROM North Sedimentation Dam			5.6	0.3		5.9
South Loop Road Sedimentation Dam		0.7		23.3		24.0
Train Loadout Sump	0.7		0.1			0.8
Wantana Central Sedimentation Dam		14.9		21.8		36.7
Wantana East Sedimentation Dam		59.4				59.4
Wantana West Dam (Sedimentation)		0.9		2.6		3.6
Washery Dam (Relocated)	4.3					4.3
Water Overflow Bypass		69.6				69.6
Western OEA Sedimentation Dam A	22.6			23.5		46.1
Total	1,153	381	161	530	56	2,281

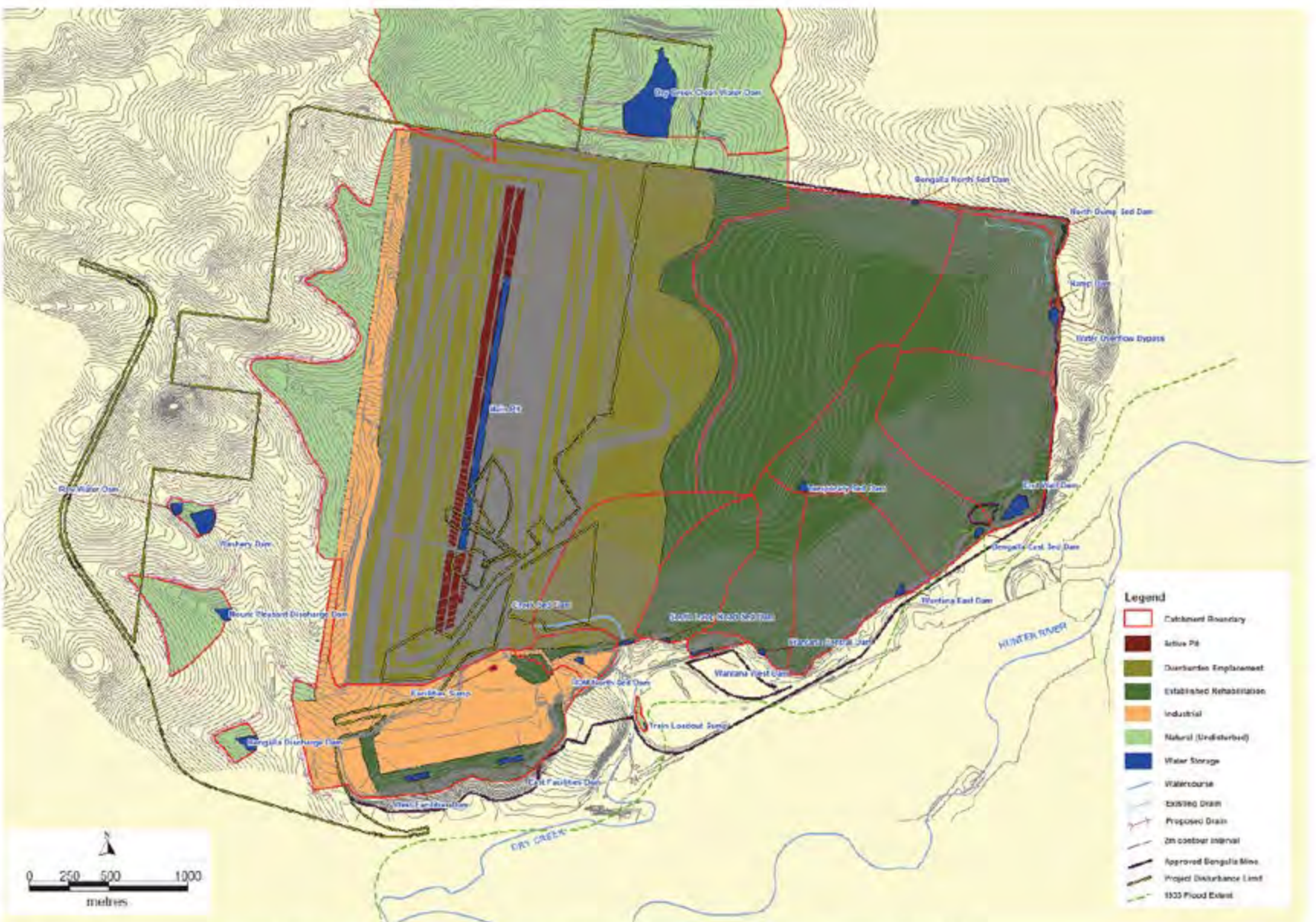


Figure 6.12 Bengalla Catchments & Land Use Classifications – Year 15

Table 6.11 Year 15 Catchments and Land Use Classifications (ha)

Storage	Undisturbed	Rehabilitation	Industrial	Overburden	Active Pit	Total
Bengalla Relocated Discharge Dam	4.2					4.2
Bengalla East Sedimentation Dam		73.1				73.1
Bengalla North Sedimentation Dam		186.1				186.1
Creek Sedimentation Dam		9.5		52.9		62.4
Dry Creek Clean Water Dam (CW1)	646.9					646.9
East & West Facilities Dam	1.5	25.0	94.4			120.9
Endwall Dam		87.3				87.3
Facilities Sump			0.1			0.1
Main Pit	95.9	33.4	48.5	494.0	54.4	726.3
North Dump Sedimentation Dam		4.8				4.8
Ramp Dam		0.2				0.2
Raw Water Dam (Relocated)	0.8					0.8
ROM North Sedimentation Dam		2.9	6.1	4.4		13.4
South Loop Road Sedimentation Dam		38.2				38.2
Train Loadout Sump	0.7		0.1			0.8
Wantana Central Sedimentation Dam		38.0				38.0
Wantana East Sedimentation Dam		59.4				59.4
Wantana West Dam (Sedimentation)		3.6				3.6
Washery Dam (Relocated)	3.5					3.5
Water Overflow Bypass		69.8				69.8
Total	754	631	149	551	54	2,140

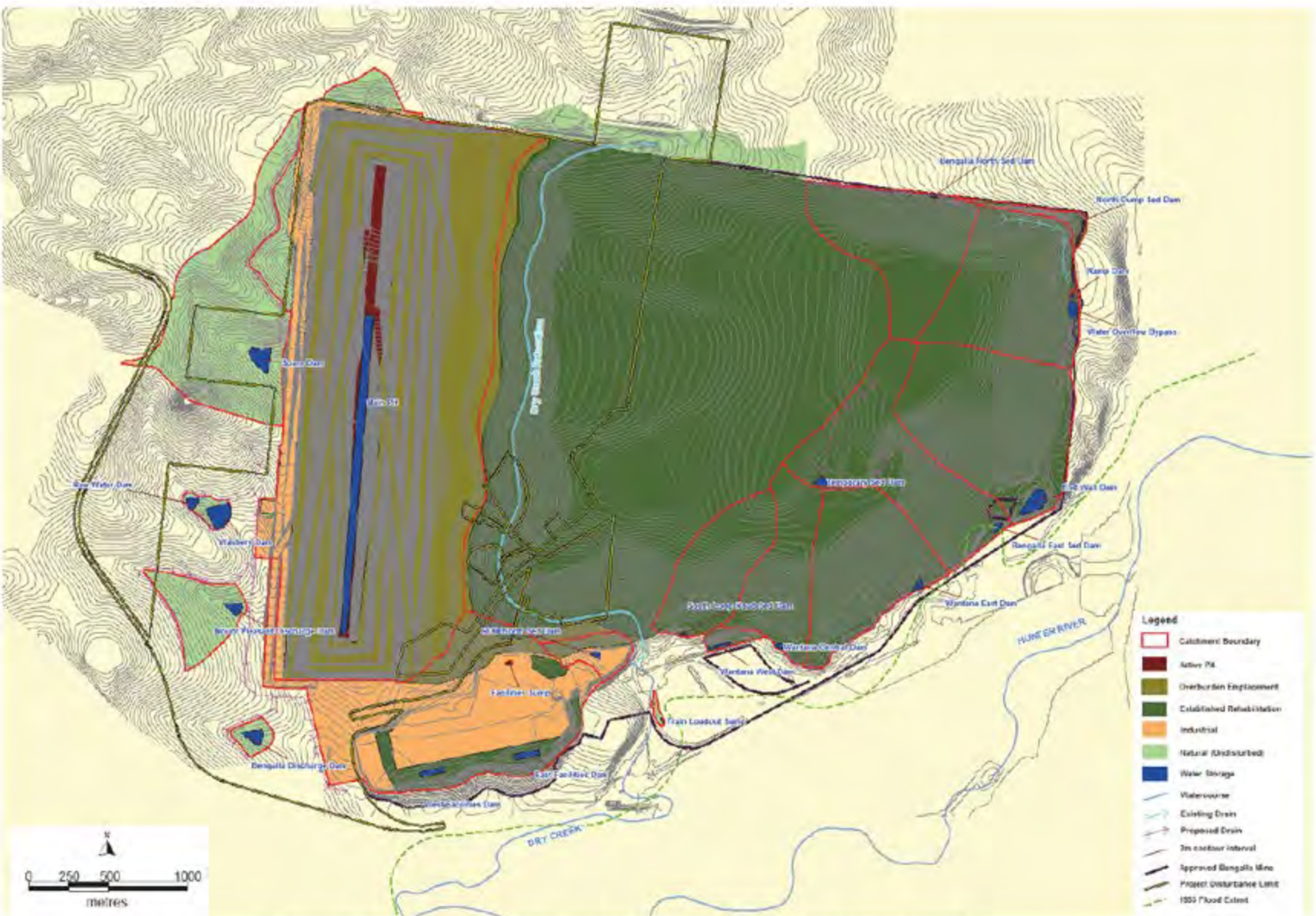


Figure 6.13 Bengalla Catchments & Land Use Classifications - Year 24

Table 6.12 Year 24 Catchments and Land Use Classifications (ha)

Storage	Undisturbed	Rehabilitation	Industrial	Overburden	Active Pit	Total
Bengalla Relocated Discharge Dam	4.2					4.2
Bengalla East Sedimentation Dam		73.2				73.2
Bengalla North Sedimentation Dam		59.1				59.1
East & West Facilities Dam		26.7	95.0	14.4		136.2
Endwall Dam		87.5				87.5
Facilities Sump			0.1			0.1
Main Pit	20.2		42.0	350.1	55.4	467.7
North Dump Sedimentation Dam		4.8				4.8
Ramp Dam		0.2				0.2
Raw Water Dam (Relocated)	0.8					0.8
ROM North Sedimentation Dam			5.5	4.4		9.9
South Loop Road Sedimentation Dam		38.2				38.2
Spare Dam	83.8					83.8
Train Loadout Sump	0.7		0.1			0.8
Wantana Central Sedimentation Dam		38.0				38.0
Wantana East Sedimentation Dam		59.4				59.4
Wantana West Dam (Sedimentation)		3.6				3.6
Washery Dam (Relocated)	3.5					3.5
Water Overflow Bypass		69.6				69.6
Total	114	460	143	369	55	1,141

6.6.6 Water Demands

Coal Handling & Preparation Plant

A production profile for the Project has been provided, with the maximum ROM throughput of 15Mtpa modelled from Year 4. The net CHPP demand is presented in Table 6.13.

Table 6.13 Net CHPP Water Loss

Mine Stage	CHPP Throughput (Mtpa)	Net CHPP Demand (ML/a)
1	10.7	830
4 - 24	15.0	1,164

The net CHPP demand is based on the average plant usage of 77.6L/ROM tonne (wet) which is based on recorded net water use during the 2011 calendar year.

Stockpile Dust Suppression

Stockpile dust suppression rates have been estimated by BMC. A proposed expansion to the stockpile area in Year 4 will increase dust suppression requirements. Adopted total dust suppression requirements are as follows:

- Existing & Year 1: 115 ML/a
- Year 4 – Year 24: 150 ML/a

Haul Road Dust Suppression

A dry day haul road watering rate of 1.9mm/d was determined based on the average recorded rate over the period 2007 to 2011.

The Project will increase the control rate to 85% for haul road dust suppression, which requires an increase in the watering rate by approximately 66% to 3.1mm/d (J Martin 2012, pers. comm., 15 October). This rate has been adopted and applied to the varying watered haul road length as the mine develops, with an assumed watered width of 25m. The resultant average dust suppression water requirements are presented in Table 6.14 below. Estimates of haul road lengths were based on mine plan information as presented in Figure 6.9 to Figure 6.13.

Table 6.14 Estimated Haul Road Dust Suppression Requirements

Mining Stage	Dust Suppression Area (ha)	85% Control	
		Maximum Daily Dust Suppression (kL/d)*	Yearly Average Dust Suppression (ML/a)**
Year 1	42.0	1,319	408
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

* For a non-rainfall (0mm) day.

** Based on long-term average including rainfall days.

Vehicle Washdown

It is assumed that vehicle washdown is proportional to throughput, and will be adjusted accordingly for the water balance modelling for the Project. The demand rate is based on the 2008 vehicle wash usage.

Demand Summary

A summary of site demands is presented in Table 6.15.

Table 6.15 Summary of the Project Site Demands – Net Usage

Mining Stage	Site Demands (ML/a)				
	CHPP Net Demand	Stockpile Dust Suppression	Haul Road Dust Suppression	Net Vehicle Washdown	Total Site Demand
Year 1	830	115	408	97	1,450
Year 4	1,164	150	457	132	1,903
Year 8	1,164	150	437	132	1,883
Year 15	1,164	150	527	132	1,973
Year 24	1,164	150	509	132	1,955

6.6.7 Proposed Sediment Dams

Figure 6.9 to Figure 6.13 present indicative locations of proposed sediment dams, and associated drainage requirements and catchment areas. All sediment dams will be sized according to Blue Book (DECC, 2008) requirements for Type D Basins. Adopted sediment dam sizes are shown in

. Note that the pump rates shown in

are based on a 5 day management period. To reduce these required pumping rates, the guidelines specify adjustment factors to the 5-day volumes for alternate management periods as 85% for 2 days, 125% for 10 days, and 170% for 20 days.

It is proposed to use the Endwall Dam and West Wantana Dam as sediment dams once they are no longer part of the mine water system. It is also proposed to enlarge the South Loop Road Sediment Dam. Alternatively, new sediment dams may be constructed in these locations with the volumes specified in Table 6.16 to the same effect.

Table 6.16 Proposed Sedimentation Dam Sizing

Sediment Dam	Catchment Area* ¹ (ha)	5-Day Volume (ML)	5-Day Pump Out Rate (L/s)	Construct Prior to
Bengalla East Sedimentation Dam	76.1	43	100	Year 1
Bengalla North Sedimentation Dam	186.1	106	250	Year 1
Creek Sedimentation Dam	62.4	36	80	Year 15
Endwall Dam	95.2	80* ²	125	Existing
South Loop Road Sedimentation Dam	38.2	22	50	Existing – needs to be enlarged by Year 8
Wantana Central Sedimentation Dam	38.0	22	50	Year 1
Wantana East Sedimentation Dam	62.6	36	80	Existing, needs to be enlarged by Year 1
West Wantana Dam	3.6	16* ²	5	Existing
Western OEA Sedimentation Dam A	46.1	26	60	Year 8
Western OEA Sedimentation Dam B	29.5	17	40	Year 1

Note: *¹ Maximum catchment area reporting to sediment dam over Project life.

*² Existing capacity is greater than required for sediment treatment.

6.6.8 Hunter River Salinity Trading Scheme

The HRSTS discharges have been modelled as follows:

1. Hunter River Streamflow time series – simulated streamflow data was obtained from the NSW Office of Water IQQM model (this model is still under review and not yet signed off for Water Sharing Plan Rules) for the period 1/1/1900 to 30/6/2007.
2. Salinity – Recorded salinity data was obtained for the Hunter River at Denman (#210055) from PINEENA, covering the period February 1993 to October 2010. Based on the recorded historical data, a relationship between streamflow and water quality was developed. EC's for high flows only (1,000 – 4,000 ML/d) were plotted against flow rates and a logarithmic trend line fitted to the data, giving salinity as a function of flow rate.
3. Using IQQM flows at Denman, Glennies Creek and Singleton – the flow is classified at Denman as low, high or flood on a daily basis (e.g. flow at Denman is only high if high in all sectors).
4. The salinity function is then applied to get a Hunter River flow and EC time series at Denman which is used in OPSIM as the reference node.
5. In OPSIM, controlled discharges were simulated using an Environmental Transfer (ETN) node with two 'rules' for discharge. Rule 1 limits the volume of discharges based on the flow rates in the Hunter River, as shown in Table 6.17. Rule 2 limits the salt load discharged based on the salinity in the Hunter River, as shown in Table 6.18.

Table 6.17 HRSTS Rule 1 (Volume Limit Rating)

Hunter River Q _{ref} (ML/d)	Site Discharge Q _{max} (ML/d)	Apply Rule 2	Comment
0	0	x	No site discharges allowed when Hunter River flows are <1,000 ML/d.
999	0	x	
1,000	200	✓	When Hunter River flows are 1,000 -4,000 ML/d, up to 200 ML/d can be discharged from site, with salinity restrictions as per 'Rule 2'.
4,000	200	✓	
> 4,000	200	x	When Hunter River flows are >4,000 ML/d, up to 200 ML/d can be discharged from site, with no salinity restrictions.

Where:

- Q_{ref} is the reference volume [ML/d] (in this case, the Hunter River).
- Q_{max} is the discharge limit [ML/d] for Q_{ref}.

Table 6.18 HRSTS Rule 2 (TDS Rating)

Method	Cr (µS/cm)	K Value	Comment
K + Cr	0	600	If the EC in the Hunter River is zero, the concentration in the Hunter River can increase by up to 600 µS/cm due to discharges under the HRSTS.
K + Cr	600	0	If the EC in the Hunter River is 600 µS/cm, the concentration in the Hunter River can increase by zero µS/cm due to discharges under the HRSTS.

Where:

- Cr is the concentration at the Reference Node (in this case, the Hunter River).
- K is concentration increase (linearly interpolated between the specified values).
- Limiting transfer concentration is calculated as K+Cr.

For the purposes of the water balance modelling, it has been assumed that a low water inventory trigger of 200ML is set on the Staged Discharge Dam/Bengalla Relocated Discharge Dam and Main Pit (i.e. no discharges if volume in Staged Discharge Dam + Main Pit < 200ML). For the purposes of the water balance modelling it is assumed that the Washery Dam transfers to the Staged Discharge Dam when it reaches >80% capacity (20ML).

A sample of the simulated Discharge Dam behaviour is shown in Figure 6.14, including simulated Hunter River flows and salinity (at Denman), Pit and Discharge Dam stored inventories and simulated discharges from the Discharge Dam under the HRSTS.

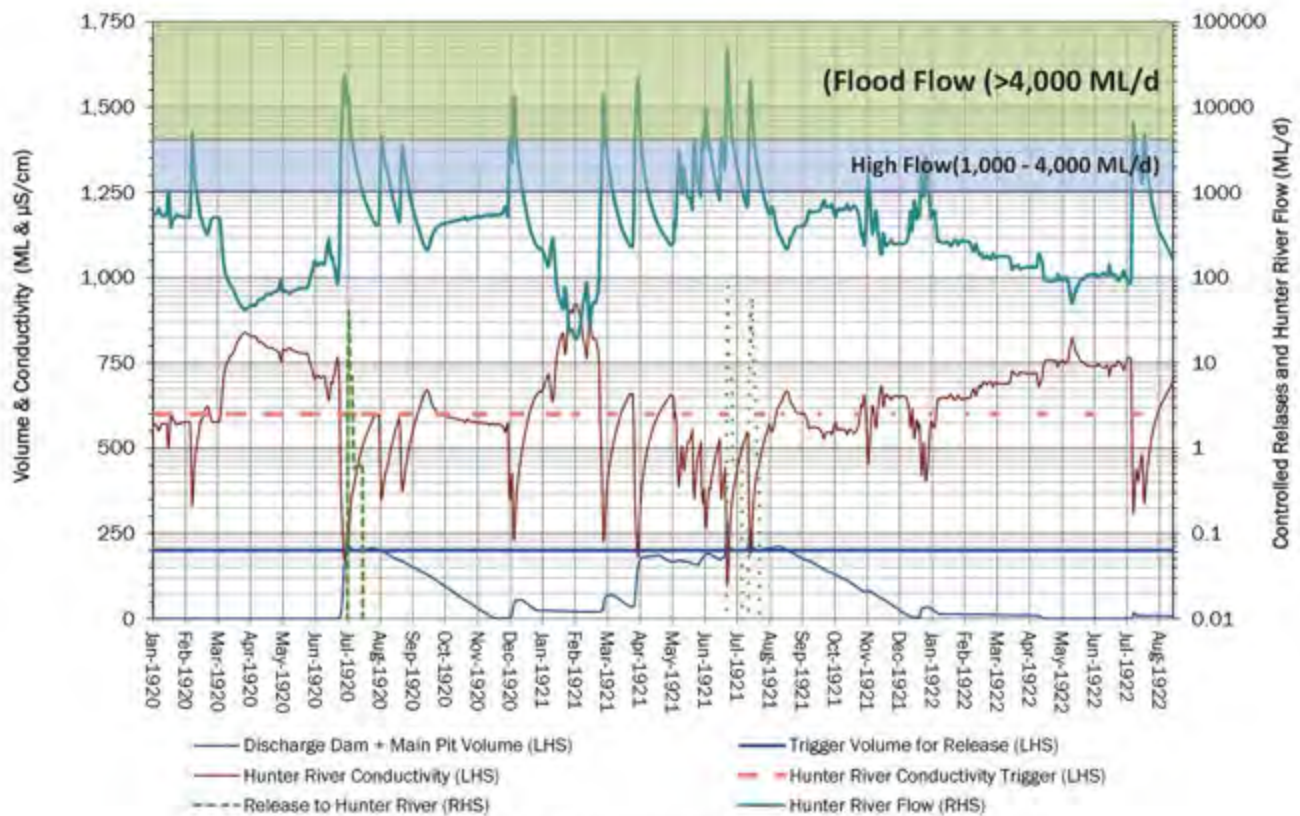


Figure 6.14 Sample of Simulated Discharge Dam Behaviour

6.7 WATER BALANCE MODEL RESULTS

6.7.1 Overview

The Project water balance model results are presented for two types of simulation methodologies: static and forecast. The overall site water balance presented in Section 6.7.2 is based on a long-term static simulation of each mine stage, whereas the results presented in Sections 6.7.3 to 6.7.6 are based on the dynamic forecast simulation methodology. Refer to Section 6.2 for a more detailed description of the simulation methodologies.

6.7.2 Overall Site Water Balance

The predicted overall average annual site water balance is summarised in Table 6.19; based on 'static' simulations of each mine stage over 114 years of historical climate data. The static simulation provides a snapshot of selected mine plans so that the average site water balance can be reporting over long term historical climate data. In summary, the following observations can be made on the average annual water balance over the Project life:

Outflows

- Total water demand ranges between 1,451 ML/a and 1,974 ML/a.
- Total evaporation loss from storages ranges between 57 and 115 ML/a.
- HRSTS discharges range between 19 and 85 ML/a.
- Clean water pumped from clean water dams (CW1, Satellite Dam, Diversion Dam and Spare Dam) to Dry Creek ranges from 0 ML/a to 779 ML/a.

Inflows

- Rainfall and runoff yield contributes between 557 to 1,469 ML/a.
- Net groundwater inflow to open cut pits contributes between 0 and 199 ML/a.
- Raw water from the Hunter River Intake ranges between 972 and 1,345 ML/a.
- Additional external water supply requirements (beyond current Hunter River licensed extraction volume) ranges from 3 to 163 ML/a.

The assessment also considered the water balance for very dry conditions. Table 6.20 lists the predicted inflows and outflows based on climatic data for the year 1980 which was the driest year on record.

Table 6.19 Average Annual Water Balance

	Year 1	Year 4	Year 8	Year 15	Year 24
Water Inputs (ML/a)					
Rainfall/Runoff Yield					
<i>Mine Water System</i>	210	299	443	453	342
<i>Clean Water System</i>	3	765	733	468	64
<i>Sedimentation System</i>	344	336	294	435	325
Total	557	1,400	1,469	1,356	731
Groundwater Inflows	199	14	0	3	0
Hunter River Intake	972	1,323	1,267	1,263	1,345
Gross Water Inputs	1,727	2,736	2,736	2,622	2,076
Water Outputs (ML/a)					
Evaporation from Storages					
<i>Mine Water System</i>	19	35	21	22	19
<i>Clean Water System</i>	4	9	9	9	9
<i>Sedimentation System</i>	92	50	27	45	40
Total	115	93	57	75	68
Dam Overflows (off-site)					
<i>Mine Water System</i>	0	0	0	0	0
<i>Clean Water System</i>	0	0	0	0	0
<i>Sedimentation System</i>	145	69	74	136	110
Total	145	69	74	136	110
HRSTS Discharges	19	19	82	85	44
CHPP Demand (Loss)	830	1,164	1,164	1,164	1,164
Stockpile Dust Suppression	115	150	150	150	150
Haul Road Dust Suppression	409	458	438	528	510
Vehicle Wash	97	132	132	132	132
Clean Water Pumped to Dry Creek	0	779	728	464	60
Gross Water Outputs	1,730	2,864	2,825	2,735	2,239
Water Balance (ML/a)					
Change in Storage Volumes	0	0	0	0	0
Gross Water Balance (deficit)	3	128	89	114	163

Table 6.20 1980 Climatic Conditions (Very Dry) Water Balance

	Year 1	Year 4	Year 8	Year 15	Year 24
Water Inputs (ML/a)					
Rainfall/Runoff Yield					
<i>Mine Water System</i>	22	35	45	45	35
<i>Clean Water System</i>	1	88	84	54	8
<i>Sedimentation System</i>	40	38	31	48	37
Total	62	161	160	147	81
Groundwater Inflows	199	14	0	3	0
Hunter River Intake	1,205	1,676	1,666	1,709	1,710
Gross Water Inputs	1,466	1,851	1,826	1,859	1,791
Water Outputs (ML/a)					
Evaporation from Storages					
<i>Mine Water System</i>	13	41	11	11	11
<i>Clean Water System</i>	5	9	9	9	9
<i>Sedimentation System</i>	23	9	7	15	14
Total	40	59	27	34	34
Dam Overflows (off-site)					
<i>Mine Water System</i>	0	0	0	0	0
<i>Clean Water System</i>	0	0	0	0	0
<i>Sedimentation System</i>	1	0	0	0	0
Total	1	0	0	0	0
HRSTS Discharges					
CHPP Demand (Loss)	830	1,164	1,164	1,164	1,164
Stockpile Dust Suppression	115	150	150	150	150
Haul Road Dust Suppression	435	487	466	563	543
Vehicle Wash	97	132	132	132	132
Clean Water Pumped to Dry Creek	0	88	82	52	7
Gross Water Outputs	1,520	2,081	2,022	2,095	2,031
Water Balance (ML/a)					
Change in Storage Volumes	-51	-33	-9	-9	-9
Gross Water Balance (deficit)	3	197	186	227	231

6.7.3 External Water Supply Requirements

The raw water source for the site demands is the Raw Water Dam, which is maintained at full capacity by the Hunter River Supply Scheme. BMC holds 1,449 units under the Hunter River Supply Scheme, which equates to 1,449 ML/a when 100% allocation is announced. Raw water is used as a last priority to meet site demands, with the exception of the vehicle wash demand which ranges between 97 and 132 ML/a.

Figure 6.15 shows the total annual modelled demand for water from an external source over the Project period. Review of the results indicates the following:

- There is a marked increase in raw water requirement in Year 4 of the Project life. This is likely due to the increase in CHPP throughput and increased haul road dust suppression requirements.
- The median (50th percentile) raw water requirement from an external source is approximately 1,500 ML/a during Years 5 to 24; and
- The 99th percentile raw water requirement from an external source is approximately 2,200 ML/a during Years 5 to 24.

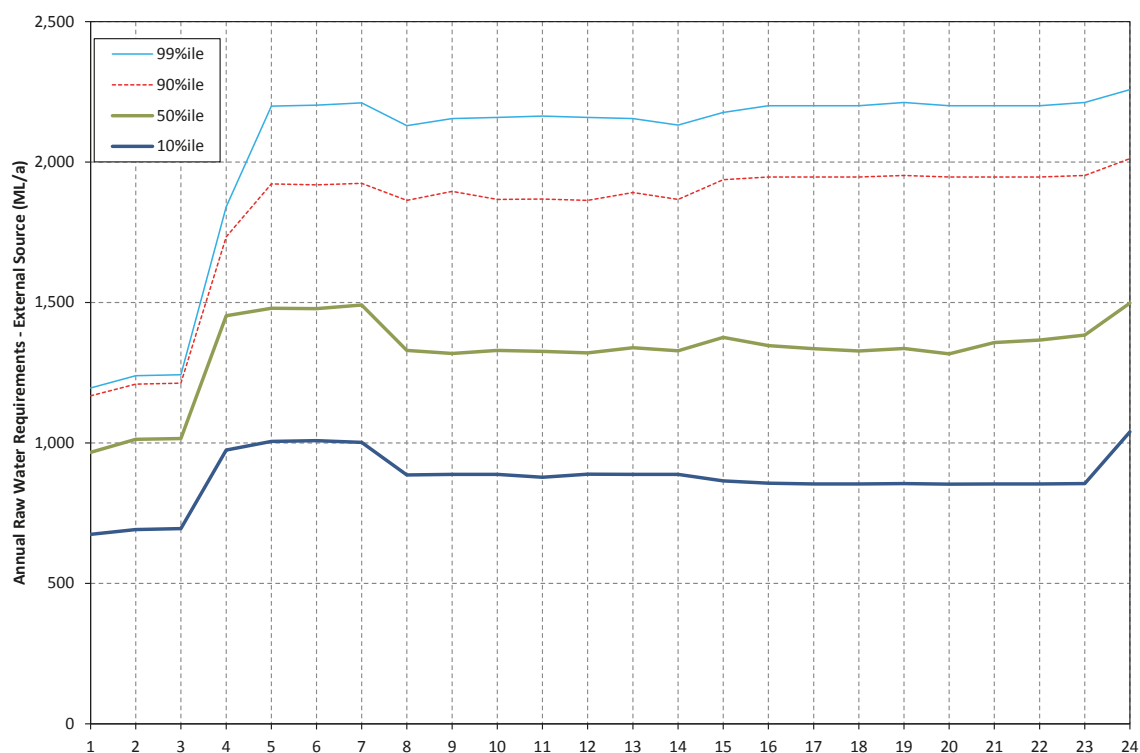


Figure 6.15 Annual Raw Water Requirements – External Source

6.7.4 Mining Pit Inundation Characteristics

Figure 6.16 and Figure 6.17 show the stored inventory in the Main Pit and Satellite Pit respectively over the Project life. Review of the results indicates the following:

- The median (50th percentile) inventories of Main Pit and Satellite Pit show that the pits are maintained dry.
- The 90th percentile inventory in Main Pit reaches 100ML, but is able to be dewatered by the following year. The 90th percentile inventory in Satellite Pit shows that it is kept almost dry for the Project life. Note that the Satellite Pit is mined through by Year 8.

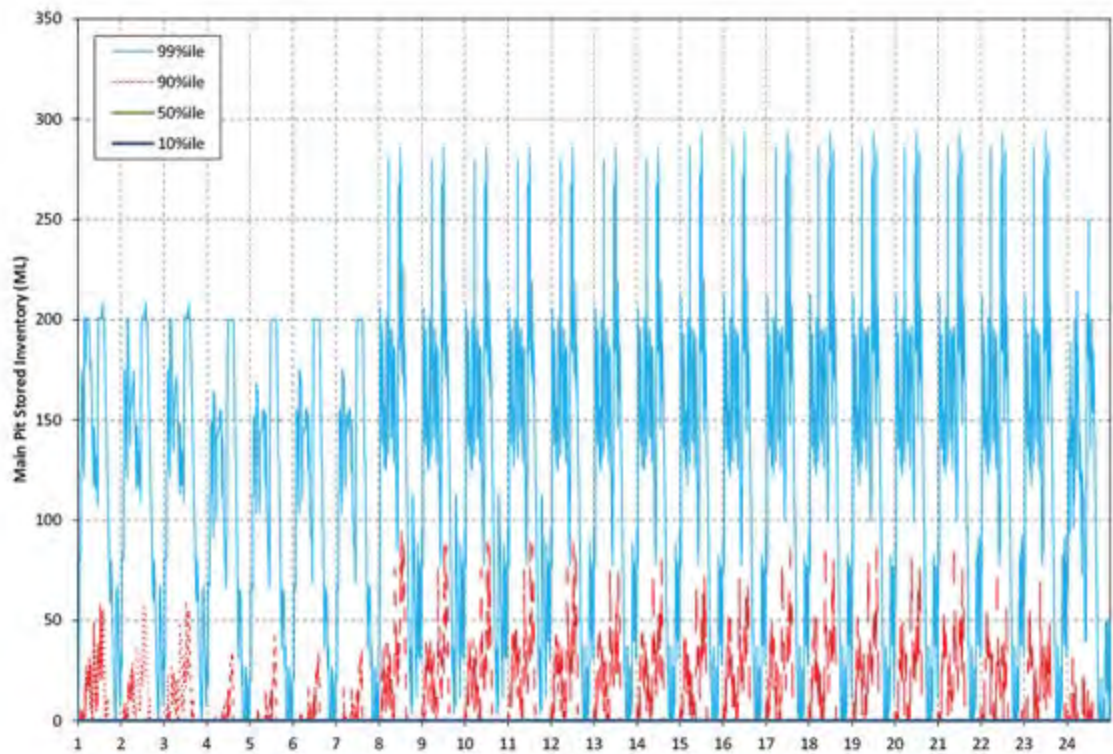


Figure 6.16 Main Pit Stored Inventory (ML)

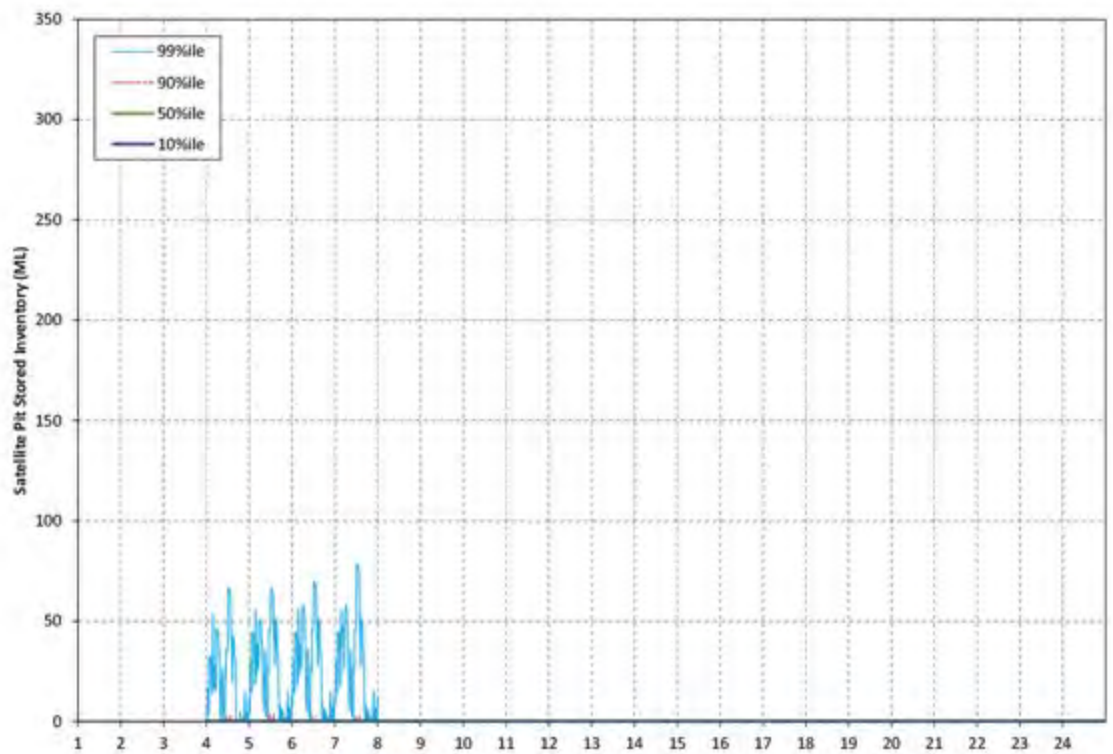


Figure 6.17 Satellite Pit Stored Inventory (ML)

6.7.5 Controlled Offsite Discharges

Controlled offsite discharges refers to water discharged under the HRSTS directly from the Staged Discharge Dam/Bengalla Relocated Discharge Dam to Dry Creek. Figure 6.18 shows the total annual water discharges to Dry Creek over the Project period. Review of the results indicates the following:

- The 50th percentile annual discharge shows that no discharges are required under the HRSTS.
- The 90th percentile annual discharge shows that up to approximately 350 ML/a are discharged under the HRSTS.
- The 99th percentile annual discharge shows that up to approximately 1,000 ML/a are discharged under the HRSTS. There is a marked increase in potential discharges in Year 8 of Project life, likely associated with the large increase in catchment area reporting to the mine water system. Year 4 has a total 'disturbed' footprint of 515 ha (industrial + overburden + active pit areas), compared to 747 ha in Year 8 (refer Section 6.6.4).

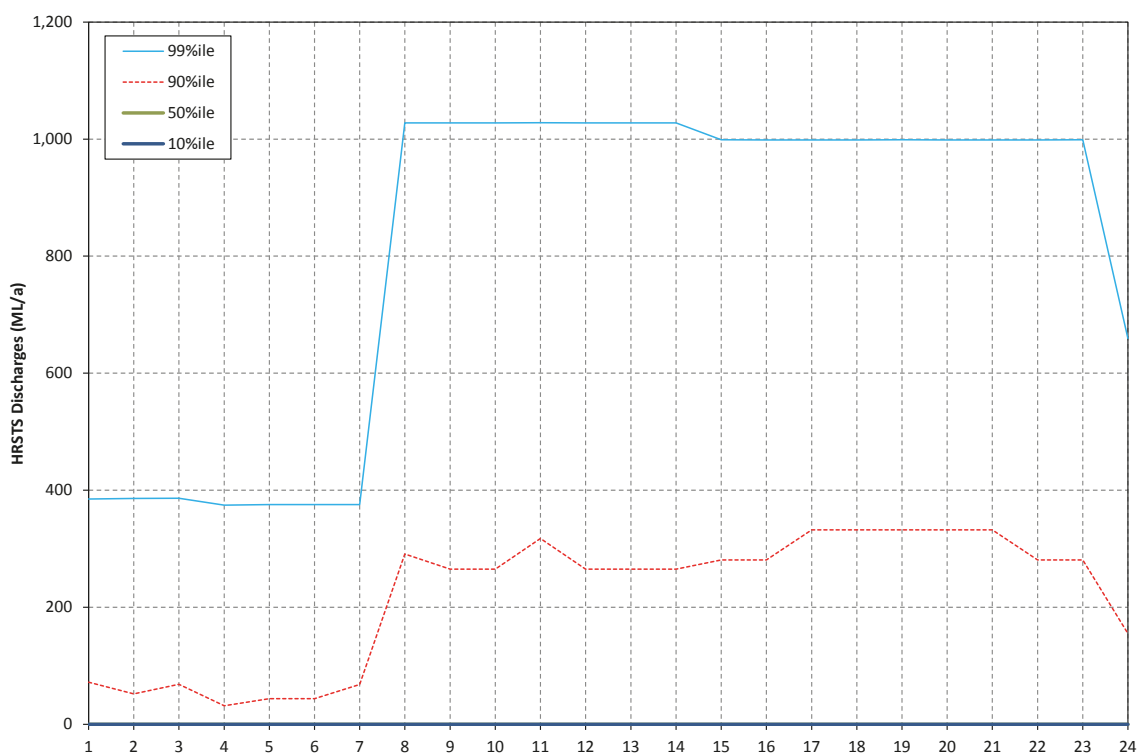


Figure 6.18 Annual HRSTS Discharges

Simulated water quality results in the Staged Discharge Dam and Bengalla Relocated Discharge Dam indicated that for stored volumes greater than 5ML, the maximum and average electrical conductivities are 1,520 and 1,185 $\mu\text{S}/\text{cm}$ respectively.

6.7.6 Uncontrolled Offsite Releases

The results of the site water balance modelling show that the site water management system can be operated to ensure no uncontrolled release of saline water over the Project life. The only uncontrolled offsite releases will be from sedimentation dams, which have been treated for sediment.

6.7.7 Hunter River Flow Characteristics

Figure 6.19 shows the flow duration relationship for the Hunter River at Denman for the 'with discharges' and 'no discharges' cases. The results are presented for the 24 year realisation with the average cumulative Hunter River flows. Figure 6.20 and Figure 6.21 show the Hunter River flow duration relationship for the 10th percentile and 90th percentile cumulative Hunter River flows which represent dry and wet 24 years climatic realisations respectively. Review of the results indicates the following:

- Results for the average, wet and dry climate scenarios show similar outcomes. For all climate scenarios, the impacts of HRSTS controlled discharges from Bengalla on the Hunter River flow duration relationship are negligible.

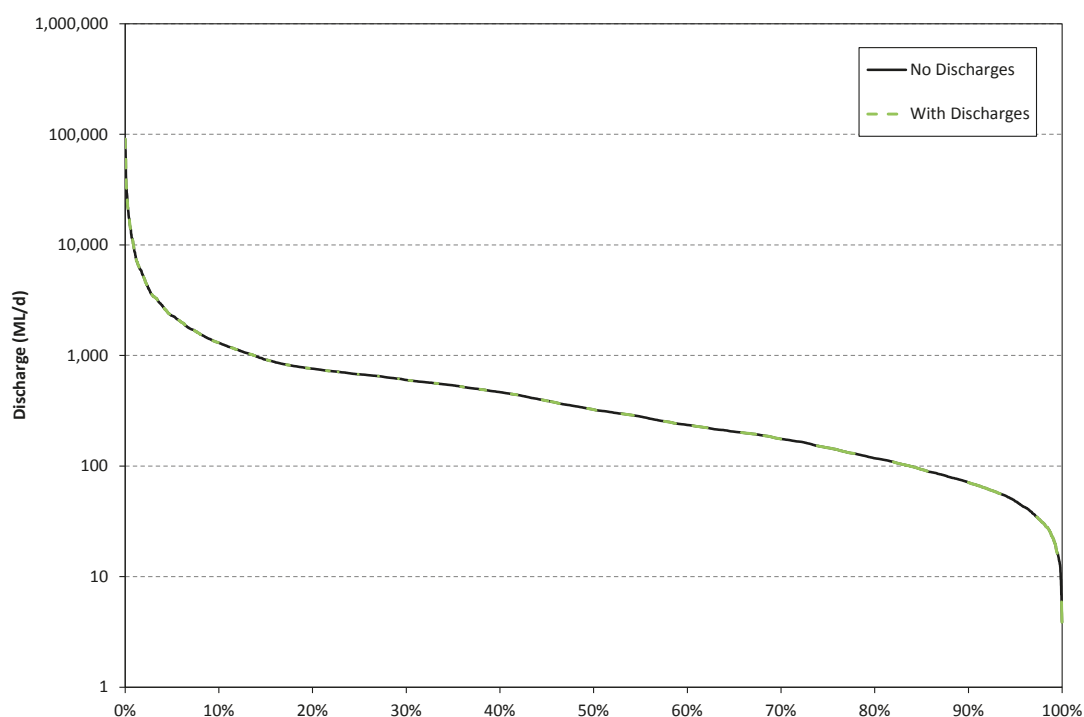


Figure 6.19 Hunter River at Denman Flow Duration Relationship, "Average" Climate Realisation

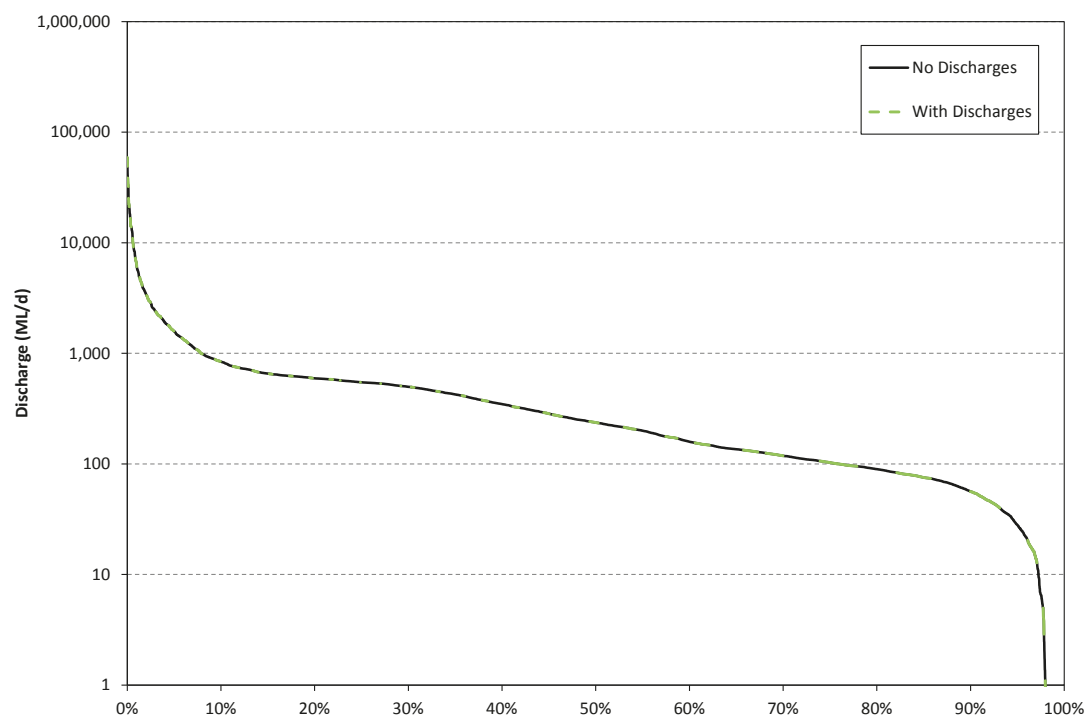


Figure 6.20 Hunter River at Denman Flow Duration Relationship, "Dry" Climate Realisation

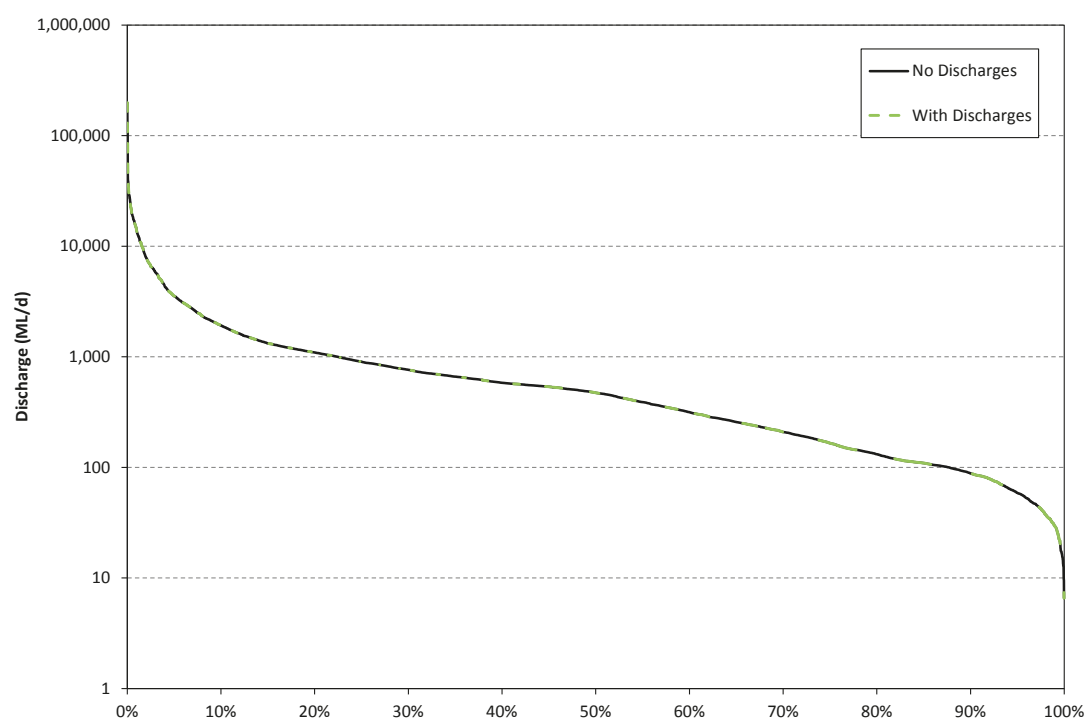


Figure 6.21 Hunter River at Denman Flow Duration Relationship, "Wet" Climate Realisation

6.7.8 Surface Runoff Salt Balance

The OPSIM model was used to assess the likely impact of the Project on the salt load released to receiving waters as surface flow. Representative salinities (expressed as electrical conductivity – EC) were assigned to runoff from various catchment types, as well as groundwater inflows to the mining pit and raw water imported to the mine site. The adopted salinities were based on water quality monitoring results and are shown in Table 6.7.

To assess the impacts of the Project on the receiving water salt balance, the OPSIM model was run as a static simulation. For the static simulation, each stage of mine development is modelled separately from the other stages, over the full historical climatic data set (1893-2006).

The following assumptions were adopted for analysis:

- Hunter River pre-mine catchment area to Dry Creek confluence: 4,202 km²
- Total Dissolved Solids = 0.6 x Electrical Conductivity
- Average annual rainfall = 590 mm/year

Table 6.21 provides a summary of the salt balance for the pre-mine catchment and stages of the Project life. The model results show that the total average salt load released off-site in surface runoff is not significantly increased or reduced by the Project. Years 1 and 4 show a slight increase in salt load and for all other mine stages the salt load is reduced.

Table 6.21 Long Term Average Surface Water Salt Balance

Mining Stage	Hunter River Salt Load (tonnes/day)			Total
	Catchment Runoff	Sediment Dam Overflows	HRSTS Discharges	
Pre-Mining	130.92	-	-	130.92
Existing (2011)	130.68	0.07	0.06	130.81
Year 1	130.67	0.28	0.04	130.99
Year 4	130.62	0.36	0.04	131.02
Year 8	130.53	0.18	0.21	130.92
Year 15	130.46	0.18	0.21	130.85
Year 24	130.55	0	0.14	130.69
Final Landform	130.75	-	-	130.75

6.8 FINAL VOID STORAGE AND WATER QUALITY BEHAVIOUR

The OPSIM model was used to assess the likely long term water level behaviour and salt balance of the final void should BMC not seek and gain approvals to continue mining beyond this time. A salinity of 240 µS/cm for runoff from the rehabilitated catchment areas draining to the final void and a salinity of 1,300 µS/cm for groundwater inflows have been adopted. The final void configuration and contributing catchment areas are shown in Figure 6.22. Long term groundwater inflows to the final void were provided by AGE groundwater consultants. An evaporation factor of 0.7 was applied to the water surface evaporation from the final void to account for reduced evaporation due to wind effects and shading in deep pits.

Figure 6.23 shows the long term (1,000 year) volume and salinity expected in the final void. A sensitivity analysis on the initial conditions has been undertaken as follows:

- Initial volume 0 ML, electrical conductivity 0 $\mu\text{S}/\text{cm}$
- Initial volume 45,000 ML, electrical conductivity 20,000 $\mu\text{S}/\text{cm}$

Review of the results indicates the long term volume in the final void is expected to be approximately 45,000 to 52,000 ML (64 to 71 mRL). Note that the overflow level for the final void is 160mRL. Hence, the final void water level is expected to stabilise 90m below that overflow level.

Long term salinity in the final void initially increases at a rate of approximately 5 $\mu\text{S}/\text{cm}$ per year (after 1,000 years the salinity has reached 5,000 $\mu\text{S}/\text{cm}$). The sensitivity analysis of the initial electrical conductivities shows that at high salinities ($>20,000 \mu\text{S}/\text{cm}$), the salinity is generally stable. The long term salinity in the final void is therefore expected to increase initially at a rate of 5 $\mu\text{S}/\text{cm}$ per year (average over 1,000 years) and reach a stable salinity less than 20,000 $\mu\text{S}/\text{cm}$.



Figure 6.22 Final Void Mine Plan

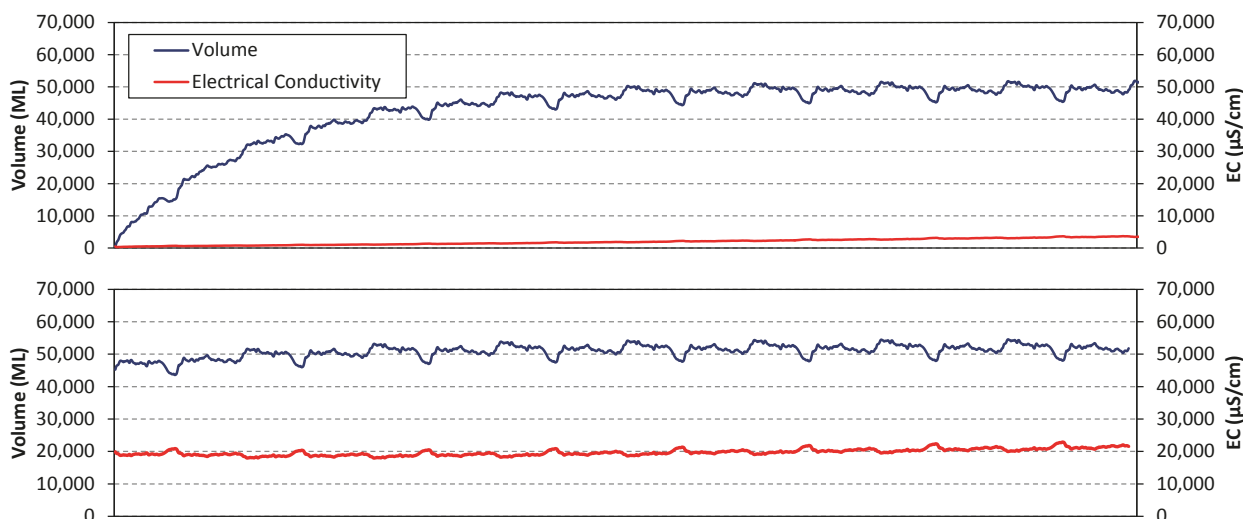


Figure 6.23 Final Void Volume and Electrical Conductivity

6.9 MINE WATER BALANCE SUMMARY

Results of the mine water balance are summarised below:

- Water is required from the Hunter River Intake for all years of Project life. The maximum (99th percentile) external water requirement is approximately 2,200 ML/a between Years 5 to 24. The median (50th percentile) external water requirement is approximately 1,500 ML/a. The 10th percentile requirement is approximately 1,000 ML/a. After Year 4, a maximum plant throughput of 9.5 Mtpa can be sustained with the currently available water allocation from the Hunter River (1,449 units) based on the 99th percentile results.
- Maximum (99th percentile) HRSTS discharges are approximately 1,000 ML/a. The median (50th percentile) annual discharges are zero for the life of the Project.
- There are no simulated uncontrolled discharges from the Mine Water system for the 99th percentile in any year of Project life.
- The impacts of HRSTS controlled discharges from the Project on the Hunter River flow duration relationship are negligible.
- The long term volume in the final void is expected to be approximately 45,000 to 52,000 ML (64 to 71 mRL, or about 90 m below the surrounding ground level).
- The long term salinity in the final void is expected to increase initially at a rate of 5 µS/cm per year (average over 1,000 years) and reach a stable salinity less than 20,000 µS/cm.

7

MITIGATION AND MANAGEMENT MEASURES

7.1 OVERVIEW

The impacts of the Project on surface water resources will be mitigated through the implementation of the following measures to be documented in the revised site Water Management Plan:

- A mine site water management system to control the flow and storage of water of different qualities across the site;
- A sediment control plan to reduce sediment loads from disturbed area runoff;
- A surface water monitoring program to continually assess environmental impacts and ensure that the site water management system is meeting its objectives of managing impacts on receiving waters; and
- A Dry Creek Interim Management System and Conceptual Re-establishment Study (Parsons Brinckerhoff Australia Pty Limited, 2012).

An overview of each of these management measures are provided in the following sections.

7.2 MINE WATER MANAGEMENT SYSTEM

A key objective of the mine water management system will be to manage the risk of uncontrolled discharges from mine site storages. To achieve this objective, operation of the mine water management system will be based on the following principles:

- Diversion of clean surface water runoff away from areas disturbed by mining activities;
- Operation of the mine water management system to ensure no uncontrolled releases of mine water from the site;
- Collection of potentially sediment-affected runoff in sediment dams for treatment prior to discharges from site or reuse in the mine water management system;
- Transfer of mine water (groundwater inflows) to the Washery Dam for reuse as a water supply;
- Collection of contaminated water from industrial areas for treatment in an oil and grease separator prior to recycling in the mine water management system; and
- Minimisation of fresh water usage by recycling water from the mine water system before taking additional water from the mine's external supply source.

Key components of existing and proposed water management infrastructure for Bengalla are presented in Figure 3.1 and Figure 6.9 to Figure 6.13 respectively. Details of the operations of the existing and proposed mine water management system are provided in Section 6.3 and 6.6 respectively.

7.3 EROSION AND SEDIMENT CONTROL PLAN

The design of sediment control measures for the Project will be based on the principle of ensuring that runoff from disturbed areas is separated from clean area runoff and collected in sediment dams for treatment. Design of proposed erosion and sediment control measures will be based on the recommended design standards in the following guidelines:

- Managing Urban Stormwater, Soils and Construction (Landcom, 2004); and
- Managing Urban Stormwater, Soils and Construction, Volume 2E Mine and Quarries (DECC, 2008).

Proposed sediment dam sizes and locations are detailed in Section 6.6.7.

7.4 DRAINAGE OF FINAL LANDFORM

The rehabilitated overburden east of mining operations will be drained using the approach currently adopted at Bengalla which is based on:

- Topsoiling and revegetation of the finished landform;
- Construction of contour drains across the batter slope to minimise the potential for rilling and gullyng of the finished landform;
- Collection of inflows from contour drains in rock chutes which flow downslope; and
- Flows from rock chutes are directed to sediment basins prior to release from the Project.

7.5 DRY CREEK INTERIM MANAGEMENT & RE-ESTABLISHMENT PLAN

A detailed assessment of the Dry Creek realignment has been undertaken and is documented in a separate report (Parsons Brinckerhoff Australia Pty Limited, 2012).

7.6 SURFACE WATER MONITORING PROGRAM

The basis of the current Surface Water Monitoring Program, as described in Section 3.6.1, will be revised and continue to be implemented for the Project. Onsite dam surface water monitoring locations will be relocated as appropriate when the dam is relocated (e.g. Discharge Dam, Washery Dam). Relocation of the discharge location and Dry Creek requires changes to the receiving water monitoring locations, as shown in Figure 7.1. The purpose, type of analysis and frequency of the monitoring points is as per Table 3.3.

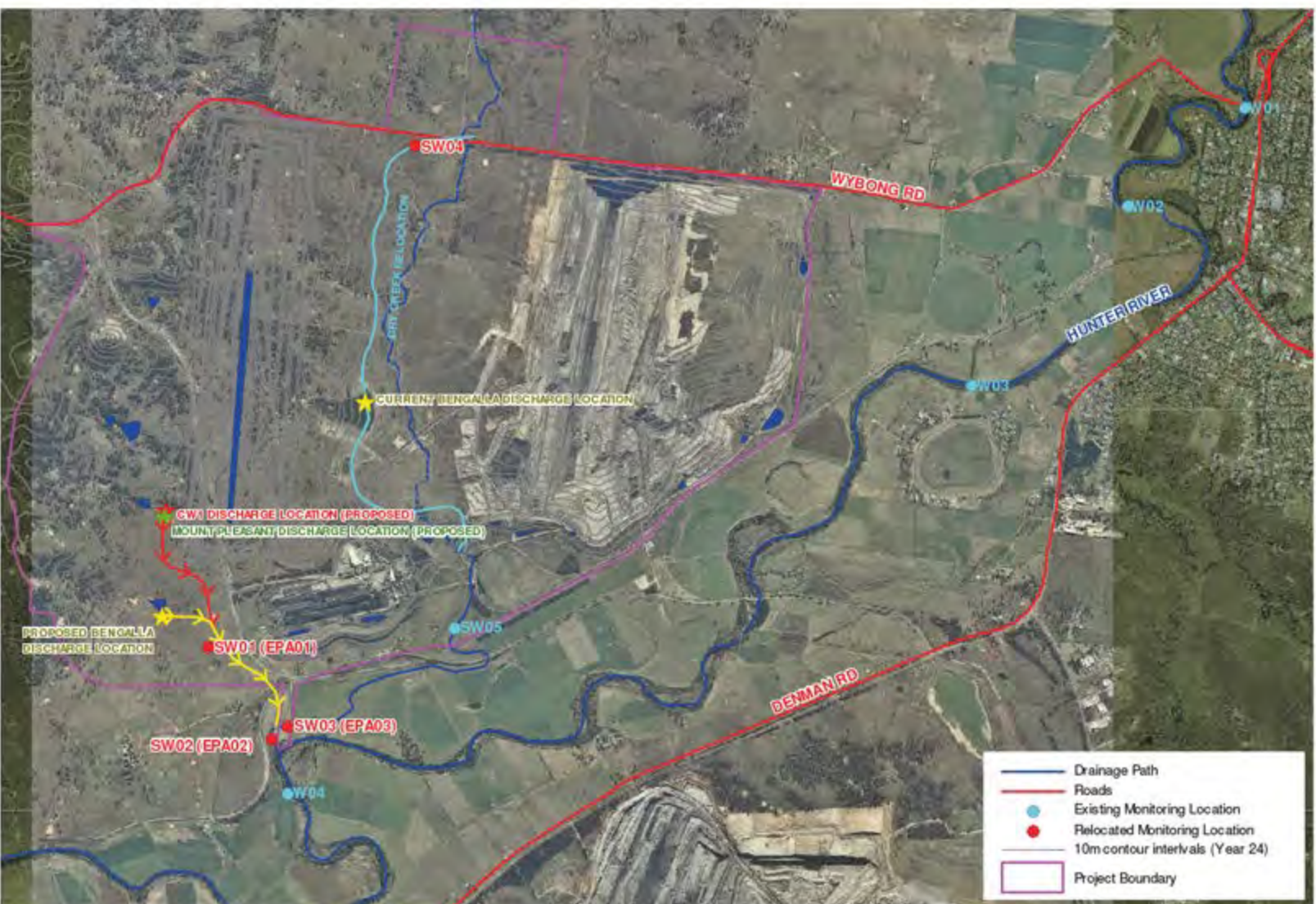


Figure 7.1 Proposed Surface Water Monitoring Program – Receiving Waters

7.7 RESIDUAL IMPACTS

Whilst the proposed mitigation measures will limit the surface water impacts of the Project, some residual impacts will occur. These residual impacts will include:

- Potential additional water demand from the Hunter River to meet increased water requirements for the Project. A maximum (99th percentile) annual water requirement of 2,200 ML/a could potentially be required under extreme drought conditions. BMC currently holds a licensed allocation of 1,449 units (equates to 1,449 ML/a when 100% allocation is announced).
- A maximum reduction of the order of 39% of the total Dry Creek catchment area to the confluence of the Hunter River during mining (not including the diverted clean water catchment to the north of Wybong Road). Post-mining, the reduction in catchment area will be in the order of 22%. The Project will mine through the existing Dry Creek channel downstream of Wybong Road and replace the natural watercourse with an engineered channel in the final landform.
- A small reduction (0.1%) in total catchment area draining to the Hunter River at Dry Creek confluence.
- Post-mining, the median Hunter River flows at Denman will be reduced by a maximum of 0.2% annually due to capture of runoff within the final void.
- Should further approvals at Bengalla for continued mining after 24 years not be sought or given, the creation of a permanent Final Void lake that is likely to increase in salinity over time would occur. The water level of the lake will take hundreds of years to stabilise at a level of about 90 m below the surrounding ground level.

8 SUMMARY OF FINDINGS

The findings of the assessment of surface water impacts for the Project may be summarised as follows:

- Water is required from the Hunter River for all years of the Project life. The maximum (99th percentile) external water requirement is approximately 2,200 ML/a between Years 5 to 24. The median (50th percentile) external water requirement is approximately 1,500 ML/a. The 10th percentile external water requirement is approximately 1,000 ML/a.
- Maximum (99th percentile) HRSTS discharges are approximately 1,000ML/a. The median (50th percentile) annual discharges are zero for the life of the Project.
- The 99th percentile simulated uncontrolled discharges from the Mine Water system is zero in all years of Project life.
- Median Hunter River flow volumes will reduce by 0.5% at Denman during the Project life. Post-mining, the median Hunter River flows at Denman will be reduced by approximately 0.2% annually.
- The long term volume in the final void is expected to be approximately 45,000 to 52,000 ML (approximately 90 m below the surrounding ground level). The long term salinity in the final void is expected to increase initially at a rate of 5 $\mu\text{S}/\text{cm}$ per year (average over 1,000 years) and reach a stable salinity less than 20,000 $\mu\text{S}/\text{cm}$.
- A maximum reduction in the order of 39% of the total Dry Creek catchment area to the confluence of the Hunter River during mining. Post-mining, the reduction in catchment area will be in the order of 22%.
- A small reduction (0.1%), in total catchment area draining to the Hunter River at Dry Creek confluence.

Overall, the impacts of the Project on surface water resources are unlikely to be significantly greater than those of the existing mining operation.

9

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APPENDIX A

SURFACE WATER QUALITY MONITORING RESULTS - ONSITE DAMS

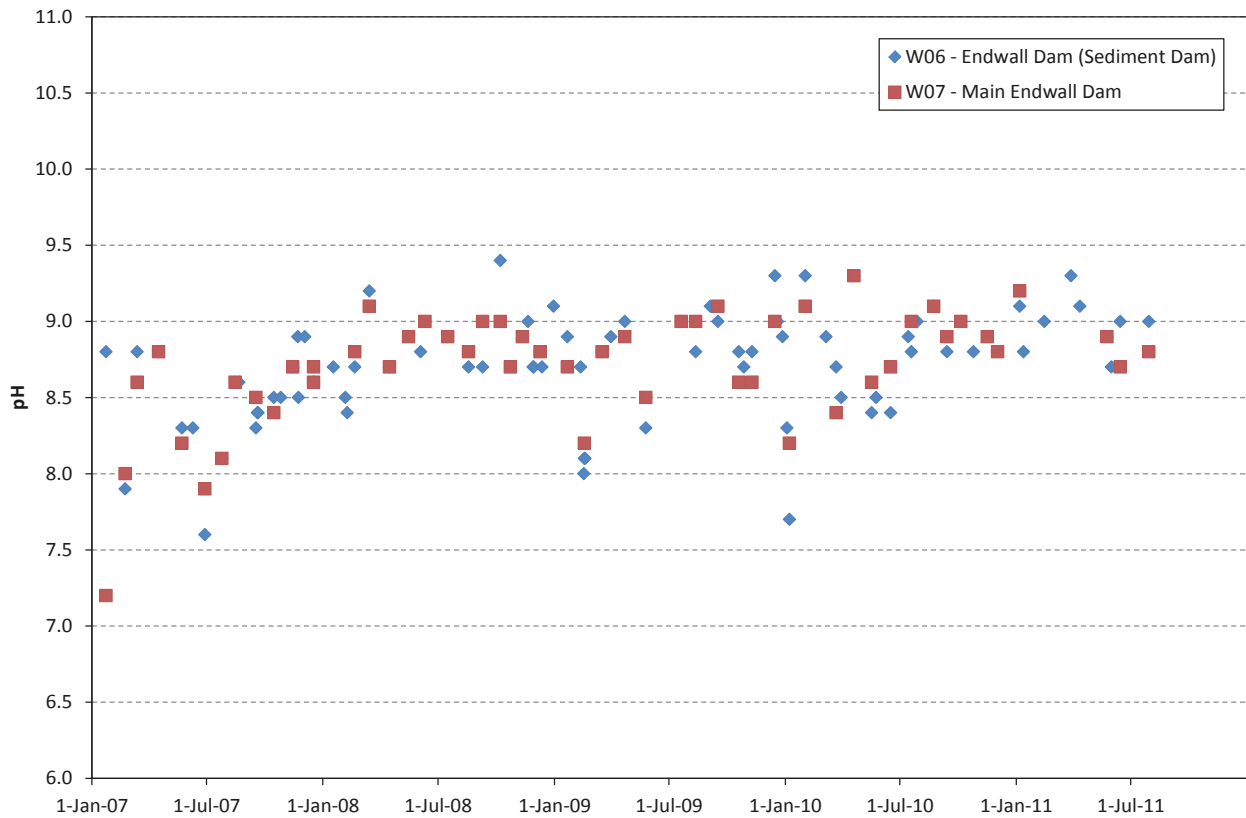


Figure 9.1 Endwall Dams pH

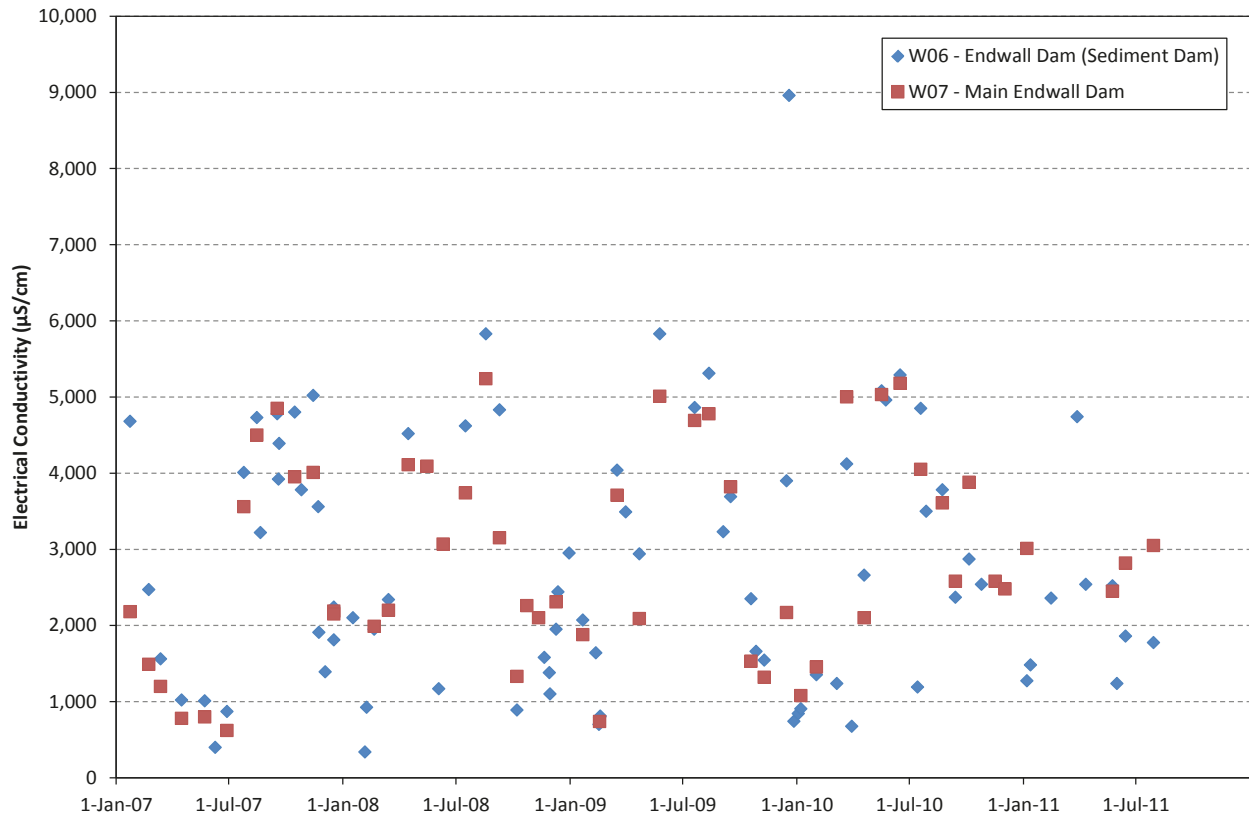


Figure 9.2 Endwall Dams Electrical Conductivity

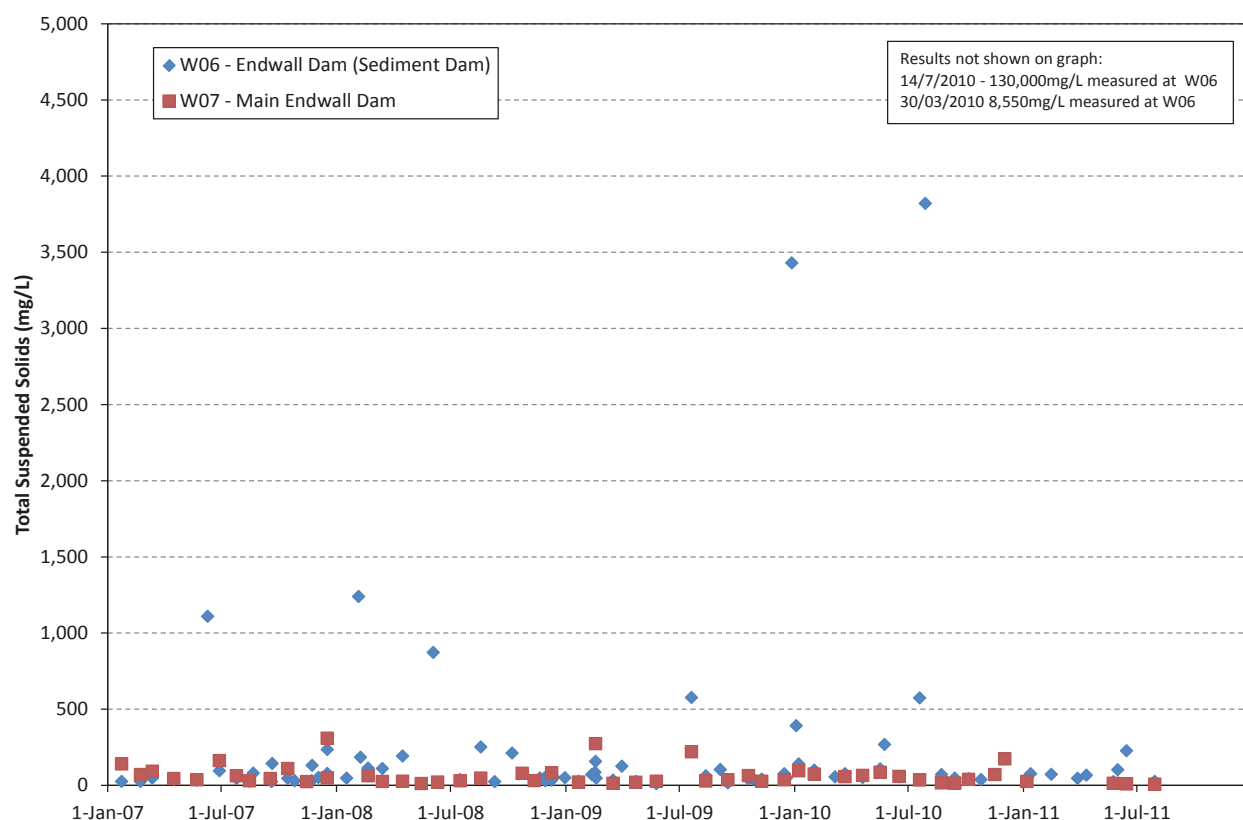


Figure 9.3 Endwall Dams Total Suspended Solids

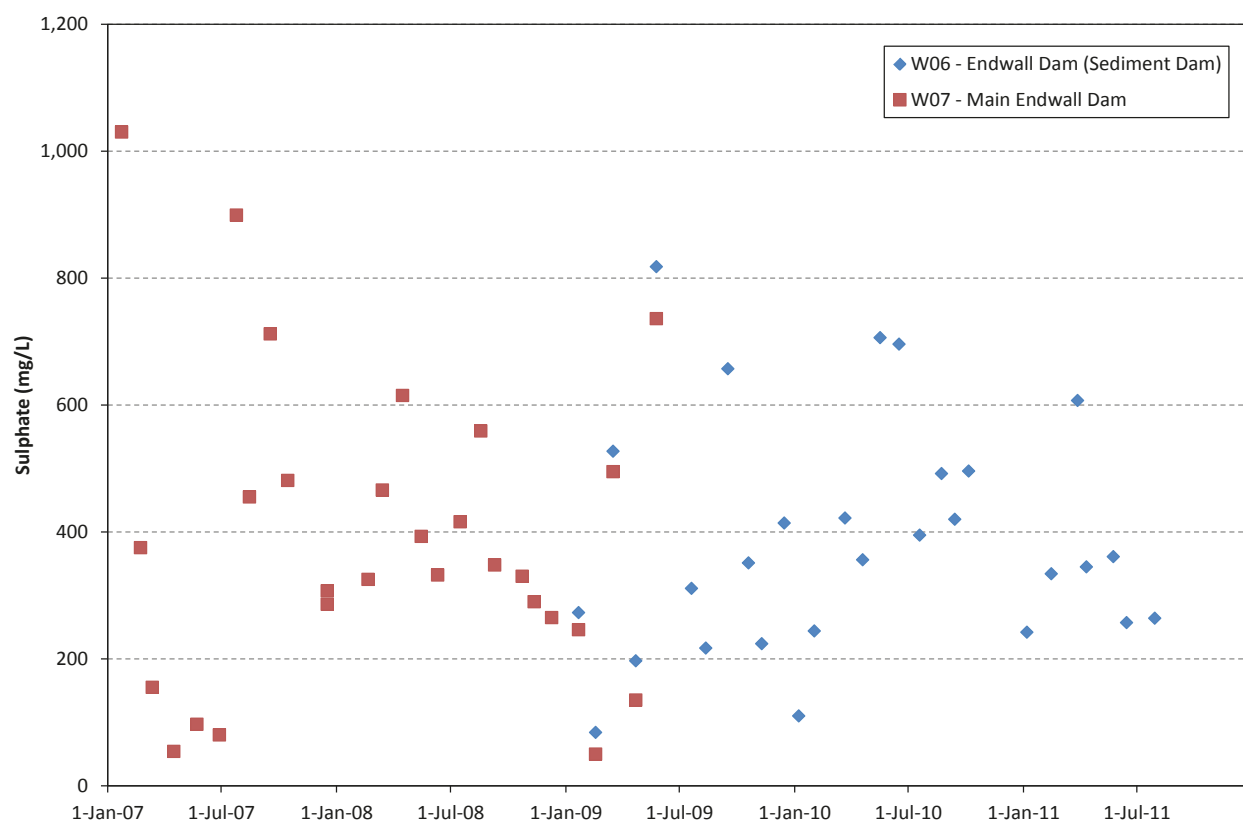


Figure 9.4 Endwall Dams Sulphate

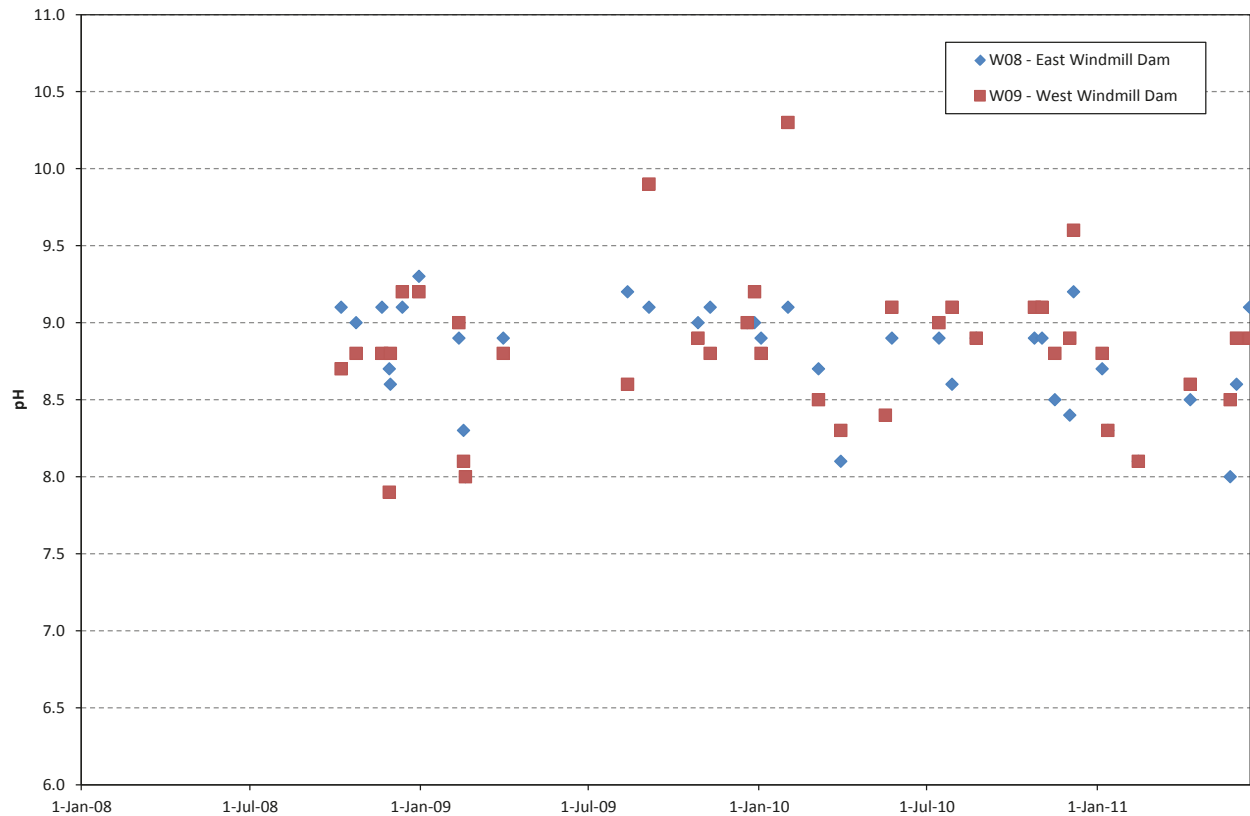


Figure 9.5 Windmill Dams pH

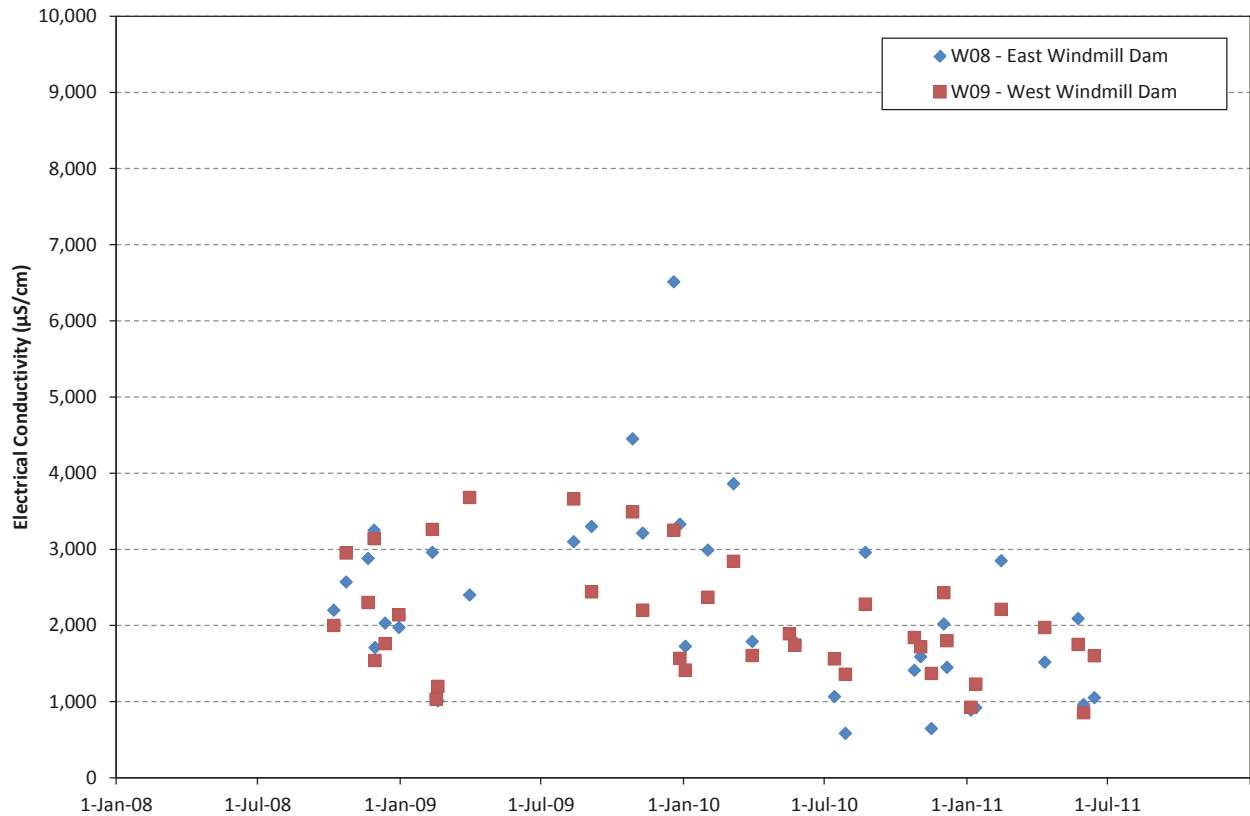


Figure 9.6 Windmill Dams Electrical Conductivity

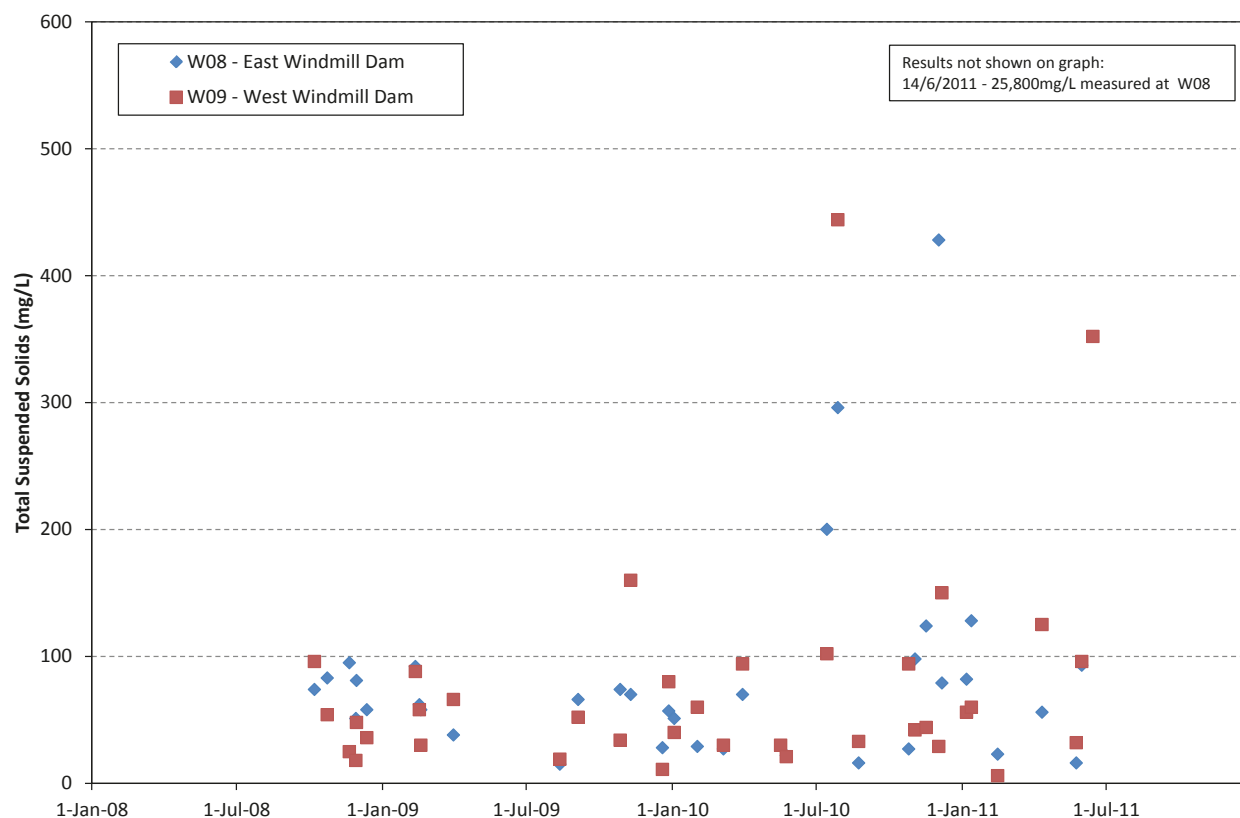


Figure 9.7 Windmill Dams Total Suspended Solids

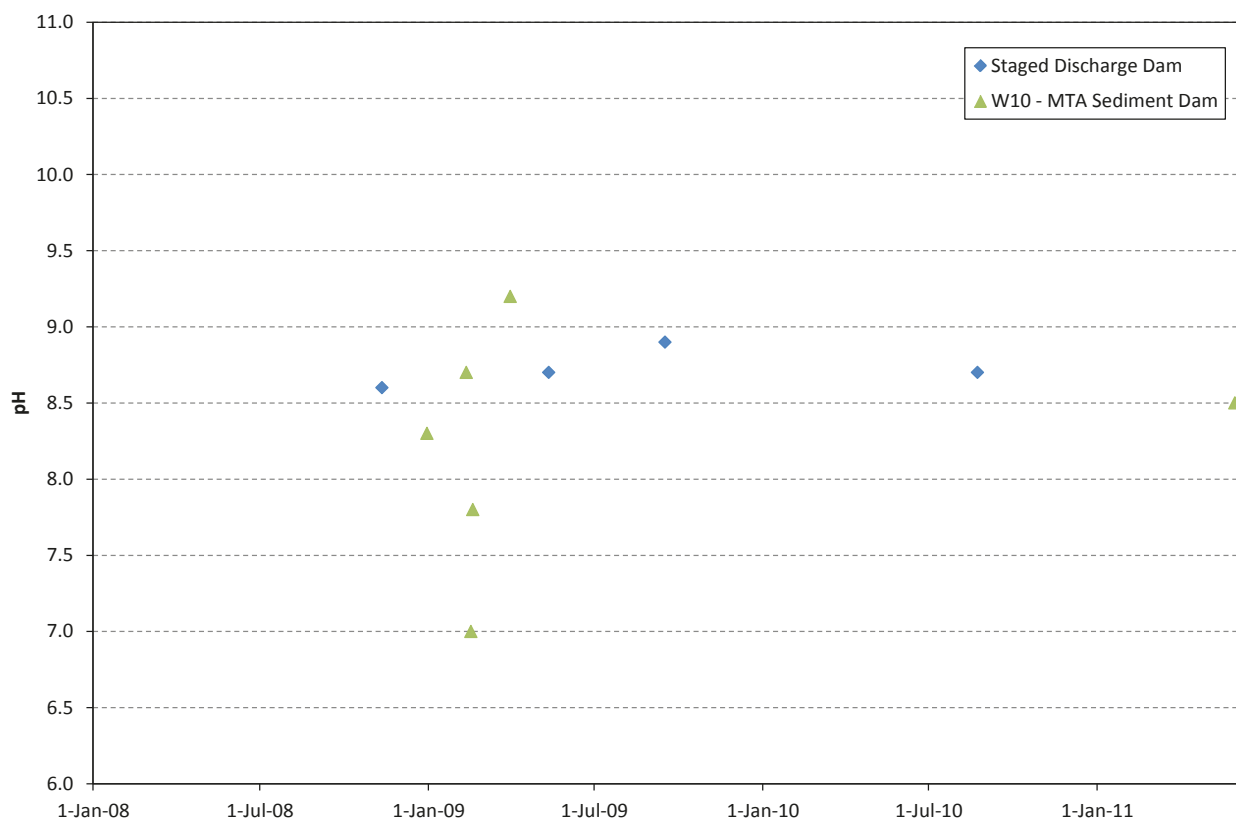


Figure 9.8 Other Onsite Dams pH

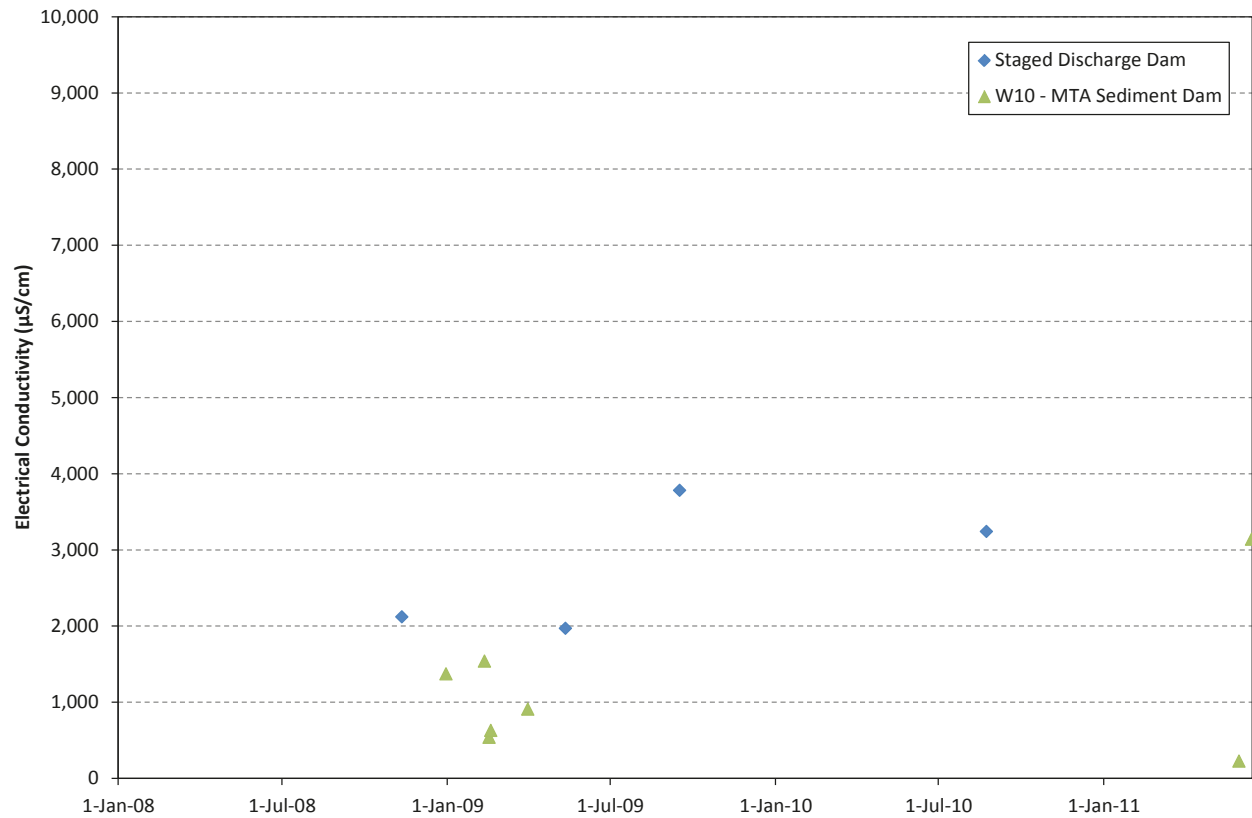


Figure 9.9 Other Onsite Dams Electrical Conductivity

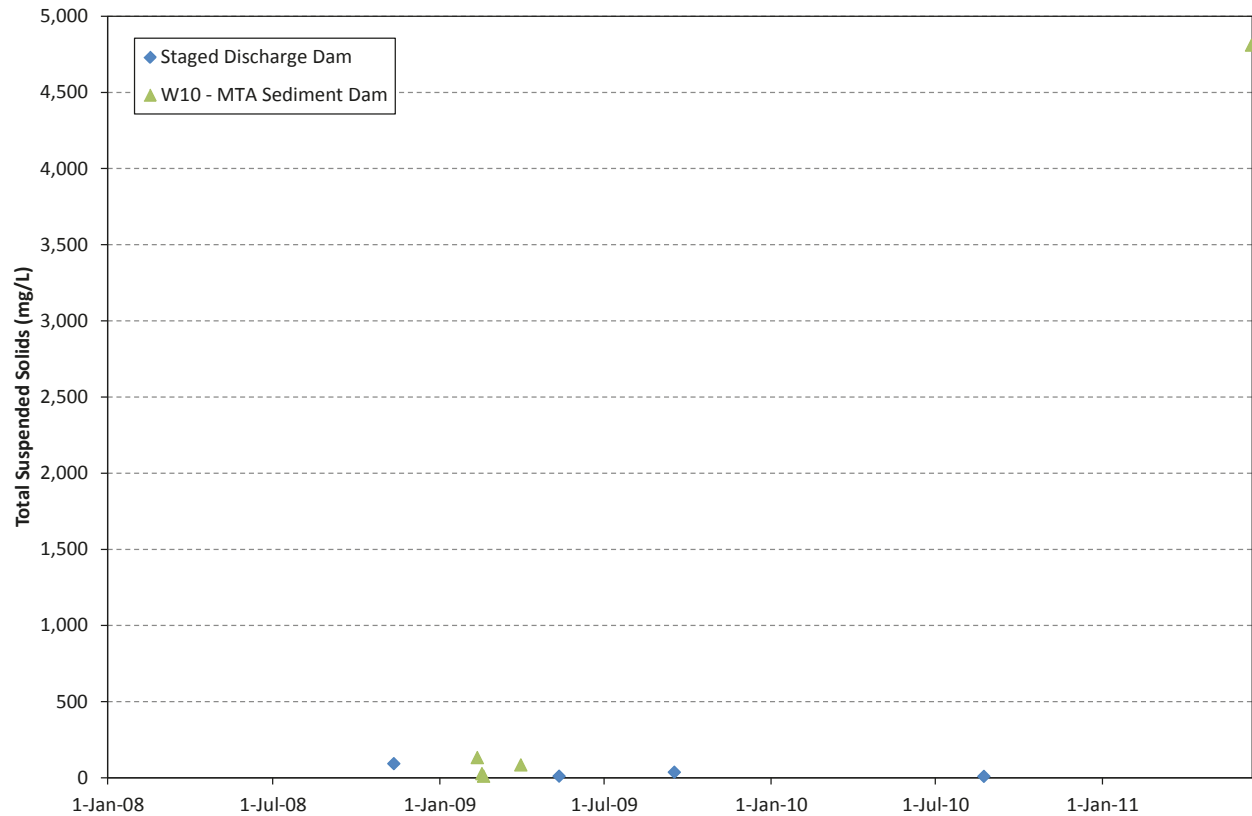


Figure 9.10 Other Onsite Dams Total Suspended Solids

APPENDIX B

HUNTER RIVER WATER QUALITY DATA

HUNTER RIVER AT MUSWELLBROOK BRIDGE**Station Number:** 210002**Grid Coordinates:**

Easting: 301108

Long: 150.8886 deg E

Northing: 6429240

Lat: 32.2559 deg S

Zone 56 MGA94

Datum: GDA94

Variable	Number	Earliest Date	Latest Date
Algae Bluegreen - Count and Identification	42	22/12/1998	06/05/2003
Algae other than bluegreen - Count and Identification	42	22/12/1998	06/05/2003
Alkalinity (Total) as CaCO ₃	3	22/04/2002	13/04/2005
Alkalinity as Bicarbonate (HCO ₃)	190	08/01/1979	13/05/1999
Alkalinity as Carbonate (CO ₃)	190	08/01/1979	13/05/1999
Ammonia as N - total	183	08/01/1979	12/09/2005
Boron as B - total	150	05/02/1979	25/06/1991
Calcium as Ca - total	187	08/01/1979	25/06/1991
Chloride as Cl	198	08/01/1979	07/07/1999
Chlorophyll-a	146	17/06/1980	07/07/1999
Colour - Apparent	17	06/09/1979	03/10/1980
Colour - True	207	06/09/1979	25/06/1991
Dissolved Organic Carbon	1	13/05/1999	13/05/1999
Electrical Conductivity (uncompensated)	48	05/06/1980	03/06/2011
Electrical Conductivity @25°C	1089	01/04/1971	06/04/2011
Faecal Coliform - membrane filtration count	103	04/04/1995	06/06/2006
Flow - instantaneous	487	01/04/1971	16/02/2006
Fluoride as F - soluble	165	28/02/1979	25/06/1991
Hardness as CaCO ₃ (measured)	73	14/12/1999	06/06/2006
Height - Water Column	12	07/01/2008	03/06/2011
Iron as Fe - soluble	139	25/10/1988	25/06/1991
Iron as Fe - total	130	08/01/1979	25/06/1991
Level - Stream Water (Gauge Height)	574	01/04/1971	18/05/1999
Magnesium as Mg - total	187	08/01/1979	25/06/1991
Manganese as Mn - soluble	54	09/05/1989	25/06/1991
Manganese as Mn - total	66	18/07/1989	08/01/1991
Nitrate + nitrite as N (NO _x)	301	21/01/1999	06/04/2011
Nitrate as N	221	08/01/1979	04/11/2004
Nitrogen - Kjeldahl	18	25/10/1990	25/10/1990
Nitrogen - total	200	21/08/1991	06/04/2011
Oxygen - dissolved saturation	4	08/03/2011	03/06/2011
Phaeophytin	126	25/10/1988	07/07/1999
Phosphorus - acid hydrolysable - total	9	30/05/1989	05/09/1989
Phosphorus - reactive (orthophosphate) - dissolved (FRP)	176	29/09/1999	06/04/2011
Phosphorus - reactive (orthophosphate) - total	106	21/01/1999	04/07/2002
Phosphorus - total	600	08/01/1979	06/04/2011
Potassium as K - soluble	187	08/01/1979	25/06/1991
Silica as SiO ₂ - reactive	182	08/01/1979	25/06/1991
Silica as SiO ₂ - soluble	168	22/12/1998	12/09/2005
Sodium as Na - soluble	198	08/01/1979	07/07/1999
Solids - total dissolved @ 105°C	33	23/03/2004	06/06/2006
Solids - total suspended @ 105°C	167	09/05/1989	06/04/2011
Strontium as Sr - total	75	09/05/1989	25/06/1991
Sulphate as S	11	22/12/1998	07/07/1999
Sulphate as SO ₄	187	08/01/1979	25/06/1991
Temperature - Air maximum	6	29/04/1980	09/10/1980
Temperature - Surface	1	03/04/2002	03/04/2002

Variable	Number	Earliest Date	Latest Date
Temperature - Water	711	01/04/1971	03/06/2011
Total Coliform - membrane filtration count	68	17/06/1980	06/06/2006
Total Organic Carbon (TOC)	9	30/05/1989	05/09/1989
Turbidity	905	30/08/1976	03/06/2011
Zinc as Zn - total	106	13/12/1982	18/06/1991
pH	822	28/05/1976	03/06/2011

(New South Wales Office of Water, 2011)

HUNTER RIVER AT DENMAN**Station Number:** 210055**Grid Coordinates:** Easting: 284757
Long: 150.712 deg E

Northing: 6415100

Lat: 32.3804 deg S

Zone 56 MGA94

Datum: GDA94

Variable	Number	Earliest Date	Latest Date
Algae Bluegreen - Count and Identification	42	22/12/1998	05/05/2003
Algae other than bluegreen - Count and Identification	42	22/12/1998	05/05/2003
Alkalinity (Total) as CaCO ₃	3	22/04/2002	12/04/2005
Alkalinity as Bicarbonate (HCO ₃)	15	20/12/1978	13/05/1999
Alkalinity as Carbonate (CO ₃)	15	20/12/1978	13/05/1999
Ammonia as N - total	131	20/12/1978	04/02/2003
Boron as B - total	3	09/02/1979	13/05/1989
Calcium as Ca - total	12	20/12/1978	13/05/1989
Chloride as Cl	23	20/12/1978	07/07/1999
Chlorophyll-a	22	25/10/1988	07/07/1999
Colour - Apparent	6	13/09/1979	01/10/1980
Colour - True	10	13/09/1979	25/10/1988
Dissolved Organic Carbon	1	13/05/1999	13/05/1999
Electrical Conductivity @25°C	108	15/06/1971	16/02/2006
Flow - instantaneous	84	15/06/1971	16/02/2006
Fluoride as F - soluble	4	28/02/1979	13/05/1989
Iron as Fe - soluble	2	25/10/1988	13/05/1989
Iron as Fe - total	4	20/12/1978	25/10/1988
Level - Stream Water (Gauge Height)	35	06/11/1975	25/10/1984
Magnesium as Mg - total	12	20/12/1978	13/05/1989
Nitrate + nitrite as N (NO _x)	146	21/01/1999	12/04/2005
Nitrate as N	6	20/12/1978	13/05/1989
Nitrogen - total	44	03/02/1999	12/04/2005
Phaeophytin	12	25/10/1988	07/07/1999
Phosphorus - reactive (orthophosphate) - dissolved (FRP)	74	29/09/1999	12/04/2005
Phosphorus - reactive (orthophosphate) - total	75	21/01/1999	04/07/2002
Phosphorus - total	47	20/12/1978	12/04/2005
Potassium as K - soluble	12	20/12/1978	13/05/1989
Silica as SiO ₂ - reactive	11	20/12/1978	13/05/1989
Silica as SiO ₂ - soluble	146	22/12/1998	05/05/2003
Sodium as Na - soluble	23	20/12/1978	07/07/1999
Solids - total suspended @ 105°C	1	13/05/1989	13/05/1989
Strontium as Sr - total	1	13/05/1989	13/05/1989
Sulphate as S	11	22/12/1998	07/07/1999
Sulphate as SO ₄	11	09/02/1979	13/05/1989
Temperature - Water	87	15/06/1971	16/12/2005
Turbidity	49	03/09/1976	12/04/2005
Zinc as Zn - total	2	25/10/1988	13/05/1989
pH	48	01/02/1977	12/04/2005

(New South Wales Office of Water, 2011)