APPENDIX H

Surface water assessment

H

MANGOOLA COAL MODIFICATION TO PROJECT APPROVAL

SURFACE WATER ASSESSMENT

EMGA | Mitchell McLennan
April 2013

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CLIENT: EMGA | Mitchell McLennan, on behalf of Xstrata Mangoola

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For and on behalf of
WRM Water & Environment Pty Ltd

Michael Batchelor
Director

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1 INTRODUCTION

1.1 OVERVIEW

Xstrata Mangoola Pty Limited (Xstrata Mangoola) operates the Mangoola Coal open cut coal mine (Mangoola Coal), approximately 20 kilometres (km) west of Muswellbrook and 10 km north of Denman. The location of Mangoola Coal is shown in Figure 1.1.

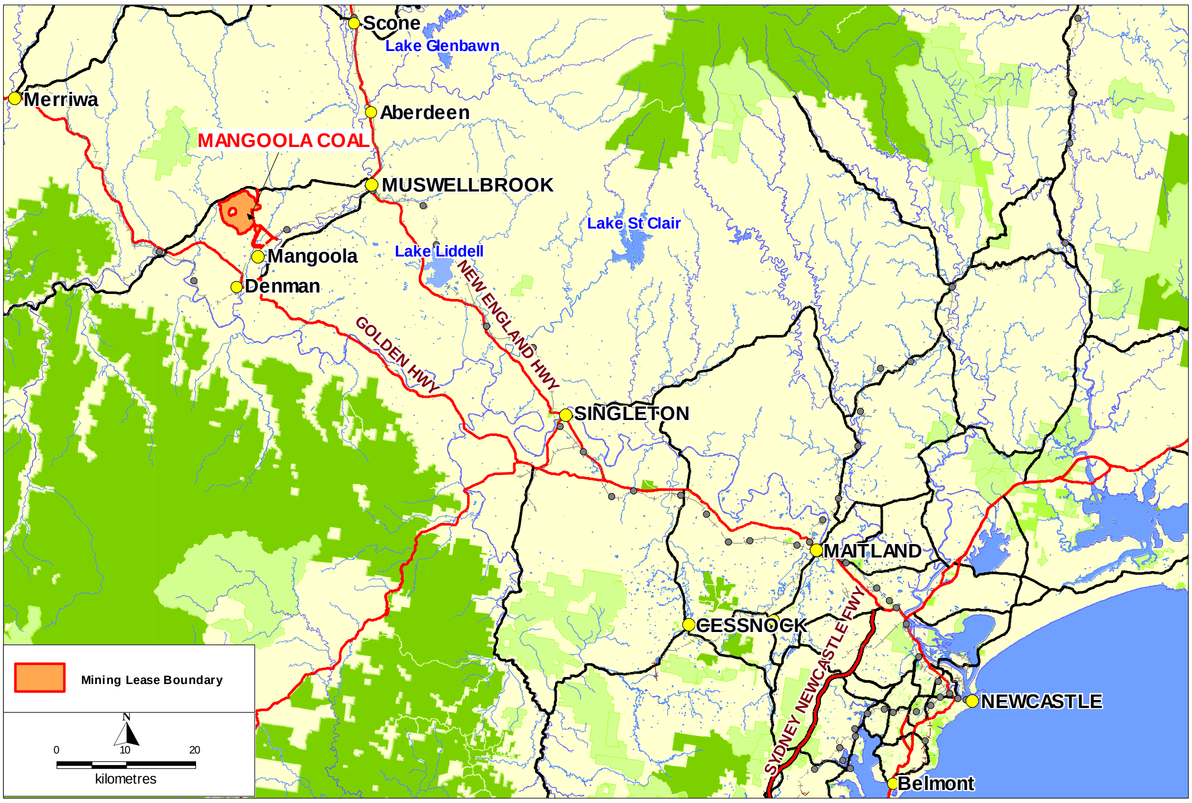


Figure 1.1 Regional Locality

Project approval 06_0014 (PA 06_0014) for Mangoola Coal was granted in June 2007 under Part 3A of the NSW *Environmental Planning and Assessment Act 1979* (EP&A Act). References to PA 06_0014 in this document refer to the project approval as modified, dated 22 June 2012. Operations at Mangoola Coal approved under PA 06_0014 are referred to herein as the 'current operations'. Mangoola Coal commenced mining operations in September 2010. Existing infrastructure at the site is indicated in Figure 1.2.

Xstrata Mangoola is seeking approval from the Minister for Planning and Infrastructure (or the Planning Assessment Commission (PAC) under delegation) to modify PA 06_0014 under section 75W of the EP&A Act. The key modification sought is an increase in the maximum rate of extraction from 10.5 million tonnes per annum (Mtpa) run-of-mine (ROM) coal to 13.5 Mtpa ROM coal.

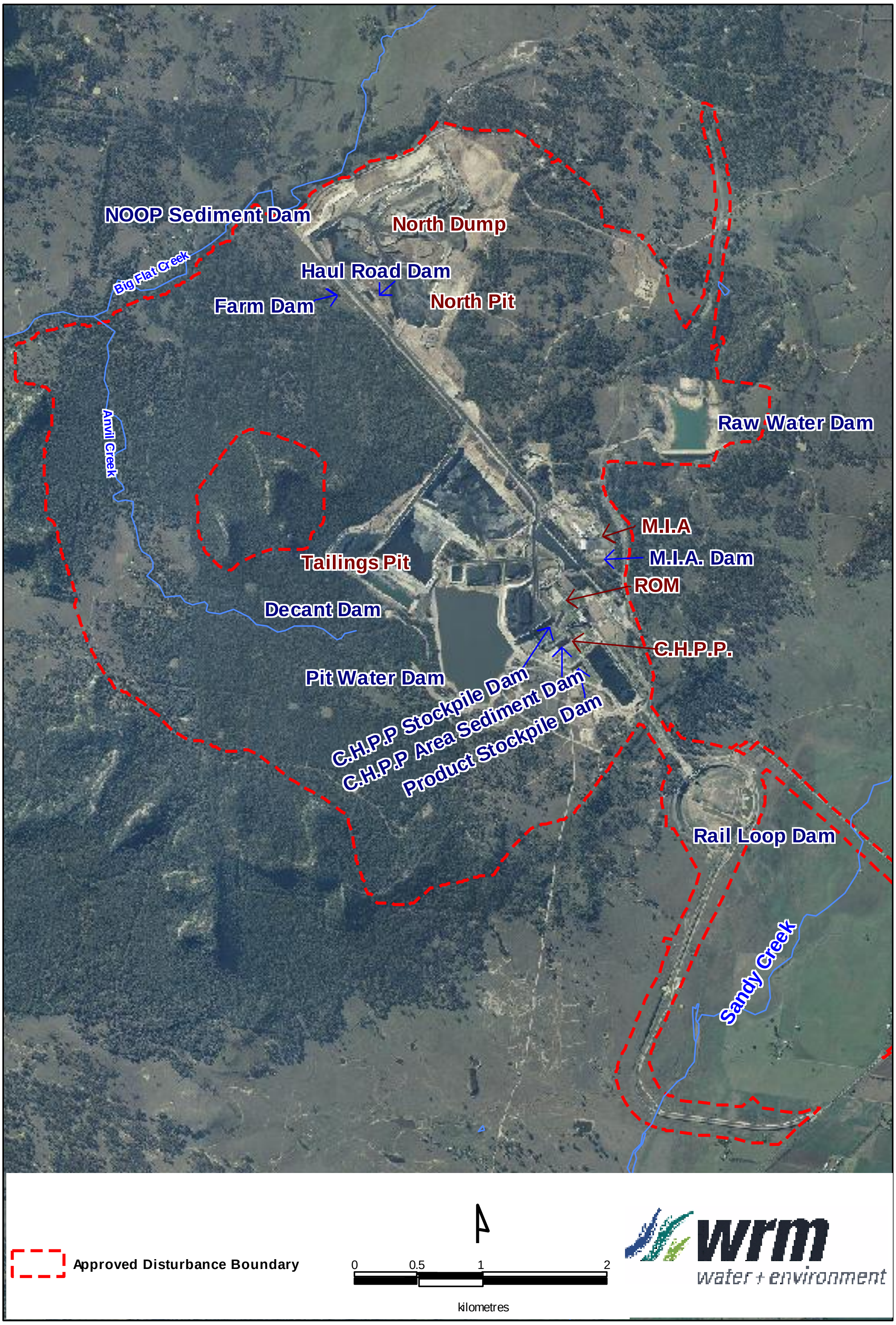


Figure 1.2 Existing infrastructure

Associated with this change are the following key aspects:

- increase in equipment numbers to support increased mining intensity (though the operation will remain a truck and shovel/excavator operation);
- increase in employee numbers to support additional equipment and operational needs and requirements. Up to 150 additional employees, employed over the next few years to meet peak operational capacity and continue to maintain a safe and efficient operation. Additionally, up to 90 full time equivalent contractors may also be required and are considered in this assessment;
- amendment to blasting conditions relating to maximum instantaneous charge (MIC) and frequency of blasting to allow greater flexibility and to assist with dust and fume management. Xstrata Mangoola is not seeking to modify blasting limits that apply at existing receptors;
- re-define one temporary ROM stockpile to a permanent (life of mine) ROM stockpile;
- utilisation of suitable mined waste rock for onsite gravel production. Up to 50,000 tonnes of gravel may be crushed annually for use on site; and
- discharge of saline water to the Hunter River under the rules and regulations of the Hunter River Salinity Trading Scheme (HRSTS).

The changes sought for Modification 6 to PA 06_0014 and hereafter are referred to as the proposed modification.

The proposed modification will result in changes to the overall water balance and the potential impacts on surface water, due to:

- more rapid development of the site water management system in response to the increased rate of land disturbance;
- a potentially higher demand for water for coal processing and handling at the coal handling and processing plant (CHPP) (though the total volume used over the life of the project will not increase, as the total minable resource is unchanged);
- ability to discharge water to the Hunter River under the rules of the HRSTS if required during extended wet periods; and
- minor changes to the layout of the overburden dumps, resulting in modifications to the layout and sizing of sediment dams and the associated drains. These changes are detailed in Section 3.

The changes to the mine layout are relatively minor, and the footprint of the catchment disturbance will be largely unchanged from the approved project.

1.2 ASSESSMENT APPROACH

The Mangoola Coal surface water management strategy was developed as a condition of PA 06_0014. Condition 31 of PA 06_0014 required preparation of a Site Water Management Plan (SWMP), which was approved in January 2009 and subsequently revised in December 2010 (Umwelt, 2010a).

In the Surface Water Assessment for Modification 4 (Umwelt, 2010b), the revised water management performance was compared with that outlined in the original surface water assessment (Umwelt, 2006), and the approved Site Water Balance (Umwelt, 2010a).

As the changes to the water management system under the proposed modification are limited to relatively minor relocations of water infrastructure, the Modification 4 approach has been repeated for this assessment. Where there is no material change proposed under the proposed modification, reference is made to the outcomes of the Modification 4 assessment.

The surface water assessments for previous modifications were prepared before Mangoola Coal commenced operations. Where possible, the observed site water management system performance has been used to verify the methodology for this assessment.

Coal handling infrastructure at Mangoola Coal allows sized (crushed) coal to bypass the washery component of the CHPP and be transported directly by enclosed conveyor from the surge bin straight to the product coal stockpile area. When utilised, this bypass system reduces water demand at the CHPP. This has been accounted for in the water balance through the modelling of two possible operational scenarios:

- Scenario 1 – High Water Demand - up to 13.5 Mtpa of ROM coal washed through the CHPP. Maximum water use would occur under this scenario; and
- Scenario 2 – Low Water Demand - up to 8 Mtpa of ROM coal washed through the CHPP, with the remaining 5.5 Mtpa of ROM coal bypassing the washery producing a bypass coal product (i.e. unwashed). Water usage would be reduced under this scenario.

These scenarios provide the potential upper and lower bounds of expected site water demand under the proposed modification.

1.3 DIRECTOR-GENERAL'S REQUIREMENTS

The Director General's Requirements (DGRs) for the preparation of the Environmental Assessment of the proposed modification were issued on 3 December 2012. Requirements relating to Water Resources are listed in Table 1.1, along with the section of this report where the issue is addressed.

Table 1.1 Director General's Requirements

Requirement	Section reference
Water Resources - including:	
• a detailed site water balance, including	4.2
▪ a description of site water demands,	3.4
▪ water disposal methods (inclusive of	1.4.4, 2.4.2, 3.5
- volume and frequency of any water discharges),	3.5.1, 3.6, 4.3
- water supply infrastructure and	3.5, 3.6
- water storage structures; and	2.4, 3.2, 3.5
• assessment of potential impacts on the quality and	4.11.2
• quantity of existing surface water resources, including:	
▪ detailed information of potential impacts associated with proposed discharges under, and in compliance with, the Hunter River Salinity Trading Scheme; and	4.11
▪ impacts on riparian, ecological, geo-morphological and hydrological values of watercourses, including environmental flows;	4.1, 4.8, 4.9

1.4 REGULATORY FRAMEWORK

The following legislation, plans, policies and regulations are relevant to the proposed modification with respect to water management:

- *Protection of the Environment Operations Act 1997*;
- *Water Management Act 2000* and applicable water sharing plans and harvestable rights provisions;
- 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.

1.4.1 Protection of the Environment Operations Act 1997

Mangoola Coal is licensed under *Protection of the Environment Operations Act 1997*. The existing environment protection licence (EPL) (EPL No. 12894) does not make provision for release of water from the site (except as allowed under the Erosion and Sediment Control System Plan).

Controlled release of water from the Saline Water Zone (open cut pits, Pit Water Dam, Tailings Dam, CHPP, ROM and product stockpiles, rail loading facilities, coal haul roads) via controlled discharge in accordance with the rules and regulations of the HRSTS forms part of the proposed modification and does not form part of current operations.

If the proposed modification is approved, the EPL would need to be modified to accommodate proposed controlled discharges to the Hunter River from the Saline Water Zone under the HRSTS.

1.4.2 Water Management Act 2000

Water Sharing Plans

The *Water Management Act 2000* requires all extraction of surface or groundwater be properly accounted for under the rules of the relevant water sharing plans. Any surface water runoff harvested, diverted or captured in excess of the site's harvestable right must be assigned against access licences for the relevant surface water source.

The current operation's surface waters associated with the approved project disturbance boundary and the Hunter River itself are accounted for through the following water sharing plans:

1. *Wybong Creek Water Sharing Plan 2003.*

   The approved project disturbance boundary is mostly contained within the Wybong Creek catchment. PA 06_0014 (Condition 29) requires that the Project "shall not use any licensable water from the Wybong Creek Water Source for mining purposes". As discussed in the Modification 4 Surface Water Assessment (Umwelt 2010b) and the Site

Water Management Plan (Umwelt 2010a), current operations do not use water from the Wybong Creek water source except:

- under Harvestable Rights provisions,
- if the water has come into contact with coal (saline water);
- if the water is used for dust suppression.

"Saline water dams" and "Dirty water dams" fall within the "excluded works" exemption. The "excluded works" exemption applies to dams which are "*solely for the capture, containment and recirculation of drainage and/or effluent, consistent with best management practice or required by a public authority .... to prevent contamination of a water source, that are located on a minor stream*".

2. ***Hunter Unregulated and Alluvial Water Sources Sharing Plan 2009.***

   Surface waters in Sandy Creek and its tributaries within the approved project disturbance boundary are regulated under this plan. Where water volumes extracted from these catchments exceed the Harvestable Right provisions, a water entitlement (an unregulated river access license) is required. The plan limits annual extraction to a limit which provides for no new growth in water entitlements. No additional surface water harvesting infrastructure is sought as part of the proposed modification.

3. ***Hunter Regulated River Water Sharing Plan 2003***.

   All water extractions from the Hunter River will continue to be managed under appropriate water access licenses (WALs). Xstrata Mangoola holds approximately 2,774 general security units and 17 high security units of Hunter River water shares. Water will continue to be extracted from existing licenses, and there will therefore be no cumulative impact on water supplies in the Hunter River catchment caused by the proposed modification.

Harvestable Rights

Where the capture of runoff from undisturbed areas is unavoidable, use of clean runoff will be limited to Harvestable Rights provisions specified under the *Water Management Act 2000*. The Modification 4 Surface Water Assessment (Umwelt, 2010b) estimated the Mangoola Coal's Harvestable Right as approximately 600 Megalitres per annum (ML/a), based on contiguous land holdings of 8,575 ha at a rate of 0.07ML/ha/a. Of this, approximately 135ML/a was estimated to be captured in existing farm dams, leaving 465ML/a for other purposes.

1.4.3 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. As discussed in the Modification 4 Surface Water Assessment (Umwelt, 2010b), current operations are consistent with the objectives of the SWMOP and CAP, given:

- surface disturbance is restricted to the area of the project site. Impacts will be mitigated within the site water management system. Erosion and sediment controls will be designed and operated in accordance with the Blue Book requirements (DECC, 2008);
- any extraction of water will be in accordance with licensing provisions;

- discharges from the site will only occur if water complies with the EPL and where applicable, the HRSTS.

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

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

Releases of saline water to the Hunter River can be made in accordance 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 discharges 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 µS/cm at Denman and 900 µS/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% 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 though 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. Mangoola Coal lies in the Upper Sector (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 1.2.

Table 1.2 HRSTS Flow & River Salinity Thresholds, Upper Sector

Hunter River 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	600µS/cm	Limited discharges allowed, controlled by salt credits and Total Allowable Discharge (TAD)
>4,000	Flood	600µS/cm	Unlimited discharges

The water in the Hunter River is divided into numbered blocks. The scheme operators monitor the flow and salinity in each block, and calculate the 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.

2 EXISTING ENVIRONMENT

Details of the surface water receiving environment relevant to the proposed modification are outlined in the following sections.

2.1 LOCAL DRAINAGE CHARACTERISTICS

Figure 2.1 shows the drainage characteristics in the region of the approved project disturbance boundary. As previously stated, Mangoola Coal is largely within the Wybong Creek catchment, however, the approved project disturbance boundary is within a number of sub-catchments of smaller tributaries and streams, namely; Sandy Creek, Clarks Gully, Anvil Creek and Big Flat Creek. Sandy Creek (a fifth order stream) is a tributary of the Hunter River, and flows into the Hunter River at the township of Denman. The Hunter River flows in a south-westerly direction approximately 5km to the south-east of Mangoola Coal.

Clarks Gully and Anvil Creek (both second order streams) are tributaries of Big Flat Creek (a fourth order stream), itself a tributary of Wybong Creek which in turn is a tributary of the Goulburn River. The junction of the Goulburn and Hunter Rivers is approximately 4.8km downstream of Denman. The upper part of Clarks Gully is within the approved project disturbance boundary and has been altered by current operations.

2.2 DOWNSTREAM WATER USERS

Figure 2.2 presents the surface and groundwater licences from the NOW database in the vicinity of Mangoola Coal (Umwelt, 2006). Figure 2.2 indicates that within 2km downstream of the proposed discharge point there are seven surface water extraction licences along the Hunter River, and an additional nine surface water extraction licences in the following 4km downstream.

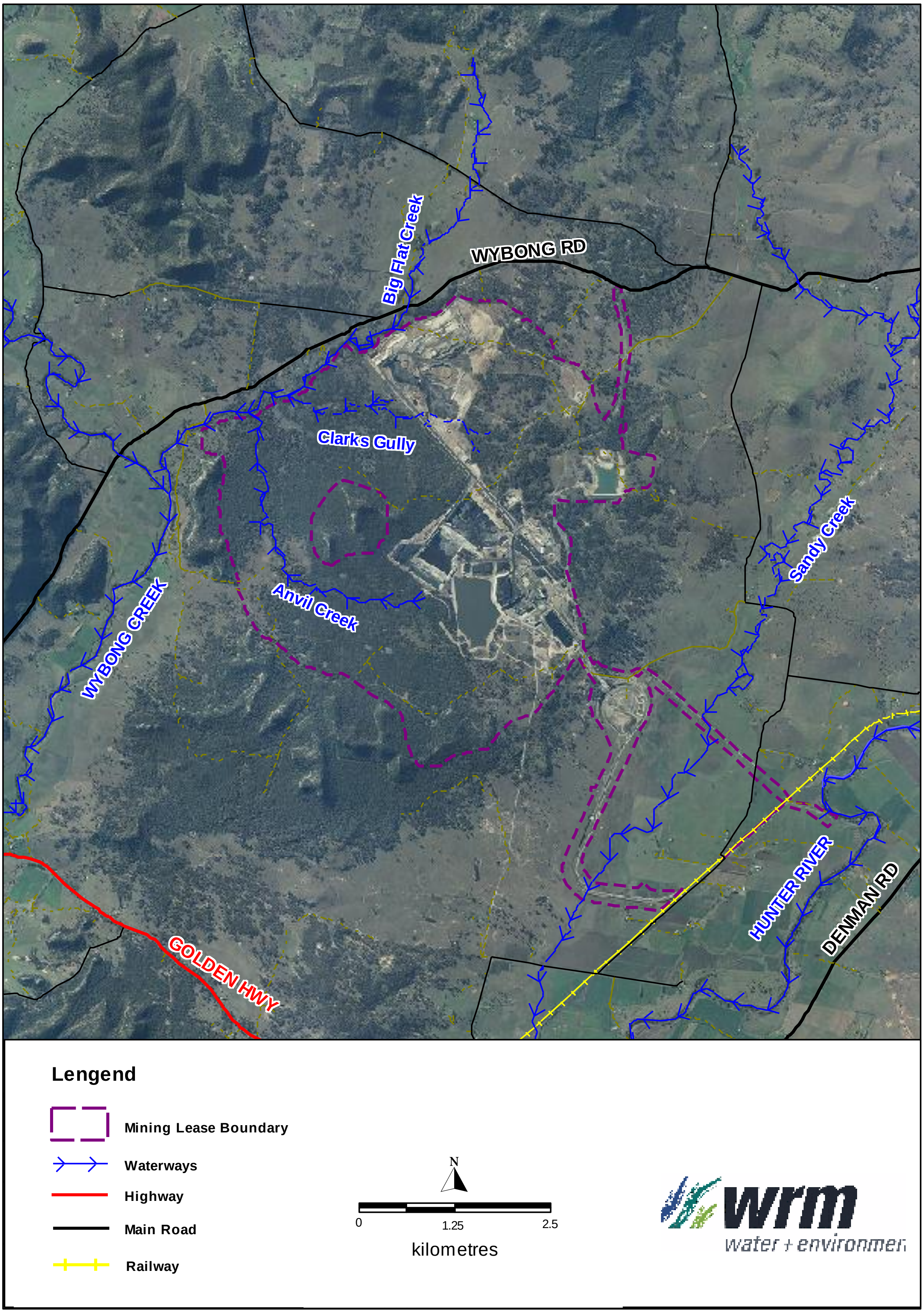


Figure 2.1 Mangoola Coal Local Streams

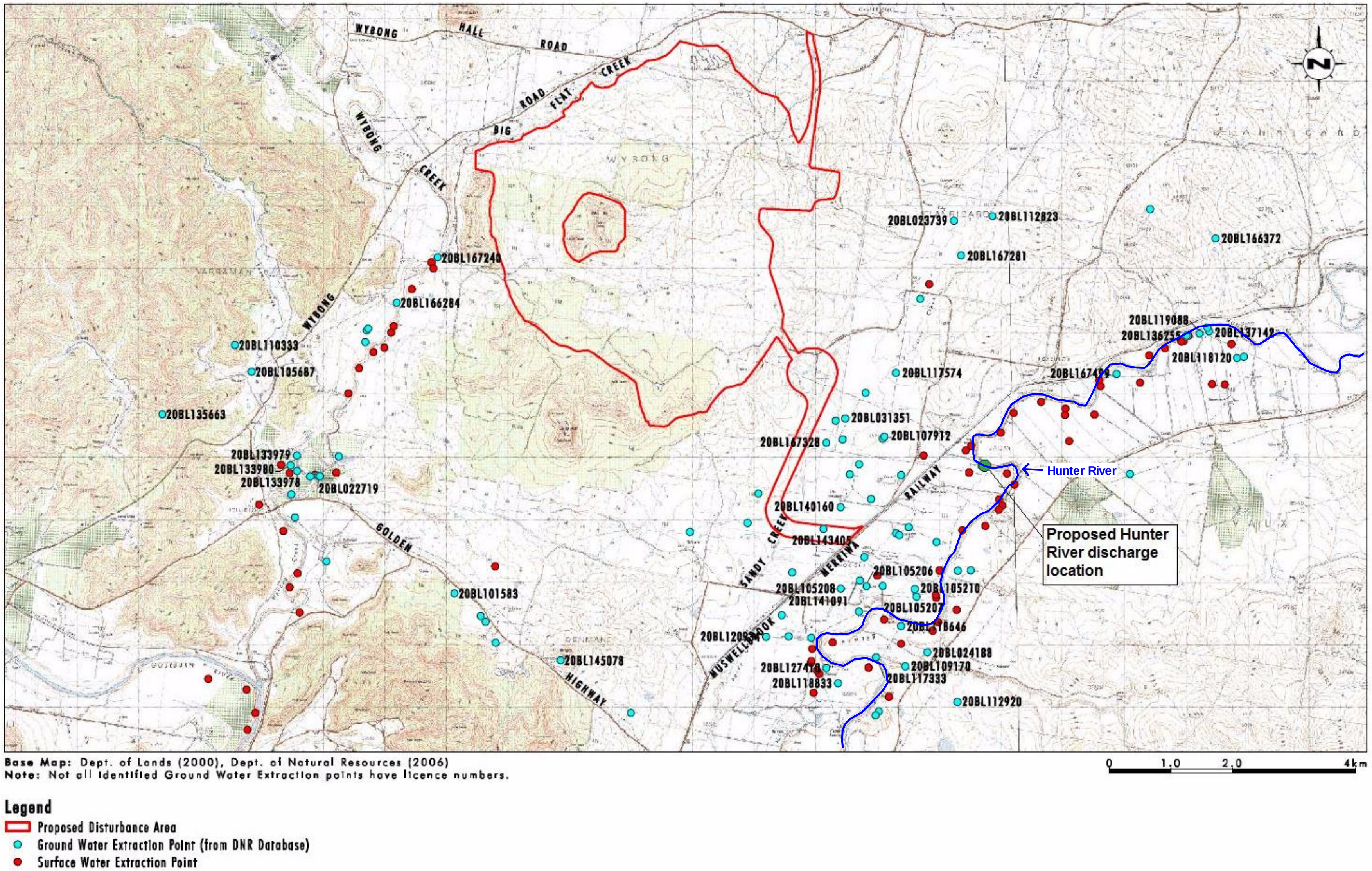


Figure 2.2 Licensed Surface Water & Groundwater Extraction Points (Source: Umwelt 2006)

2.3 HUNTER RIVER STREAMFLOW AND WATER QUALITY

Streamflow and water quality data for the Hunter River was sourced from NOW at two locations shown in Figure 2.3:

- Station No. 210002 – Hunter River at Muswellbrook Bridge (approximately 25km upstream of proposed discharge point). The catchment area of the river to the gauge is approximately 4,220 km^2. 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 (downstream of proposed discharge point).

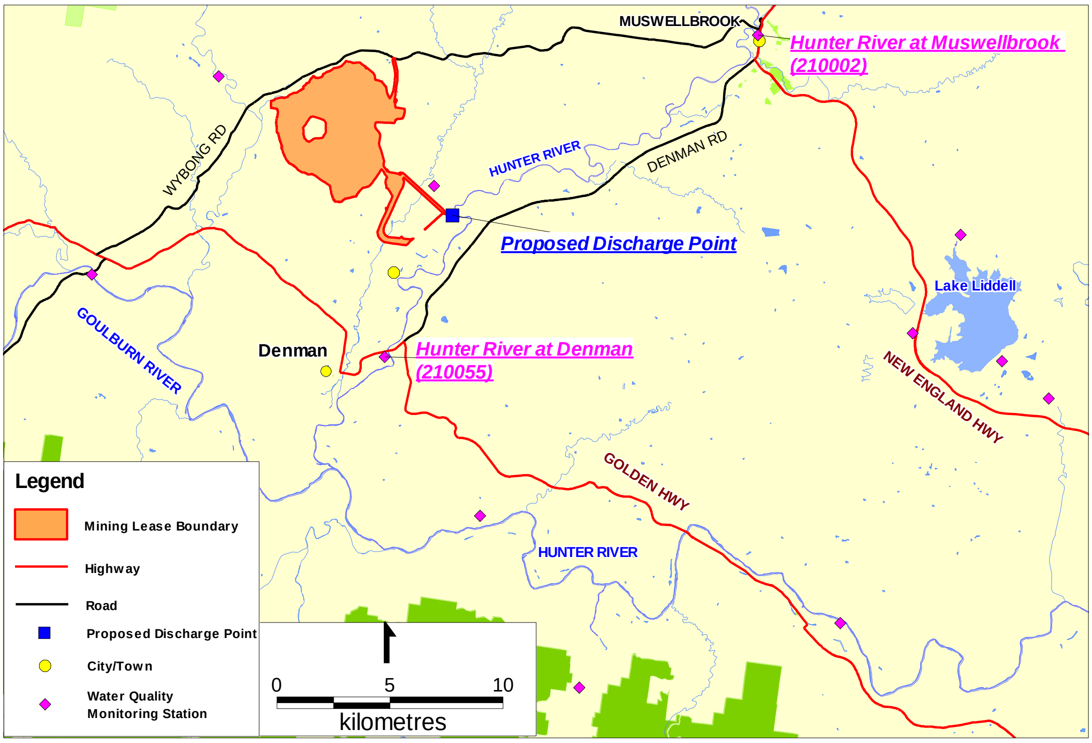


Figure 2.3 Locations of Nearby NOW Hunter River Streamflow and Quality Monitoring Stations

Figure 2.4 shows the recorded daily flow-duration relationships for streamflow recorded in the Hunter River at Muswellbrook Bridge (Station No. 210002) and Denman (Station No. 210055), for the common period of record (1993 to 2013).

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 Megalitres per day (ML/d). The median (50th percentile) flow rate is about 300 ML/d and the 95th percentile (low flow) flow rate is around 100 ML/d.

Hunter River water quality data has been collected since the 1970s. The available data is summarised in Table 2.1 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 Nitrogen, Total Phosphorous, Zinc and pH, but all other constituents are below trigger levels. Further details are presented in Appendix B.

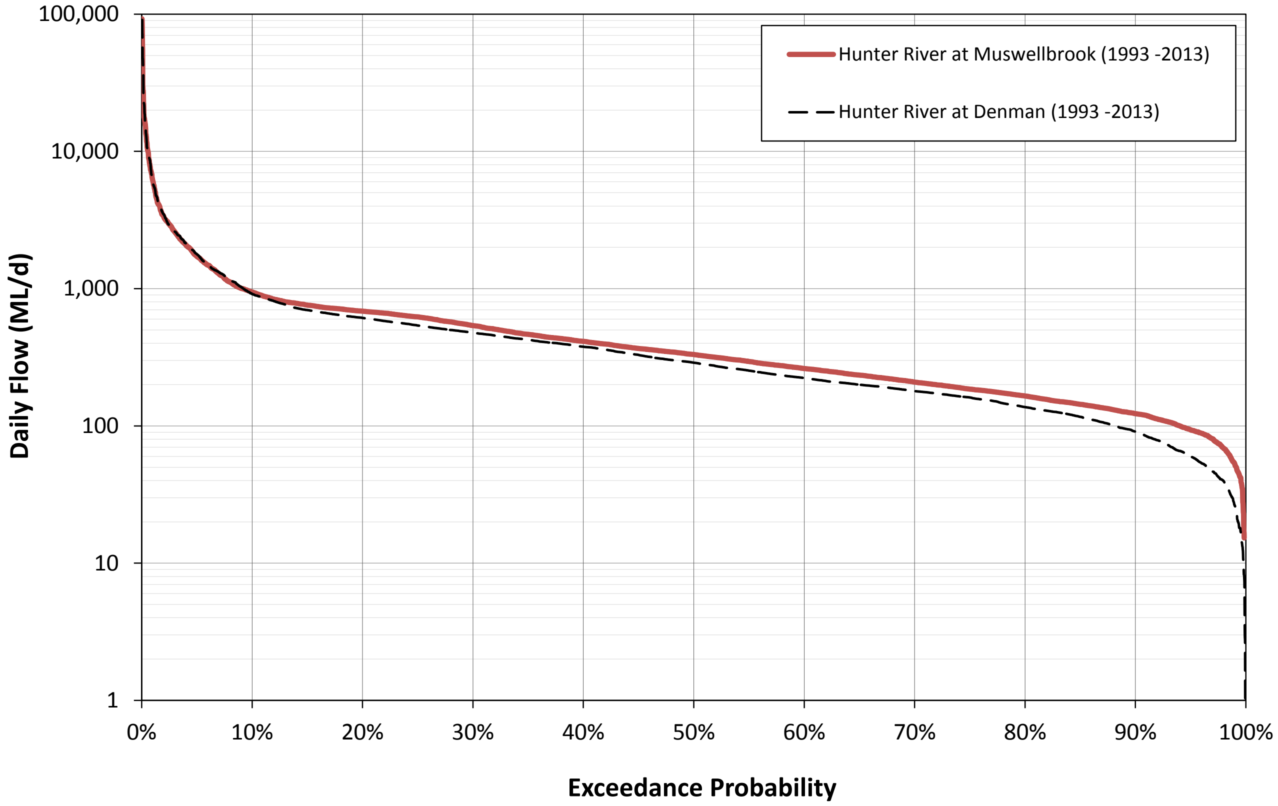


Figure 2.4 Flow-Duration Curves for Hunter River at Muswellbrook and Denman, 1993-2013

Table 2.1 Summary of Hunter River Water Quality Data at Muswellbrook Bridge and Denman (NOW)

		ANZECC Trigger Value				U/S (MUSWELLBROOK BRIDGE - 210002)			D/S (HUNTER RIVER DENMAN - 210055)		
Parameter	Unit	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 (HCO_3)	mg/L	-				232.5	292.8	168	220.7	257.6	15
Sulphate as SO_4	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 (Fl-)	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

^ Lowland river (<150m altitude).
^^ 95% of species protected.
^^^ Nitrate only.
* Lowest recommended value.
** Cattle (insufficient information on other livestock).
*** Sensitive crops.

2.4 EXISTING WATER MANAGEMENT SYSTEM

Mangoola Coal commenced mining operations in September 2010. Throughout this surface water assessment, the 'current operations' system is the system in place in late 2011. The current site water management system was developed in accordance with the principles proposed in the original EA for Mangoola Coal (Umwelt, 2006) and subsequent modifications. As detailed in the Mangoola Water Management Plan (Umwelt 2010a), the system is managed in three separate zones:

- **Dirty Water Zone** – manages runoff (Dirty Water) from areas disturbed by mining and construction, including overburden emplacement areas and rehabilitated areas. Runoff (or Dirty Water) within these areas potentially has high sediment loads but has not come into contact with coal or saline water.

- **Saline Water Zone** – contains water that has been in contact with coal or carbonaceous material (Saline Water).

- **Raw Water Zone** – water extracted from the Hunter River and pumped to the Raw Water Dam (Raw Water) as well as the catchment area of some 195ha upslope.

To comply with PA 06_0014, which requires that licensable water from the Wybong Creek Water Source is not used for mining purposes, demands are met from the following hierarchy of sources:

1. Dirty Water Zone water to supply dust suppression;
2. Saline Water Zone water for process water and dust suppression within the Saline Water Zone;
3. Pit groundwater inflows for process water and dust suppression within the Saline Water Zone;
4. Dirty Water Zone runoff for process water use;
5. Water from the Hunter River using current WALs;
6. Runoff from undisturbed areas for dust suppression;
7. Runoff from undisturbed areas for use within the Saline Water Zone under the Harvestable Rights provisions.

2.4.1 Water Supply

Mangoola Coal's current operations include a pump station and 710mm pipeline from the Hunter River, known as the Hunter River pipeline and pump station, which is used to supply the Raw Water Dam. The pump station comprises two bank-mounted multistage turbine pumps delivering water to site via a tank and booster station. The Hunter River pipeline design was based on a capacity of 60-70ML/d, with an upper limit of 100ML/d. Note that for water balance modelling a design flow rate of 50ML/d was assumed.

2.4.2 Water Storages

The current water management system comprises two main water storage dams, the Pit Water Dam and Raw Water Dam, and a number of sediment dams associated with both the Saline and Dirty Water Zones. The layout of the surface water management infrastructure is shown in Figure 2.10.

The Pit Water Dam (shown in Figure 2.5) is the main mine water storage and supplies the CHPP and dust suppression demands. The Pit Water Dam is part of the Saline Water Zone, however it can also receive Dirty Water from sediment dams in the Dirty Water Zone subject to available freeboard. Water decanted from the Tailings Pit or captured in the various sediment dams is transferred to the Pit Water Dam for reuse.

Figure 2.5 Pit Water Dam (in background)

Water extracted from the Hunter River is pumped via the Hunter River pipeline to the Raw Water Dam (shown in Figure 2.6). The Raw Water Dam augments supplies in the Pit Water Dam as needed. Xstrata Mangoola holds approximately 2,774 general security units and 17 high security units of Hunter River water shares.

Figure 2.6 Raw Water Dam

Sediment dams in the Dirty Water Zone include:

- Northern Out of Pit (NOOP) Sediment Dam (see Figure 2.7);
- Farm Sediment Dam; and
- Anvil Creek Sediment Dam.

Figure 2.7 Northern Out of Pit (NOOP) Sediment Dam

Dams in the Saline Water Zone include:

- Haul Road Sediment Dam;
- Mining Infrastructure Area (MIA) Sediment Dam;
- CHPP Area Sediment Dam (see Figure 2.8);
- Product Stockpile Dam;
- CHPP Stockpile Sediment Dam;
- Rail Loop Dam;
- Tailings Pit;
- Decant Pit; and
- Pit Water Dam.

Figure 2.8 Current operations CHPP Area Sediment Dam (in foreground)

The storage capacities of the dams which form part of current operations are listed in Table 2.2.

Table 2.2 Storage Capacities of Water Dams

Dam	Capacity (ML)
Saline Zone	
MIA Sediment Dam	2
Product Stockpile Dam	4
CHPP Area Stockpile Sediment Dam	6
Haul Road Sediment Dam	8
CHPP Area Sediment Dam	25
Rail Loop Dam	28
Pit Water Dam	1,495
Dirty Water Zone	
Farm Sediment Dam	1
Anvil Creek Sediment Dam	10
NOOP Sediment Dam	46
Raw Water Zone	
Raw Water Dam	2,566

The current water management system is shown schematically in Figure 2.9 and in the layout plan in Figure 2.10.

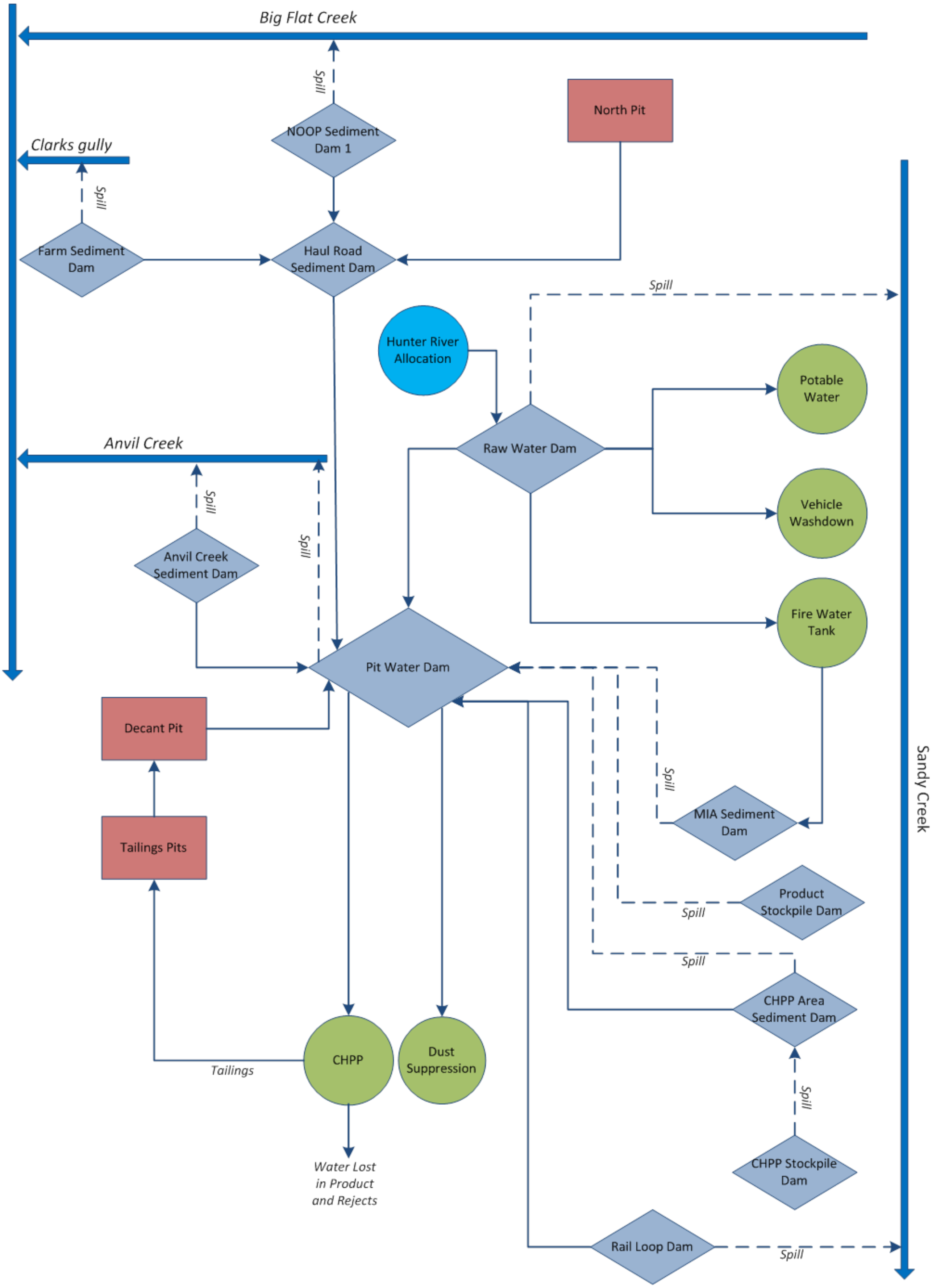


Figure 2.9 Current Water Management System Schematic

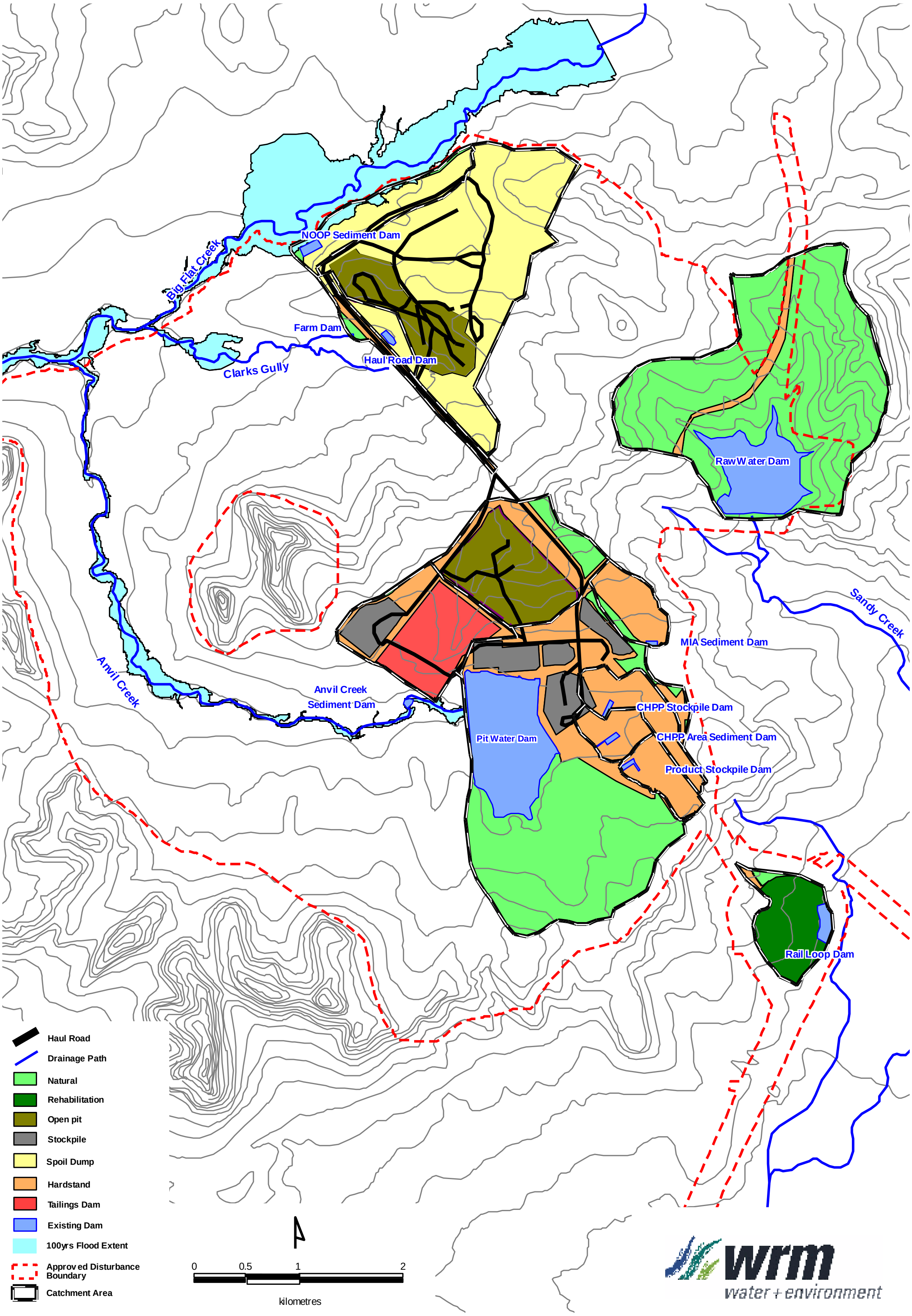


Figure 2.10 Current Operations Water Management System Layout

2.4.1 Water Releases

Saline Water Zone

The current system is currently managed to achieve zero discharges of water from the Saline Water Zone. The current EPL and project approval does not permit the release of Saline Water.

During construction of infrastructure for the Hunter River pipeline and pump station, provision was made for releasing water to the Hunter River, subject to relevant approvals and licences. While current operations only extract water from the Hunter River, the pipeline and pump station has two-way flow capability and is capable of both mine water supply as well as mine water discharge.

A discharge outlet is located at the Hunter River pump station. The discharge outlet is a 600mm steel pipe with concrete headwall. The pipe discharges into a rock-lined swale, which runs adjacent to and beneath the dual water supply pump tubes.

A floating pipeline and discharge pumps will need to be constructed across the Pit Water Dam to the Hunter River pipeline to allow it to be used as a discharge pipeline. These works are within the approved project disturbance boundary and in already disturbed areas.

Dirty Water Zone

Dirty Water runoff from active overburden emplacement areas and rehabilitated areas is managed in accordance with Mangoola Coal's Erosion and Sediment Control Plan, and captured in sediment dams for storage, treatment and release in accordance with Blue Book requirements (DECC, 2008). Experience gained since operations commenced indicates that while the overburden emplacement material is generally non-dispersive with a low proportion of fines, the native topsoil is dispersive. Once rehabilitation of an area commences, suspended solids in runoff from respread topsoil does not settle rapidly. As a result, water captured in the sediment dams is sometimes unsuitable for release due to higher levels of suspended solids. If this is the case, the captured water is used in nearby operations or returned to the Pit Water Dam.

It will be important to establish vegetation cover as quickly as possible to reduce sediment loads on topsoiled landforms. Once vegetation is established (after approximately 2 years), Xstrata Mangoola anticipates that water quality from rehabilitated landforms will be such that runoff can be redirected off site without treatment in Sediment Dams.

Raw Water Zone

When the Raw Water Dam water levels are close to the Full Supply Level (FSL), water may occasionally overflow into the local catchment following large runoff events via the Raw Water Dam spillway. Any overflows are unlikely to adversely affect downstream water quality, as the Raw Water Dam is to contain only clean runoff mixed with water pumped from the Hunter River water. Based on the results of water balance modelling for this assessment, the salinity of discharges is unlikely to exceed 600μS/cm.

2.5 CURRENT WATER DEMANDS

2.5.1 CHPP

Data collected by Xstrata Mangoola on current operations indicated current CHPP water use is approximately 327L/feed tonne. With a tailings decant return rate of 51% this is equivalent to a water loss of 155L/feed tonne, where "water loss" refers to the net supply rate required to maintain production after moisture retention in the rejects and product moisture streams. This rate is compared with the rates adopted in previous assessments (prepared prior to commencement of mining operations) in Table 2.3.

Table 2.3 Comparison of Previous CHPP Demand Estimates (10.5Mtpa)

Source Study	Water Loss	
	ML/a	L/ROM t
Original EA Suface Water Assessment (Umwelt 2006)	1,220	116
Modification 4 Suface Water Assessment (Umwelt December 2010)	1,825	173
Current operations (WRM)	1,632	155

2.5.2 Haul Dust Suppression

Dust suppression requirements at Mangoola Coal comprise haul road dust suppression and stockpile dust suppression. Xstrata Mangoola personnel have indicated haul road dust suppression water use is approximately 1ML/d. This is equivalent to a dry day application rate of 3.1mm/d on a watered road width of 22m over the estimated current active haul road length of 17.4km (based on aerial photography), and is consistent with WRM's experience at similar sites.

2.5.3 Vehicle Wash

The annual vehicle wash requirement is 30ML/a.

3 PROPOSED WATER MANAGEMENT SYSTEM

3.1 WATER MANAGEMENT SYSTEM LAYOUT

The proposed modification will result in some minor changes to the water management system layout. The proposed water management system is shown in the layout plans in Figure 3.1 to Figure 3.4 for each of the mine plan stages analysed for this assessment (Years 2, 5 and 10).

The land use classifications within the water management system at various stages of the mine life are summarised in Table 3.1.

Table 3.1 Catchment Land Use Areas (ha)

Stage	Land Use Classification								
	Natural	Hardstand	Open Cut	Tailings	Active Waste	Rehab Waste	Stockpile	Estab. Rehab[1]	TOTAL
Current	404	145	73	32	157	28	34	0	**873**
Year 2	378	129	131	52	90	108	29	148	**1,065**
Year 5	277	137	155	168	206	78	29	466	**1,516**
Year 10	370	101	135	135	121	223	29	880	**1,994**

[1] 'Established rehabilitation' is defined as waste areas which have been rehabilitated for at least 2 years.

The water management system under the proposed modification will evolve as the mine develops, as follows (refer Figures 3.1 to 3.3):

- Year 2: early stage of mining with coal extraction occurring in the north-east area of the mine (the Northern Pit) and progressing in a south-easterly direction towards the mine infrastructure area. The overburden emplacement area is well established behind the general progression of the pit. Runoff from areas of established rehabilitation will be directed off site. Runoff from overburden emplacement areas is captured by NOOP Sediment Dams 1, 2, 3 and 4 (refer to Section 3.2 for details). Water collected in the pit is transferred to the Pit Water Dam.
- Year 5: coal extraction occurs in the north-west area (the Main Pit) and southern area (the Southern Pit) of the mine. The Main Pit progresses in a southwest direction around Anvil Hill and Southern Pit in a north-west direction. By this time, large portions of the out of pit overburden dumps will have been rehabilitated for at least 2 years. Runoff from these areas will be directed off site. The water management infrastructure will comprise:
  - Farm Sediment Dam, Haul Road Dam and Anvil Creek Sediment Dam are mined through as Main and Southern Pits progress;
  - Main Pit Sediment Dam (Main 1) constructed to capture runoff from the overburden emplacement area behind the Northern Pit;

  - Southern Out-of-Pit (SOOP) Dump Sediment Dams (SOOP1, SOOP2 and SOOP3) constructed to capture runoff from the overburden emplacement areas behind the Southern Pit.
- Year 10: there is only one active pit in the south-western area of the approved project disturbance boundary. The majority of the mined land is rehabilitated by this time and represents the end stage of the mine life. The Main Pit Sediment Dam (Main 2) is constructed to capture runoff from the recently rehabilitated overburden emplacement areas. Areas of established rehabilitation are diverted off site.

Changes to the positioning and sizing of the sediment dams within the water management system are described in the Section 3.2.

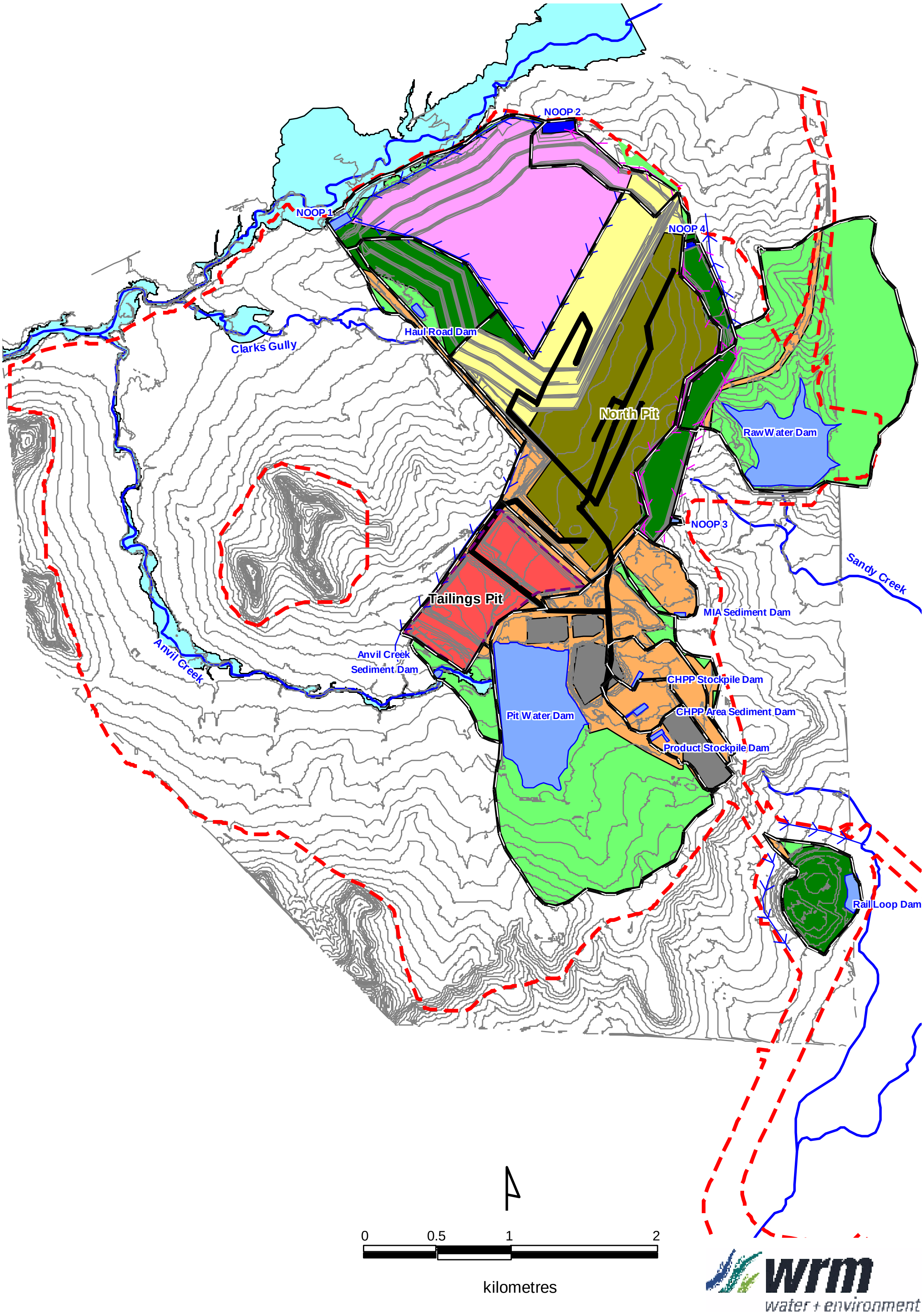


Figure 3.1 Proposed Water Management Layout – Year 2

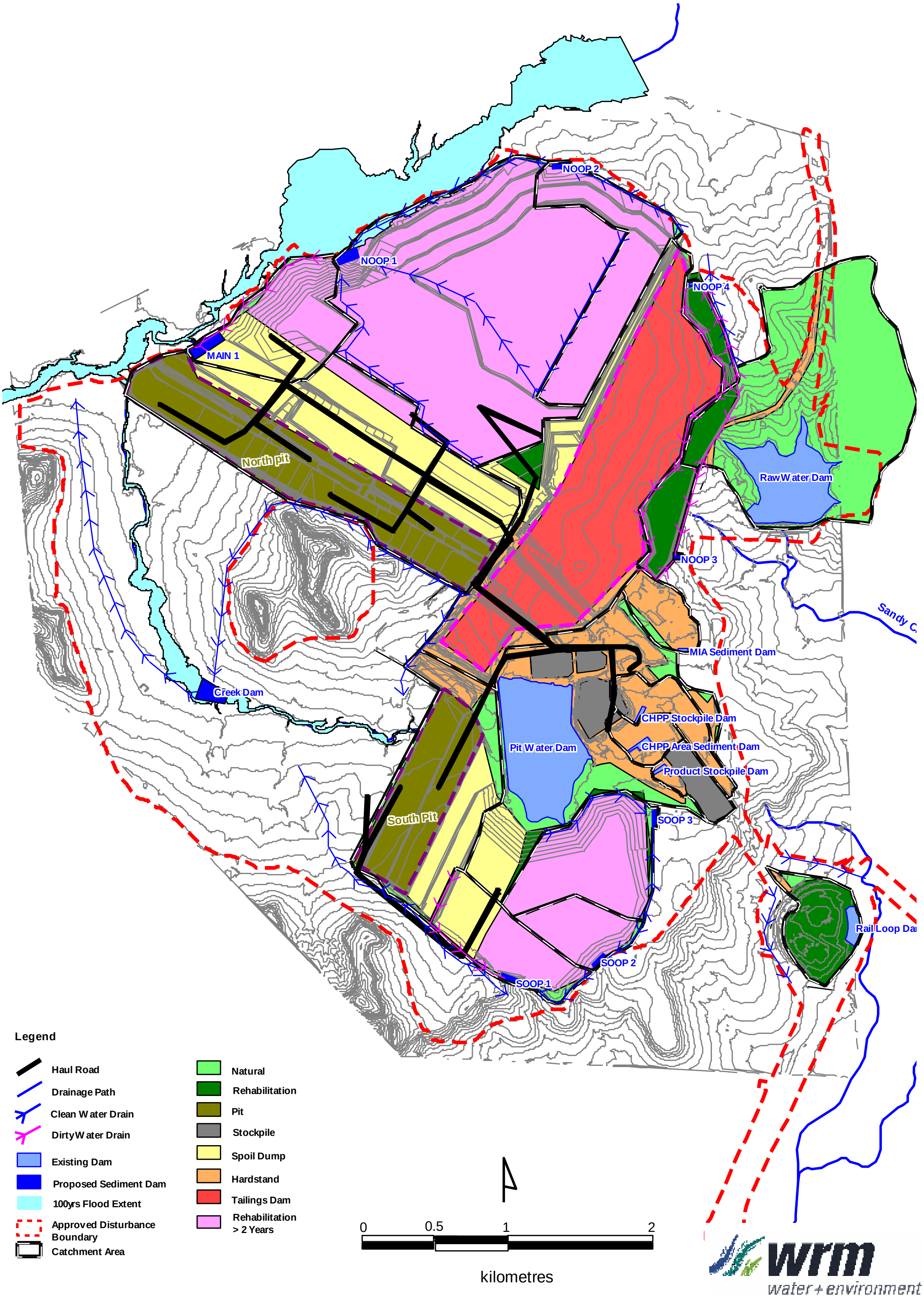


Figure 3.2 Proposed Water Management Layout – Year 5

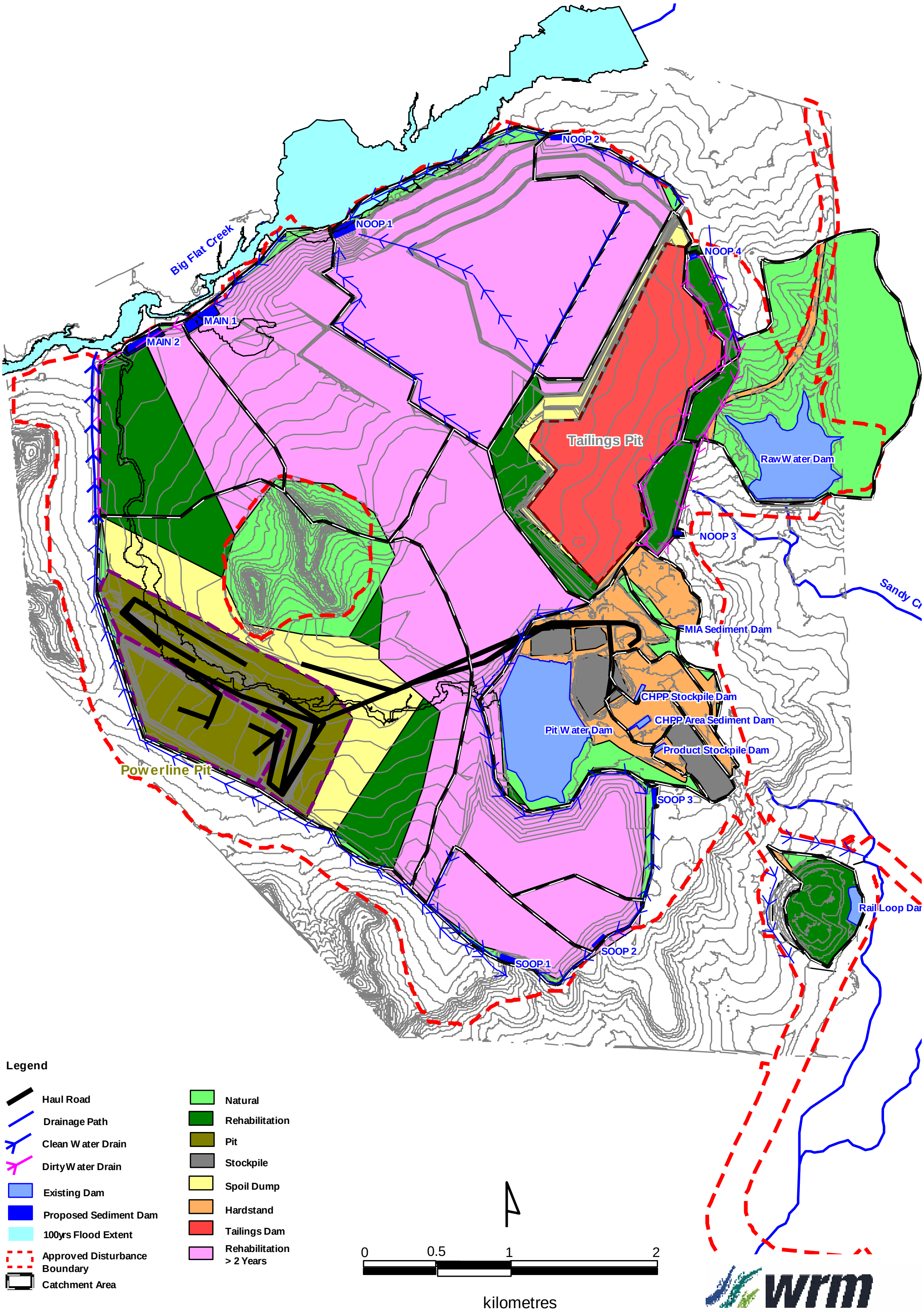


Figure 3.3 Proposed Water Management Layout – Year 10

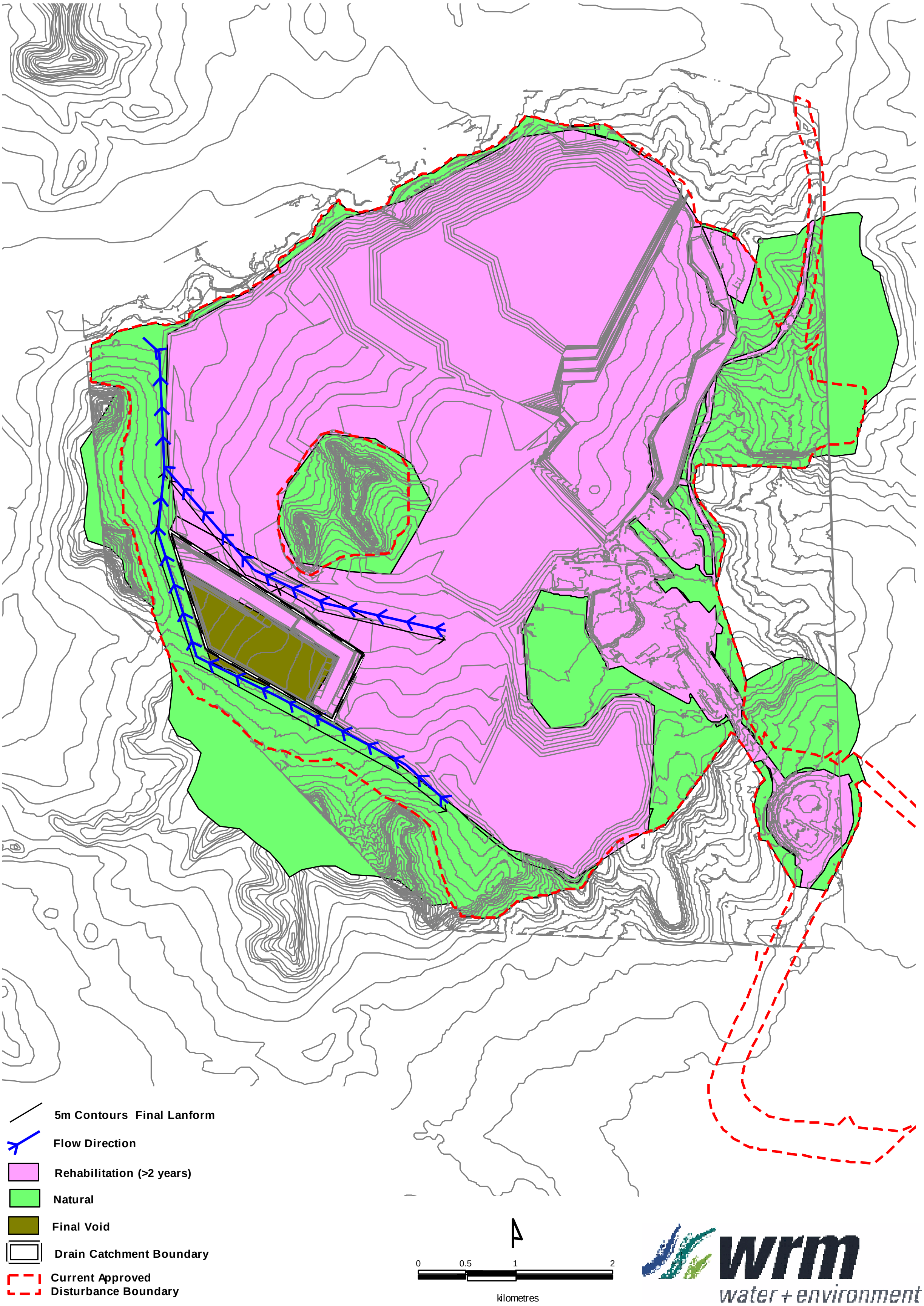


Figure 3.4 Proposed Water Management Layout – Conceptual Final Landform

3.2 REVISED SEDIMENT DAM DETAILS

The main changes to the water management system required for the proposed modification are related to the Dirty Water Zone sediment dams. Most of the changes are relatively minor relocations and realignments of sediment dams and associated drainage requirements. The water management system layouts in Figure 3.1 to Figure 3.4 reflect the following changes:

- Within the Northern Pit, previous assessments considered two sediment dams at the northern-most overburden emplacement area (NOOP overburden emplacement area). These have not yet been constructed, and instead the entire overburden emplacement area drains to a sediment dam, known as the NOOP Sediment Dam, via a drain along the existing toe of the emplacement area. The revised layout proposed includes the northern-most of these two dams (NOOP Sediment Dam 2) which is proposed to be located at the upstream end of the existing drain, and receive runoff from the NOOP overburden emplacement areas as it extends further eastwards (see Figure 3.1).
- Runoff from the top of the NOOP overburden emplacement area will be directed to the active pit (to be the Tailings Dam in later years) so that NOOP Sediment Dam 1 and NOOP Sediment Dam 2 receive runoff solely from the spoil batters.
- To protect water quality in Sandy Creek, a new sediment dam (NOOP Sediment Dam 3) will be required to capture runoff from the overburden emplacement area proposed between the Northern Access Road and the active pit in the Northern Pit in Year 2 (see Figure 3.1).
- Sediment dams have been sized based on the largest unrehabilitated catchment area requiring sediment treatment. During rehabilitation, some emplacement runoff will be directed to the pits. Once an emplacement area adjacent to a sediment dam is rehabilitated (2 years after establishment) the rehabilitated areas will be redirected offsite.

All sediment dams will be sized according to Blue Book Requirements (DECC, 2008) for Type D Basins, including the requirement to be provided with sufficient pump capacity to empty each dam within five days of filling. The following sediment dam sizes have been adopted for assessment purposes.

Table 3.2 Sediment Dam Sizing

Sediment Dam	Catchment Area*1 (ha)	Volume (ML)	Pump Out Rate (L/s)	Surface Area (ha)	Construct Prior to
MAIN 1	150.4	85.6	200	2.06	Year 5
MAIN 2	153.5	87.4	200	2.09	Year 10
NOOP 1*2	64.5	46.0	85	0.97	Year 2
NOOP 2	27.2	15.5	40	0.48	Year 2
NOOP 3	21.0	11.9	30	0.36	Year 2
NOOP 4	11.4	6.5	15	0.22	Year 2
SOOP 1	42.7	24.3	60	0.70	Year 5
SOOP 2	24.8	14.1	35	0.43	Year 5
SOOP 3	26.0	14.8	35	0.45	Year 5

*1 Maximum catchment area requiring sediment treatment reporting to sediment dam over mine life
*2 Existing Volume and Capacity have been adopted

3.3 CATCHMENTS AND LAND USE CLASSIFICATION

Catchment delineation and land use classifications for Years 2, 5, 10 and the final landform under the proposed modification are presented in Figures 3.1 to 3.4. Catchment areas and associated land use classifications are summarised for current operations and for Year 2, 5 and 10 in Table 3.3 to Table 3.6.

Table 3.3 Mangoola Coal Catchment Land Use Areas (ha) – current operations

Storage Name	Land Use Classification								Total Area
	Natural (grassed)	Hardstand	Open Cut	Tailings	Active Waste	Rehab Waste	Stockpile	Estab. Rehab.	
Pit Water Dam	164.5	35.5					23.2		223.2
Raw Water Dam	204.4	7.3							211.5
North Pit	0.3		31.9		123.0				155.2
Decant Pit	8.5	16.4	40.7						65.6
Rail Loop Dam	1.3	0.9				28.3			30.5
Tailings	1.1	13.2		32.2			9.2		55.7
Haul Road Sed. Dam					9.0				9.0
Farm Dam	1.3	7.7			1.4				10.4
CHPP Stockpile Dam	0.5	20.3					1.3		22.1
CHPP Area Sed. Dam		12.3					0.5		12.8
Product Stockpile Dam		14.6							14.6
MIA Sed. Dam	2.3	15.9							18.2
NOOP Dam	4.2				23.6				27.8
Anvil Ck Sed. Dam	15.2	0.7							15.9

Table 3.4 Mangoola Coal Catchment Land Use Areas (ha) – Year 2

Storage Name	Land Use Classification								Total Area
	Natural (grassed)	Hardstand	Open Cut	Tailings	Active Waste	Rehab Waste	Stockpile	Estab. Rehab.	
Pit Water Dam	164.5	43.0					15.6		223.1
Raw Water Dam	173.6	7.3				8.6			189.5
North Pit	0.7	17.8	131.1		83.0	4.5			237.2
Rail Loop Dam	1.3	0.9				28.3			30.5
Tailings	0.5	11.9		51.6			9.2		64.0
Haul Road Sed. Dam	6.1					32.8			38.9
Farm Dam	1.8	7.6			1.1				10.5
CHPP Stockpile Dam	0.5	20.3					1.3		22.1
CHPP Area Sed. Dam		12.3					0.5		12.8
Product Stockpile Dam		3.1					11.6		14.7
MIA Sed. Dam	2.3	15.9							18.2
Anvil Creek Sed. Dam	15.2	0.7							15.9
NOOP 1	9.3					4.2		132.8	146.4
NOOP 2	1.3				6.0			15.1	22.4
NOOP 3	0.8					19.2			20.0
NOOP 4	0.3	0.2				10.5			11.0

Table 3.5 Mangoola Coal Catchment Land Use Areas (ha) – Year 5

Storage Name	Land Use Classification								Total Area
	Natural (grassed)	Hardstand	Open Cut	Tailings	Active Waste	Rehab Waste	Stockpile	Estab. Rehab.	
Pit Water Dam	66.5	43.1			16.9	3.9	15.7	1.0	147.1
Raw Water Dam	173.5	7.3				8.6			189.4
Main Pit	3.2	1.0	103.0		87.7			9.6	204.5
South Pit	13.3	9.2	52.4		28.8				103.7
Rail Loop Dam	1.3	0.9				28.3			30.5
Tailings	0.9	23.7		168.2	32.2	6.3			231.4
CHPP Stockpile Dam	0.5	20.3					1.3		22.1
CHPP Area Sed. Dam		12.3					0.5		12.8
Product Stockpile Dam		3.1					11.6		14.7
MIA Sed. Dam	2.3	15.9							18.2
NOOP 1	2.4							257.6	259.9
NOOP 2	1.3							63.1	64.4
NOOP 3	0.8					19.2			20.0
NOOP 4	0.3	0.2				10.5			11.0
SOOP 1	4.4				16.3			22.1	42.8
SOOP 2	1.0							23.8	24.8
SOOP 3	2.9					1.0		56.8	60.7
Main 1	2.1				23.7			31.6	57.4

Table 3.6 Mangoola Coal Catchment Land Use Areas (ha) – Year 10

Storage Name	Land Use Classification								Total Area
	Natural (grassed)	Hardstand	Open Cut	Tailings	Active Waste	Rehab Waste	Stockpile	Estab. Rehab.	
Pit Water Dam	63.8	39.0				1.2	15.6	8.0	127.5
Raw Water Dam	173.5	7.2				8.6			189.4
Main Pit	86.3		135.1		93.6	62.3		76.0	453.4
Rail Loop Dam	1.3	0.9				28.3			39.8
Tailings		2.4		131.1	26.9	28.2		2.8	191.4
CHPP Stockpile Dam	0.5	20.3					1.3		22.1
CHPP Area Sed. Dam		12.3					0.5		12.8
Product Stockpile Dam		3.1					11.6		14.6
MIA Sed. Dam	2.3	15.9							18.2
NOOP 1	10.6							242.3	252.9
NOOP 2	1.8							63.2	65.0
NOOP 3	0.8					19.3			20.0
NOOP 4		0.2				10.7			11.0
SOOP 1	3.5							39.2	42.8
SOOP 2	0.1							24.7	24.8
SOOP 3	5.3					0.4		200.1	205.7
Main 1	17.4							176.7	194.1
Main 2	2.7					64.3		47.3	114.3

3.4 WATER DEMANDS

3.4.1 Coal Handling and Preparation Plant

The water use per dry feed tonne based on current operations has been adopted for the assessment and scaled up to the proposed maximum extraction rate of 13.5 Mtpa.

Two demand scenarios have been investigated as part of this surface water assessment:

- Scenario 1 – High Water Demand - 13.5 Mtpa of ROM coal washed through the CHPP; and
- Scenario 2 – Low Water Demand - 8.0 Mtpa of ROM coal washed through the CHPP and 5.5 Mtpa of ROM coal processed as bypass coal (i.e. unwashed).

Xstrata Mangoola estimates that bypass coal production will require negligible water use, as this product is not washed through the CHPP.

Table 3.7 presents the adopted CHPP water use for the two demand scenarios considered for this surface water assessment. Note that in this table, “Water Use” refers to the total inflow from the Pit Water Dam to the CHPP, while “Water Loss” is the net supply rate to maintain production after moisture retention in to the rejects and product moisture streams.

Table 3.7 CHPP Water Usage

	ROM Throughput* (Mtpa)	Water Use (ML/a)	Water Loss (ML/a)
Scenario 1 - High Water Demand			
CHPP	13.5 (wet) 12.2(dry)	3,970	2,099
Scenario 2 - Low Water Demand -			
CHPP	8.0 (wet) 7.2 (dry)	2,355	1,244
Bypass	5.5 (wet)	0	0

*A ROM moisture content of 10.1% has been adopted based on data supplied by Xstrata Mangoola.

3.4.2 Haul Road Dust Suppression

For the purpose of the water balance assessment, a dry day haul road watering rate of 3.1mm/d has been applied to a watered haul road area that changes as the mine develops. Modelled dust suppression requirements reduce with increasing daily rainfall. When rainfall exceeds 5mm/d, no dust suppression water will be required. The resultant average dust suppression demand is presented in Table 3.8. Estimates of haul road lengths were based on the mine plans for Years 2, 5 and 10 supplied by Xstrata Mangoola.

Table 3.8 Estimated Haul Road Dust Suppression Requirements

Mining Year	Dust Suppression Area (ha)	Maximum Daily Dust Suppression (kL/d)*[1]	Yearly Average Dust Suppression (ML/a)*[2]
Current operations	38.3	1,173	365
Y2	35.0	1,070	333
Y5	50.4	1,545	480
Y10	40.0	1,224	380

*[1] For a non-rainfall day.
*[2] Based on long-term average including rainfall days.

Table 3.8 indicates the highest dust suppression requirement occurs in Year 5, when there are active overburden emplacement areas behind both the Main Pit and the Southern Pit. Year 2 has the lowest dust suppression demand, as the active pit (Northern Pit) is located near the active overburden emplacement area and the CHPP.

3.4.1 Stockpile Dust Suppression

Xstrata Mangoola personnel have advised that ROM and product stockpile dust suppression sprays are typically not required due to the moisture content of both ROM and product coal. For water balance modelling, it has been assumed both ROM and product stockpile dust suppression demand is negligible.

3.5 FUTURE DAM OPERATING RULES

It is expected that the operating rules for the Pit Water Dam and Raw Water Dam under current operations will be applied to operation of the water management system under the proposed modification, however, some modifications are required to incorporate HRSTS releases. Full details of the operating rules adopted for water balance modelling are provided in Appendix C. For the Pit Water Dam and Raw Water Dam, the rules are based on the following information on current operating procedures:

- Storage versus Level Relationships for Raw Water Dam and Pit Water Dam from the Mangoola Coal Operation & Maintenance Manual, ATC Williams - 14/4/11.; and
- Mangoola Coal Site Water Balance (Xstrata Doc No. 98-ATC-590-0000-REP-5032), ATC Consultants – 17/9/09.

A daily Hunter River streamflow dataset was obtained from NOW for the purpose of modelling releases under the HRSTS. The dataset was obtained from the results of full development IQQM model of the Hunter River (with 2004 water sharing plan rules). The associated modelled daily

Available Water Determinations (AWDs) were also provided by NOW for use in modelling the supplies available from the Hunter River. The use of a modelled dataset is preferred to a historical dataset because it includes the impact of upstream extractions and dam operations on water demands. While the dataset also has the benefit of being continuous, it excludes post 2007 streamflow.

3.5.1 Pit Water Dam

Pumping to the Pit Water Dam (PWD) from the Saline and Dirty Water Zones will cease once the Maximum Operating Level (MOL) in the Pit Water Dam (RL 177.22m) is exceeded. The MOL is 0.75m below the FSL. When levels are at the MOL, the stored water volume is 1,000ML (450ML less than the 1,450ML stored to FSL).

Water will be pumped from the Raw Water Dam to the Pit Water Dam when the stored water volume in the Pit Water Dam falls below 300ML. Pumping will cease when the volume exceeds 300ML. This is to ensure there is an adequate water supply for the CHPP.

For the purpose of this analysis, it is proposed that releases from the Pit Water Dam under the HRSTS will only be allowed if the Pit Water Dam stored water volume exceeds 1,000ML.

Under this arrangement, the Pit Water Dam water level will generally be maintained at 300ML, except after significant rainfall, when water volumes will rise toward the MOL. The MOL will only be exceeded if there is further rainfall following significant pumped inflows.

Figure 3.5 shows a sample of the simulation of the Pit Water Dam during Year 10 operations under Scenario 2 (low water demand). The figure illustrates that had the mine been operating in the 1920s and early 1930s, the extended period of wet weather would have seen the Pit Water Dam at high levels. During this period, there would have been a number of opportunities to release into the Hunter River.

Figure 3.5 also shows a period in the late 1930s and early 1940s, during which the Pit Water Dam water levels would have been maintained at or just above 300ML through supplementation by extraction from the Hunter River (via the Raw Water Dam) for extended periods.

Figure 3.6 shows a shorter period of simulated behaviour at the Pit Water Dam. It shows HRSTS releases being constrained by Hunter River salinity and flow, as well as stored volumes.

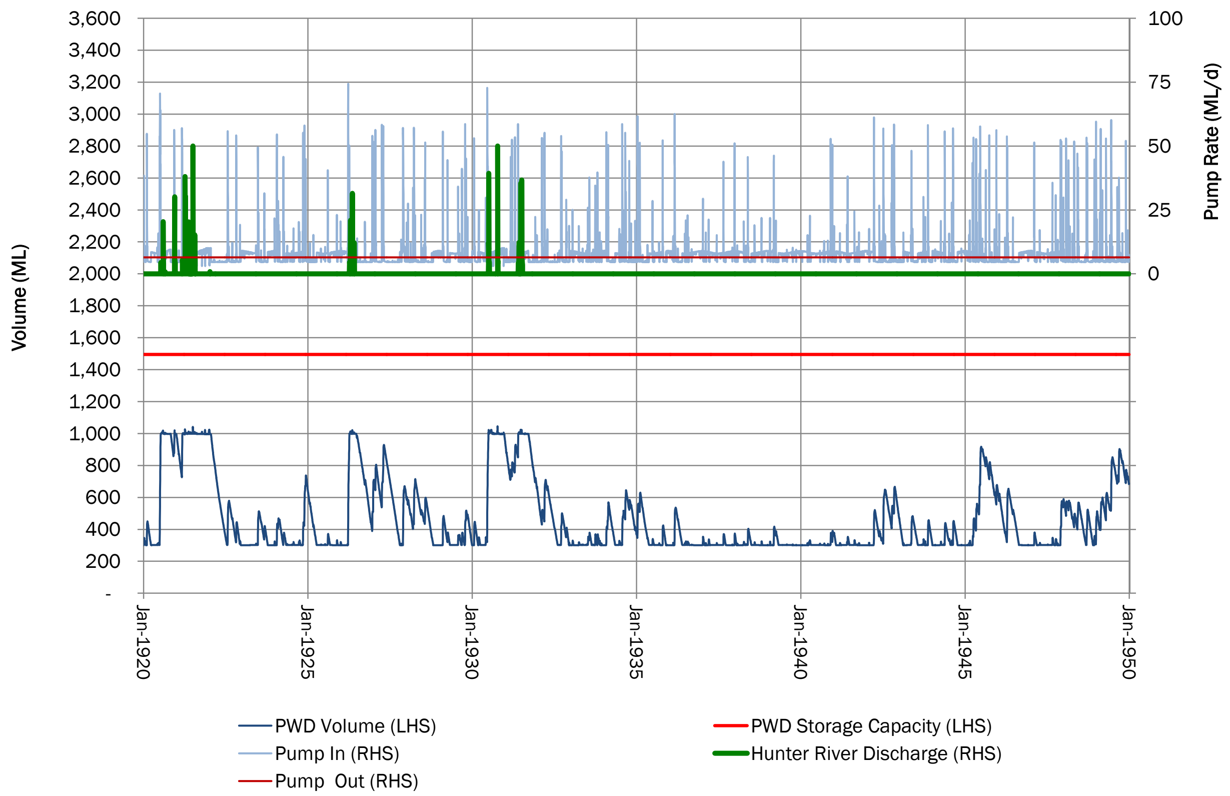


Figure 3.5 Sample of simulated PWD behaviour for Y10 operations (Low Demand)

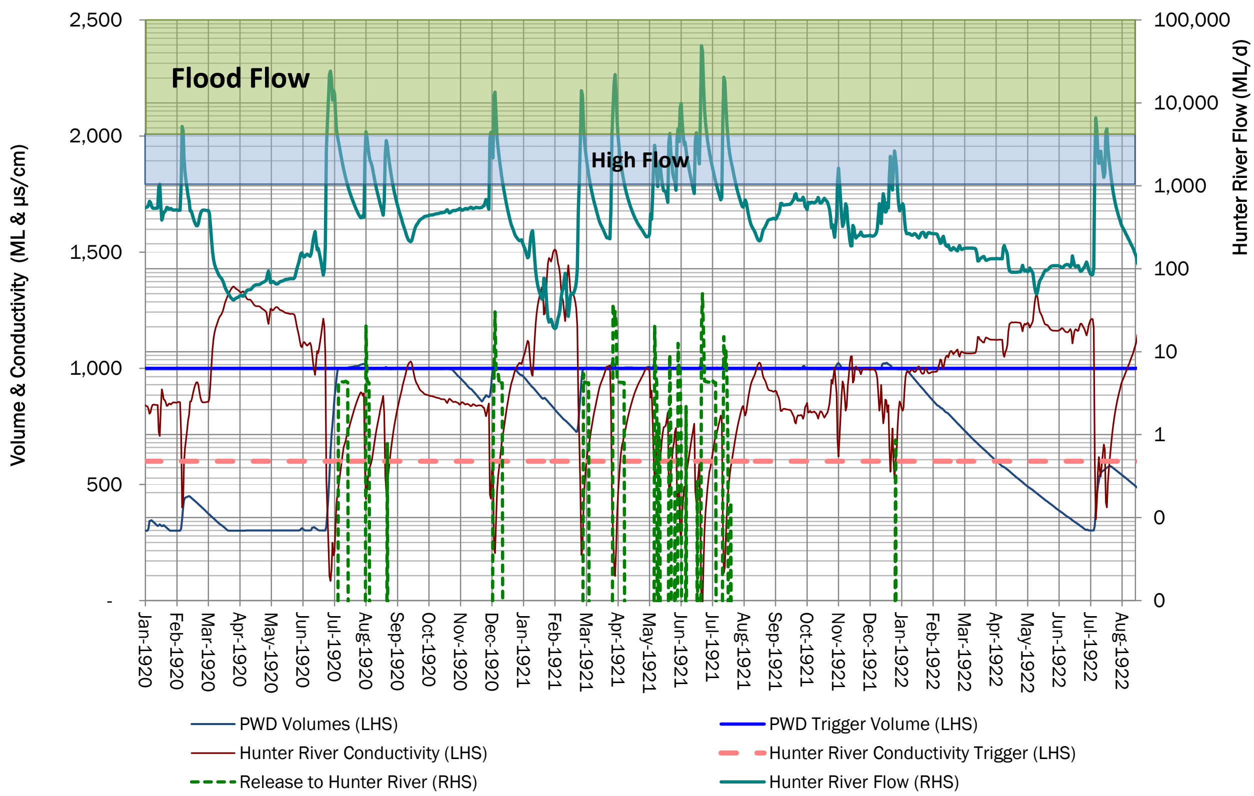


Figure 3.6 Sample of PWD releases for Y10 operations (Low Demand)

3.5.2 Raw Water Dam

Extraction from the Hunter River and pumping to the Raw Water Dam will typically commence when the stored water volume in the Raw Water Dam falls below 1,300ML (RL 180.4m AHD), and will cease when the MOL (180.4m AHD) is reached.

Pumping from the Raw Water Dam to the Pit Water Dam will cease when the water level in the Raw Water Dam drops below the Minimum Operating Level (172m AHD). Under this arrangement, the Raw Water Dam water level will be maintained by pumping from the Hunter River to keep pace with demands from the Pit Water Dam and evaporation in the Raw Water Dam itself.

3.5.3 Sediment Dams

Prior to topsoil placement it is likely that water captured from overburden emplacements will be suitable for release (following capture in sediment dams). It is also anticipated that once rehabilitation is established, overburden runoff will not be sediment-laden, and may be released. However, to ensure Pit Water Dam discharge risk estimates are conservative, the site water balance model assumes that runoff captured in sediment dams is pumped to the Pit Water Dam (if operating levels allow).

3.6 PUMP CAPACITIES

The water management schematic for operations under the proposed modification is presented in Figure 3.7. The following pump capacities have been provided by Xstrata Mangoola and adopted for water balance modelling:

- NOOP Sediment Dam to Pit Water Dam – 70L/s;
- Farm Sediment Dam to Pit Water Dam – 50L/s;
- Haul Road North Sediment Dam to Pit Water Dam – 100L/s (pit dewatering); and
- Hunter River Pump Station to Raw Water Dam – 2x290L/s.

Based on the above, as well as sediment dam pump out requirements described in Section 3.2, the following pump rates have been adopted for water balance modelling:

- Pit dewatering – 100L/s;
- Pumps from Pit Water Dam, Tailings Dam and Raw Water Dam – 100L/s;
- Hunter River water supply – 2 x 290L/s;
- HRSTS discharge rate –50ML/d; and
- Pumps from Rail Loop Dam – 110L/s.

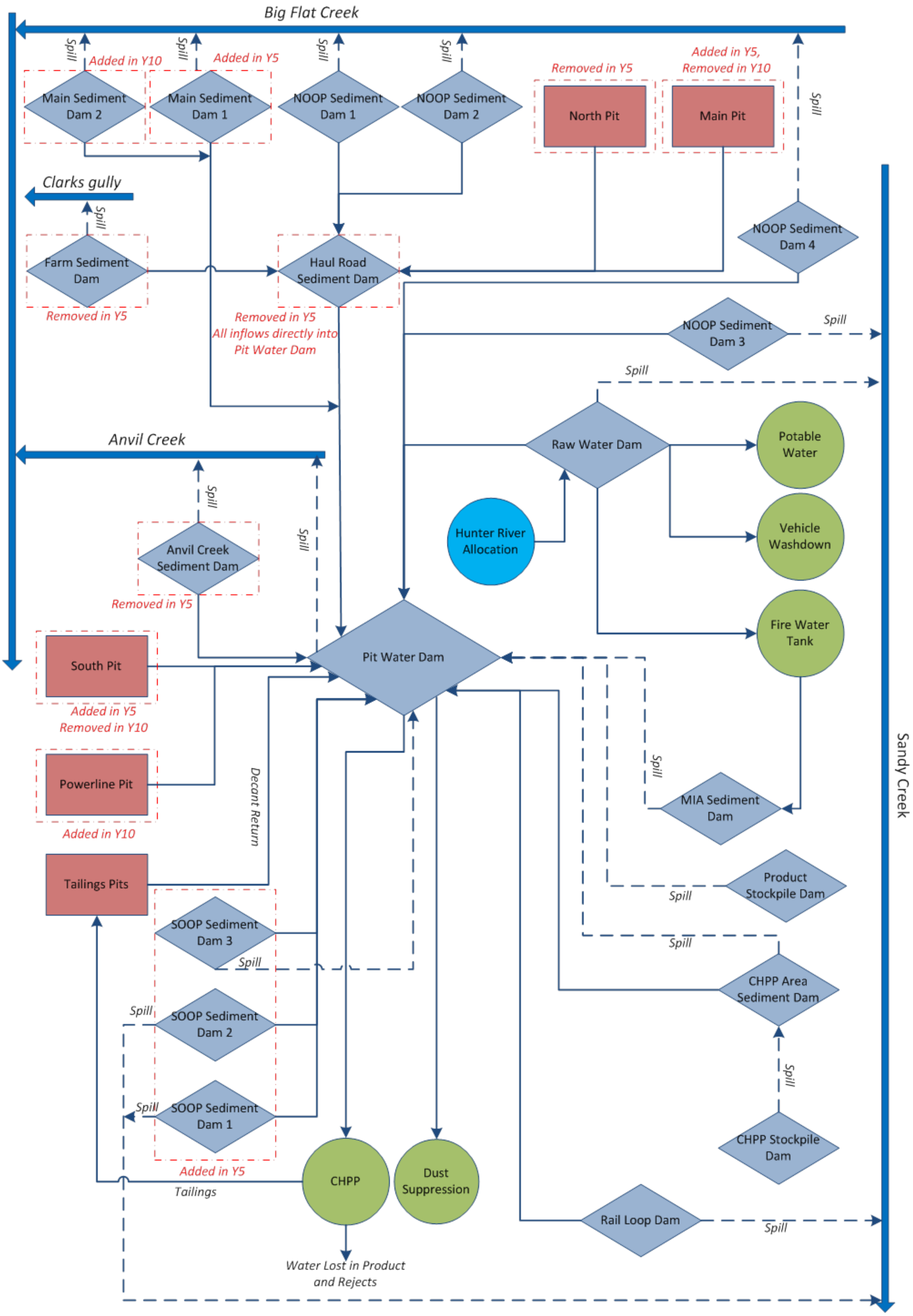


Figure 3.7 Water Management Schematic – proposed modification

4 IMPACT ASSESSMENT

4.1 ANNUAL FLOW VOLUMES AND DOWNSTREAM WATER USERS

While runoff captured within the Dirty Water Zone sediment dams can generally be released to surrounding catchments if water quality meets the EPL and Erosion and Sediment Control Plan requirements. Runoff in the Saline Water Zone is not allowed off site under current operations.

The portions of the catchment areas of Wybong Creek and Sandy Creek contained within the Dirty, Saline and Clean Water Zones over the life of the project under the proposed modification are summarised in Table 4.1. The table shows that in Year 10 up to 1.1% of the total catchment area of Wybong Creek, and up to 1.4% of its upper catchment will be captured within the mine water management system. These temporary changes are similar to those highlighted in the Modification 4 assessment (see Table 4.2).

In addition, runoff from up to 2.2% of the catchment area of Sandy Creek will be captured in the mine water management system under the proposed modification. This temporary change is larger than that nominated in the Modification 4 assessment (0.4%) (see Table 4.2).

At the end of the mine life under the proposed modification, it is estimated that approximately 0.1% of the catchment area of Wybong Creek will be captured in the final void. This is less than that estimated for the Modification 4 assessment (0.2%).

Table 4.1 Proportion of Catchment Captured in the Water Management System under the Proposed Modification

	Wybong Creek Captured Catchment Area			Sandy Creek Captured Catchment Area	
		Proportion			
Year	Area (ha)	Upper Catchment Area	Total Catchment Area	Area (ha)	Proportion of Total Catchment Area
Current operations*	610	0.9%	0.7%	247	1.8%
Year 2	647	1.0%	0.8%	288	2.1%
Year 5	801	1.2%	1.0%	304	2.2%
Year 10	918	1.4%	1.1%	288	2.1%

*As at December 2011

Table 4.2 Proportion of Catchment Captured in the Water Management System (Current Operations)

	Wybong Creek Captured Catchment Area			Sandy Creek Captured Catchment Area	
		Proportion			
Year	Area (ha)	Upper Catchment Area	Total Catchment Area	Area (ha)	Proportion of Total Catchment Area
Current operations*	717	1.1%	0.9%	29	0.2%
Year 2	509	0.8%	0.6%	61	0.4%
Year 5	1891	1.3%	1.1%	52	0.4%
Year 10	587	0.9%	0.7%	51	0.4%

*As at December 2011

4.2 OVERALL SITE WATER BALANCE

The site water balance will vary significantly from year to year, due to climatic variability. The performance of the water management system under the proposed modification was assessed using a daily timestep historical simulation water balance model, OPSIM. This methodology is significantly more detailed than that adopted for previous assessments, which were based on annual averages. Further details of the water balance modelling methodology and results are provided in Appendix C.

The model was run over 114 years of historical climate data (1893 to 2006). This period was limited by the simulated Hunter River streamflow time series data obtained NOW's Hunter River IQQM model.

The predicted overall average annual site water balance is summarised in this section based on simulations of each mine stage (Year 2, 5 and 10) over 114 years of historical climate data, for the following demand scenarios:

- Scenario 1 – High Water Demand – up to 13.5 Mtpa of ROM coal washed through the coal handling and processing plant (CHPP). Maximum water use would occur under this scenario.
- Scenario 2 – Low Water Demand – up to 8.0 Mtpa of ROM coal washed through the CHPP, with the remaining 5.5 Mtpa of ROM coal bypassing the CHPP as bypass coal product (i.e. unwashed).

4.2.1 Scenario 1 - High water demand

The water balance under Scenario 1 is summarised in Table 4.3. Water demands are highest under this scenario. Over the life of the project, on average:

Outflows

- Total water demand ranges between approximately 2,040ML/a and 2,620ML/a;
- Evaporation ranges between approximately 690ML/a and 760ML/a; and
- Hunter River discharges range between 1ML/a and 23ML/a.

Inflows

- Runoff yield contributes between approximately 970ML/ and 1,430ML/a;
- Groundwater contributes between approximately 530ML/a and 660ML/a; and
- Hunter River extraction varies from approximately 850ML/a to 1,070ML/a.

Deficit

The site deficit varies from approximately 380ML/a to 500ML/a.

Table 4.3 Mangoola Project Annual Water Balance – Scenario 1 – High water demand

	Annual Average Water Balance			
	Current operations*	Year 2	Year 5	Year 10
Parameters				
ROM Coal (Mt)	10.5	13.5	13.5	13.5
Bypass Coal (Mt)	0	0	0	0
Water Inputs (ML/annum)				
Rainfall Yield (Dams and Catchment Runoff)	971	1,078	1,433	1,431
Clean Water System	*212*	*191*	*191*	*191*
Dirty Water System	*20*	*23*	*47*	*44*
Saline Water System	*739*	*820*	*1,073*	*962*
Established Rehabilitation System	-	*44*	*123*	*234*
Pipeline Water (Hunter River)	854	1,073	889	883
Groundwater Inflow to Open Cut Pits	526	526	657	562
Gross Water Inputs	**2,352**	**2,677**	**2,979**	**2,876**
Water Outputs (ML/annum)				
Evaporation from Dams and Ponds	693	703	760	745
Clean Water System	*361*	*360*	*360*	*360*
Dirty Water System	*3*	-	*1*	*2*
Saline Water System	*329*	*340*	*395*	*378*
Established Rehabilitation System	-	*3*	*4*	*4*
Dam Overflows (off-site)	0	1	10	23
Clean Water System	-	-	-	-
Dirty Water System	-	-	-	*1*
Saline Water System	-	-	-	-
Established Rehabilitation System	-	*1*	*10*	*22*
Off-site Release (HRSTS)	1	2	16	23
Net Loss from CHPP	1,632	2,099	2,099	2,099
Net Loss from Plant Bypass	-	-	-	-
Potable + Vehicle Wash	39	39	39	39
Dust Suppression	365	333	481	381
Gross Water Outputs	**2,730**	**3,176**	**3,405**	**3,309**
Gross Water Deficit	**379**	**499**	**425**	**432**

*As at December 2011

4.2.2 Scenario 2 – Low water demand

The water balance under Scenario 2 is summarised in Table 4.4. Water demands are lowest under this scenario, where a portion of coal bypasses the washery component of the CHPP. For this assessment, it has been assumed that a maximum of 5.5 Mtpa of coal would be processed as bypass coal product.

Over the life of the project, on average:

Outflows

- Total water demand ranges between approximately 1,600ML/a and 2,040ML/a;
- Evaporation ranges between approximately 690ML/a and 820ML/a;
- Hunter River discharge ranges up to approximately 84ML/a.

Inflows

- Runoff yield contributes between approximately 970ML/ and 1,450ML/a;
- Groundwater contributes between approximately 530ML/a and 660ML/a;
- Hunter River extraction varies from approximately 380ML/a to 850ML/a.

Deficit

- The site deficit varies from approximately 190 to 380ML/a.

Table 4.4 Mangoola Project Annual Water Balance – Scenario 2 – Low water demand

	Annual Average Water Balance			
	Current operations*	Year 2	Year 5	Year 10
Parameters				
ROM Coal (Mt)	10.5	8.0	8.0	8.0
Bypass Coal (Mt)	0	5.5	5.5	5.5
Water Inputs (ML/annum)				
Rainfall Yield (Dams and Catchment Runoff)	971	1,091	1,454	1,456
Clean Water System	*212*	*191*	*191*	*191*
Dirty Water System	*20*	*24*	*47*	*45*
Saline Water System	*739*	*833*	*1,092*	*985*
Established Rehabilitation System	-	*44*	*123*	*235*
Pipeline Water (Hunter River)	854	524	386	382
Groundwater Inflow to Open Cut Pits	526	526	657	562
Gross Water Inputs	**2,352**	**2,141**	**2,490**	**2,385**
Water Outputs (ML/annum)				
Evaporation from Dams and Ponds	693	737	823	804
Clean Water System	361	360	360	360
Dirty Water System	3	-	4	5
Saline Water System	329	374	454	432
Established Rehabilitation System	-	3	5	7
Dam Overflows (off-site)	-	1	17	32
Clean Water System	-	-	-	-
Dirty Water System	-	-	*1*	*2*
Saline Water System	-	-	-	-
Established Rehabilitation System	-	*1*	*16*	*30*
Off-site Release (HRSTS)	1	15	84	81
Net Loss from CHPP	1,632	1,244	1,244	1,244
Net Loss from Plant Bypass	-	-	-	-
Potable + Vehicle Wash	39	39	39	39
Dust Suppression	365	333	481	381
Gross Water Outputs	**2,730**	**2,369**	**2,680**	**2,585**
Gross Water Deficit	**379**	**228**	**189**	**199**

*As at December 2011

4.2.3 Hunter River Pipeline Demand and Raw Water Shortfall

The primary water source for site water demands (including the CHPP and haul road dust suppression) is the Pit Water Dam. When water transferred from the Saline and Dirty Water zones is insufficient to match demands from the Pit Water Dam, raw water is transferred from the Raw Water Dam to the Pit Water Dam. Raw Water Dam water levels are maintained by pumping from the Hunter River when necessary in accordance with WALs via Mangoola Coal's Hunter River pipeline.

Table 4.5 and Table 4.6 show the modelled demand from Mangoola Coal for water from the Hunter River over the period of historical climate data, as well as the predicted raw water shortfall. The results show that total raw water requirements are greater for Scenario 1 (High Demand). For both scenarios, the median results show the Hunter River allocation will be sufficient to meet site raw water requirements (no shortfall). However, a combination of reduced Hunter River supply and low rainfall could result in shortfalls of up to 2,300ML/a (Scenario 1 - High Demand) and 1,400ML/a (Scenario 2 – Low Demand).

Table 4.5 Annual Raw Water Demand from the Hunter River & Raw Water Shortfall (ML/a) – Scenario 1 – High water demand

	Hunter River				Shortfall			
	Current operations*	Year 2	Year 5	Year 10	Current operations*	Year 2	Year 5	Year 10
Maximum	2,032	2,424	2,378	2,376	1,840	2,266	2,204	2,193
95th Percentile	1,750	2,151	2,070	2,061	1,728	2,119	2,018	2,013
90th Percentile	1,581	1,943	1,802	1,796	1,392	1,757	1,538	1,542
Average	854	1,073	889	883	379	499	425	432
Median	892	1,136	896	900	5	6	6	6

*As at December 2011

Table 4.6 Annual Raw Water Demand from the Hunter River & Raw Water Shortfall (ML/a) – Scenario 2 – Low water demand

	Hunter River				Shortfall			
	Current operations*	Year 2	Year 5	Year 10	Current operations*	Year 2	Year 5	Year 10
Maximum	2,032	1,583	1,416	1,388	1,840	1,399	1,355	1,341
95th Percentile	1,750	1,285	1,119	1,046	1,728	1,265	1,166	1,151
90th Percentile	1,581	1,083	895	907	1,392	902	736	741
Average	854	524	386	382	379	228	189	199
Median	892	529	235	226	5	2	1	1

*As at December 2011

Figure 4.1 presents the proportion of the site water demand that would have been supplied by the water management system and extraction from the Hunter River, respectively, if Mangoola Coal was operating for the duration of the historical climate record. The Year 5 mine plan operating under Scenario 1 (highest water demand) was adopted. Figure 4.1 shows that in most years, the water contained within the water management system will make a significant contribution to the site water supply. However, during extended dry periods, a large proportion of annual supply will need to be drawn from the Hunter River. At 100% available water determination (AWD), Mangoola can draw up to 2,791ML/a, which is in excess of total water demands for both scenarios. A long period of drought in the late 1930s through to the 1940s shows that extraction from the Hunter River supply would have been unavailable for a period of more than 10 years, leaving a shortfall of raw water required to operate the site.

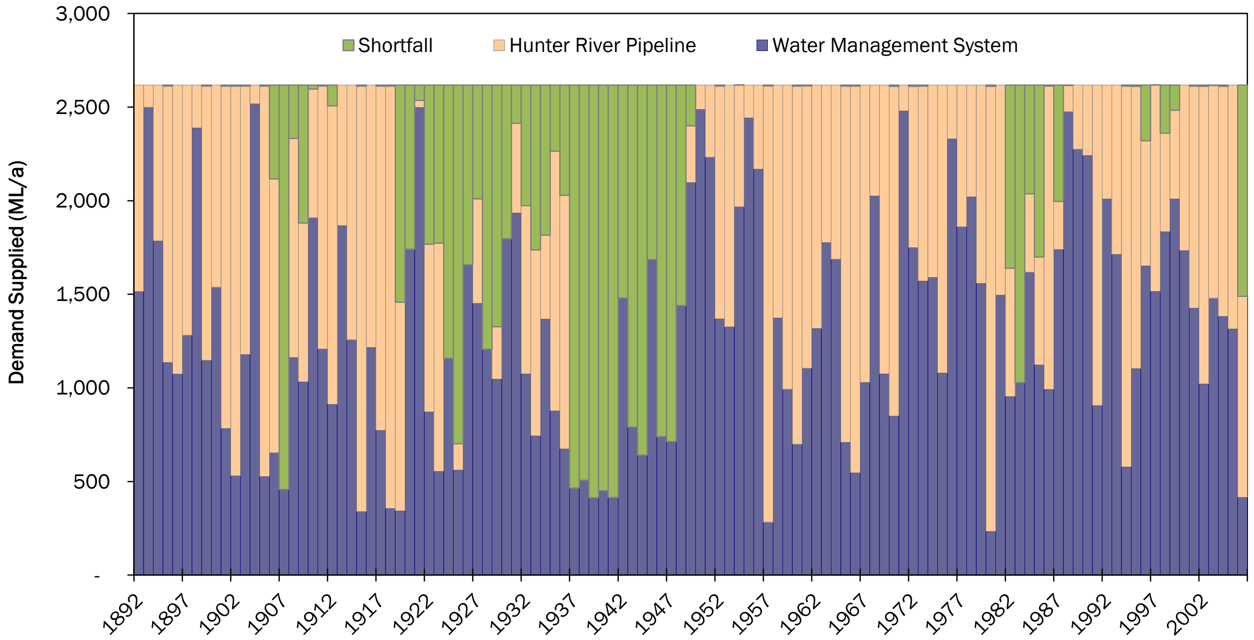


Figure 4.1 Simulated Water Supplies Year 5 – Scenario 1 (high water demand)

Figure 4.2 to Figure 4.4 show the annual shortfall as a percentage of years for each mine stage and scenario as well as the annual shortfall under Current Operations for comparative purposes. Review of the results indicates that adequate supply is available under both Scenario 1 and Scenario 2 for approximately 60% and 70% of years, respectively.

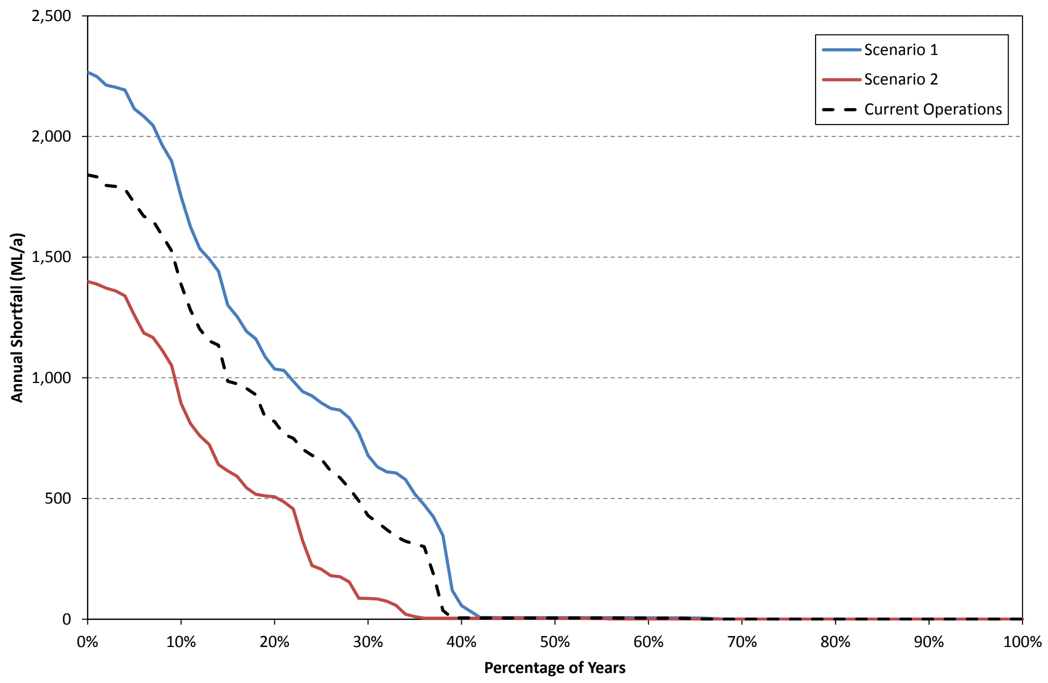


Figure 4.2 Risk of Water Supply Shortfall – Year 2

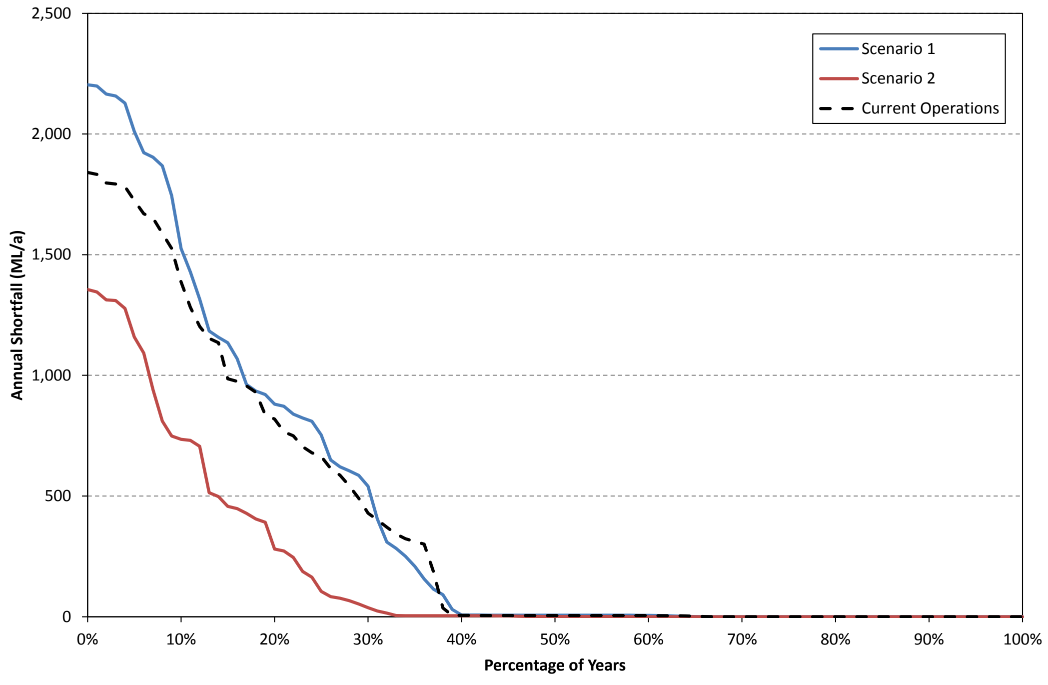


Figure 4.3 Risk of Water Supply Shortfall – Year 5

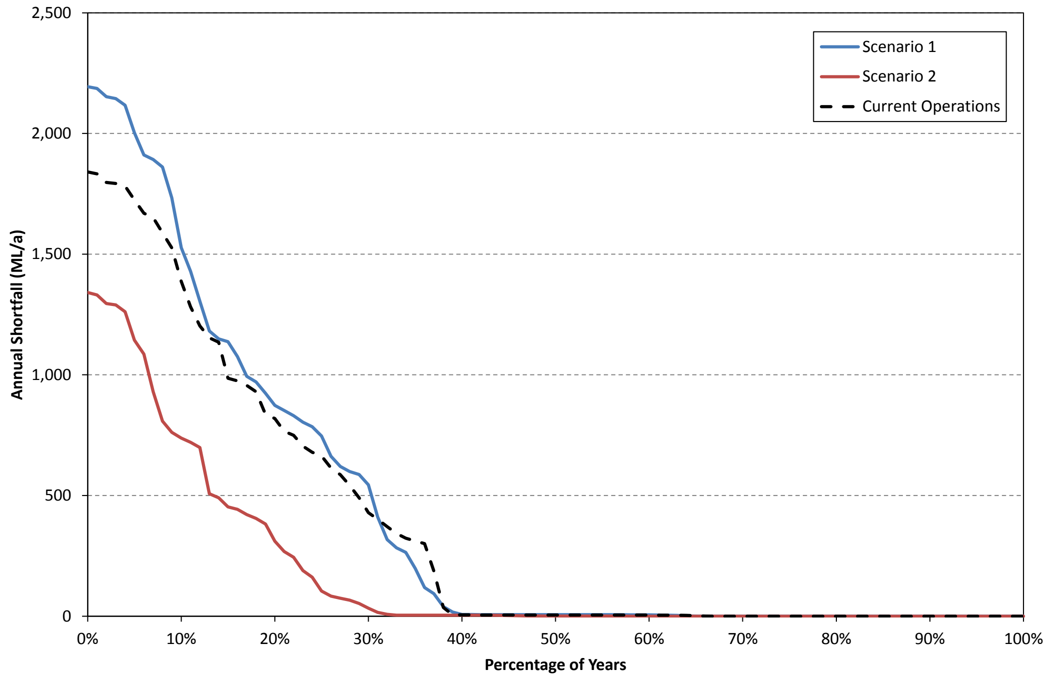


Figure 4.4 Risk of Water Supply Shortfall – Year 10

It should be noted that the reported short-term risks are likely to be overestimated. This is because the analysis does not account for:

- Current stored water inventories in the site water management system;
- Current stored water volumes in the Glenbawn Dam;
- The effect of any operational responses, such as water saving measures which Mangoola could implement if required.
- Accessing “off-allocation” or “supplementary” flows in the Hunter River when AWD’s are insufficient to supply the project, but river inflows occur downstream of Glenbawn Dam;

Mangoola coal intends to use a number of operational responses to address potential supply shortfalls. One or more of these actions could be investigated in the event of extended drought:

- Review of haul road dust suppression water demand by use of dust suppression agents;
- Review of CHPP water demand by increasing bypass coal (due to the significantly lower unit water demand compared to washed coal);
- Reduce site wide water demand by scaling back production;
- Investigate alternative water supplies.

Due to the long lead time of some of these actions, it will be important to forecast potential shortfalls well in advance. To make this assessment, the site water balance will be reviewed annually. Actions would be triggered when unacceptable risk levels are predicted at two to three year planning horizon. The annual review will include:

- an audit of the current site water inventory;
- an update of the site water balance model to reflect changes to the water management system during the previous 12 months;
- an assessment of the site water balance model’s ability to reproduce the observed behaviour of the site water inventory;

- a forecast of the likely range of Available Water Determination (AWDs) over the coming 3 years, based on current stored water levels in Glenbawn Dam; and
- a 3 year forecast of site water inventory, and potential water supply shortfall based on the planned changes to the mine and site water management system. The forecast should be based on stochastic analysis using historical climate and modelled Hunter River streamflow data (and AWDs) at the Hunter River Pump Station, to give the probability and magnitude of potential shortfalls over the forecast period.

4.3 CONTROLLED HRSTS DISCHARGES FROM PIT WATER DAM

Table 4.7 shows how the simulated controlled HRSTS discharges from the Pit Water Dam (via the Hunter River pipeline) could vary over each stage of mining over the simulation period under the proposed modification and for current operations, for demand Scenarios 1 and 2.

Table 4.7 Controlled HRSTS Discharges from Pit Water Dam

Mine Plan	Scenario 1 (high water demand)			Scenario 2 (low water demand)		
	Total Number of Discharge Days[2]	Annual Average Discharge Days[2]	Maximum Volume of Discharge Event (ML)	Total Number of Discharge Days[2]	Annual Average Discharge Days[2]	Maximum Volume of Discharge Event (ML)
Current operations[1]	16	0.1	31	16	0.1	31
Year 2	23	0.2	35	178	1.5	121
Year 5	213	1.9	187	1,106	9.6	722
Year 10	318	2.8	372	1,040	9.0	717

[1] As at December 2011.
[2] Over 114 year historical simulation period.

The results show the likelihood of discharge will increase over time due to the increase in Saline Water Zone catchment as the mine develops under both current operations and the proposed modification. Under Scenario 1 (High Demand), the frequency and magnitude of discharges is smaller than under Scenario 2. This is due to the larger Scenario 1 CHPP water demand reducing the volume of water accumulating in the Pit Water Dam.

However, the number of releases required is highly climate dependent. Figure 4.5 shows the simulated controlled discharges over the 114 year simulation period from the Pit Water Dam under Scenario 2 for Year 10. The figure shows that releases are likely to be made infrequently, with periods of several years in between. However, during prolonged wet periods (such as the 1950s), a greater number of large releases could have been made in several consecutive years.

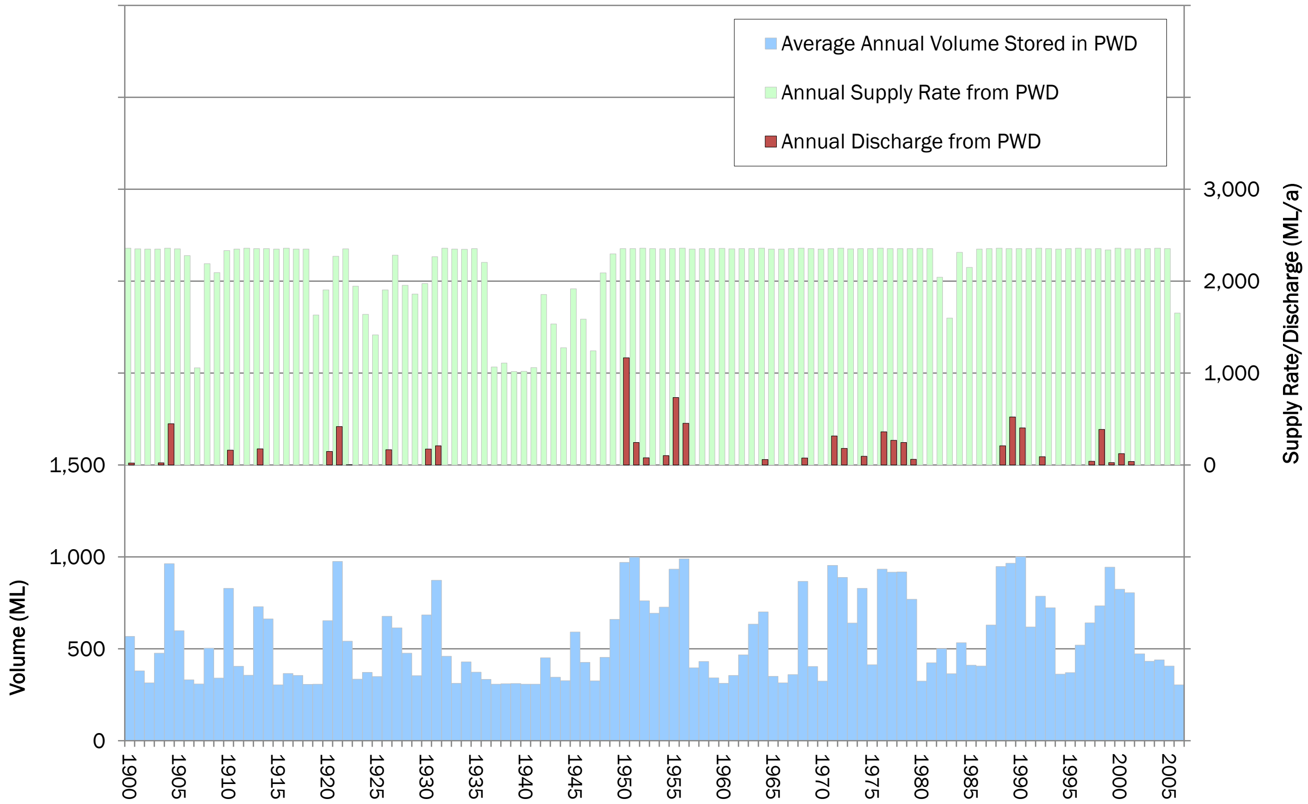


Figure 4.5 Simulated PWD Behaviour – Scenario 2 (low water demand), Year 10

This is further illustrated in Table 4.8 and Table 4.9, which show that:

1. Under Scenario 1 (high water demand):
   - the likelihood of discharge increases from 4% in Year 2 to 16% in Year 10;
   - there is a 90% chance that no discharge would be required in Year 2 and that the annual discharge would be less than 69ML or for 13 days in Year 10;
   - there is a less than 1% chance that the annual discharge would approach 600ML in Year 10.

2. Under Scenario 2 (low water demand):
   - the likelihood of discharge increases from 12% in Year 2 to 35% in Year 10;
   - there is a 90% chance that the annual discharge in Year 2 would be less than 26ML and that the annual discharge would be less than 335ML/a or for 27 days in Year 10
   - there is a less than 1% chance that the annual discharge would approach 1200ML in Year 10.

Details of the effect of HRSTS discharges on reducing the risk of pit inundation are presented in Appendix E.

Table 4.8 Controlled HRSTS Discharges from Pit Water Dam (ML/a)

Mine Plan	Scenario 1 (high water demand)		Scenario 2 (low water demand)	
	10th percentile	90th percentile	10th percentile	90th percentile
Current operations[1]	0	0	0	0
Year 2	0	0	26	0
Year 5	52	0	283	0
Year 10	69	0	335	0

[1] As at December 2011.

Table 4.9 Controlled HRSTS Discharges from Pit Water Dam (days per year)

Mine Plan	Scenario 1 (high water demand)		Scenario 2 (low water demand)	
	10th percentile	90th percentile	10th percentile	90th percentile
Current operations[1]	0	0	0	0
Year 2	0	0	5	0
Year 5	8	0	30	0
Year 10	13	0	27	0

[1] As at December 2011.

4.4 STORED WATER QUALITY

The OPSIM model was also used to simulate salinity in the site water management system. Table 4.10 shows modelled salinity in the Pit Water Dam. The results show the maximum modelled salinity levels (measured as electrical conductivity (EC)) when the volume contained within the dam is greater than 50% of the total capacity. The results show Scenario 1 (high water demand) has the effect of improving stored water quality (due to salts being pumped out and used in the CHPP process). The results also suggest that stored water quality could be expected to deteriorate as the mine progresses. The modelled salinities are consistent with (though slightly lower than) laboratory testing of samples collected from the Pit Water Dam. This may be because of the relatively small disturbance area in operations to date. A summary of test results are presented in Table 4.11, with further details in Appendix B.

Table 4.10 Maximum[2] Modelled Pit Water Dam Salinity (EC µS/cm)

Mine Stage	Scenario 1 (High Water Demand)	Scenario 2 (Low Water Demand)
Current operations[1]	1,528	1,528
Y2	2,364	2,967
Y5	3,292	4,070
Y10	2,746	3,800

[1] As at December 2011
[2] Maximum modelled EC when the volume contained within the dam is greater than 50% of the dam capacity

Table 4.11 Pit Water Dam Water Quality (Current Operations)

Parameter	Unit	Median	90%ile
pH	pH	8.5	8.9
EC (uncompensated)	µS/cm	1,914	2,830
EC (25C)	µS/cm	2,300	2,529
Total Dissolved Solids (TDS)	mg/L	1,160	1,570
Total Suspended Solids (TSS)	mg/L	12	126
Calcium (Ca)	mg/L	58	68
Magnesium (Mg)	mg/L	73	86
Sodium (Na)	mg/L	337	376
Potassium (K)	mg/L	16	18
Bicarbonate (HCO_3)	mg/L		
Sulphate as SO_4	mg/L	198	235
Chloride as Cl	mg/L	550	649
Fe (Soluble)	mg/L	0.09	0.36
Fe (Total)	mg/L		
Boron (B)	mg/L	0.12	0.16
Manganese (Mn)	mg/L	0.012	0.021
Zinc (Zn)	mg/L	0.005	0.012
Fluoride (Fl-)	mg/L	0.5	0.6
Nitrite and nitrate as N	mg/L		
Total Kjeldahl Nitrogen (TKN)	mg/L		
Total nitrogen (Total N)	mg/L	0.98	1.38
Total phosphorus (Total P)	mg/L		

4.5 UNCONTROLLED OFFSITE DISCHARGES

The water balance model indicates there would be no uncontrolled spillway overflows from the Saline Water Zone as a result of the proposed modification (under historical climate conditions).

Uncontrolled spillway overflows would be expected from Sediment Dams designed in accordance with Blue Book requirements. Sediment Dam discharges are likely to be compliant with the EPL and ESCP requirements. The capacity of the proposed pumping system is sufficient to prevent overflows from the Dirty Water Zone except in the very wet years.

4.6 SITE WATER MANAGEMENT PLAN

The changes to the arrangement and scheduling of the site water management measures outlined in the previous sections as part of the proposed modification will be incorporated into the Site Water Management Plan. The current Erosion and Sediment Control Plan (part of the Site Water Management Plan (Umwelt, 2010a)) will continue to be implemented under the proposed modification.

The current site water management strategy (modified to match changes to the mine layout) will continue to be appropriate for managing the downstream impact of the proposed modification.

4.7 FINAL VOID BEHAVIOUR

Mining is proposed to finish after Year 10 at a maximum extraction rate of 13.5 Mtpa. The final pit void will be retained, and its catchment minimised. The arrangement is similar to the current operations.

Any minor changes are unlikely to affect outcomes of the final void analysis undertaken as part of the Modification 4 investigations (Umwelt 2010), which concluded the water level in the final void will take approximately 100 years to stabilise to an elevation of approximately 129m AHD. The proposed edge of the final void is over 20m metres above the final modelled water level. As a result, the void will be self-contained, and water will not overflow into the downstream drainage systems or receiving environment.

4.8 CHANNEL STABILITY AND INSTREAM HABITAT (ANVIL CREEK REDIVERSION)

No changes to in-channel habitat as a result of the proposed modification are expected in Sandy Creek or its tributaries, or Wybong Creek.

The proposed modification will require slight realignment and rescheduling of diversion of Anvil Creek and Clarks Gully within the approved disturbance boundary compared to current operations, however the final landform drainage plan under the proposed modification is largely consistent with current operations. During rehabilitation, the final landform will be shaped to be a broad, free-draining, stable, vegetated drainage line along the approximate alignment of the existing Anvil Creek which is consistent with the principles of current operations. It would be possible to re-establish in-channel habitat that mimics features in the Anvil Creek system. The design will be addressed in detail in the Mine Closure Plan.

Under the Surface Water Monitoring Plan (Umwelt, 2010) annual channel stability monitoring is undertaken for Anvil Creek, Big Flat Creek and Sandy Creek. The monitoring involves documenting representative reaches through photographs and written descriptions so that changes to channel morphology can be identified through comparisons with the baseline channel survey which was undertaken in June 2008.

Stream health monitoring is also taken bi-annually in autumn and spring in Anvil Creek, Big Flat Creek, Wybong Creek and Sandy Creek. Assessments of macroinvertebrate assemblages and riparian vegetation are undertaken to identify any impacts of current operations on stream health.

4.9 FLOODING

The proposed modification will have no additional impact on disturbance of the neighbouring floodplains. Therefore there will be no additional impact on the extent, frequency or duration of flooding in the vicinity of the approved project disturbance boundary.

The original flood impact assessment carried out for Mangoola Coal (Umwelt, 2006), found that there would be insignificant impacts on flooding in Big Flat Creek or Wybong Creek. Given no additional disturbance of the neighbouring floodplains is expected, these findings remain relevant for the proposed modification.

4.10 IMPACTS OF CLIMATE CHANGE

Under the maximum extraction rate of 13.5 Mtpa, the life of the mine within the approved project disturbance boundary would be reduced compared to current operations. This reduces the potential exposure of Mangoola Coal's operations to climate change impacts.

The Modification 4 Surface Water Assessment (Umwelt, 2010b) described the findings of the Hunter, Central and Lower North Coast Regional Climate Change Project 2009 (Blackmore and Goodwin, 2009), which provides climate change projections for the period 2020 to 2080.

The climate change projections have limited applicability to the proposed modification, as the life of the mine would be complete within the first five to ten years of the climate change projection period. However, the previous conclusions, that the impact of climate change on the annual site water balance is likely to be small, are also applicable to the proposed modification, as the projected likely change to rainfall during the life of the mine is within the bounds of historical variability.

4.11 IMPACTS OF RELEASES TO HUNTER RIVER

The Hunter River Salinity Trading Scheme: Guideline and rulebook (EPA, 1995), sets out a number of factors to be considered assessing the potential for the proposed discharge to harm the environment or excessively interfere with downstream users:

- Potential physical and biological impacts – stability of stream banks and beds;
- Impacts on downstream landholders – esp. crossings. culverts, and instream structures;
- Mitigation measures for potential erosion hazards and impacts on downstream landholders;
- Discharge monitoring.

These factors are addressed in the following sections.

4.11.1 Potential Bank Erosion

The proposed modification includes discharge of saline water from Mangoola Coal to the Hunter River in accordance with the rules and regulations of the HRSTS.

Mangoola Coal's Hunter River pump station includes a discharge outlet, which is located on the outside of a wide bend on the Hunter River, shown in Figure 4.6. The discharge outlet is a 600mm steel pipe with a concrete headwall. The pipe discharges into a rock-lined swale, which runs adjacent to and beneath the dual water supply pump tubes (see photographs in Figure 4.7 and Figure 4.8). The riverbank outfall design is presented in Appendix A. The design includes provision for scour protection on the channel banks. The following design specifications were detailed for construction (ATC Williams, 2009), and would provide adequate protection of the bed and banks during release:

- 1(v):2(h) outfall slope;
- 1(v):3(h) side slope on the bank nearest to the discharge location;
- 1(v):3(h) side slope on the bank furthest from the discharge location;
- d_{50} > 500mm rock beaching for the upper 20m of outfall;
- d_{50} > 700mm rock beaching for the remaining lower outfall portion; and
- Geotextile barrier to be used under all rock beaching.

Figure 4.6 Hunter River Pump Station and Proposed Discharge Point

Due to the appropriate design of the discharge point, it is unlikely that the releases would cause significant impacts on either bank stability or erosion.

To manage potential impacts to channel stability and in-stream habitats as a result of the proposed modification, Xstrata Mangoola will update the Surface Water Monitoring Plan to include:

- monitoring of bank erosion at the discharge outlet on the Hunter River during and following HRSTS discharges, and identification of corrective actions if any unexpected erosion of the bank occurs; and
- monitoring of the Hunter River channel at the discharge outlet annually as part of the Channel Stability Monitoring component of the Surface Water Monitoring Plan and during and following any HRSTS discharge to assess channel stability, and corrective actions if any unexpected impacts arise to channel stability as a result of discharges at the outlet.

Figure 4.7 Hunter River at the Hunter River Discharge Outlet

Figure 4.8 Proposed Hunter River discharge outlet

4.11.2 Impacts on Water Quality

Water released under the HRSTS will impact on water quality in the Hunter River. The effect of these impacts on downstream environmental values will be dependent on the concentrations of contaminants in the discharge water, and the receiving Hunter River water quality.

In the immediate vicinity of the discharge point, inside a mixing zone, contaminant concentrations will be elevated compared to adjacent areas. However, secondary velocity currents induced by the nearby channel bends and turbulence induced by the riparian vegetation will promote mixing of the discharge water with the Hunter River flow. It is therefore likely that complete mixing of the discharge water with the river flow will occur within a few hundred metres of the outlet.

Outside of the mixing zone, the concentration of contaminants can be estimated by a simple conservative solute balance, and will depend on background concentrations and the level of dilution from the Hunter River flows.

Comparison of Hunter River and Discharge Water Quality Characteristics

The results of laboratory analysis of samples from the Pit Water Dam are compared with the ANZECC Trigger Values in Table 4.12. The table includes results for key parameters (for which Hunter River data is available). Results for the full list of tested parameters are given in Appendix B.

Table 4.12 indicates Pit Water Dam water exceeds the Trigger Values for pH, salinity (TDS and EC), sodium, chloride, zinc, and total nitrogen. Other parameters potentially of concern are Aluminium, Manganese and Iron.

As previously shown in Table 2.1, the Hunter River background data indicates existing exceedances of the 95th Percentile Aquatic Ecosystem Protection Trigger Values for pH, total nitrogen, total phosphorous and zinc. It is also notable that Boron concentrations and pH are similar to those of the Pit Water Dam.

Table 4.12 Comparison of Pit Water Dam and Hunter River Water Quality Data with ANZECC Trigger Values

		ANZECC Trigger Value				Pit Water Dam			Hunter River at Denman		
Parameter	Unit	Irrigation	Livestock drinking	Eco-system	Recreational	Median	90%ile	count	Median	90%ile	count
pH	pH	6.0 - 9.0		6.5 - 8^	6.5 - 8.5	8.5	8.9	21	8.2	8.6	48
EC (uncompensated)	µS/cm	1,000*				1,914	2,830	21			
EC (25C)	µS/cm					2,300	2,529	14	485	691	108
Total Dissolved Solids (TDS)	mg/L		2,000*		1,000	1,160	1,570	21			
Total Suspended Solids (TSS)	mg/L					12	126	21	3	3	1
Calcium (Ca)	mg/L		1,000			58	68	15	37.6	43.8	12
Magnesium (Mg)	mg/L		2,000**			73	86	15	25	32.8	12
Sodium (Na)	mg/L	115			300	337	376	15	44.0	57.4	23
Potassium (K)	mg/L					16	18	15	1.4	1.8	12
Bicarbonate (HCO_3)	mg/L	-							220.7	257.6	15
Sulphate as SO_4	mg/L		1,000		400	198	235	15	30.0	43.5	11
Chloride as Cl	mg/L	175***			400	550	649	15	59.0	91.3	23
Fe (Soluble)	mg/L	0.2	-		0.3	0.09	0.36	15	0.01	0.02	2
Fe (Total)	mg/L								0.11	0.37	4
Boron (B)	mg/L	0.5	5	0.37^^	1	0.12	0.16	15	0	0.17	3
Manganese (Mn)	mg/L	0.2	-	1.9^^	0.1	0.012	0.021	15			
Zinc (Zn)	mg/L	2	20	0.008^^	5	0.005	0.012	15	0.01	0.016	2
Fluoride (Fl-)	mg/L	1	2			0.5	0.6	15	0.33	0.44	4
Nitrite and nitrate as N	mg/L		30	0.7^^^	11				0.17	0.40	143
Total nitrogen (Total N)	mg/L	5		0.5^		0.98	1.38	15	0.52	0.95	183
Total phosphorus (Total P)	mg/L	0.05		0.05^					0.08	0.13	46

Note shading denotes an exceedance of the trigger value
^ Lowland river (<150m altitude).
^^ 95% of species protected.
^^^ Nitrate only.
* Lowest recommended value.
** Cattle (insufficient information on other livestock).
*** Sensitive crops.

Change in Contaminant Concentrations Downstream of Mixing Zone

Under the HRSTS, the minimum river flow rate at which releases are allowed is 1,000ML/d (at Denman). As this is a very large flow compared to the proposed release rate, the discharges will be significantly diluted.

The site water balance model results were used to estimate the dilution ratios (ratio of Hunter River streamflow to release flow rate) for the releases modelled at each stage of the proposed modification.

As shown in Figures 4.10 and 4.11 the modelled dilution ratios are highly variable – occasionally exceeding 100,000, and rarely below 100. Dilution ratios are lowest in Year 2 for Scenario 1 (median 900), and Year 5 for Scenario (median 700). The minimum modelled dilution ratio was 46, which is significantly larger than the theoretical limit of 20 (for a release rate of 50ML/d), due the other limitations on discharge (minimum PWD operating volume and HRSTS salinity limits).

At these dilution ratios, the resultant increase in Hunter River contaminant concentrations during HRSTS discharges will be small. As it is likely that complete mixing of the discharge water in the river flow will occur within a few hundred metres of the outlet, the impact on the nearby licensed water users shown in Figure 2.2 would be minimal.

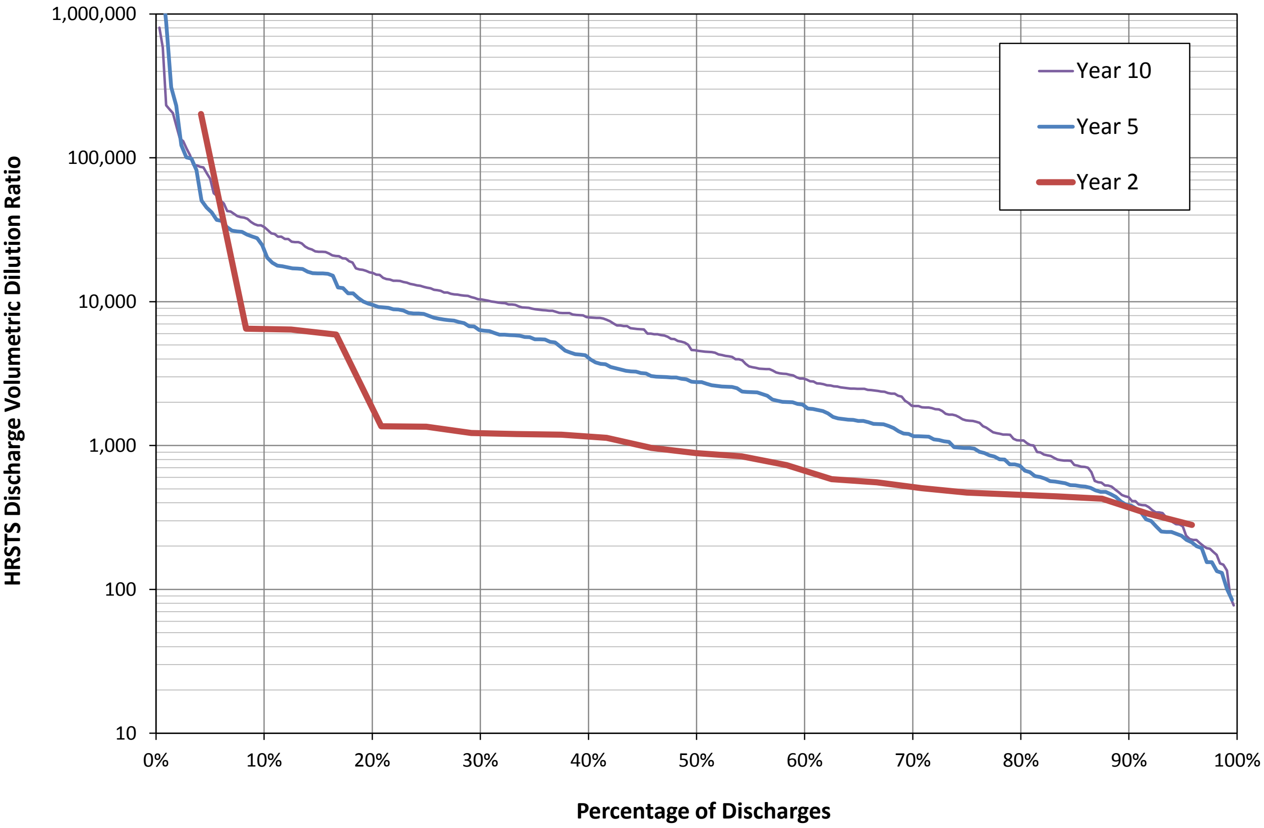


Figure 4.9 Dilution Ratio - Hunter River Flow at Denman to HRSTS Release Rate (Scenario 1)

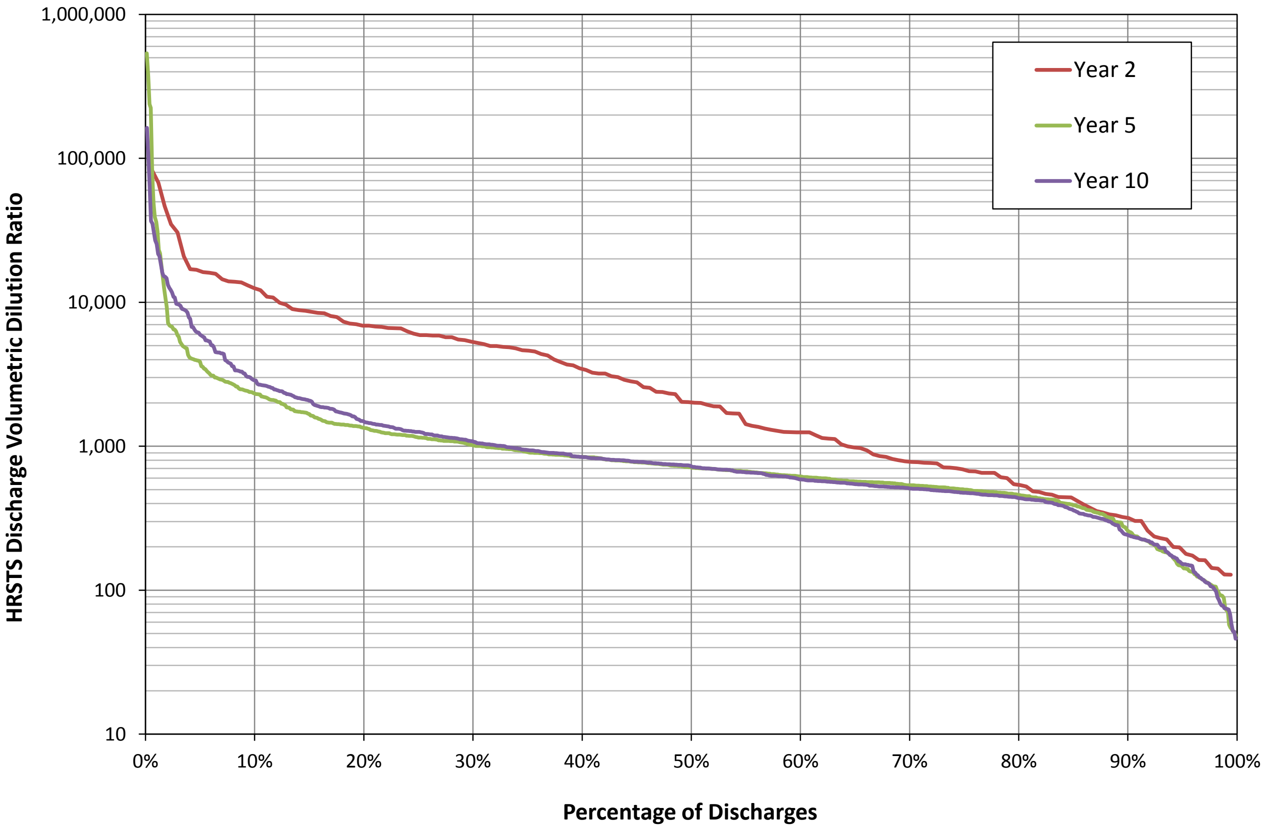


Figure 4.10 Dilution Ratio - Hunter River Flow at Denman to HRSTS Release Rate (Scenario 2)

Increase in Total Hunter River Salt Load

The site water balance model was used to assess the likely increase in Hunter River salt load resulting from the proposed HRSTS discharges. Table 4.13 shows the increase in average Hunter River salt load (at Denman) is likely to be less than 0.4%.

Table 4.13 Average Hunter River Salt Load

Mining Stage	Average Salt Load (tonnes/day)				
	Upstream Hunter River	HRSTS Discharges from Mangoola Coal		Total Downstream Hunter River at Denman	
		Scenario 1 (High Demand)	Scenario 2 (Low Demand)	Scenario 1 (High Demand)	Scenario 2 (Low Demand)
Year 2	106.7	0	0.05	106.7	106.7
Year 5	106.7	0.06	0.39	106.7	107.1
Year 10	106.7	0.05	0.31	106.7	107.0

4.11.3 Water Quality Monitoring

The Surface Water Monitoring Plan (Umwelt, 2010), describes the water quality monitoring program for current operations. This plan was developed to satisfy the monitoring requirements of the PA 06_0014 and EPL Licence No 12894.

Surface water quality is monitored at 17 locations in streams surrounding Mangoola Coal. Monthly recordings are made of pH, electrical conductivity, TSS, TDS, and flow conditions. In addition, annual samples are analysed to establish concentrations of a range of analytes, including metals, and nutrients. The sampling points of relevance to the HRSTS discharges are shown in Figure 4.11. SW17 is located upstream of the Hunter River pump station and proposed location for HRSTS discharges under the proposed modification. SW01 is located downstream of the proposed discharge location at the Denman Road crossing – which is also the location of NOW's Hunter River at Denman gauge (210055).

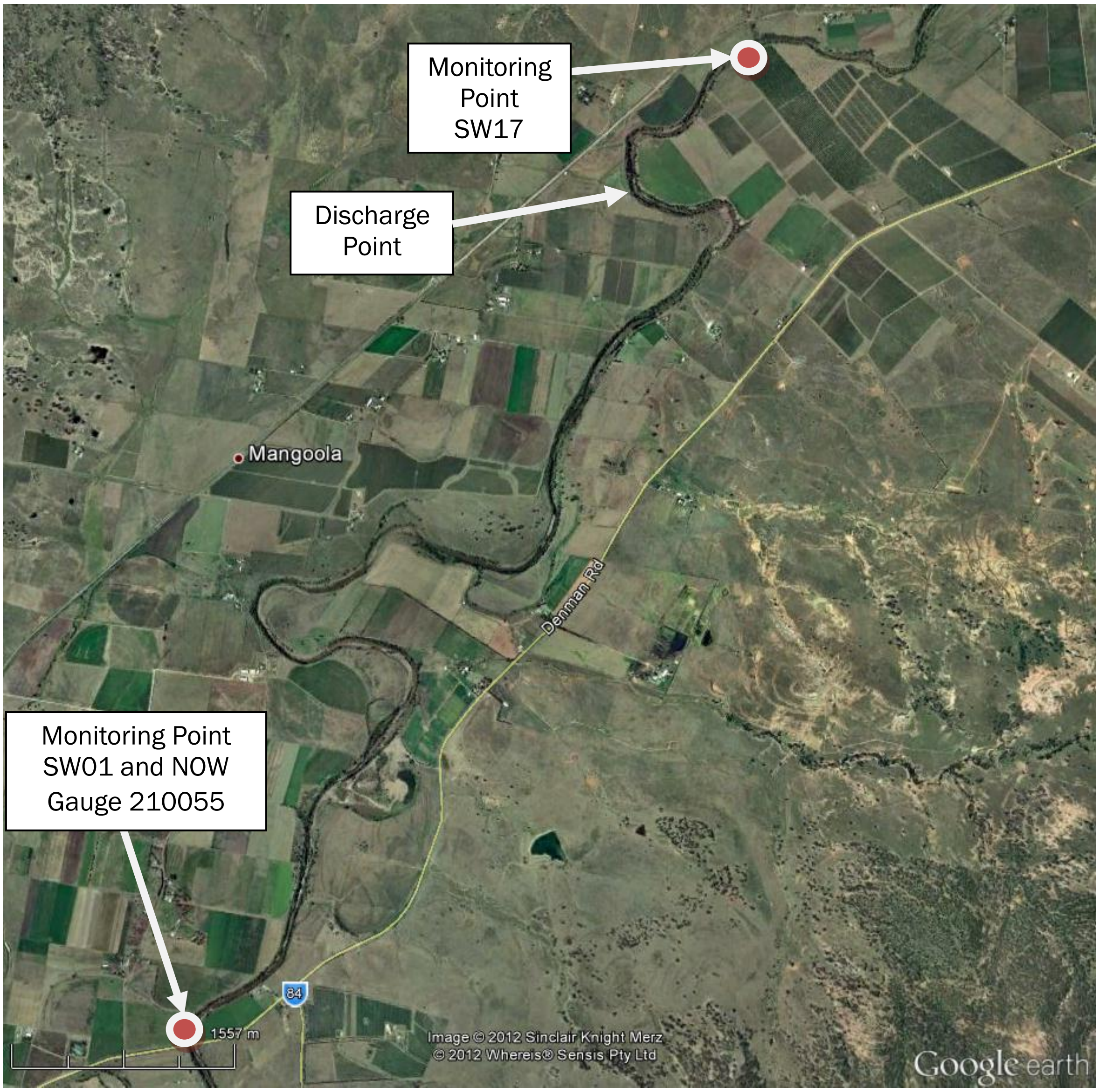


Figure 4.11 Hunter River Monitoring Points near Proposed Discharge Outlet

The current surface water monitoring network is considered adequate for measuring compliance with the HRSTS and future EPL requirements. To manage and monitor discharges to the Hunter River under the rules and regulations of the HRSTS under the proposed modification, Xstrata Mangoola will update the SWMP to include the following:

- description of the rules, regulations and operating parameters of the HRSTS and Mangoola Coal's responsibilities;
- requirement to notify downstream water users within 1 km of the proposed discharge outlet when discharges to the Hunter River (dictated by the rules and regulations of the HRSTS) are scheduled; and
- monitoring of water quality in the saline water zone, including the PWD, routinely, and prior to discharge, to ensure that guideline trigger values are met;
- continuous real-time monitoring of the discharge rate and salinity (in accordance with HRSTS requirements). New equipment will be installed at the HRSTS discharge point to allow this to occur. It is proposed that NOW's Hunter River at Denman Gauge 210055 would be used for real time monitoring of river conditions.

5 CONCLUSIONS

The proposed modification will result in minor changes to the Mangoola Coal site layout and the associated water management infrastructure requirements. Compared to the current operations, the main changes are:

- more rapid evolution of the water management system;
- changes in the proposed pit and dump layouts – which will result in changes to the locations of some water management dams, and realignment of the proposed Anvil Creek and Clarks Gully diversions.

However, the proposed changes are relatively minor, and the current water management strategy will generally be appropriate for the proposed modification. The final landform drainage plan and final void will be consistent with current operations and the change to the frequency, extent, duration and velocity of flooding in Big Flat Creek and Wybong Creek will be negligible. No changes to previously estimated water quality impacts are predicted for Big Flat Creek, Wybong Creek and Sandy Creek.

It is proposed to increase the production rate, and as a result, depending on the quantity of coal "bypassing" the coal washery, the water demand will also increase. Water balance modelling shows that during extended dry periods there is a risk that Hunter River water supplies would be inadequate to meet project demands for prolonged periods. Unless significant quantities of coal bypass the coal washery, this risk is increased under the proposed modification. Mangoola Coal has identified appropriate contingencies which can be explored as required to deal with the risks to the operation associated with shortfalls in water supply during climate extremes.

Discharge of saline water direct to the Hunter River is proposed in accordance with rules and regulations of the HRSTS. The benefit of this change is a reduction in the risk of uncontrolled overflows from Mangoola Coal's saline water catchments.

Given the expected quality of water stored in the Pit Water Dam, and the predicted levels of dilution resulting from operation in accordance with the HRSTS rules, it is unlikely that discharges from Mangoola Coal would cause exceedances of ANZECC trigger values for salt or other potential contaminants in the Hunter River.

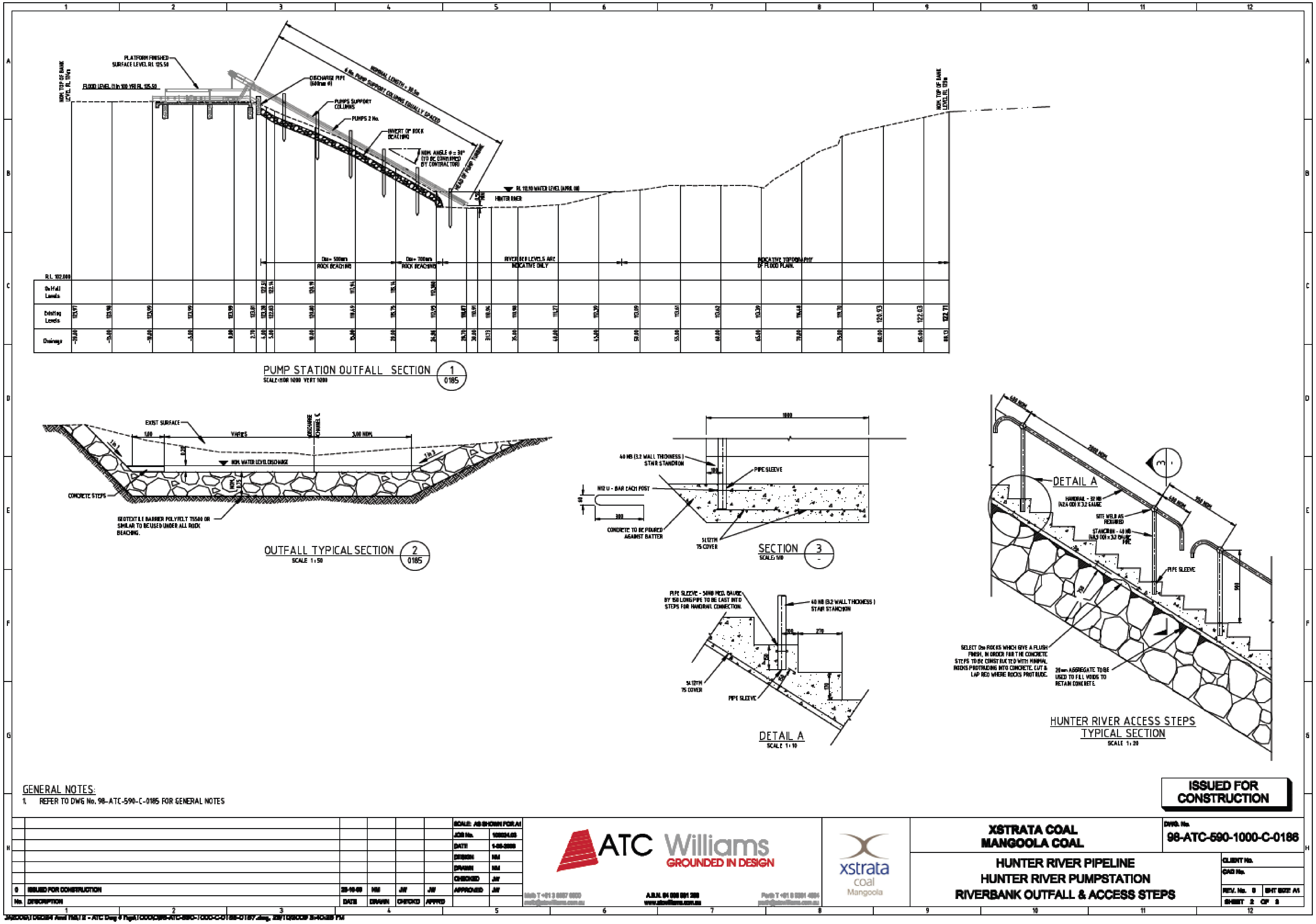
No changes to Hunter River in-stream habitat or channel stability are anticipated. The riparian, ecological, geo-morphological and hydrological values of the Hunter River are unlikely to be significantly impacted by the proposed modification.

6 REFERENCES

ANZECC/ARMCANZ (2000)	National Water Quality Management Strategy: Australian Guidelines for Fresh and Marine Water Quality
Blackmore, K.L & Goodwin, I.D (2009)	Report 3: Climatic Change Impact for the Hunter, Lower North Coat and Central Coast Region of NSW. A report prepared for the Hunter and Central Coast Region of NSW. A report prepared for the Hunter and Central Coast Regional Environmental Management Strategy, NSW.
EPA (1995)	Hunter River Salinity Trading Scheme : Guideline and rulebook – Northern Regions, Legal Services, and Economics & Environmental Reporting Branches of the NSW Environment Protection Authority, May 1995.
Umwelt Environmental Consultants (2006)	Anvil Hill Project Environmental Assessment – Surface Water Assessment, Centennial Hunter Pty Limited, August 2006.
Umwelt Environmental Consultants (2010a)	Mangoola Water Management Plan, December 2010.
Umwelt Environmental Consultants (2010b)	Surface Water Assessment – Proposed Mine Plan Modification, Mangoola Coal, December 2010.
Umwelt Environmental Consultants (2010c)	Surface Water Monitoring Plan – Mangoola Coal, December 2010.

APPENDIX A

HUNTER RIVER PUMP STATION DESIGN DRAWINGS


PUMP STATION OUTFALL SECTION
SCALE: HOR 1000 VERT 1000
OUTFALL TYPICAL SECTION
SCALE 1:50
SECTION 3
DETAIL A
SCALE 1:10
HUNTER RIVER ACCESS STEPS
TYPICAL SECTION
SCALE 1:20
GENERAL NOTES:
1. REFER TO DWG No. 98-ATC-590-C-0185 FOR GENERAL NOTES
ISSUED FOR CONSTRUCTION
ATC Williams
GROUNDED IN DESIGN
xstrata coal Mangoola
XSTRATA COAL
MANGOOLA COAL
HUNTER RIVER PIPELINE
HUNTER RIVER PUMPSTATION
RIVERBANK OUTFALL & ACCESS STEPS
98-ATC-590-1000-C-0186

APPENDIX B

WATER QUALITY DATA SUMMARY

Hunter River at Muswellbrook Bridge – Water Samples Collected by NOW

Station Number:	210002		
Grid Coordinates:	Easting: 301108	Northing: 6429240	Zone 56 MGA94
	Long: 150.8886 deg E	Lat: 32.2559 deg S	Datum: GDA94

Variable	Number of Samples	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 @25ºC	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 @ 105ºC	33	23/03/2004	06/06/2006
Solids - total suspended @ 105ºC	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
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

Hunter River at Denman – Water Quality Samples Collected by NOW

Station Number:	210055		
Grid Coordinates:	Easting: 284757	Northing: 6415100	Zone 56 MGA94
	Long: 150.712 deg E	Lat: 32.3804 deg S	Datum: GDA94

Variable	Number of Samples	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 @25ºC	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	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 @ 105ºC	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

Pit Water Dam – Water Samples Collected by Mangoola Coal

Statistics									
Parameter	Units	Number of Samples	Max	90% ile	80% ile	Med	Mean	10% ile	Min
Field measurements (February 2011 to October 2012)									
pH		21	9.2	8.9	8.8	8.54	8.58	8.3	8.2
EC	uS/cm	21	3110	2830	2480	1914	1848	686	615
TSS	mg/L	21	343	126	73	12	52.3	3	2
TDS	mg/L	21	1760	1570	1460	1160	1073	440	394
Turbidity	NTU	20	160	101.5	90	17.6	46.2	3.62	1.2
Laboratory measurements (December 2011 to July 2012)									
pH	pH unit	14	8.71	8.61	8.59	8.53	8.50	8.32	8.26
EC	uS/cm	14	2610	2529	2480	2300	2290	2060	1880
TDS	mg/L	14	1550	1460	1436	1345	1332	1180	1080
TSS	mg/L	14	169	43.6	30.8	10	26.3	5.6	5
Colour	PCU	14	15	15	12	10	10.1	7.2	1
Turbidity	NTU	13	107	18.8	10.74	4.4	13.5	1.44	1.2
Hardness	mg/L	14	544	492.4	483.2	441	439.5	361.3	327
Alkalinity (total)	mg/L	15	202	193.8	184.4	175	175.2	162.4	149
Sulfate	m/L	15	240	235.4	230	198	199.1	164.4	144
Free Chlorine	mg/l	5	0	0	0	0	0	0	0
Cl	mg/L	15	667	649.4	627.2	550	562.7	498.6	448
Ca	mg/L	15	71	67.6	63.2	58	58.1	48.2	42
Mg	mg/L	15	90	85.8	81	73	73.2	60	54
Na	mg/L	15	389	376	360.2	337	328.4	272	258
K	mg/L	15	19	18	17.2	16	16	13.4	13
Al	mg/L	14	2.41	0.50	0.45	0.19	0.37	0.043	0.03
Sb	mg/L	14	0.001	0.001	0.001	0.001	0.001	0.001	0.001
As	mg/L	15	0.01	0.0026	0.0012	0.001	0.0018	0.001	0.001
Ba	mg/L	15	0.14	0.13	0.12	0.11	0.10	0.087	0.01
Be	mg/L	14	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Cd	mg/L	15	0.005	0.0001	0.0001	0.0001	0.0004	0.0001	0.0001
Co	mg/L	14	0.002	0.001	0.001	0.001	0.0011	0.001	0.001
Cr	mg/L	14	0.002	0.001	0.001	0.001	0.0011	0.001	0.001
Cu	mg/L	15	0.058	0.0072	0.0022	0.001	0.0057	0.001	0.001
Mn	mg/L	15	0.092	0.0206	0.014	0.012	0.0164	0.0054	0.004
Ni	mg/L	14	0.006	0.006	0.006	0.004	0.0046	0.0033	0.003
Pb	mg/L	15	0.01	0.0016	0.001	0.001	0.0017	0.001	0.001
V	mg/L	14	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Zn	mg/L	15	0.017	0.012	0.0068	0.005	0.0068	0.005	0.005
Mo	mg/L	14	0.022	0.022	0.022	0.02	0.020	0.0173	0.014
Se	mg/L	15	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Ag	mg/L	15	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Sn	mg/L	1	0.001	0.001	0.001	0.001	0.001	0.001	0.001
B	mg/L	15	0.17	0.156	0.15	0.12	0.124	0.094	0.08
Fe	mg/L	15	1.92	0.36	0.30	0.09	0.25	0.05	0.05
Hg	mg/L	15	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Cyanide	mg/L	14	0.004	0.004	0.004	0.004	0.004	0.004	0.004
Flouride	mg/L	15	1	0.56	0.5	0.5	0.52	0.4	0.4
Ammonia	mg/L	14	0.11	0.10	0.072	0.035	0.047	0.02	0.01
Total N	mg/L	15	1.75	1.378	1.3	0.98	1.10	0.80	0.73
Sulfide	mg/l	14	0.1	0.1	0.1	0.1	0.1	0.1	0.1

APPENDIX C

WATER BALANCE MODEL

C.1 INTRODUCTION

An Operational Simulation (OPSIM) model has been developed for Mangoola Coal. The OPSIM model dynamically simulates the operation of the site's water management system and keeps complete account of all site water and representative water quality on a daily time step basis.

The model has been configured to simulate the operations of all major components of the water management system including:

- Climatic variability – rainfall and evaporation;
- Catchment runoff and collection;
- Pit dewatering;
- Pump and gravity transfers;
- Water storage filling, spilling and leaking;
- Industrial water extraction, usage and return; and
- Discharge to the Hunter River under the HRSTS.

For modelling purposes, the Project life has been broken into a series of stages as outlined in Table C.1.

Table C.1 Stages of Evolution of the Site Water Management System

Stage	Calendar Year	Project Year	Layout
1	2013	1	2011[1]
2	2014	2	Y2
3	2017	5	Y5
4	2022	10	Y10

[1] As at December 2011

C.2 MODEL DETAILS

C.2.1 Rainfall

Table C.2 shows summary details of Bureau of Meteorology (BoM) rainfall recording stations in the vicinity of Mangoola Coal.

Table C.2 Bureau of Meteorology Rainfall Stations

Station No.	Station Name	Elevation	Lat (ºS)	Long (ºE)	Distance from Site	Opened	Closed
061016	Denman (Palace St)	105m	32.39	150.69	11km	1883	-
061053	Muswellbrook (Lower hill St)	143m	32.26	150.88	17km	1870	-

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 site 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"* (Bureau of Meteorology, 2006).

A comparison of the mean monthly and annual rainfalls from Data Drill and BoM station data over the common continuous 71 year period (1939-2010) is presented in Table C.3.

Table C.3 Mean Monthly and Annual Rainfall (mm) (1939-2010)

Month	Denman (Palace St) - 061016	Muswellbrook (Lower Hill St) - 061053	Data Drill Mangoola
Jan	74	73	71
Feb	67	69	63
Mar	53	56	54
Apr	40	44	39
May	35	41	37
Jun	41	52	40
Jul	39	46	37
Aug	35	40	34
Sep	39	39	37
Oct	49	48	48
Nov	54	55	51
Dec	66	69	64
Total	**594**	**631**	**575**

C.2.2 Evaporation

Table C.4 and Figure C.1 present the mean monthly Class A pan evaporation for the Mangoola Coal site obtained from the Data Drill service.

Table C.4 Mean Monthly and Annual Pan Evaporation

Month	Pan Evaporation (mm)
Jan	220.4
Feb	174.7
Mar	156.2
Apr	110.2
May	72.4
Jun	52.9
Jul	61.5
Aug	86.9
Sep	117.5
Oct	158.1
Nov	187.3
Dec	222.4
Year	**1,620**

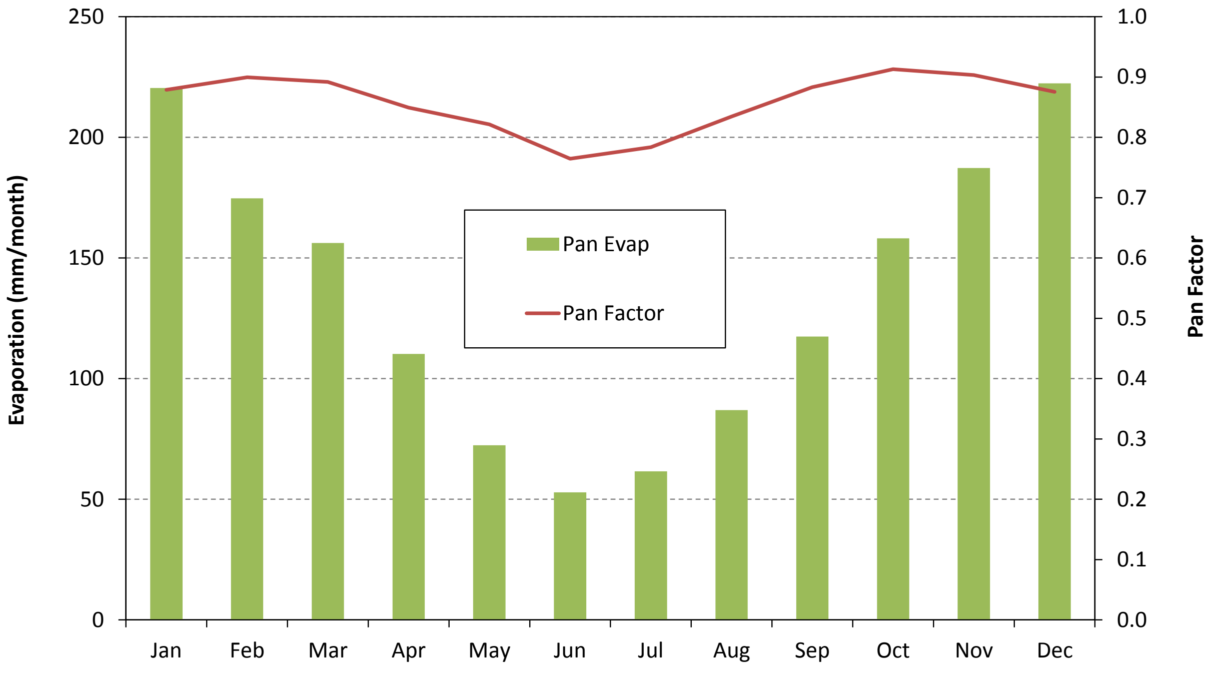


Figure C.1 Mean Monthly Pan Evaporation & Pan Factors

Mean annual evaporation is almost three times the mean annual rainfall. Evaporation factors which have been applied to the water balance modelling are presented in Table C.5.

For water balance modelling, daily Data Drill estimates of Class A Pan evaporation were used for evaporation from open water bodies. A pan factor was used to convert Class A pan evaporation rates to evapotranspiration rates, and a Storage Factor was used to reduce evaporation rates from water stored in deep pits.

Table C.5 Adopted Evaporation/Evapotranspiration Factors

Description	Factor	Applied to:
Evaporation Factor	0.85 – 1.2	Convert Pan evaporation to evapotranspiration (Refer Table C.6).
Storage Factor	0.5 – 1.0	Reduce evaporation rates in mining pits with increased depths due to effect of wind sheltering and shading from pit walls. This factor was interpolated between 0.5 for pit depths >50m and 1.0 for 0m depth.

C.2.3 Catchment Yield Characteristics

The OPSIM model uses the Australian Water Balance Model (AWBM) (Boughton & Chiew 2003) 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.

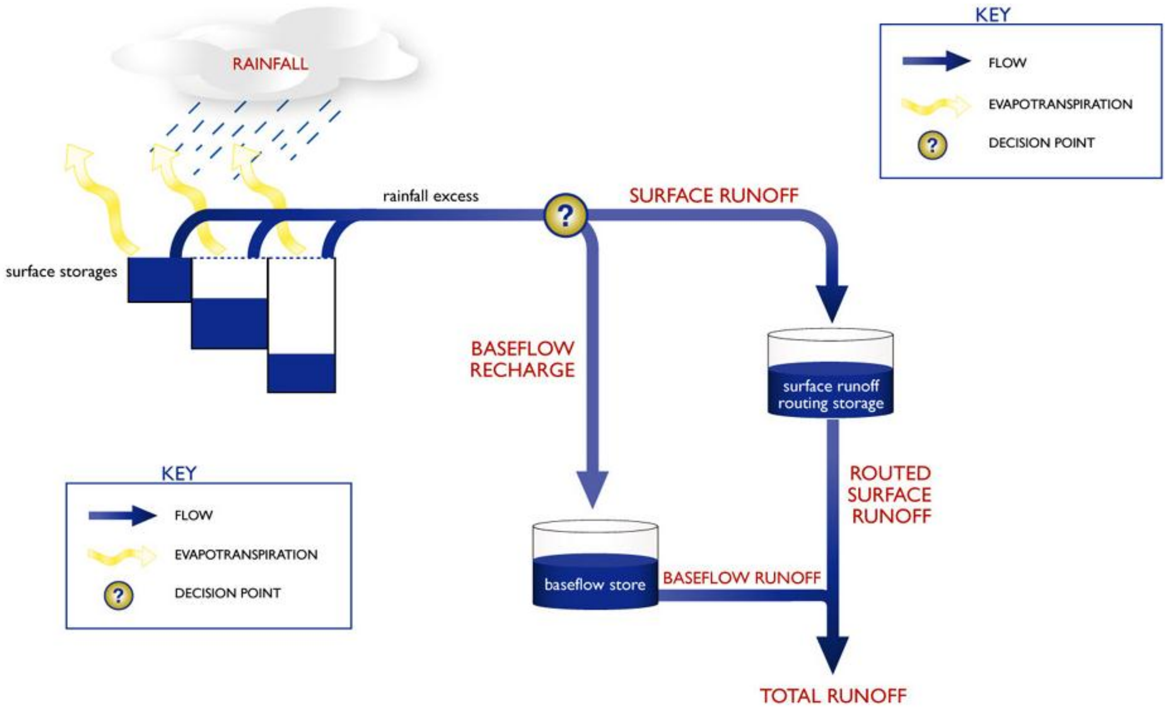


Figure C.2 AWBM Model

At each time step, the AWBM behaves as follows:

- Rainfall is added to each of the 3 surface moisture stores and evapotranspiration is subtracted from each store. The water balance equation is:
  $store_n = store_n + rain - evap$ (n = 1 to 3)
- If the value of moisture in the store becomes negative, it is reset to zero. If the value of moisture in the store exceeds the capacity of the store, the moisture in excess of capacity becomes runoff and the store is reset to the capacity.
- When runoff occurs from any store, part of the runoff becomes recharge of the baseflow store. The fraction of the runoff used to recharge the baseflow store is BFI*runoff, where BFI is the baseflow index.
- The remainder of the runoff, i.e. (1.0 - BFI)*runoff, is surface runoff.
- The baseflow store is depleted at the rate of (1.0 - K)*BS where BS is the current moisture in the baseflow store and K is the baseflow recession constant of the time step being used (daily or hourly).
- The surface runoff can be routed through a store if required to simulate the delay of surface runoff reaching the outlet of a medium to large catchment. The surface store acts in the same way as the baseflow store, and is depleted at the rate of (1.0 - KS)*SS, where SS is the current moisture in the surface runoff store and KS is the surface runoff recession constant of the time step being used.

The model parameters define the storage depths, the proportion of the catchment draining to each of the storages, and the rate of flux between them (Boughton, 2003). Catchment evapotranspiration was calculated by estimating daily evapotranspiration by multiplying daily Class A Pan evaporation by a monthly pan factor (0.85 - 1.2).

The model parameters were selected for consistency with previous modelling at the site (Gilbert and Associates, 2011), which was based on previous experience with modelling at other Hunter Valley mine operations. The adopted parameters are presented in Table C.6.

Table C.6 Adopted AWBM Parameters for Various Catchment Types

Parameter	Natural (grassed)	Hardstand	Open Cut	Tailings	Active Waste	Rehab Waste*	Stockpile
A1	0.134	0.5	0.1	0.5	0.05	0.134	0.1
A2	0.433	0.5	0.9	0.5	0.95	0.433	0.9
C1	12.5	5	5	5	5	12.5	5
C2	121.2	5	20	15	70	121.2	50
C3	254.5	0	0	0	0	254.5	0
BFI	0.22	0	0.1	0	0.3	0.22	0.5
Kb	0.861	0	0.96	0	0.3	0.3	0.98
Evapo-transpiration Factor	0.85	1.0	1.1	1.2	0.85	0.85	1.2
Long Term Runoff Coefficient	5.2%	41.8%	22.0%	30.8%	8.2%	5.2%	10.2%

* Including established rehabilitation.

C.2.4 Modelling of Releases from the PWD under the HRSTS

The following approach to the HRSTS modelling was adopted:

1. Hunter River Streamflow time series – simulated streamflow data was obtained from the NSW Office of Water's IQQM model (full development case with 2004 water sharing plan rules) for the period 16/09/1892 to 30/6/2007.
2. Salinity –Recorded salinity data was obtained for the Hunter River at Denman (#210055) from the PINEENA database, 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 trendline fitted to the data, giving salinity as a function of flowrate.
3. Using IQQM, predicted flows at Denman, Glennies Creek and Singleton – the flow was 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 was then applied to get a Hunter River flow and EC time series at Denman which was 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 C.7. Rule 2 limits the salt load discharged based on the salinity in the Hunter River and the Pit Water dam, as shown in Table C.8. In addition, low water inventory trigger of 1,000ML set on the Pit Water Dam (i.e. no discharges if volume in PWD < 1,000ML).

Table C.7 HRSTS Rule 1 (Volume Limit Rating)

Hunter River Qref (ML/d)	Site Discharge Qmax (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	
1000	50	✓	When Hunter River flows are 1,000 – 4,000 ML/d, up to 50 ML/d can be discharged from site, with salinity restrictions as per 'Rule 2'.
4000	50	✓	
High	50	x	When Hunter River flows are >4,000 ML/d, up to 50 ML/d can be discharged from site, with no salinity restrictions.

Where:

- Qref is the reference volume [ML/d] (in this case, the Hunter River).
- Qmax is the discharge limit [ML/d] for Qref.

Table C.8 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 inrease 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 cannot increase due to discharges under the HRSTS.

Where:

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

Note that it is assumed that the number of salt credits held by Mangoola Coal is not a limitation to releases. Historically there have been sufficient credits available for trade.

C.2.5 Runoff Water Salinity

Runoff water salinities measured as electrical conductivity (EC) have been considered to allow a credible estimate of potential discharges under the HRSTS. Each catchment type has been assigned a representative runoff salinity value as presented in Table C.9. The adopted salinities were selected based on available water quality data from Mangoola Coal as well as experience at similar nearby operations.

Table C.9 Adopted Water Quality Criteria

Catchment Type	Electrical Conductivity (µS/cm)
Natural (grassed)*1	200
Hunter River Water Source*2	500
Hardstand*3	1,000
Open Cut	1,500
Tailings	5,000
Active Waste*4	4,000
Rehab Waste	1,000
Stockpile	5,000
Groundwater*5	4,900

*1 – Based on Anvil Creek Sediment Dam water quality records
*2 – Average Historical EC at Muswellbrook and Denman
*3 – Based on Farm Dam and CHPP Area Sediment Dam water quality records
*4 – Based on NOOP Sediment Dam water quality records
*5 – Based on coal measure water samples taken as part of original Environmental Assessment (Umwelt, 2006)

C.2.6 Groundwater

Groundwater inflow rates provided in the original EA were adopted for this assessment (as advised by Mackie Environmental Research (pers. comm, 2011)), with changes to the timing to reflect the accelerated rate of mining.

C.2.7 Model Operating Rules

The following rules have been applied to the OPSIM model.

Table C.10 OPSIM operating rules

NODE NO.	NODE NAME	OPERATING RULES
RAW WATER SUPPLY		
24.	HUNTER RIVER (SOURCE)	o SUPPLIES TO RAW WATER DAM AS REQUIRED AT A MAXIMUM RATE OF 50 ML/D AND MAXIMUM YEARLY ALLOCATION OF 3,383 ML/A.
25.	GROUNDWATER	o CONTINUOUS PIT GROUNDWATER INFLOWS. o 2011: • NORTH PIT - 526ML/A (1,440 KL/D) o YEAR 2: • NORTH PIT – 526ML/A (1,440 KL/D) o YEAR 5: • MAIN PIT – 329ML/A (900 KL/D) • SOUTH PIT –329ML/A (900 KL/D) o YEAR 10: • POWERLINE PIT – 562ML/A (1,540 KL/D)
WATER DEMANDS		
1.	CHPP	o OPERATES AT THE FOLLOWING ROM (WET) THROUGHPUTS: • 2011 – 10.5 MTPA • 'LOW DEMAND' SCENARIO – 8.0 MTPA • 'HIGH DEMAND' SCENARIO – 13.5 MTPA o DEMANDS FROM THE PIT WATER DAM AT THE FOLLOWING RATES: • 2011 – 3,090 ML/A (8,460 KL/D) • ' 'LOW DEMAND' SCENARIO – 2,354 ML/A (6,446 KL/D) • 'HIGH DEMAND' SCENARIO – 3,973 ML/A (10,878 KL/D) o DIRECTS FINE TAILINGS TO TAILINGS PIT (1,2,3,4).
42.	PLANT BYPASS	o OPERATIONAL ONLY FOR 'LOW DEMAND' SCENARIO AT 5.5MTPA, DURING YEAR 2, 5 & 10 STAGES. o
5.	HAUL ROAD DUST SUPPRESSION	o DEMANDS FROM THE PIT WATER DAM AT 3.1MM/D, SCALED TO 0MM/D FOR RAINFALLS DEPTHS >5MM/D. AVERAGE RATES ARE AS FOLLOWS: • 2011 – 365 ML/A • YEAR 2 –333 ML/A • YEAR 5 – 480 ML/A • YEAR 10 – 380 ML/A o 100% LOSS.
6.	POTABLE WATER	o CONTINUOUS DEMAND SOURCED FROM THE RAW WATER DAM AT 25KL/D. o 100% LOSS.
7.	VEHICLE WASH	o CONTINUOUS DEMAND SOURCED FROM THE RAW WATER DAM AT 106KL/D. o 100% LOSS.

OPERATIONAL PITS		
15.	NORTH PIT	○ OPERATIONAL DURING 2011 & YEAR 2 STAGES. ○ RECEIVES GROUNDWATER INFLOWS. ○ DEWATERS TO HAUL ROAD DAM AT A RATE OF 100 L/S (8,640 KL/D).
34.	MAIN PIT	○ OPERATIONAL DURING YEAR 5 STAGE. ○ RECEIVES GROUNDWATER INFLOWS. ○ DEWATERS TO PIT WATER DAM AT A RATE OF 100 L/S (8,640 KL/D).
33.	SOUTH PIT	○ OPERATIONAL DURING YEAR 5 STAGE. ○ RECEIVES GROUNDWATER INFLOWS. ○ DEWATERS TO PIT WATER DAM AT A RATE OF 100 L/S (8,640 KL/D).
39.	POWERLINE PIT	○ OPERATIONAL DURING YEAR 10 STAGE. ○ RECEIVES GROUNDWATER INFLOWS. ○ DEWATERS TO PIT WATER DAM AT A RATE OF 200 L/S (17,280 KL/D).
WATER STORAGES		
8.	PIT WATER DAM	○ SUPPLIES WATER TO THE FOLLOWING DEMANDS AS REQUIRED: • CHPP • PLANT BYPASS • HAUL ROAD DUST SUPPRESSION ○ DEMANDS FROM RAW WATER DAM AS REQUIRED. ○ RECEIVES DECANT RETURN FROM DECANT PIT OR TAILINGS PIT (1,2,3,4). ○ RECEIVES PIT DEWATERING DIRECTLY OR VIA HAUL ROAD DAM. ○ RECEIVES SEDIMENT DAM PUMPED TRANSFERS. ○ RECEIVES UNCONTROLLED OVERFLOWS FROM THE FOLLOWING LOCATIONS: • TAILINGS DAM (1,2,3,4) • MIA SEDIMENT DAM • PRODUCT STOCKPILE DAM • CHPP AREA SEDIMENT DAM • SOOP 3 SEDIMENT DAM ○ SPILLS TO ANVIL CREEK. ○ CONTROLLED DISCHARGE POINT TO HUNTER RIVER UNDER HRSTS.
9.	RAW WATER DAM	○ DEMANDS FROM HUNTER RIVER AS REQUIRED. ○ SUPPLIES TO PIT WATER DAM AS REQUIRED. ○ SUPPLIES WATER TO POTABLE AND VEHICLE WASH DEMANDS. ○ SPILLS TO SANDY CREEK.
10.	TAILINGS PIT (1,2,3,4)	○ RECEIVES FINE TAILINGS FROM CHPP WITH THE FOLLOWING CHARACTERISTICS: • INITIAL MOISTURE CONTENT – 68 % • END OF FILLING DRY DENSITY – 0.65 T/M^3 • COAL TAILINGS PARTICLE DENSITY – 2 G/CM^3 • FINAL IN-SITU MOISTURE CONTENT (MOISTURE RETENTION) – 51% ○ TRANSFERS DECANT TO DECANT PIT OR PIT WATER DAM AT A RATE OF 100 L/S (8,640 KL/D). ○ SPILLS TO PIT WATER DAM.

17.	DECANT PIT	o OPERATIONAL DURING 2011 STAGE ONLY. o RECEIVES DECANT RETURN FROM TAILINGS PIT. o TRANSFERS TO PIT WATER DAM AT A RATE OF 100L/S (8,640KL/D).
13.	HAUL ROAD DAM	o OPERATIONAL DURING 2011 & YEAR 2 STAGES. o RECEIVES PIT DEWATERING FROM NORTH PIT. o RECEIVES SEDIMENT DAM PUMPED TRANSFERS. o TRANSFERS TO PIT WATER DAM AT 100 L/S (8,640 KL/D).
SEDIMENT DAMS		
21.	FARM DAM	o OPERATIONAL DURING 2011 & YEAR 2 STAGES. o TRANSFERS TO HAUL ROAD DAM AT A RATE OF 50L/S (4,320KL/D). o SPILLS TO CLARKS GULLY.
11.	RAIL LOOP DAM	o TRANSFERS TO PIT WATER DAM AT A RATE OF 115 L/S (9,940 KL/D). o SPILLS TO SANDY CREEK.
26.	PRODUCT STOCKPILE DAM	o SPILLS TO PIT WATER DAM.
27.	MIA SEDIMENT DAM	o SPILLS TO PIT WATER DAM.
28.	CHPP STOCKPILE DAM	o SPILLS TO CHPP AREA SEDIMENT DAM.
29.	CHPP AREA SEDIMENT DAM	o TRANSFERS TO PIT WATER DAM AT A RATE OF 50 L/S (4,320 KL/D). o RECEIVES UNCONTROLLED OVERFLOWS FROM CHPP STOCKPILE DAM. o SPILLS TO PIT WATER DAM.
41.	ANVIL CREEK SEDIMENT DAM	o OPERATIONAL DURING 2011 & YEAR 2 STAGES. o TRANSFERS TO PIT WATER DAM AT A RATE OF 50 L/S (4,320 KL/D). o SPILLS TO ANVIL CREEK.
14.	NOOP 1 SEDIMENT DAM	o TRANSFERS TO HAUL ROAD DAM OR PIT WATER DAM AT A RATE OF 70 L/S (6,048 KL/D) WHEN VOLUME >10%. o SPILLS TO BIG FLAT CREEK.
30.	NOOP 2 SEDIMENT DAM	o TRANSFERS TO HAUL ROAD DAM OR PIT WATER DAM AT A RATE OF 50 L/S (4,320 KL/D) WHEN VOLUME >10%. o SPILLS TO BIG FLAT GULLY.
31.	NOOP 3 SEDIMENT DAM	o TRANSFERS TO PIT WATER DAM AT A RATE OF 50 L/S (4,320 KL/D) WHEN VOLUME >10%. o SPILLS TO SANDY CREEK.
32.	NOOP 4 SEDIMENT DAM	o TRANSFERS TO PIT WATER DAM AT A RATE OF 50 L/S (4,320 KL/D) WHEN VOLUME >10%. o SPILLS TO BIG FLAT CREEK.

35.	SOOP 1 SEDIMENT DAM	○ TRANSFERS TO PIT WATER DAM AT A RATE OF 50 L/S (4,320 KL/D) WHEN VOLUME >10%. ○ SPILLS TO SANDY CREEK.
36.	SOOP 2 SEDIMENT DAM	○ TRANSFERS TO PIT WATER DAM AT A RATE OF 50 L/S (4,320 KL/D) WHEN VOLUME >10%. ○ SPILLS TO SANDY CREEK.
37.	SOOP 3 SEDIMENT DAM	○ TRANSFERS TO PIT WATER DAM AT A RATE OF 50 L/S (4,320 KL/D) WHEN VOLUME >10%. ○ SPILLS TO PIT WATER DAM.
38.	MAIN 1 SEDIMENT DAM	○ TRANSFERS TO PIT WATER DAM AT A RATE OF 50 L/S (4,320 KL/D) WHEN VOLUME >10%. ○ SPILLS TO BIG FLAT CREEK.
40.	MAIN 2. SEDIMENT DAM	○ TRANSFERS TO PIT WATER DAM AT A RATE OF 50 L/S (4,320 KL/D) WHEN VOLUME >10%. ○ SPILLS TO BIG FLAT CREEK.
<u>WATERCOURSES</u>		
18.	ANVIL CREEK	○ RECEIVES UNCONTROLLED OVERFLOWS FROM THE FOLLOWING LOCATIONS: • PIT WATER DAM • ANVIL CREEK SEDIMENT DAM
19.	SANDY CREEK	○ RECEIVES UNCONTROLLED OVERFLOWS FROM THE FOLLOWING LOCATIONS: • RAW WATER DAM • RAIL LOOP DAM • NOOP 3 SEDIMENT DAM • SOOP 1 SEDIMENT DAM • SOOP 2 SEDIMENT DAM
22.	BIG FLAT CREEK	○ RECEIVES UNCONTROLLED OVERFLOWS FROM THE FOLLOWING LOCATIONS: • NOOP 1 SEDIMENT DAM • NOOP 2 SEDIMENT DAM • NOOP 4 SEDIMENT DAM • MAIN 1 SEDIMENT DAM • MAIN 2 SEDIMENT DAM
20.	HUNTER RIVER DOWNSTREAM	○ RECEIVES CONTROLLED RELEASES FROM PIT WATER DAM UNDER HRSTS.
23.	CLARKS GULLY	○ RECEIVES UNCONTROLLED OVERFLOWS FROM THE FOLLOWING LOCATIONS: • FARM DAM

C.2.8 Model Limitations

The water balance analysis results should be interpreted with a number of potential uncertainties in mind:

- Catchment response to rainfall – in the absence of sufficient site-specific data, AWBM model parameters have been adopted from experience with models at other nearby sites. However, mine site catchment behaviour can vary significantly from site to site (and from pit to pit).
- The HRSTS releases are limited by the magnitude of Hunter River streamflow derived through catchment modelling. The results of such modelling are subject to significant uncertainty.
- Hunter River salinity records were only available for a small portion of the flow record. The derived salinity record is based on a relationship between flow and salinity.
- Tailings storage facility response to rainfall – we do not have sufficient data to allow us to calibrate a runoff model for the proposed tailings storage facility. The adopted runoff parameters result in a relatively high runoff to rainfall ratio – and will therefore tend to overestimate the risk of discharge, and the reliability of water supply.
- System operation – the model assumes the water management system is operated in a systematic, and predictable way. In reality, day-to-day water management decisions can be driven by other operational imperatives, and this will affect the system performance.

C.3 REFERENCES

Boughton WC (1993)	A Hydrograph-Based Model for Estimating the Water Yield of Ungauged Catchments, Hydrology and Water Resources Symposium, Newcastle, June 1993.
DECC (2008)	Managing Urban Stormwater – Soils and Construction, Volume 2E Mines and Quarries.
GSS Environmental (2011)	Mangoola Coal - Annual Environmental Management Report, 1 July 2010 to 30 June 2011, Xstrata Mangoola Pty Limited, October 2011.
Jeffrey SJ, Carter JO, Moodie KM & Beswick AR (2001)	Using Spatial Interpolation to Construct a Comprehensive Archive of Australian Climate Data, Environmental Modelling & Software, Vol 16/4, pp 309 – 330, 2001.

APPENDIX D

SENSITIVITY ANALYSIS – HIGH RUNOFF

D.1 OVERVIEW

Further analysis was undertaken to assess the sensitivity of the water management system behaviour to an increase in the runoff to rainfall ratio. Under this scenario, the evaporation and evapotranspiration rates were modified as follows:

- Morton's Lake rate evaporation rate was used for water surface storage evaporation (annual average of 1,416 mm/a)
- A factor of 0.67 was applied to convert the Morton's Lake evaporation to Morton's actual evapotranspiration

These changes resulted in long term runoff coefficients as follows:

- Natural (grassed): 7.6%
- Hardstand: 54%
- Open cut: 33%
- Tailings: 45%
- Active waste: 13%
- Rehab waste: 7.6%
- Stockpile: 19%

D.2 OVERALL SITE WATER BALANCE

The site water balance for Year 10 (when impacts are greatest) is presented in Table D.1. On average:

Outflows

- Total water demand ranges between approximately 1,664ML/a (Scenario 2) and 2,519ML/a (Scenario 1);
- Evaporation is approximately 700ML/a and 850ML/a for Scenario 1 (High Demand) and Scenario 2 (Low Demand) respectively;
- Hunter River discharge is approximately 70ML/a and 220ML/a for Scenario 1 (High Demand) and Scenario 2 (Low Demand) respectively;

Inflows

- Runoff yield contributes approximately 2,000ML/a in each scenario;
- Groundwater contributes approximately 560ML/a;
- Hunter River extraction is approximately 580ML/a to 140ML/a for Scenario 1 (High Demand) and Scenario 2 (Low Demand) respectively.

Deficit

The site deficit is approximately 290ML/a and 150ML/a for Scenario 1 (High Demand) and Scenario 2 (Low Demand) respectively.

Table D.1 Mangoola Project Annual Water Balance – High Runoff Sensitivity Analysis, Year 10

	Annual Average Water Balance (ML)	
	High Demand (Scenario 1)	Low Demand (Scenario 2)
Parameters		
ROM Coal (Mt)	13.5	8.0
Bypass Coal (Mt)	0	5.5
Water Inputs (ML/annum)		
Rainfall Yield (Dams and Catchment Runoff)	1,936	2,000
Clean Water System	*218*	*218*
Dirty Water System	*65*	*70*
Saline Water System	*1,310*	*1,366*
Established Rehabilitation System	*342*	*346*
Pipeline Water (Hunter River)	584	137
Groundwater Inflow to Open Cut Pits	562	562
Gross Water Inputs	**3,062**	**2,699**
Water Outputs (ML/annum)		
Evaporation from Dams and Ponds	716	853
Clean Water System	317	317
Dirty Water System	5	16
Saline Water System	388	504
Established Rehabilitation System	6	15
Dam Overflows (off-site)	74	108
Clean Water System	-	-
Dirty Water System	7	19
Saline Water System	-	
Established Rehabilitation System	66	89
Off-site Release (HRSTS)	74	223
Net Loss from CHPP	2,099	1,244
Net Loss from Plant Bypass	-	-
Potable + Vehicle Wash	39	39
Dust Suppression	381	381
Gross Water Outputs	**3,382**	**2,846**
Water Balance		
Gross Water Deficit (ML/annum)	**284**	**147**

D.3 UNCONTROLLED OFFSITE DISCHARGES

The water balance model results show that there are no simulated uncontrolled overflows from the Pit Water Dam for Scenario 1 (High Demand). There is one modelled uncontrolled overflow of 6ML from the Pit Water Dam for Scenario 2 (Low Demand), over the 114 year historical simulation period. However, in reality, it is likely that a small overflow such as this could be avoided with adaptive management. There are no uncontrolled overflows from the Rail Loop Dam or Raw Water Dam for either scenario (high/low demand) in any year.

Table D.2 Uncontrolled Offsite Discharges from Pit Water Dam

	Total Number of Discharge Days	Maximum Volume of Discharge (ML)	Average Volume of Discharge (ML)
High Demand (Scenario 1)			
Y10	0	0	0
Low Demand (Scenario 2)			
Y10	1	6	6

D.4 CONTROLLED DISCHARGES (HRSTS)

Results of the water balance modelling indicate controlled HRSTS discharges from the Pit Water Dam would average between 6 and 19 release days per year for Scenario 1 and 2 respectively.

Table D.3 Controlled HRSTS Discharges from Pit Water Dam

Mine Plan	Scenario 1 High Water Demand			Scenario 2 Low Water Demand		
	Total Number of Discharge Days[1]	Annual Average Discharge Days[1]	Maximum Volume of Discharge Event (ML)	Total Number of Discharge Days[1]	Annual Average Discharge Days[1]	Maximum Volume of Discharge Event (ML)
Year 10	705	6.1	746	2,172	19	1,209

[1] Over 114 year historical simulation period.

APPENDIX E

PIT AVAILABILITY

PIT AVAILABILITY

The change in pit it inundation characteristics over the project life, and the benefit of HRSTS discharge in reducing the risk of pit inundation was assessed using the water balance model. The following scenarios were modelled:

- Scenario 1 – 13.5 Mtpa washed, with HRSTS discharges
- Scenario 2 – 8.0 Mtpa washed + 5.5 Mtpa bypass, with HRSTS discharges
- Scenario 3 – 13.5 Mtpa washed, without HRSTS discharges
- Scenario 4 – 8.0 Mtpa washed + 5.5 Mtpa bypass, without HRSTS discharges

The Pit inundation characteristics are presented below. In all years, Scenarios 2 and 4 (i.e. without HRSTS discharges) have higher pit inundation characteristics.

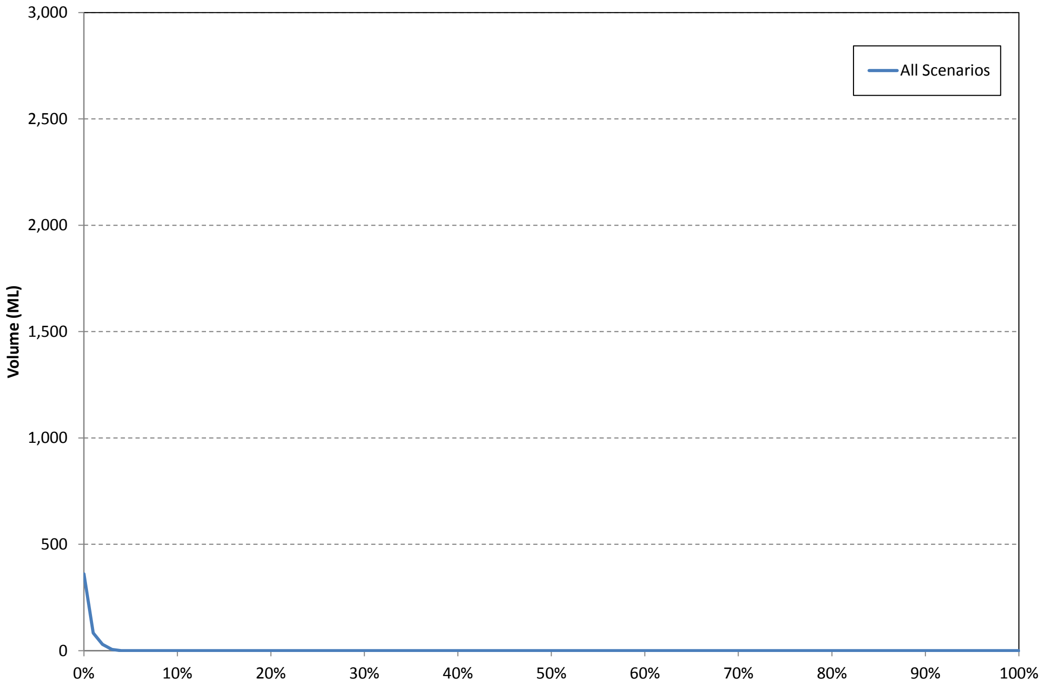


Figure E.1 North Pit Inundation Characteristics, Existing

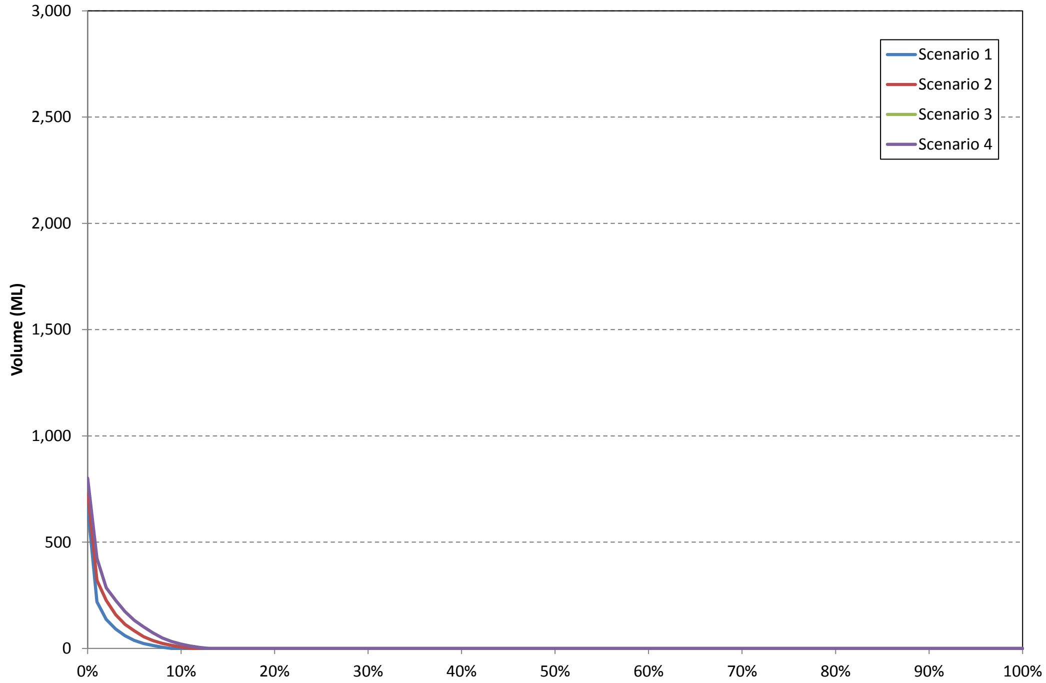


Figure E.2 North Pit Inundation Characteristics, Year 2

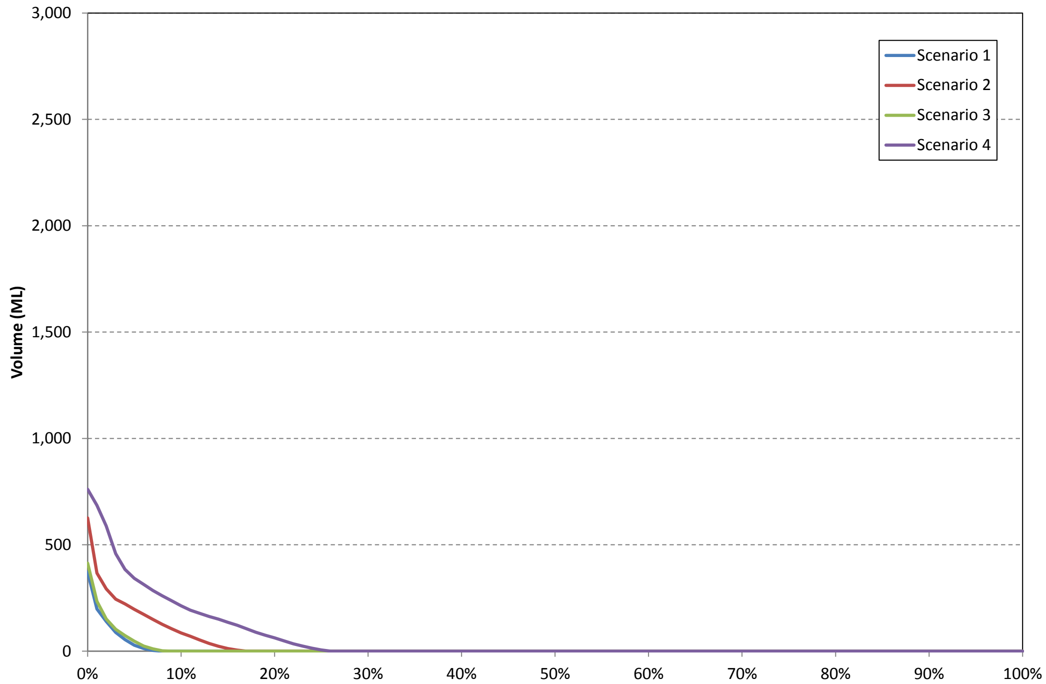


Figure E.3 South Pit Inundation Characteristics, Year 5

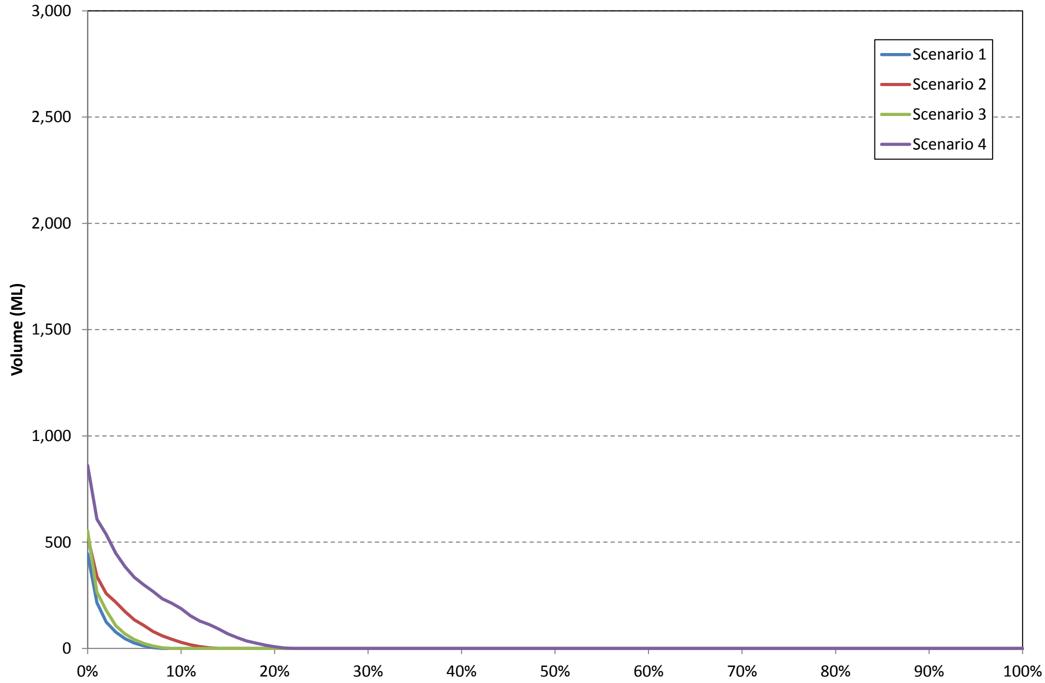


Figure E.4 Main Pit Inundation Characteristics, Year 5

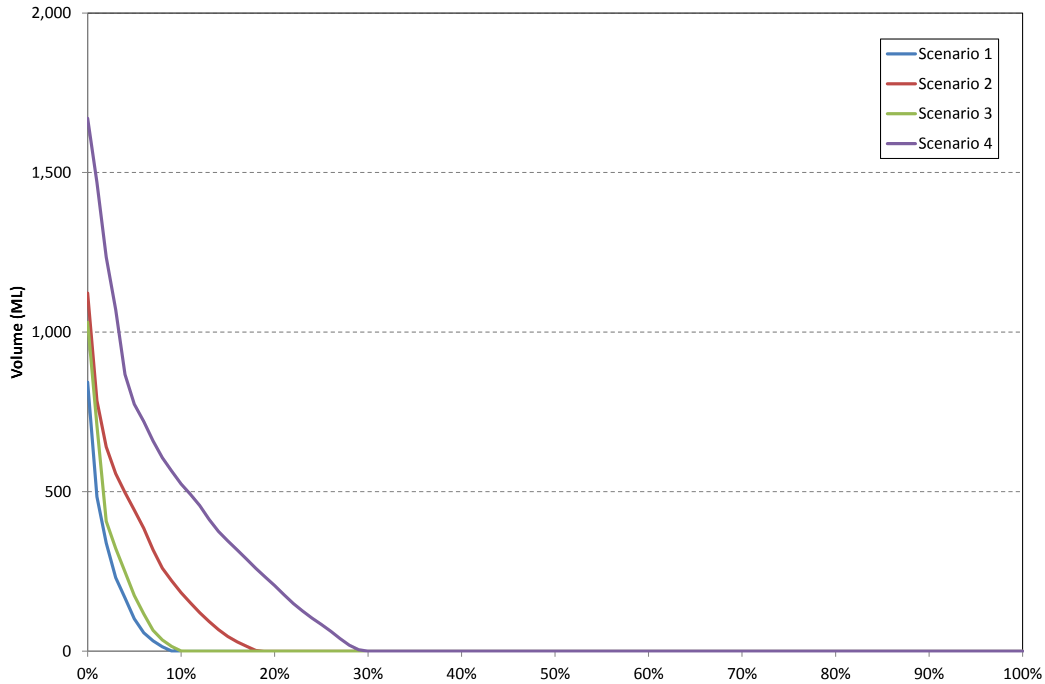


Figure E.5 Main Pit Inundation Characteristics, Year 10