APPENDIX L

Surface Water Impact Assessment

SURFACE WATER IMPACT ASSESSMENT FOR MAULES CREEK COAL PROJECT

Aston Resources Ltd
9 February 2011

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REPORT TITLE: Surface Water Impact Assessment for Maules Creek Coal Project
CLIENT: Aston Resources Ltd
REPORT NUMBER: 0644-01-C [Rev 4]

Revision Number	Description	Report Date	Report Author	Reviewer
0 (Draft)	Initial draft with preliminary groundwater inflows	16 December 2010	DN	GR
1 (Draft)	Updated draft incorporating feedback from Hansen Bailey	20 December 2010	DN	GR
2	Revised report including finalised groundwater inflows	28 January 2011	DN	GR
3	Revised report incorporating feedback from Hansen Bailey	3 February 2011	DN	GR
4	Minor revisions	9 February 2011	DN	GR

For and on behalf of
WRM Water & Environment Pty Ltd

David Newton
Director

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1 INTRODUCTION

The proposed Maules Creek Coal Project (the Project) is located about 18 km north-east of Boggabri in New South Wales. The location of the Project is shown in Figure 1.1.

WRM Water & Environment Pty Ltd was commissioned by Hansen Bailey on behalf of Aston Resources Limited (Aston Resources) to undertake a surface water impact assessment for the Project. The assessment will form part of an Environmental Assessment (EA) being prepared by Hansen Bailey to support an application for a contemporary Project Approval under Part 3A of the Environmental Planning and Assessment Act 1979 (EP&A Act) to facilitate the development of a 21 year open cut coal mining operation and associated infrastructure.

Specifically, the Project will consist of:

- The construction and operation of an open cut mining operation extracting up to 13 Million tonnes per annum (Mtpa) Run of Mine (ROM) coal to the Templemore Seam;
- Open cut mining fleet including excavator / shovels and fleet of haul trucks, dozers, graders and water carts utilising up to 470 permanent employees;
- The construction and operation of a Coal Handling and Preparation Plant (CHPP) with a throughput capacity of 13 Mtpa ROM coal;
- The construction and operation of a Tailings Drying Area;
- The construction and operation of a rail spur, rail loop, associated load out facility and connection to the Werris Creek to Mungindi Railway Line;
- The construction and operation of a Mine Access Road;
- The construction and operation of administration, workshop and related facilities;
- The construction and operation of water management infrastructure including a water pipeline, pumping station and associated infrastructure for access to water from the Namoi River;
- The installation of supporting power and communications infrastructure; and
- The construction and operation of explosive magazine and explosives storage areas.

This report presents the methodology and results of surface water investigations undertaken to assess the potential impacts of the Project on local surface hydrology and water quality.

This report contains a further 6 sections:

- Section 2 describes the existing surface water environment, including the drainage network and the quantity and quality of surface runoff;
- Section 3 provides an overview of water-related infrastructure proposed for the Project;
- Section 4 summarises the potential impacts of the Project on surface water resources and presents an assessment of the magnitude of these impacts;
- Section 5 presents the methodology and results of a detailed assessment of the site water balance;
- Section 6 presents the proposed mitigation and management measures that will be used to avoid or minimise the potential surface water impacts of the Project;

- Section 7 presents a summary of the surface water environmental assessment; and
- Section 8 provides a list of references.

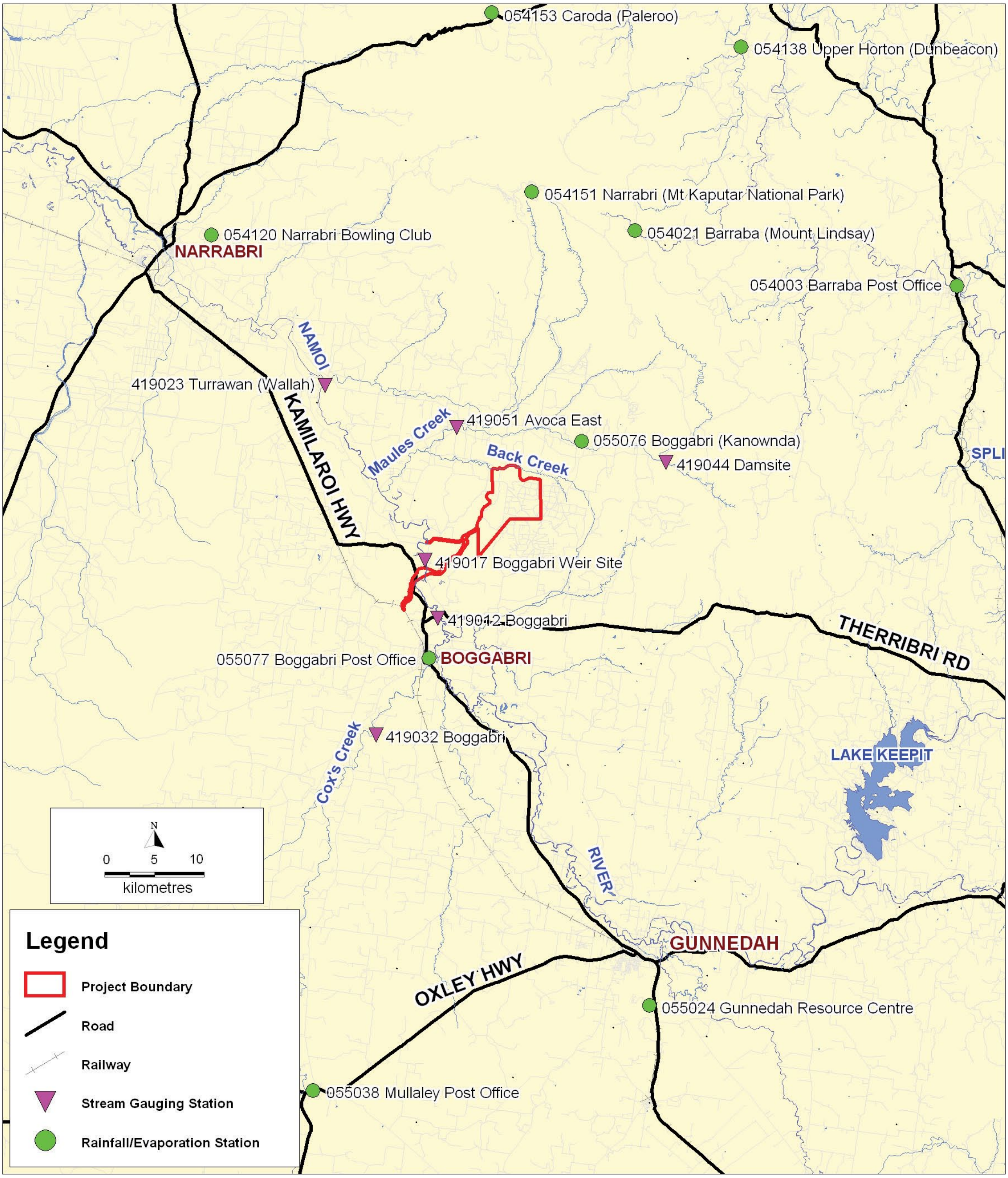

Figure 1.1 Locality Plan, Maules Creek Coal Project

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2 EXISTING SURFACE WATER ENVIRONMENT

2.1 REGIONAL DRAINAGE NETWORK

The Project Boundary is located on the southern side of Back Creek (see Figure 1.1), a tributary of Maules Creek. Maules Creek drains westwards into the Namoi River about 30 km south-east of Narrabri. Flow in the Namoi River is significantly affected by releases from Keepit Dam, a 420 GL storage located about 50 km south-east of Boggabri. The Namoi River has a catchment area to Boggabri of about 22,600 km^2 and consists of an incised main channel that meanders across a wide alluvial floodplain. Figure 2.1 shows a photograph of the Namoi River main channel close to the location of a proposed offtake for a water supply pipeline to the Project.

Figure 2.1 Photograph of Namoi River Main Channel Near Proposed Pipeline Offtake

2.2 LOCAL DRAINAGE NETWORK

The northern boundary of the Project Boundary adjoins Back Creek. Back Creek has a catchment area of 44 km^2 to the upstream end of the Project Boundary, and 63 km^2 to the downstream end of the Project Boundary. Back Creek is a fourth-order stream under the Strahler ordering system and flows through land that has been fully or partially cleared for grazing and other agricultural activities. The Back Creek main channel consists of an incised main channel, about 1 to 1.5 m deep, within a wide, flat floodplain. Whilst most of the floodplain has been cleared, some mature riparian vegetation remains along the channel banks and overbank areas. Back Creek is ephemeral, flowing only for a short period after rainfall. Figure 2.2 shows photographs of the Back Creek main channel and the southern floodplain near the downstream boundary of the Project Boundary.

The main areas of proposed disturbance (overburden emplacement and Open Cut Pit) are drained by numerous small tributaries of Back Creek which flow northwards from the Willowtree Range through the Leard State Forest. The Project Boundary also includes some small gully catchments on the southern side of Willowtree range which drain southwards to the Namoi River floodplain.

Figure 2.3 shows the topography and the location of tributaries draining the Project Boundary. Under existing conditions, the upper reaches of these tributaries (first and second-order watercourses) consist of steep gullies with poorly defined channel banks and moderate vegetative cover (see Figure 2.4). The gradient of the local tributary streams decreases as they flow northwards, discharging onto flatter land adjacent to Back Creek which has been predominantly cleared for agriculture. Figure 2.4 shows a photograph of one of the tributaries draining the site through an area cleared for grazing. All tributaries draining the Project Boundary are ephemeral. An existing dam (Development Dam) with a capacity of about 42 ML (shown in Figure 2.3) has been constructed along one of the tributaries with a catchment area to the dam of about 9.4 km^2.


(1)


(2)

Figure 2.2 Photographs Showing Back Creek (1) Main Channel, and (2) Southern Floodplain

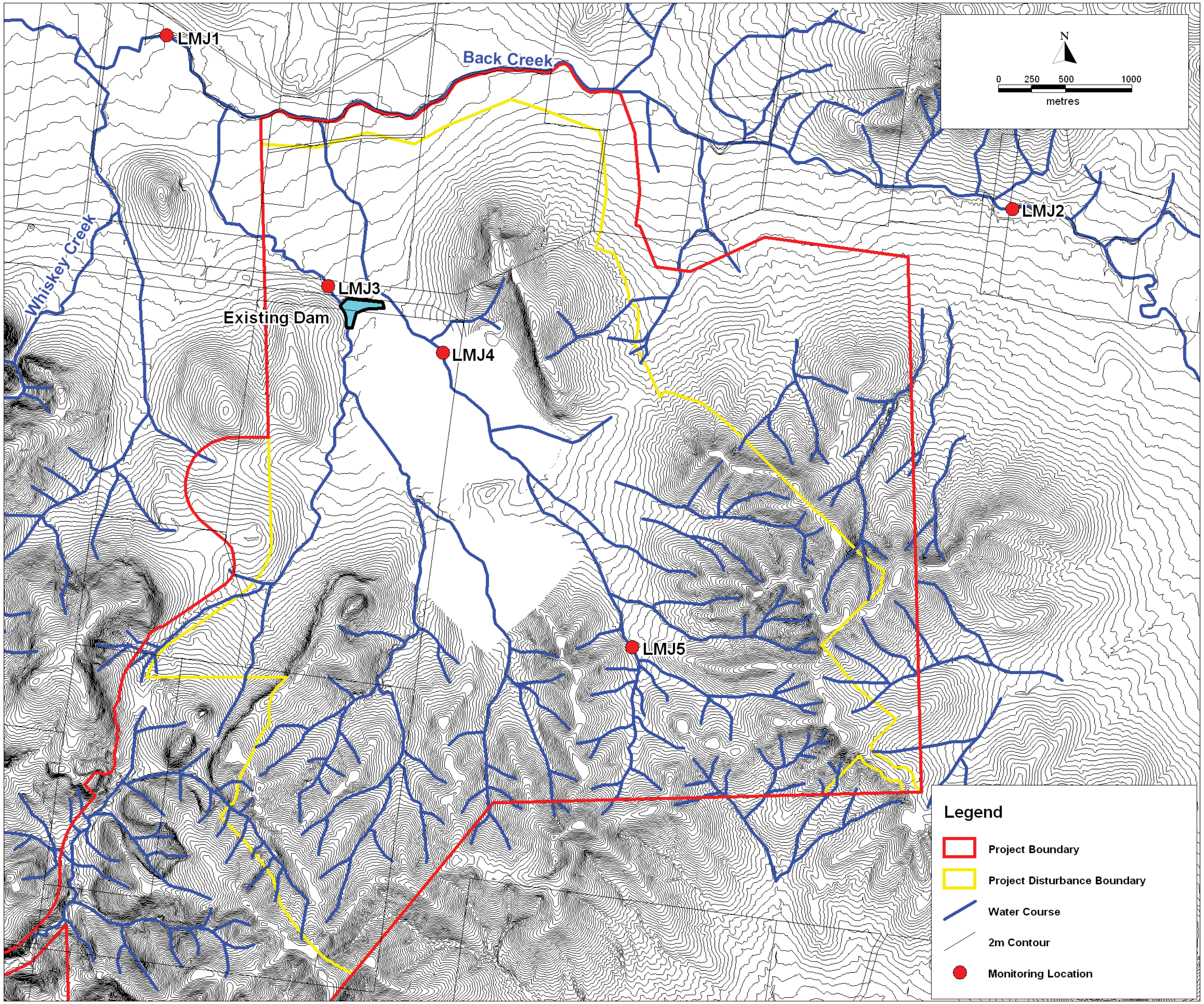

Figure 2.3 Site Topography and Local Drainage Network

(1)

(2)

Figure 2.4 Photographs Showing Tributaries Draining Project Boundary (1) Upper Reaches (2) Lower Reaches

2.3 RAINFALL AND EVAPORATION

Daily rainfalls have been recorded at Boggabri (Kanownda) (BoM Station No. 055076), about 7 km north-east of the Project Boundary, since 1899. Rainfall data recorded at this station would be representative of rainfall in the Project Boundary. The location of the rainfall station is shown in Figure 1.1. Table 2.1 shows summary details of the rainfall station. Table 2.2 shows summary rainfall statistics for the Boggabri (Kanownda) station. Mean annual rainfall is 576 mm with the highest monthly rainfalls occurring in the summer.

Table 2.1 Rainfall Station Details

Station No.	Station Name	Elevation (m)	Latitude	Longitude	Distance from Site (km)	Opened	Closed
055076	Boggabri (Kanownda)	320	30.51° S	150.21° E	7	1899	-

Table 2.2 Monthly Rainfall Statistics, Boggabri (Kanownda) (Station No. 055076), 1899-2010

	Monthly Rainfall (mm)												
Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	76.4	60.6	45.5	34.9	37.8	41.1	40.3	34.7	36.6	51.2	58.0	62.2	575.8
Lowest	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	279.8
5th %ile	9.4	3.7	0.0	0.0	0.0	2.8	3.1	0.6	0.0	6.2	3.9	6.3	334.8
10th %ile	16.5	6.8	2.3	1.5	1.2	9.1	7.6	4.0	2.8	10.4	13.7	11.0	364.4
Median	57.2	46.8	39.5	25.7	30.0	37.1	32.6	30.4	30.0	47.8	53.0	57.1	590.0
90th %ile	176.6	124.4	99.8	76.0	85.4	76.6	76.0	73.5	77.6	96.8	122.9	112.8	759.1
95th %ile	213.1	157.7	130.3	87.5	99.6	93.9	98.6	89.4	99.9	116.4	133.7	141.3	779.4
Highest	292.6	233.5	193.4	187.0	143.8	153.6	173.4	122.2	152.0	179.7	168.8	199.0	885.9

Table 2.3 shows mean monthly evaporation (based on Class A pan evaporation) recorded by the Bureau of Meteorology at Gunnedah Resource Centre (BOM Station No. 055024), located about 50 km to the south of the Project Boundary. Evaporation at this station would be representative of evaporation in the Project Boundary. Mean annual evaporation is 1,752mm, which is more than 3 times annual average rainfall.

Figure 2.5 shows the annual distribution of average monthly rainfall and evaporation. Evaporation is greater than rainfall in all months, but is much greater than rainfall in the warmer months.

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Table 2.3 Mean Monthly Pan Evaporation, Gunnedah Resource Centre, 1948 to 2010

Month	Mean Monthly Pan Evaporation (mm)
January	239
February	190
March	186
April	129
May	84
June	57
July	59
August	84
September	117
October	164
November	201
December	242
Total	1,752

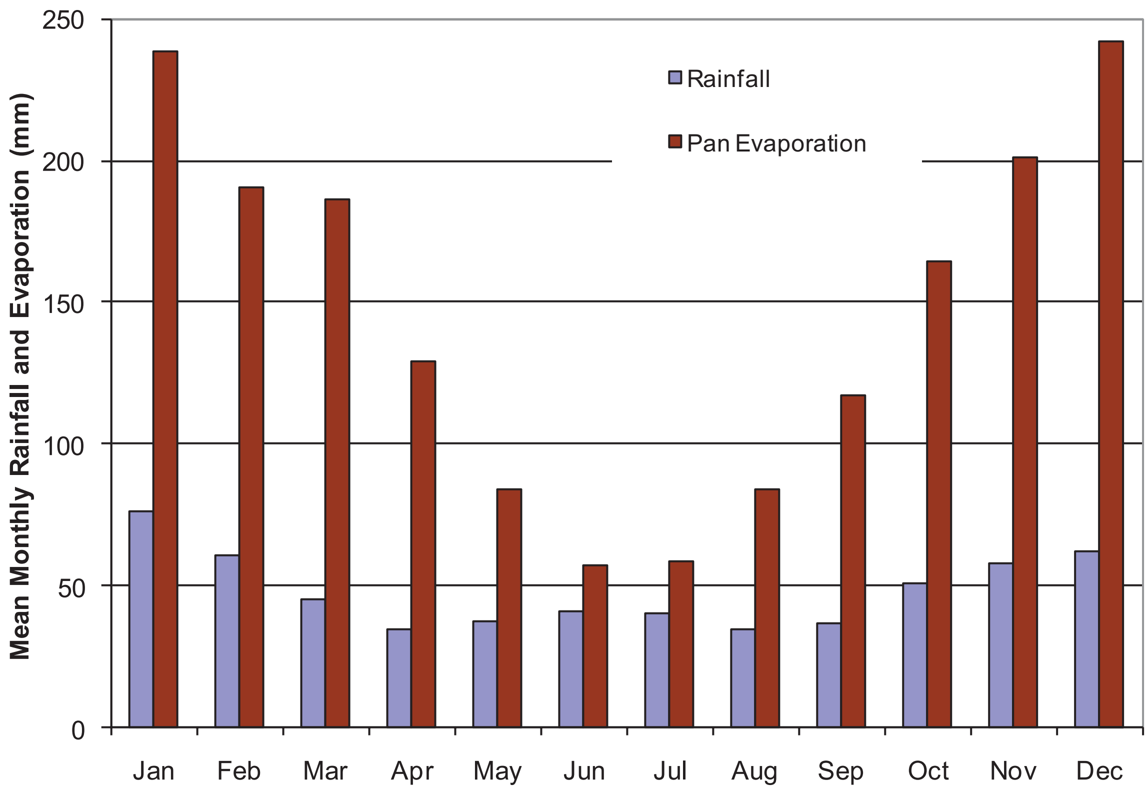

Figure 2.5 Distribution of Monthly Rainfall (Boggabri, Kanownda) and Evaporation (Gunnedah Resource Centre)

2.4 STREAMFLOW

Figure 2.6 shows stream data at three NSW Office of Water (NOW) recording stations (shown in Figure 1.1) for:

- Namoi River at Boggabri (Station No. 419012);
- Maules Creek at Dam Site (Station No. 419044); and
- Maules Creek at Avoca East (Station No. 419051).

Streamflow data is shown as a flow-duration curve where daily flows over the period of record are ranked from highest to lowest.

The Namoi River to Boggabri has a catchment area of 22,600 km^2. Flow in the river has been regulated by releases from Keepit Dam, located about 56 km west of Tamworth, since the dam's completion in 1960. Keepit Dam has a storage capacity of 425,510 ML. The median flow in the Namoi River at Boggabri since completion of the dam is about 400 ML/d.

Maules Creek is ephemeral in the upper catchment. At the Dam Site gauge (Catchment area = 171 km^2), the median flow is less than 0.2 ML/d and the creek flows for only about 60% of the time. Further downstream along Maules Creek at the Avoca East gauge (Catchment area = 663 km^2), the creek flows about 94% of the time, with a median flow rate of about 8 ML/d. Analysis of recorded streamflow data for the two gauging stations indicates volumetric runoff coefficients (proportion of rainfall that becomes surface runoff) of approximately:

- 4.5% at Avoca East (data from 1975 to 2010); and
- 5.0% at Dam Site (data from 1968 to 1992).

No continuous streamflow data is available for Back Creek. However, a temporary runoff monitoring station was established on Back Creek near the downstream boundary of the Project Boundary in the early 1980s. The streamgauge at this location recorded discharges during a number of runoff events, but continuous flow data for the gauge was not available. The event data collected from the temporary runoff monitoring station has been used in the assessment of the surface water impacts of the Project.

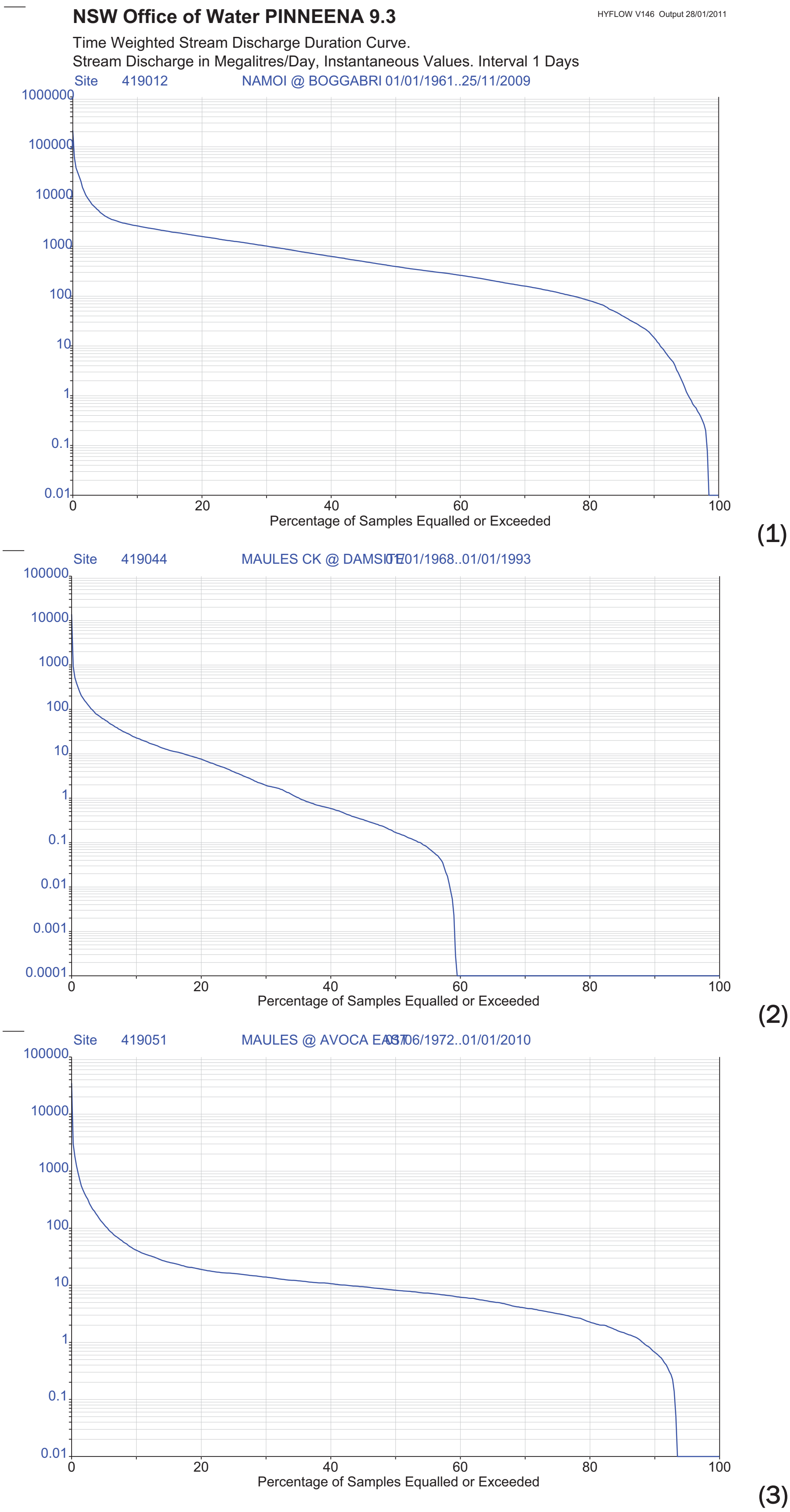

Figure 2.6 Flow-Duration Curves for (1) Namoi River at Boggabri, (2) Maules Creek at Dam Site, and (3) Maules Creek at Avoca East

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2.5 EXISTING WATER USE ENTITLEMENTS

The Project Boundary is located within the Lower Namoi Regulated River Water Source, defined by the NSW Water Management Act 2000, which extends from Keepit Dam to the Barwon River. Flows in this reach of the Namoi River are regulated through the "Water Sharing Plan (WSP) for the Lower Namoi River Water Sources" (DIPNR, 2003), which was gazetted on 21 February 2004 and amended by order on 1 July 2004. The WSP for this water source allows for some extraction of water from the river without an access licence to provide basic landholder rights, which include domestic and stock rights as well as native title rights. At the commencement of the WSP, domestic and stock extractions under basic landholder rights in the Lower Namoi were approximately 1,776 ML/year.

All water extraction that is not for basic landholder rights must be authorised by an access licence. Each access licence specifies a share component. The share components of specific purpose licences, such as town water supply, stock and domestic are expressed as ML/year. The share components of high security, general security and supplementary water access licences are expressed as a number of unit shares. Table 2.4 shows the categories of access licences in the Lower Namoi Regulated River Water Source and their total share components at the start of the WSP. Note that Aston Resources holds a large proportion of the high security allocation for the Lower Namoi (3,000 unit shares). High security licences have a higher priority allocation of water than general security licences.

Back Creek and Maules Creek are not regulated systems, however it is likely that landholders along these creeks access water for stock and domestic purposes.

Table 2.4 Lower Namoi Water Source Share Components for Different Licence Categories (Source: DIPNR, 2003)

Access Licence Category	Total Share Component in the Lower Namoi
General Security	246,692 unit shares
High Security	3,418 unit shares
Supplementary Water	115,460 unit shares
Stock & Domestic	1,967 ML per year
Local Water Utility	2,271 ML per year

2.6 WATER QUALITY

2.6.1 Regional Water Quality

Water quality data is available for the Namoi River at the Turrawan gauging station (Station No. 419023) for the period 15 October 1976 to 28 October 1986. The Turrawan gauging station is located about 15 km downstream of the Maules Creek confluence. The location of the Turrawan gauging station is shown in Figure 1.1. Table 2.5 shows a summary of available water quality data for the Namoi River at Turrawan gauging station. Over this 10 year period, the ANZECC & ARMCANZ (2000) default trigger values were exceeded 87% of the time for electrical conductivity (EC), 50% of the time for pH and 17% of the time for turbidity.

Additional water quality monitoring was undertaken at 22 sites throughout the Namoi River catchment during 2000 and 2001 (DLWC, 2002). Three of these sites, including at the Namoi River at Gunnedah, Coxs Creek at Boggabri (see Figure 1.1) and Narrabri Creek (Namoi River) at Narrabri are of relevance to regional water quality in the vicinity of the Project Boundary. Of the samples tested over this period, the ANZECC & ARMCANZ default trigger values for EC were exceeded 100% of the time at the two Namoi River stations and 97% of the time at the Coxs Creek station. The default trigger value for Turbidity was exceeded between 69% and 88% of the time at the three locations and total phosphorus (TP) was exceed between 97% and 100% of the time.

Table 2.5 Water Quality Data, Namoi River at Turrawan

Parameter	Years Data	Mean	Median	Min	Max	10th Percentile	90th Percentile
Electrical Conductivity (µS/cm)	10	545	538	275	1,720	330	716
pH	10	8.0	8.0	7.4	8.8	7.6	8.4
Temperature (°C)	10	19.6	20.5	10	30	11.0	26.5
Turbidity (NTU)	9	15.6	5.4	2	130	2.0	40.4

Insufficient water quality data is available at the Turrawan station to derive a relationship between water quality and flow rates in the Namoi River. However, continuous water quality data, measuring EC, is available between 1995 and 2005 at the Gunnedah Station (GS419001), located about 50 km upstream of Boggabri. A plot of daily flows against EC at this station is shown in Figure 2.7.

The available water quality data for the Namoi River at Gunnedah indicates that:

- EC varies between 200µS/cm and 1,200µS/cm at Gunnedah with the majority of elevated EC values occurring when flows are lower than 1,000 ML/d;
- There is a strong relationship between flow rate and EC with high flows, associated with floods, measuring lower EC values;
- Higher EC values tend to occur when there are limited releases from Keepit Dam to supply the downstream irrigation demand and the majority of the flow is being generated from the Peel and Mooki Rivers which join the Namoi between Keepit Dam and Gunnedah. This generally occurs during the winter months; and
- Elevated EC values can occur for many months during low flow periods.

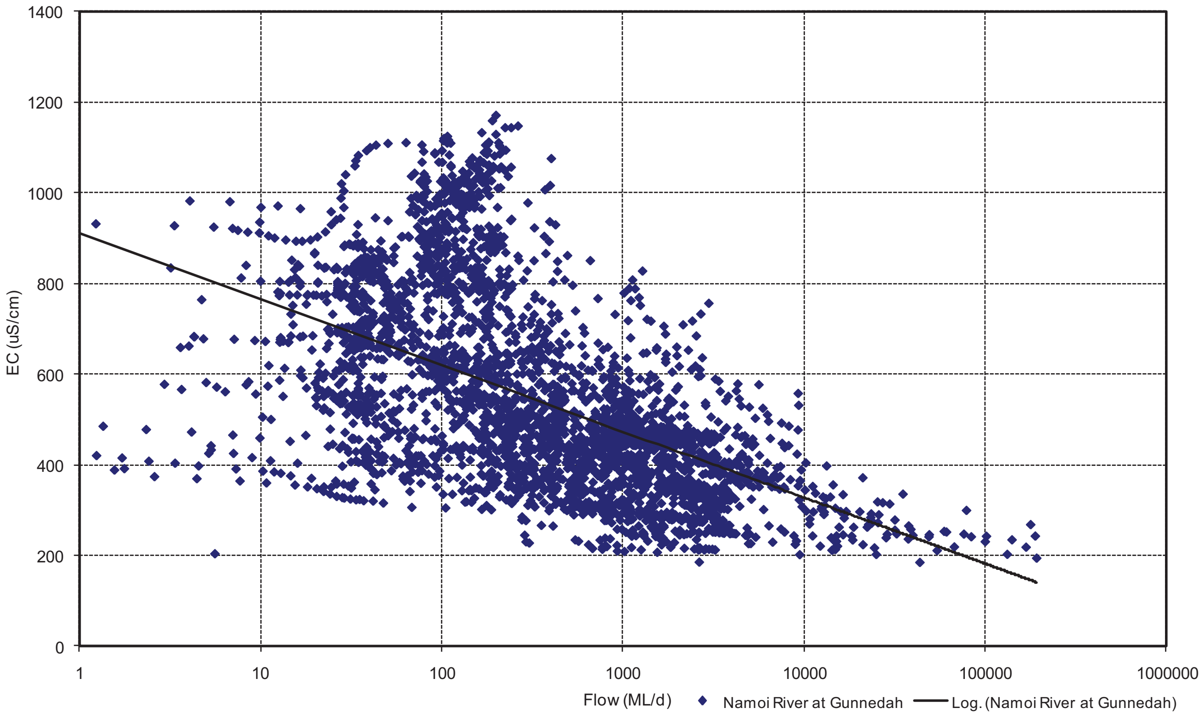

Figure 2.7 Daily Flow and Electrical Conductivity Comparison, Namoi River at Gunnedah

2.6.2 Local Catchments

Surface runoff water quality data is available from a water quality monitoring program undertaken in 1983 and 1984 by Lyall Macoun and Joy Consulting Engineers (LMJ) for Kembla Coal and Coke Pty Ltd (LMJ, 1986). Limited additional water quality sampling has also been undertaken by Aston Resources in 2010. The locations of the water sampling locations for both the LMJ studies and the recent Aston Resources sampling are shown in Figure 2.8.

Table 2.6 shows summary water quality results for the LMJ and Aston Resources sampling programs. The LMJ sampling results show consistently low EC values for Back Creek and for local catchments draining the site, with median values in the range 80 to 110 µS/cm. The LMJ sampling program also shows slightly lower pH values in the site catchments (6.8 to 7.2) compared to Back Creek (7.3) and the Namoi River (7.6 to 8.4 – see Table 3.4). Recorded TSS values for Back Creek are high with median values of 2,060 mg/L and upper values above 11,000 mg/L. Site catchment TSS values are high, but not as high as Back Creek. The reasons for the high TSS levels from on site catchments and Back Creek are uncertain.

2.6.3 Groundwater and Pit Water Quality

The results of groundwater quality sampling in the vicinity of the Project indicate that groundwater is typically slightly brackish, with an indicative Total Dissolved Solids (TDS) concentration of about 900 mg/L (AGE, 2011).

Geochemical testing of overburden and coal reject material (RGS, 2011) indicates that most overburden materials will generate slightly alkaline and relatively low-salinity runoff and seepage following surface exposure. Potential coal reject material is mostly non-acid forming (NAF), although some potentially acid forming (PAF) material is present. The PAF materials may generate acidic and more saline runoff and seepage if exposed to oxidising conditions (RGS, 2011).

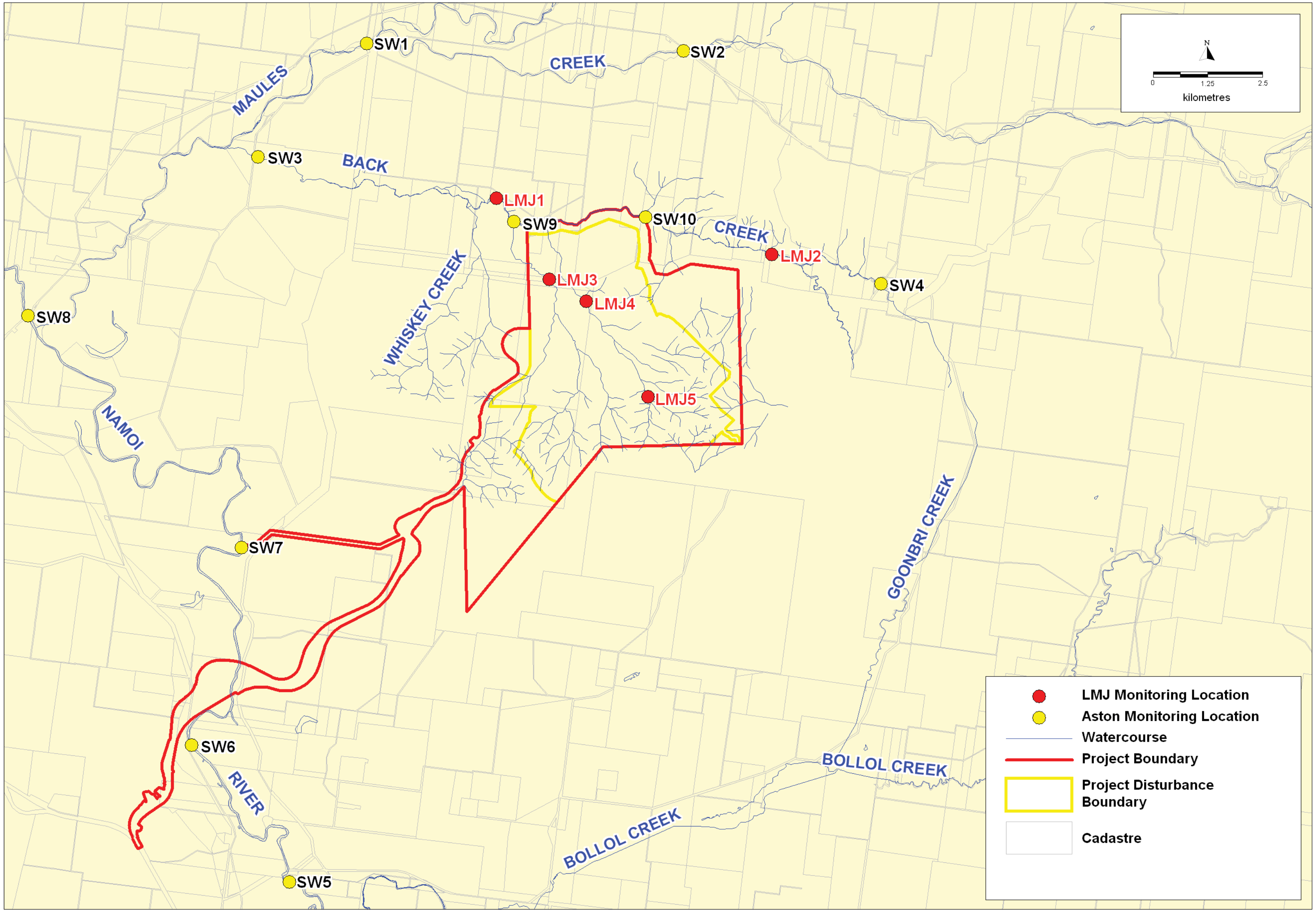

Figure 2.8 Surface Water Sampling Locations

Table 2.6 Water Quality Data, Local Monitoring Program

		Maules Creek		Back Creek				Site Catchments			Namoi River			
		SW 1	SW 2	SW 3	SW 4	LMJ 1	LMJ 2	LMJ 3	LMJ 4	LMJ 5	SW 5	SW 6	SW 7	SW 8
pH	16%ile					6.8	7.0	6.9	6.7	6.6				
	Median(N)	7.41			7.26	7.3 (38)	7.3 (14)	7.2 (8)	6.9 (8)	6.8 (16)	7.58	7.50	7.59	7.57
	84%ile					7.7	7.6	7.5	7.1	7.1				
Turbidity (NTU)	16%ile					1200								
	Median(N)					3,600(9)	1,300(2)	2,500(5)	5,700(5)	10 (2)				
	84%ile					16000								
EC (µS/cm)	16%ile					70	80	60	50	90				
	Median(N)	319			172	110(38)	110(14)	100(8)	80(8)	90(16)	245	246	240	236
	84%ile					170	140	160	110	110				
TDS/FR (mg/L)	16%ile					37	66	34	52	87				
	Median(N)	226			212	64(37)	120(12)	58(8)	96(8)	130(16)	240	210	256	220
	84%ile					180	173	98	178	194				
TSS/NFR (mg/L)	16%ile					420	360	240	90	250				
	Median(N)					2,060(37)	2,060(13)	1,050(8)	780(8)	520(16)				
	84%ile					10,100	11,900	4,600	6,700	1,100				
Fe Diss. (mg/L)	16%ile					0.7								
	Median(N)					2.6 (9)	1.7 (4)	0.24 (5)	3.4 (5)	3.5 (2)				
	84%ile					9.2								
Fe Absorb.(mg/L)	16%ile					13.0	4.4	9.7	5.5	8.5				
	Median(N)					49.2(28)	13(12)	33.4(8)	26.2(8)	12.8(13)				
	84%ile					186	38.4	114.7	124.1	19.2				
SO4 (mg/L)	16%ile					1.4	2.1	1.4	2.2	1.7				
	Median(N)	9			<1	2.9(29)	4(12)	3.2(8)	4.0(8)	3.8(13)	13	13	13	12
	84%ile					6.1	5.9	5	5.8	5.9				
Total Alkalinity as CaCO3 (mg/L)	Median(N)	130			71						97	101	95	100
Chloride (mg/L)	Median(N)	19			6						10	10	10	10
Calcium (mg/L)	Median(N)	27			12						19	21	19	20
Magnesium (mg/L)	Median(N)	10			4						10	11	10	11
Sodium (mg/L)	Median(N)	25			14						16	16	16	16
Potassium (mg/L)	Median(N)	1			11						4	4	4	4

N = No. of samples = 1 unless otherwise noted. SW = Aston Sampling Program (5/8/2010). LMJ = Lyall Macoun and Joy Sampling Program (1983/84)

3 PROPOSED INFRASTRUCTURE

The Project Disturbance Boundary is located within the catchments of a number of unnamed tributaries of Back Creek. Figures 3.1 to 3.5 show indicative locations of the key features of the mine, including infrastructure related to the management of water on the Project site for 5 different stages of mining (Years 1, 5, 10, 15 and 21). The main components of water-related infrastructure include:

- Sediment dams to collect and treat runoff from overburden emplacement areas;
- Dirty water drains to divert sediment-laden runoff from overburden emplacement areas to sediment dams;
- Clean water drains to divert runoff from undisturbed catchments around areas disturbed by mining;
- A Raw Water Dam to store fresh water from the Namoi water supply pipeline;
- A Mine Water Dam to store water pumped out of the Open Cut Pit. The Mine Water Dam will also collect runoff from the CHPP and coal stockpile area, as well as decant water from the tailings drying area; and
- 3 Highwall Dams to collect runoff from undisturbed catchments draining towards the Open Cut Pit.

Details of proposed mine site storages, including indicative storage sizes and pumping rules are provided in Section 5.

The Project also includes the construction and operation of a water supply pipeline from the Namoi River to meet water demands on site that cannot be met through recycling of water captured on site. Aston Resources holds a high security water access licence on the Namoi River which will provide access to sufficient water to meet all mine site demands.

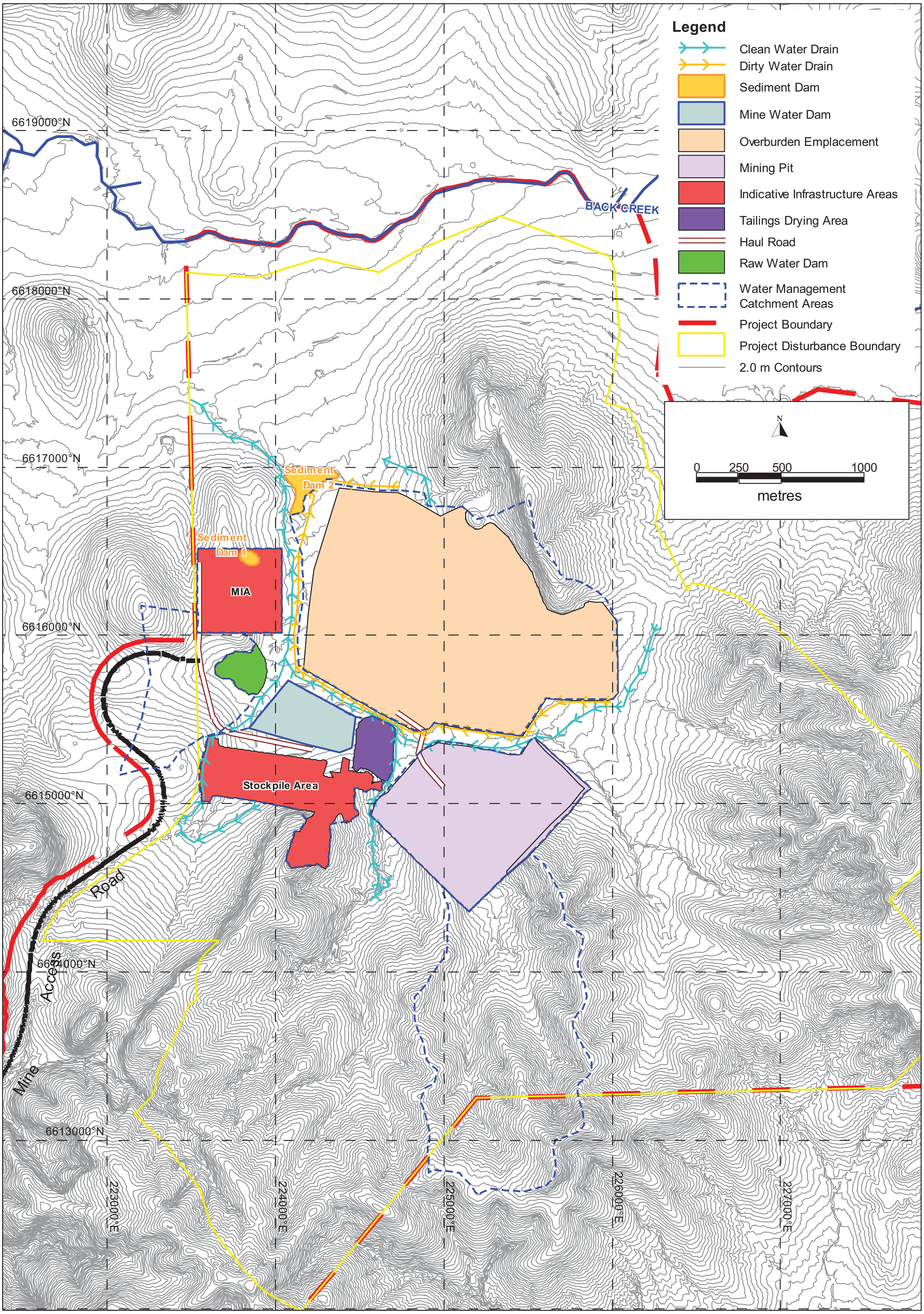

Figure 3.1 Conceptual Surface Water Management Plan, Year 1

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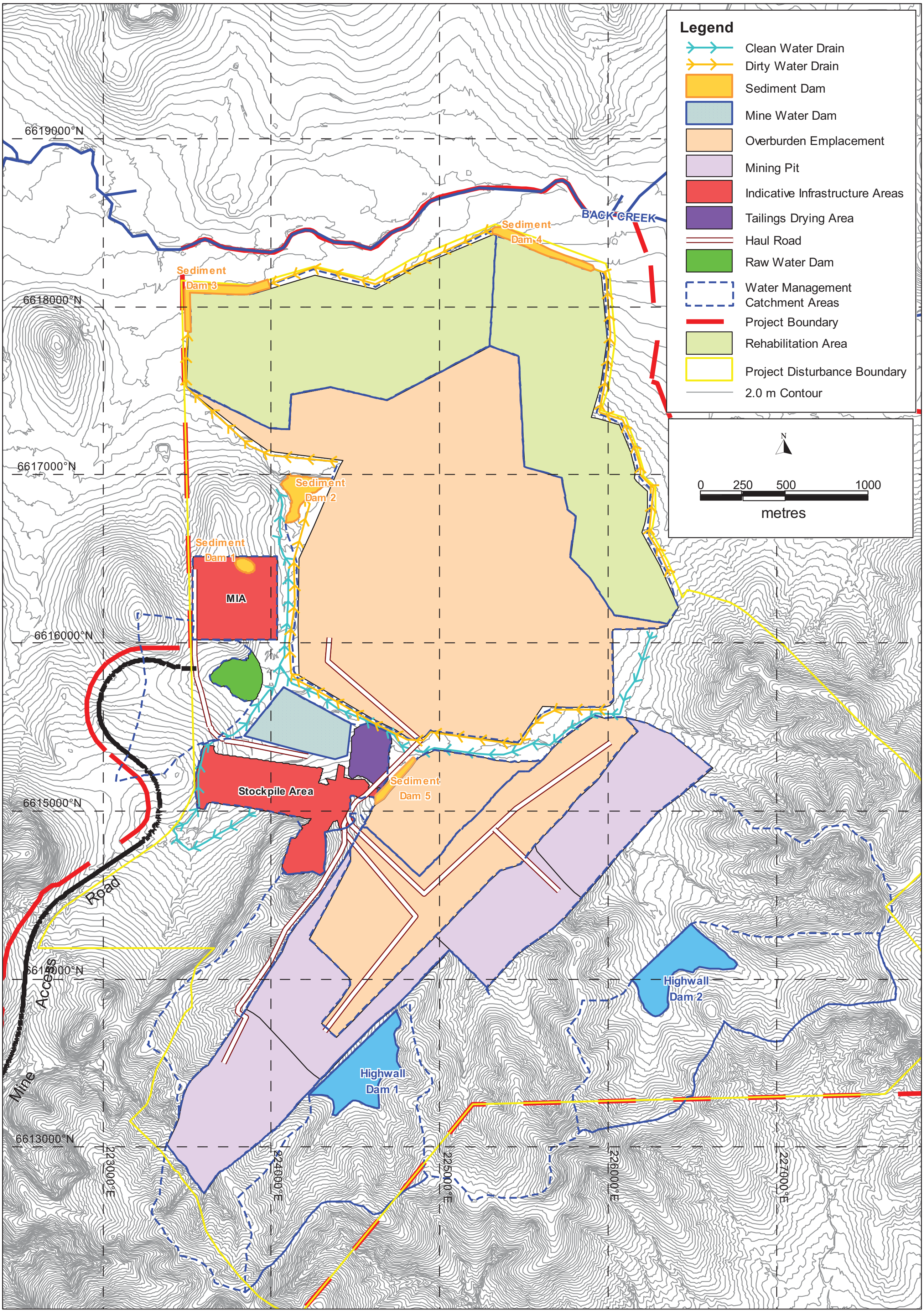

Figure 3.2 Conceptual Surface Water Management Plan, Year 5

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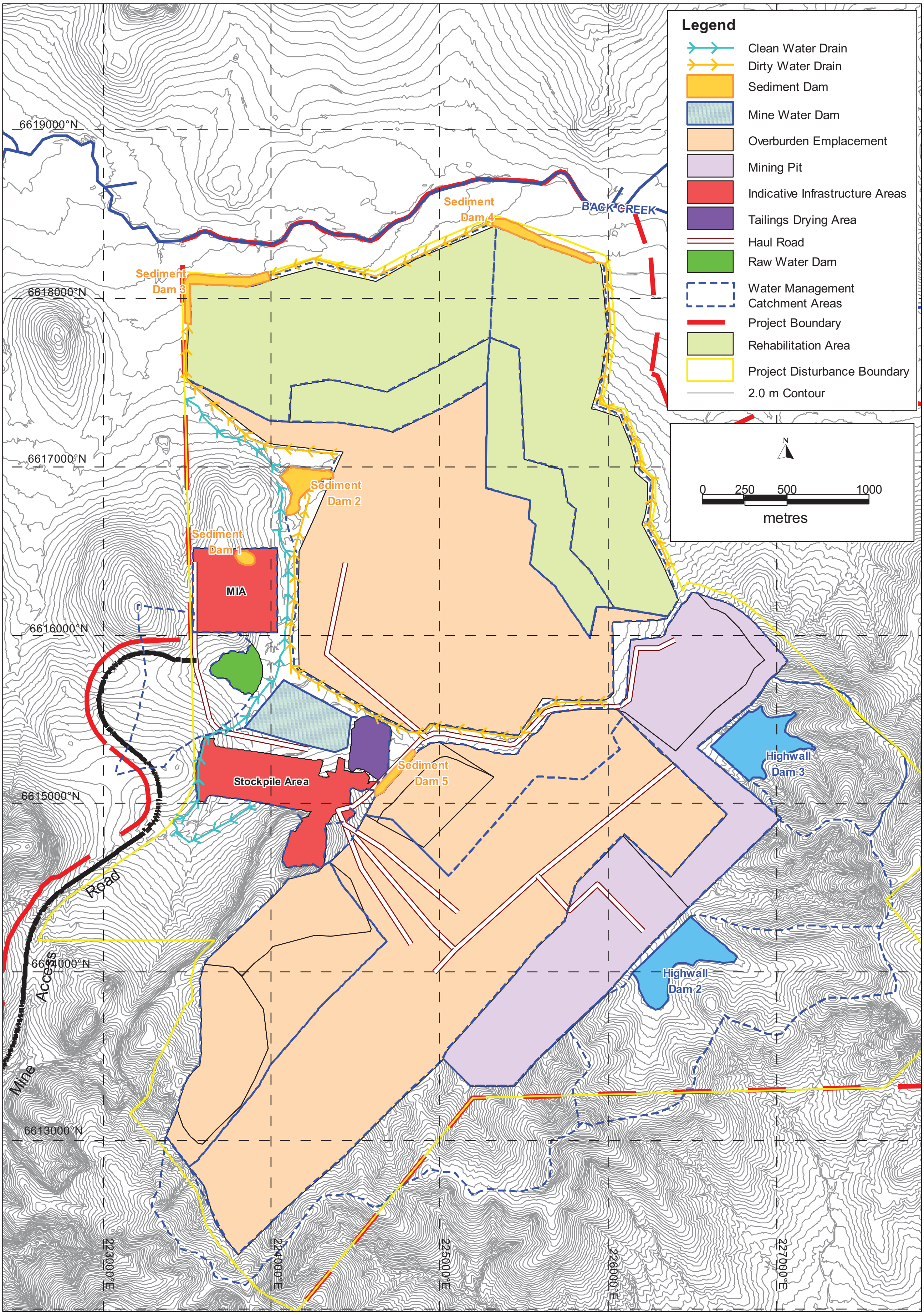

Figure 3.3 Conceptual Surface Water Management Plan, Year 10

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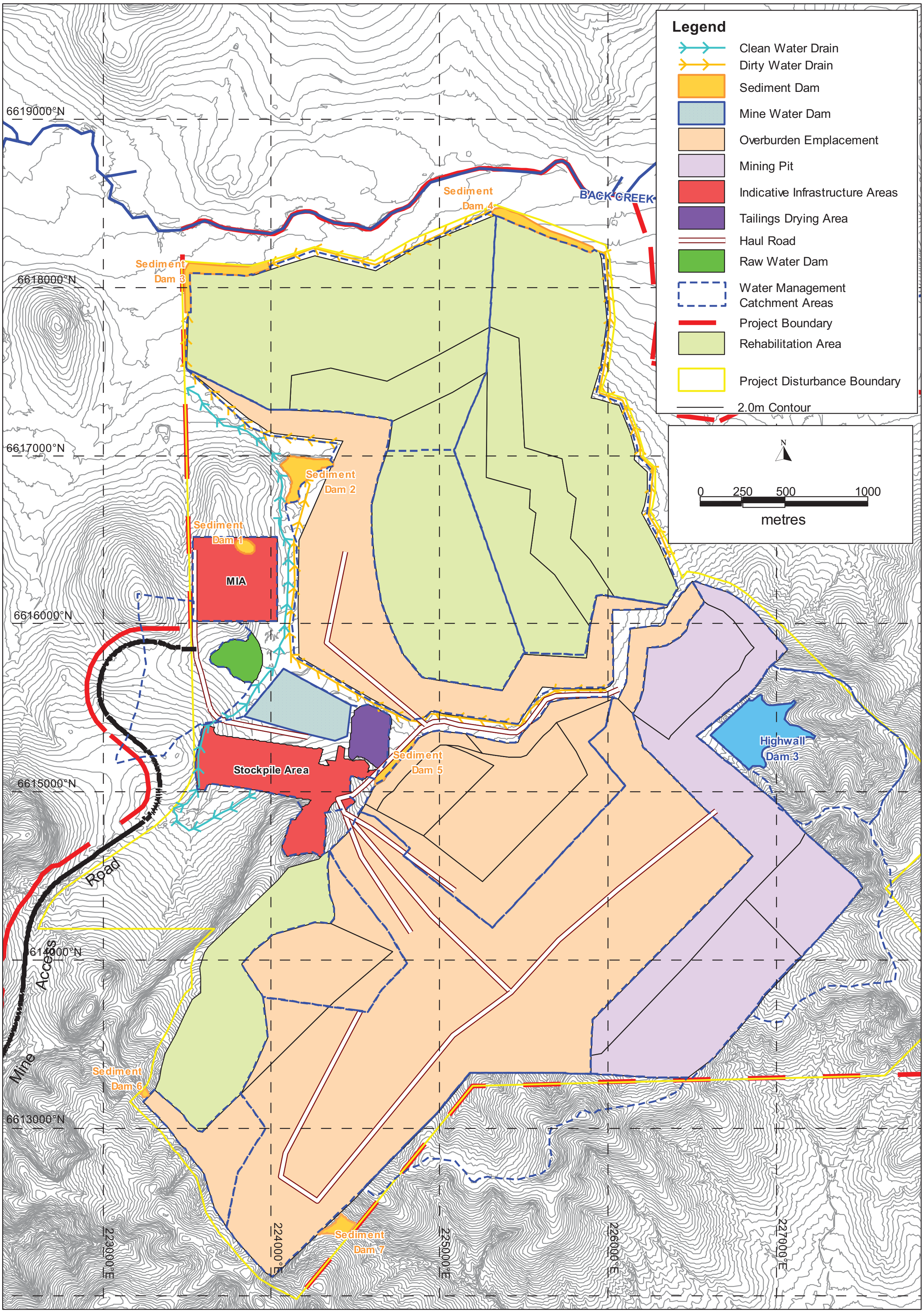

Figure 3.4 Conceptual Surface Water Management Plan, Year 15

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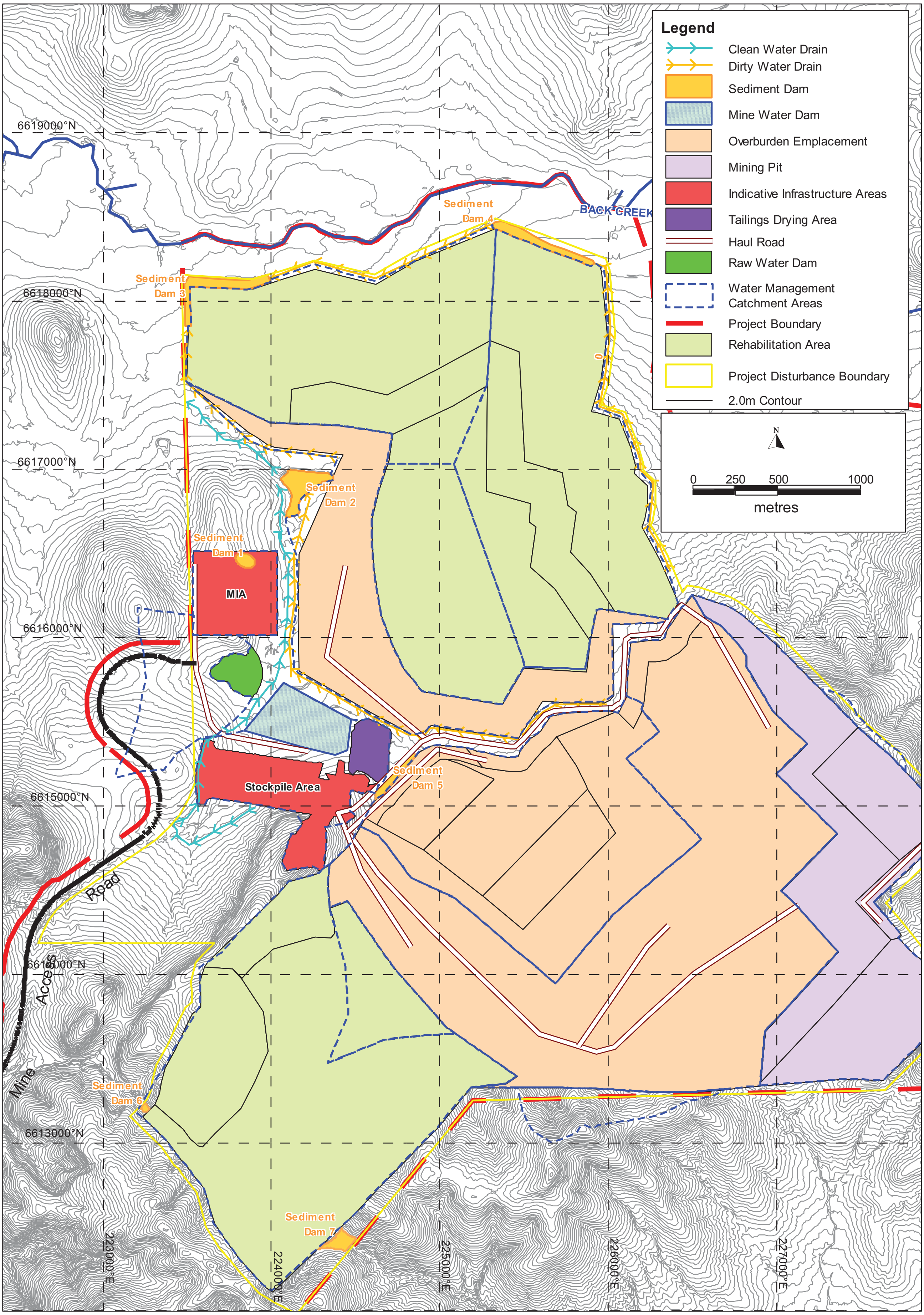

Figure 3.5 Conceptual Surface Water Management Plan, Year 21

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4 IMPACT ASSESSMENT

4.1 POTENTIAL IMPACTS

The potential impacts of the proposed mining operations on surface water resources include:

- Impacts on water availability in the Namoi River due to the operational water requirements of mining operations;
- Adverse impacts on the quality of surface runoff draining from the local on site catchments to Back Creek;
- Adverse impacts on downstream water quality associated with possible overflows from the Mine Water Management System;
- Loss of catchment area draining to Back Creek due to capture of runoff within on site storages and the Open Cut Pit. This could potentially reduce runoff volumes to Back Creek;
- Interference with flood flows along Back Creek;
- Impacts associated with the proposed pump station on the Namoi River and water supply pipeline; and
- Flood and drainage impacts associated with the proposed road and rail access to the mine.

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

4.2 MINE SITE WATER REQUIREMENTS

The maximum annual water demand during the life of the mine, including water for coal processing and dust suppression, is about 3,300 ML per year. Accounting for predicted annual groundwater inflows and surface runoff, the estimated net water requirement to be met from other sources is less than 2,000 ML per year under average climatic conditions.

The first priority source of water to satisfy mine site demands will be the Mine Water Dam as this dam is likely to contain the poorest quality water. This dam will be the main repository of water on the site and will collect surface runoff from the coal stockpiles and CHPP. Groundwater and surface runoff inflows to the Open Cut Pit will also be pumped to the Mine Water Dam, along with surface runoff inflows to the sediment dams (if water quality from the sediment dams is not acceptable for release). By maximising the recycling of water on the site, the requirements for makeup water from external sources will be minimised. Site water demand that cannot be supplied from recycled water on site will be sourced from the mine's existing water allocation from the Namoi River.

Since the quantity of water available from on site sources will be dependent on rainfall, water balance modelling was undertaken to estimate the required volume of makeup water for a range of climatic conditions. Full details of the water balance modelling are provided in Section 5. The results of the water balance model show that the mean volume of water required from the Namoi River is between about 1,100 and 1,800 ML per year.

Aston Resources already has a high security water allocation from the Namoi River of 3,000 unit shares (effectively equal to 3,000 ML/a), which is sufficient to meet the maximum net site water demand. This high security allocation is an existing entitlement which is allowed for in the WSP. Hence, use of this licence will not reduce the entitlements of other water users accessing the Lower Namoi Regulated Water Source. Note that continual underuse of Aston's high security allocation may provide a benefit for environmental flows and general water security over the long term.

4.3 SURFACE WATER QUALITY

Land disturbance associated with mining has the potential to adversely affect the quality of surface runoff in downstream receiving waters through increased sediment loads. In addition, runoff from active mining areas (pits, roads, coal stockpiles, etc.) may have increased concentrations of salts and other pollutants compared to natural runoff. The surface water generated on the mine site is categorised into five types, based on water quality:

- Clean – surface runoff from areas where water quality is unaffected by mining operations. Clean water includes runoff from undisturbed areas and any fully rehabilitated areas;
- Dirty – surface runoff water from areas that are disturbed by mining operations (including overburden emplacement areas and haul roads). This runoff may contain high sediment loads, but is not likely to contain contaminated material or high salt concentrations. This runoff must be managed to ensure that downstream water quality is within the adopted water quality compliance criteria;
- Mine water – surface water that has generally come in contact with coal such as in the pit, or from the ROM coal stockpile. This water is likely to contain higher TDS above values that represent fresh water as defined by ANZECC & ARMCANZ (2000); and
- Contaminated – surface water from areas potentially containing chemicals of various types used in the mining operations. There are restrictions on the use and release of this water. Contaminated water areas include sumps, service bays and fuel storage areas. Rainfall and resulting runoff from these areas is also potentially contaminated and therefore must be managed to avoid discharge of potentially contaminated water into the natural watercourses or treated prior to reuse in the mine water management system.

By implementing an effective system of mine water management, the Project will ensure no adverse impact on receiving waters. Key elements of the proposed water management system include:

- Diversion of runoff from undisturbed catchments away from disturbed areas, wherever possible, using surface drains;
- Treatment of runoff from overburden emplacements through sedimentation dams prior to reuse in the mine water management system or discharge from the site. All sediment dams and water management systems will be designed in accordance with relevant standards (DECC 2008). The water quality of runoff will be regularly tested to ensure that it meets relevant standards prior to release from the site. If the quality of runoff from disturbed areas is not suitable for release, this water will be pumped into the mine water management system;

- Sediment dams will be used to treat surface runoff from rehabilitated areas until the quality of runoff is suitable for release; and
- Runoff from mining areas (pits and coal stockpiles) will be collected within the Mine Water Dam for recycling on site.

Based on the information available, water pumped from the Open Cut Pit is likely to be of reasonable quality. However, due to the possible presence of PAF material and the recycling of water on site, it is unlikely that water stored in the mine water management system will be suitable for release off site without treatment.

Details of the proposed mine water management system are provided in Section 5. Water balance modelling has been undertaken to demonstrate that the operation of the mine water management system will ensure that no uncontrolled releases occur from the Mine Water Dam. Hence, the Project will not adversely affect surface water quality in downstream receiving waters. The methodology and results of the water balance modelling for the Project are provided in Section 5.

4.4 LOSS OF CATCHMENT AREA

4.4.1 During Active Mining Operations

During active mining operations, the mine water management system will capture runoff from areas that would have previously flowed to Back Creek. The captured catchment area will change as the Project develops. Initially, runoff from the northern overburden emplacement area will be collected in the proposed sediment dams and pumped into the mine water management system. However, as rehabilitation of the overburden emplacement area progresses and the quality of surface runoff improves, runoff from fully rehabilitated areas will be released back into the downstream catchment.

Table 4.1 shows the catchment area captured within the mine water management system for various stages of mine development. The maximum catchment area draining to the mine water management system is approximately 1,590 ha, which represents about 25% of the catchment area of Back Creek to the downstream boundary of the Project Boundary. The maximum captured catchment area represents only about 2.1% of the total Maules Creek catchment area. Note that during extended wet periods, some overflows from sediment dams may occur, which would effectively reduce the catchment area collected in the mine water management system. The loss of catchment from the Namoi River, which has a total catchment area 1000 times greater than the captured catchment area, is negligible.

During the latter stages of mining, the Open Cut Pit will extend slightly beyond the ridge line of Willowtree Range. The maximum catchment area on the southern side of the range that will be collected within the mine water management system in Year 21 is approximately 62 ha.

Table 4.1 Estimated Catchment Area Captured Within Mine Water Management System

Year	Captured Catchment Area (ha)				Proportion of Back Creek Catchment Area to D/S Project Boundary
	Northern Overburden Emplacement Area	Open Cut Pit	MIA / Stockpile / RW Dam	Total	
1	250	239	125	614	9.7%
5	605	860	125	1590	25.1%
10	274	975	125	1374	21.7%
15	222	917	125	1264	19.9%
21	222	774	125	1121	17.7%

4.4.2 Final Landform

There are considerable resources present beyond the 21 Year mining limit and in the future, Aston Resources may, depending upon market factors, seek relevant approval for the extraction of further coal resources. Figure 4.1 shows a conceptual final landform should the approval for the continuation of mining beyond the 21 Year mine plan not be sought and subsequently granted. The minimum ground level in the Final Void is approximately 100 mAHD, compared to a minimum natural ground level around the Final Void boundary of about 340 mAHD. The total catchment area draining to the Final Void is approximately 887 ha, which represents about 14% of the Back Creek catchment to the downstream Project Boundary.

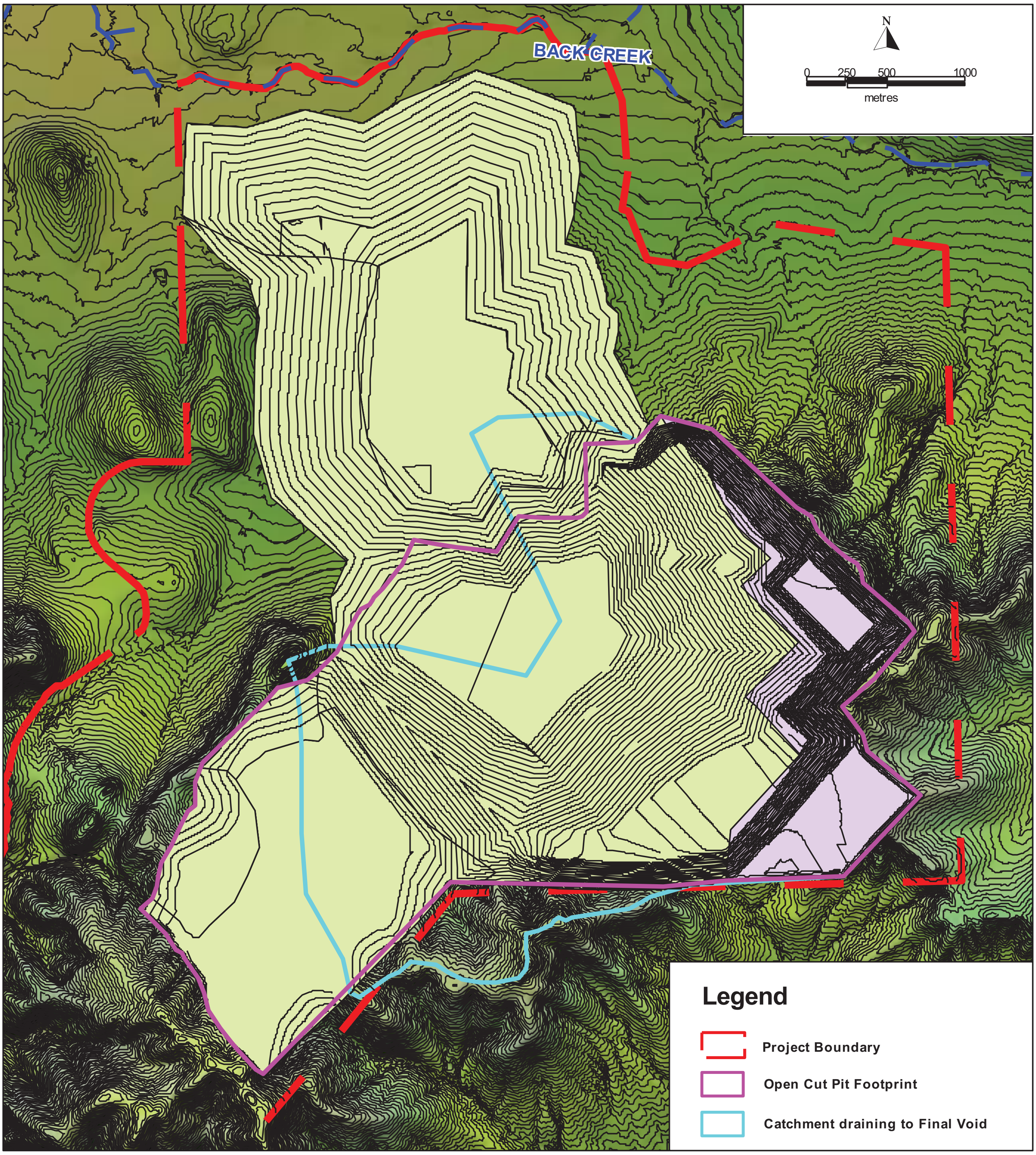

Figure 4.1 Open Cut Pit Conceptual Final Landform

4.5 BACK CREEK FLOODING

4.5.1 Overview

A flood study was undertaken to determine the extent of flooding along Back Creek and to quantify any impacts of the Project on flood levels and flood behaviour.

4.5.2 Estimation of Discharges

The Rational Method was used to estimate 100 year Average Recurrence Interval (ARI) design flood discharges in Back Creek along the reach adjacent to the proposed northern overburden emplacement area. Discharges were estimated at the upstream and downstream locations where the Project Boundary is closest to Back Creek (Locations A and B shown in Figure 4.2). Rational Method parameters were estimated using the recommended methodology in Australian Rainfall and Runoff (IEAust 1998) for eastern New South Wales. Details of the Rational Method calculations are provided in Table 4.2.

Table 4.2 Estimation of Design Discharges, Back Creek

Parameter	Location A Upstream Boundary	Location B Downstream Boundary
Catchment Area (km^2)	43.8	63.4
Time of Concentration (hrs)	3.2	3.7
Runoff Coefficient C_{10}	0.3	0.3
F_y	2.14	2.14
C_{100}	0.64	0.64
I_{100} (mm/hr)	32.4	30.3
Q_{100} (m^3/s)	254	343

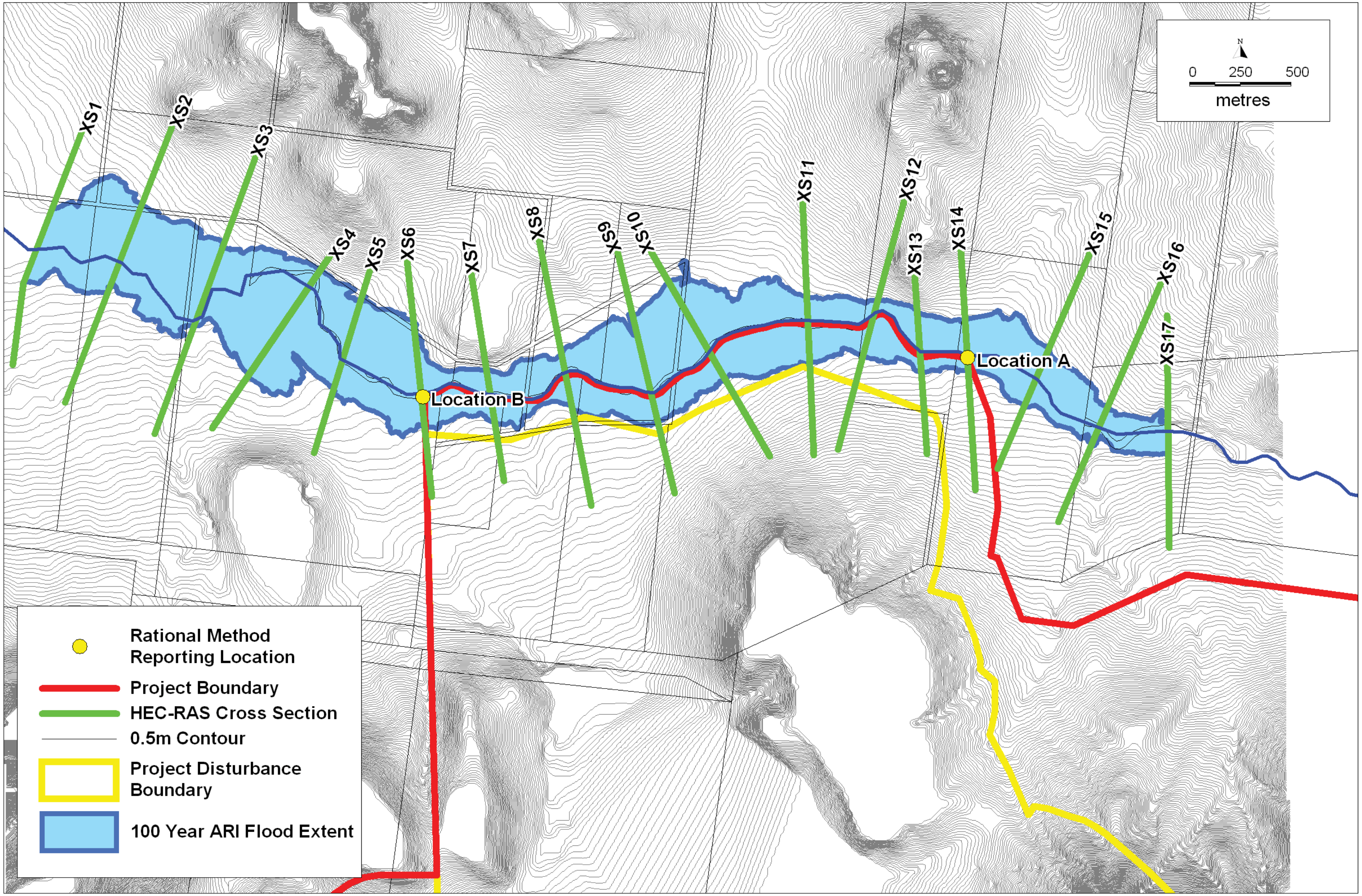

Figure 4.2 Back Creek 100 Year ARI Flood Extent

4.5.3 Estimation of Flood Levels

The HEC-RAS hydraulic model was used to estimate design flood levels along Back Creek adjacent to the Project Boundary. The model consists of 17 cross-sections, extracted from a digital elevation model of the area. The locations of the model cross-sections are shown in Figure 4.3. The vertical accuracy of the supplied topographic data is unknown. Hence, the estimated design flood levels should be used for planning purposes only and not relied upon for detailed design.

A Mannings ‘n’ value (representing the hydraulic roughness of the waterway) of 0.08 was adopted for the main channel and floodplain of Back Creek. This is a conservative (high) estimate of roughness which will provide an upper estimate of likely flood levels.

The adopted downstream boundary condition for the HEC-RAS model was based on a normal depth calculation, using the average longitudinal bedslope of Back Creek in the area of interest of approximately 0.4%.

Estimated design flood levels along Back Creek are shown in Table 4.3. Figure 4.3 shows a representative cross-section of Back Creek (XS 10). Figure 4.2 shows the estimated extent of flooding for the 100 year ARI event. The proposed limit of disturbance is outside the 100 year ARI flood extent. Hence, the Project will have no adverse impact on flood levels or flood behaviour along Back Creek for events up to the 100 year ARI event.

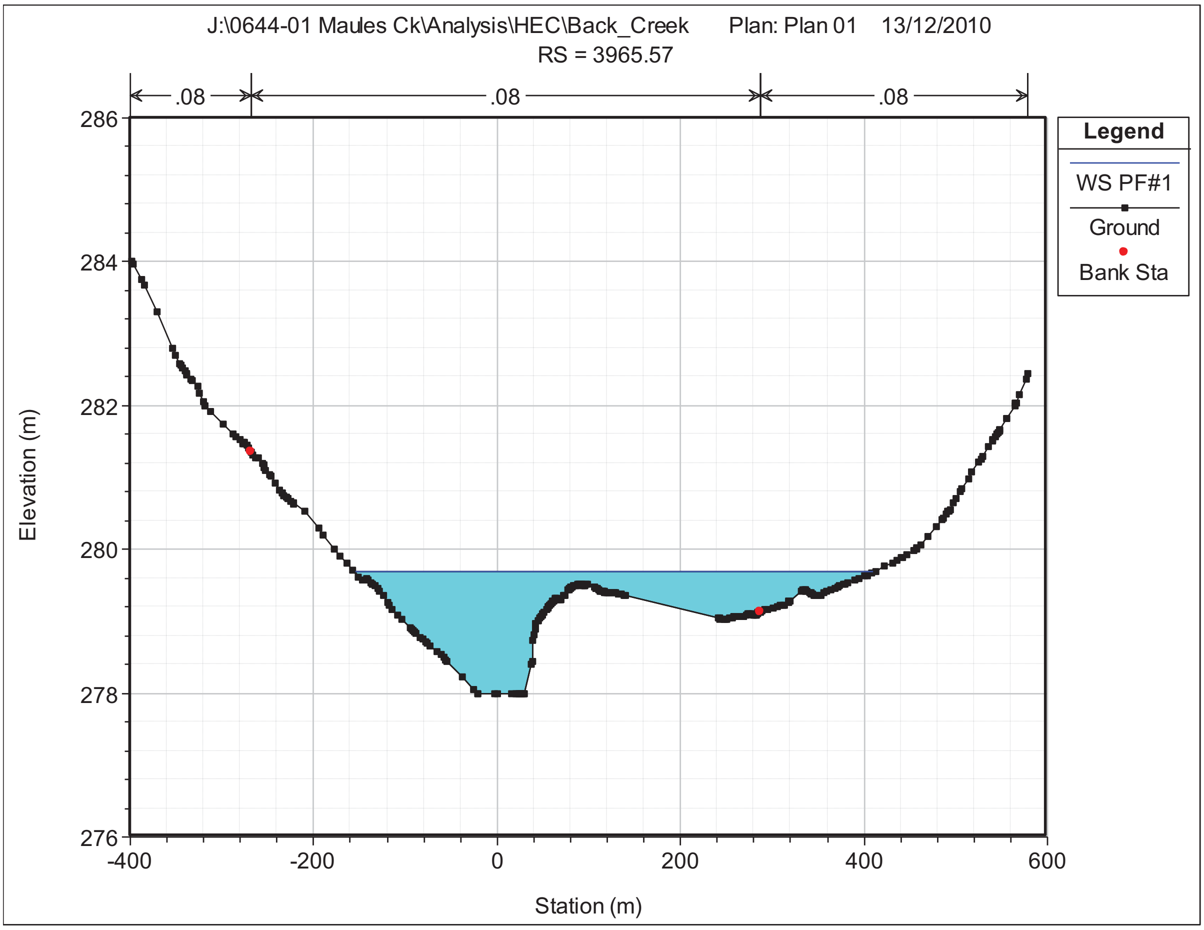

Figure 4.3 Back Creek HEC-RAS Model XS10 Showing 100 Year ARI Flood Level

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Table 4.3 Back Creek 100 Year ARI Design Flood Levels

Cross-Section	100 Year ARI Flood Results		
	100 Year ARI Peak Flood Level (mAHD)	Flood Width (m)	Flow Velocity (m/s)
XS1	263.48	379.38	0.83
XS2	265.32	444.21	0.85
XS3	267.33	418.23	0.76
XS4	269.68	631.02	0.70
XS5	271.46	466.48	0.85
XS6	273.86	529.73	0.77
XS7	274.98	262.84	0.71
XS8	276.17	258.13	0.93
XS9	278.09	535.31	0.65
XS10	279.69	565.66	0.74
XS11	282.06	332.61	0.75
XS12	283.40	289.29	0.88
XS13	284.52	299.39	0.71
XS14	285.54	252.01	1.15
XS15	287.86	308.61	0.73
XS16	289.62	196.75	0.96
XS17	291.31	150.56	1.04

4.6 NAMOI RIVER PUMP STATION AND PIPELINE

The proposed pump station on the Namoi River will be designed to current standards to ensure minimal impact on the hydraulics of the river under low and high flow conditions. The proposed water supply pipeline will also be designed to ensure that flood flow paths across the river floodplain are not affected by the pipeline.

4.7 ROAD AND RAIL ACCESS TO MINE SITE

The road and rail access to the mine will be designed to ensure no adverse impact on local catchment drainage and Namoi River flooding. Culverts for cross-drainage of local catchment runoff will be designed to relevant government standards to minimise any afflux. Flood investigations will be undertaken for any new crossing of the Namoi River and floodplain to ensure minimal affect on flood flow patterns and flood levels under a range of design flood scenarios.

The alignment for the proposed rail spur across the Namoi River floodplain is yet to be finalised. It is likely that the rail spur may join the proposed Boggabri Coal Rail Spur on the eastern side of the Namoi River. In this scenario, there would be no additional impact on Namoi River flooding (WRM, 2009). If an alternative rail alignment is adopted, flood modelling would be undertaken as part of the detailed design to minimise any impacts on flood flow patterns and flood levels under a range of design flood scenarios.

The assessment methodology and design approach for any new crossing of the Namoi River floodplain would be undertaken on a similar basis to the recent investigations for the proposed Boggabri Coal Rail Spur (WRM, 2009). The flood study for the Boggabri Coal Rail Spur (WRM,

2009) found that the proposed rail bridge crossing would have an insignificant impact on flood levels (maximum of 0.03m) and no measurable impact on flood extents for all floods investigated. That is, no additional overbank flooding was expected as a result of the rail bridge crossing. In addition, the rail bridge crossing would have an insignificant impact on flood velocities and therefore on the erosion potential across the floodplain for floods up to and including the 100 year ARI design flood.

5 MINE WATER BALANCE

5.1 OVERVIEW

The GoldSim software (developed by GoldSim Technology Group) was used to simulate the water balance of the mine on a daily basis over the 21 year life of the Project. The model was configured to represent the inflows to and outflows from the mine water management system shown in Table 5.1, as well as transfers of water between mine site storages. Details of the model configuration, input data and results are provided in the following sections.

Table 5.1 Simulated Inflows and Outflows to Mine Water Management System

Inflows	Outflows
Direct rainfall on water surface of storages	Evaporation from water surface of storages
Catchment runoff	CHPP demand
Groundwater inflows to Open Cut Pit	Dust suppression demand
Raw water supply from Namoi River	Vehicle washdown
	Pumped outflows from highwall dams
	Off site spills from storages

5.2 SIMULATION METHODOLOGY

To assess the performance of the water management system under a range of climatic conditions, water balance modelling was undertaken using a set of eighty-nine, 21 year rainfall sequences, extracted from recorded historical data. The first rainfall sequence commenced on 1/1/1900. The second commenced on 1/1/1901 and so on.

The water balance model was configured to represent the changing characteristics of the conceptual water management system over the 21 year mine life, including the addition of new storages and changes in contributing catchment areas and catchment types, as represented in the mine stage plans given in Figures 3.1 to 3.5. The model was then run for the 89 historical rainfall sequences, with a nominal starting year of 2012, to assess the performance of the water management system (storage levels, pumped volumes, etc) under the different climate scenarios.

5.3 STORAGES

Table 5.2 shows the sizes of minesite storages adopted in the site water balance model. The locations of the various storages are shown in Figures 3.1 to 3.5.

The site is able to accommodate up to approximately 1,000 ML of mine water storage. The Mine Water Dam capacity will be increased over time as expansion of the pit progresses. The total mine water storage may be provided as a number of dams, rather than a single storage. A volume of 1,000 ML has been adopted for the Mine Water Dam capacity in the water balance model.

Note that the Overflows from the Raw Water Dam, Mine Water Dam and sediment dams discharge off site. Overflows from the highwall dams discharge into the mining pit. Note that Sediment Dams 6 and 7 collect runoff from only about 5% of the disturbed catchment and hence have not been explicitly simulated in the water balance model.

Table 5.2 Adopted Storage Details, Water Balance Model

Storage	Capacity (ML)	Maximum Surface Area (ha)	Spills To
Raw Water Dam	100	6.0	Off site
Mine Water Dam	1000	16.5	Off site
SD1	5	0.8	Off site
SD2	71	3.2	Off site
SD3	37	3.4	Off site
SD4	45	2.9	Off site
SD5	37	3.0	Off site
Highwall Dam 1	80	2.8	Pit
Highwall Dam 2	100	4.1	Pit
Highwall Dam 3	60	2.3	Pit

5.4 MODEL CONFIGURATION AND ASSUMPTIONS

Figure 5.1 shows the conceptualisation of the mine water management system adopted for the water balance model. Note that the coal process water circuit was not explicitly modelled. However, the estimated net water demand from the CHPP was included in the model.

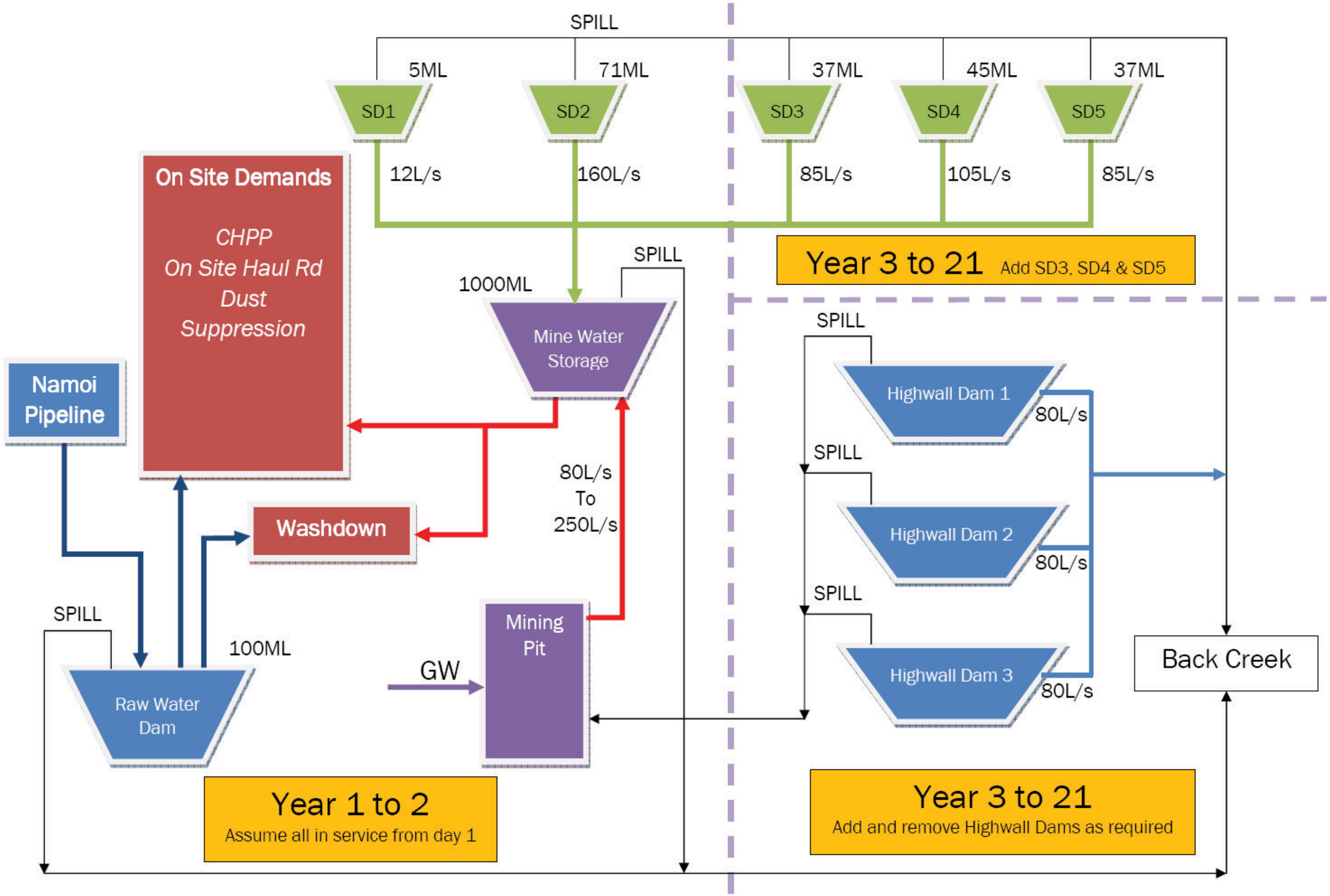

Figure 5.1 Conceptual Water Balance Model Configuration

5.5 ON SITE WATER DEMANDS

5.5.1 CHPP

The adopted water demand for the CHPP was based on an assumed water requirement of 200 L/ROM tonne, with production increasing from 4 Mtpa in Year 0 to 13 Mtpa by Year 5. The adopted time series of CHPP demand is shown in Figure 5.2.

Figure 5.2 Adopted Time Series of CHPP Water Demand

5.5.2 Haul Road Dust Suppression

The daily haul road dust suppression demand was calculated using the historical rainfall and evaporation data at the mine site. The following formulas were used to calculate the daily demand:

- Daily Haul Road water demand = max(0, Evaporation – Rainfall) x Haul Road Surface Area; and
- Haul Road Surface Area = Haul Road Length x 30 m.

The haul road length varies from about 2 km in the early stages of mining to a maximum length of about 13.8 km in the final stage of mining.

5.5.3 Vehicle Washdown

The water demand for the vehicle washdown area was adopted at 91 ML/a (~0.25ML/d) based on advice from Aston Resources.

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5.5.4 Potable Water

Potable water demands for the Project would be negligible compared to the process water demands and have not been included in the water balance model.

5.6 OPERATING RULES

The operational strategy for the mine's water management system is represented in the water balance model as a set of pumping rules that describe the interactions between the various water storages. Table 5.3 provides a summary of the adopted pumping rules for the water balance model, which are based on the following strategy:

- The Mine Water Dam was used as the first priority storage for supply of all minesite demands excluding the vehicle washdown demand which is exclusively drawn from the Raw Water Dam;
- Water accumulating in the Open Cut Pit, from groundwater and surface water runoff, is pumped to the Mine Water Dam. The pump rate increases with the volume of water within the Open Cut Pit;
- Runoff accumulating in the sediment dams is pumped to the mine water dam. The adopted pump rate for the sediment dams was selected to ensure that the dams could be dewatered within 5 days after a runoff event, in accordance with DECC (2008); and
- Pumping from all storages ceases when the Mine Water Dam reaches its maximum operating volume (MOV). The MOV has been selected to ensure no spills from the Mine Water Dam.

Table 5.3 Adopted Pumping Rules for Water Balance Model

Pump From	Pump To	Pump Rate (ML/d)	Pumping Rule (All pumps cease when Mine Water Dam Volume > MOV)
Open Cut Pit	Mine Water Dam	7 ML/d	Pit stored volume < 100 ML
		14 ML/d	Pit stored volume > 100 ML
		21 ML/d	Pit stored volume > 200 ML
SD1	Mine Water Dam	1 ML/d	
SD2	Mine Water Dam	14 ML/d	
SD3	Mine Water Dam	7 ML/d	
SD4	Mine Water Dam	9 ML/d	
SD5	Mine Water Dam	7 ML/d	

MOV = Maximum Operating Volume = 890 ML

5.7 GROUNDWATER INFLOWS

Figure 5.3 shows the adopted time series of groundwater inflows to the Open Cut Pit over the 21 year life of the Project. The groundwater inflows shown in Figure 5.3 were taken from modelling undertaken by the project groundwater consultant (AGE, 2011). The volumes shown in Figure 5.3 are estimated pumpable volumes after subtraction of 0.1 ML/d to allow for evaporation from the coal face.

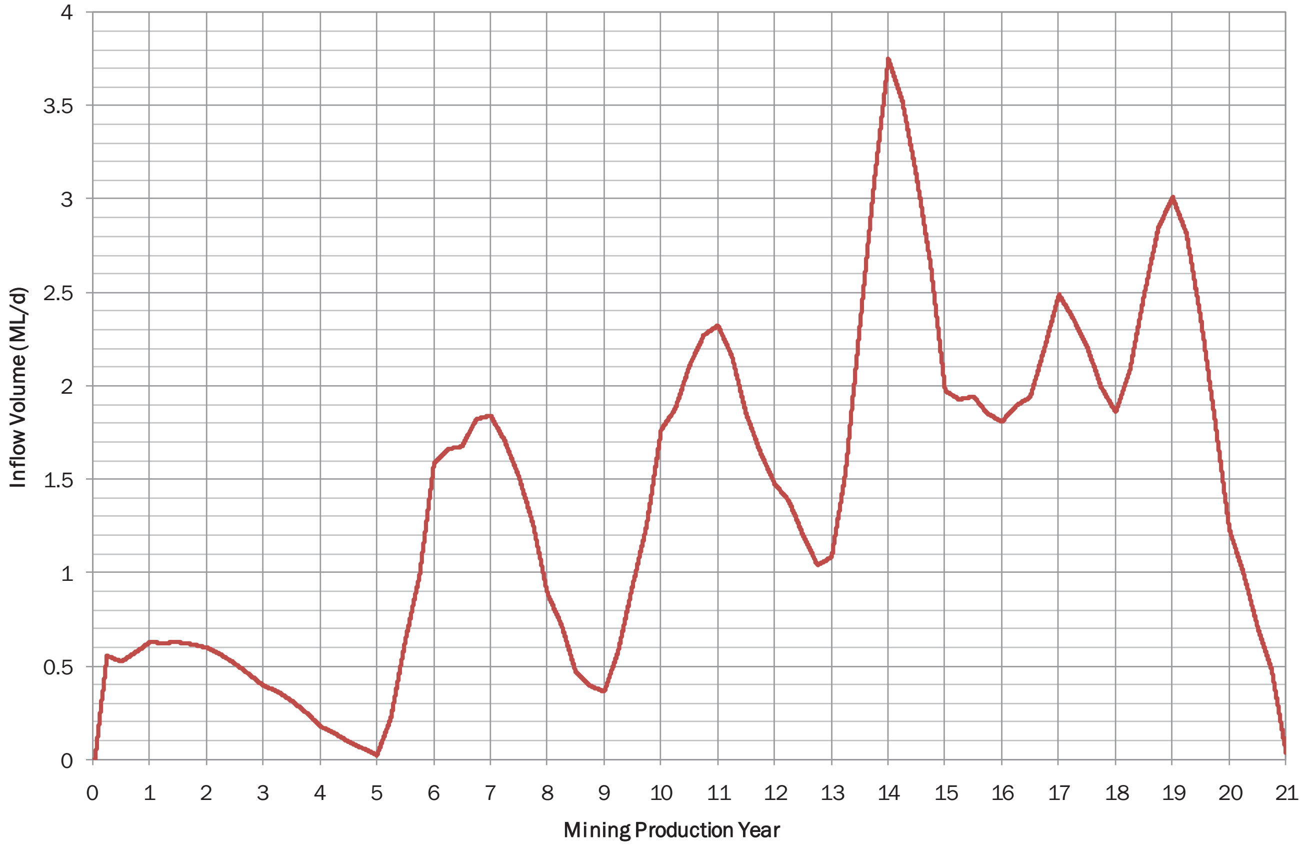

Figure 5.3 Adopted Time Series of Groundwater Inflow to Open Cut Pit

5.8 OPEN WATER EVAPORATION

Table 5.4 shows Morton's lake evaporation estimates (Morton, 1983) for the area of interest which was adopted for the water balance model. Morton's method is regarded as suitable for the estimation of lake evaporation in non-arid areas (Mulder, 1997). The estimated total annual lake evaporation is 1,505 mm which is about 15% lower than pan evaporation given in Section 2.3.

The values shown in Table 5.4 were adopted to estimate evaporation from the Mine Water Dam, Raw Water Dam and sediment dams. For the Open Cut Pit, the values shown in Table 5.4 were factored by 0.7 to reflect the likely reduction in evaporation due to the depth of the open cut below surface level.

Table 5.4 Mean Monthly Evaporation Depths from Storages

Month	Morton's Lake Evaporation, Mean Monthly (mm)
Jan	202
Feb	168
Mar	151
Apr	103
May	67
Jun	47
Jul	54
Aug	78
Sep	111
Oct	150
Nov	175
Dec	200
Total	**1,505**

5.9 CATCHMENT RUNOFF

5.9.1 Adopted Rainfall-Runoff Model

The AWBM model (Boughton & Chiew 2003) was used to estimate runoff volumes from on site catchments, based on available rainfall and evaporation data. AWBM is a saturated overland flow model which allows for variable source areas of surface runoff. 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 groundwater store. Runoff depth calculated by the AWBM model is converted into runoff volume by multiplying by the contributing catchment area. The various parameters of the AWBM model are shown in Table 5.5.

Table 5.5 Summary of AWBM Model Parameters

Parameter Specification	Description
Partial Area Fractions	Parameters A1, A2 & A3. Fraction of catchment area represented by surface storages No. 1, 2 & 3.
Soil Store Capacities	Parameter C1, C2 & C3. Soil moisture storage capacities for smallest store (No. 1), middle store (No. 2) and largest store (No. 3).
Base Flow Index	Parameter BFI. Proportion of runoff directed to baseflow store.
Daily Baseflow Recession Constant	Parameter K. Rate at which water discharges from baseflow store.

To estimate catchment runoff inflows to the mine water management system, separate AWBM model parameters were developed for the following catchment types:

- **Natural** (undisturbed catchments and fully rehabilitated spoil);
- **Compacted** (haul roads, pit floor, mine infrastructure); and
- **Spoil** (unrehabilitated overburden emplacement areas).

Details of the available data for calibration of the AWBM model and the adopted model parameters for each catchment type are provided in Section 5.9.3.

5.9.2 Site Rainfall

A representative long-term rainfall sequence for the Project Boundary was obtained from the Bureau of Meteorology's SILO Data Drill. These data are derived by interpolation of recorded rainfall data between stations as described by Jeffreys *et al* (2001). Rainfall data from the SILO Data Drill is available from the late 1800s and is corrected for missing data and accumulated totals. Hence, this data is more reliable and easier to use for computer modelling than raw recorded rainfall data. Figure 5.4 shows a comparison of mean monthly rainfall recorded at the Boggabri (Kanownda) rainfall station from 1900 to 2010 the SILO Data Drill rainfalls. The comparison indicates that the SILO data provides a good representation of recorded rainfall data in the Project Boundary. The mean annual rainfall from the SILO data (589 mm) is within 2% of the mean annual rainfall from the Boggabri (Kanownda) station (577 mm).

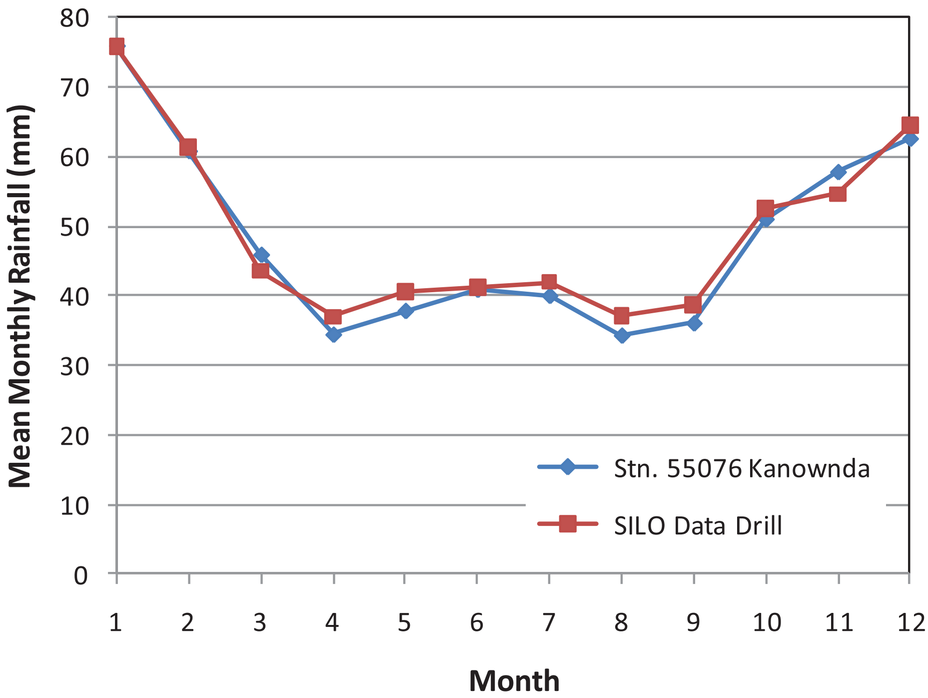

Figure 5.4 Comparison of Mean Monthly Rainfalls from SILO Data Drill and Boggabri Kanownda (55076), 1900 to 2010

5.9.3 AWBM Model Calibration

Streamflow data was recorded at two monitoring stations along local watercourses draining the Project Boundary in the early 1980s (LMJ, 1986). The locations of the historical streamflow monitoring stations are shown in Figure 2.3. Station LMJ 1 is located along Back Creek near the downstream boundary of the Project Boundary and has a catchment area of approximately

6,600 ha. Station LMJ 5 is located in the upper reaches of a tributary draining the Project Boundary and has a catchment area of approximately 300 ha.

A total of 12 runoff events were recorded at the two stations between January 1983 and December 1984. Summary details of the recorded runoff events are shown in Table 5.6. Due to the small number of runoff events available at each of the monitoring stations, the data from both the LMJ 1 and LMJ 5 sites was combined to produce a single data set against which to calibrate the AWBM model for site catchments.

The AWBM model was calibrated using the average surface storage capacity approach described by Boughton & Chiew (2003). The adopted average storage capacity was 120 mm.

Figure 5.5 shows a comparison of recorded and simulated event runoff volumes for the runoff events listed in Table 5.6.

Table 5.6 Recorded and Simulated Runoff Events from On site Catchments

Event Date	Event Rainfall (mm) [a]	Event Number	Recorded Runoff Depth (mm)		Simulated Runoff Depth (mm)
			LMJ 1	LMJ 5	
3/01/1983	33.0	1	0.5		2.7
5/02/1983	12.5	2	0.5		0.0
24/05/1983	14.5	3	3.7		3.6
28/05/1983	23.5	4	6.2		2.4
2/01/1984	6.0	5		>0	0.0
16/01/1984	6.0	6		4.0	2.6
28/01/1984	63.0	7	10.5		6.5
16/02/1984	28.5	8		0.2	2.0
22/02/1984	30.5	9		4.8	2.9
27/07/1984	87.0	10		17.0	19.6
6/11/1984	33.0	11		2.5	2.5
12/12/1984	55.0	12		1.0	5.5

[a] Recorded on site

The adopted AWBM model parameters and volumetric runoff coefficients for the three catchment types are shown in Table 5.7. Note that the volumetric runoff coefficient for on site natural catchments is almost double the observed value for runoff in Maules Creek. The lower value for Maules Creek may reflect the effect of processes that operate at the larger catchment scale, such as streambed storage and infiltration, which are not observed in the small on site catchments.

AWBM model parameters for compacted areas were selected by adopting values to provide a volumetric runoff coefficient similar to typical values for urban catchments which have similar characteristics.

AWBM model parameters for spoil catchments were adopted from a previous study of runoff from disturbed mine catchments in the Hunter Valley region (ACARP, 2001). For spoil placed within the Open Cut Pit, it was assumed that the baseflow component of spoil runoff (20% of total runoff) percolated into the Open Cut Pit even if surface flows were directed away from the pit.

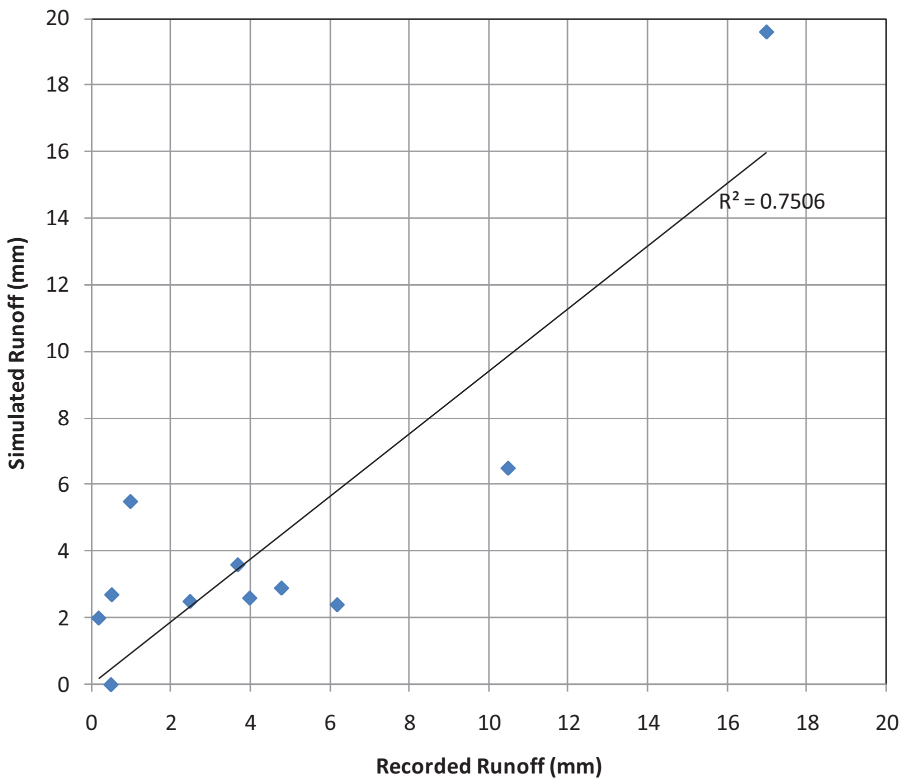

Figure 5.5 Comparison of Recorded and Simulated Surface Runoff for Back Creek and Site Tributary Catchment, 1983/84

Table 5.7 Adopted AWBM Parameters

AWBM Model Parameter		Natural	Compacted	Spoil
Partial Areas	A1	0.134	0.33	0.1
	A2	0.433	0.33	0.3
Base flow index	BFI	0	0	0.2
Surface Store Depth (mm)	C 1	9	2	15
	C 2	91	10	50
	C 3	183	30	110
Base flow recession constant	Kb	0	0	0
Volumetric Runoff coefficient for period 1900 - 2010	RC	9.3%	42%	10.8%

5.9.4 Catchment Areas

Table 5.8 shows the adopted catchment areas draining to the various minesite storages represented in the water balance model. Catchment types are represented as follows:

- **Pit spoil.** Overburden dumped within the Open Cut Pit that drains externally. 80% of simulated runoff drains externally. 20% of simulated runoff infiltrates through the overburden into the Open Cut Pit;
- **Spoil.** Overburden emplacement. 100% of simulated runoff drains to storage;
- **Compacted.** Pit floor, roads, coal stockpiles and mine infrastructure area; and
- **Natural.** Undisturbed or fully rehabilitated areas.

Table 5.8 Adopted Catchment Areas

Storage	Contributing Catchment (ha) Pit Spoil	Spoil	Compacted	Natural	Total
Raw Water Dam	0	0	6	38	44
Mine Water Dam	0	0	56	0	56
Sediment Dam 1	0	0	25	0	25
Highwall Dam 1 [a]	0	0	0	86	86
Highwall Dam 2 [b]	0	0	0	123	123
Highwall Dam 3 [c]	0	0	0	68	68
Stage 1					
Mining Pit	0	0	77	153	230
Sediment Dam 2	0	215	4	0	218
Sediment Dam 3	0	0	0	0	0
Sediment Dam 4	0	0	0	0	0
Sediment Dam 5	0	0	0	0	0
Stage 2					
Mining Pit	36	99	171	346	651
Sediment Dam 2	0	346	4	0	349
Sediment Dam 3	0	0	3	131	134
Sediment Dam 4	0	0	3	128	131
Sediment Dam 5	36	0	3	0	39
Stage 3					
Mining Pit	160	286	166	172	784
Sediment Dam 2	0	274	4	0	278
Sediment Dam 3	0	0	0	0	0
Sediment Dam 4	0	0	0	0	0
Sediment Dam 5	62	0	3	0	65
Stage 4					
Mining Pit	182	376	185	106	850
Sediment Dam 2	0	128	4	90	222
Sediment Dam 3	0	0	0	0	0
Sediment Dam 4	0	0	0	0	0
Sediment Dam 5	117	0	3	0	120
Stage 5					
Mining Pit	182	370	169	54	774
Sediment Dam 2	0	128	4	90	222
Sediment Dam 3	0	0	0	0	0
Sediment Dam 4	0	0	0	0	0
Sediment Dam 5	182	0	3	0	185

[a] Stage 2 only
[b] Stages 2 and 3
[c] Stages 3 and 4

5.10 WATER BALANCE MODEL RESULTS

5.10.1 Water Balance Summary

Table 5.9 shows a summary of the water balance model results. Results are shown for Years 1, 5, 10, 15 and 21, for the sequence with median runoff inflows. These results provide an indication of the components of the site water balance for various stages of mine development over this climate sequence. Note that the difference between total inflows and total outflows represents the change in the volume of water in storage on the site. Note also that the proposed operating rules for the Mine Water Dam ensure that this dam does not spill under any of the climate scenarios.

The results of the water balance model indicate that under average climatic conditions:

- Inflows to the mine water management system from runoff and direct rainfall are generally much larger than groundwater inflows. Predicted groundwater inflows are highest around Year 14 and are likely to exceed average runoff inflows.
- CHPP demand is the largest outflow from the mine water management system, representing 80% of all outflows.

Table 5.9 Water Balance Model, Summary Results

		Annual Volume for Realisation with Median Runoff (ML)				
		Stage 1	Stage 2	Stage 3	Stage 4	Stage 5
INFLOWS	Source	Year 1	Year 5	Year 10	Year 15	Year 21
Runoff & Direct Rainfall	All Catchments	694	1,233	1,103	1,109	1,115
Pipeline Water	Namoi Pipeline	290	1,620	1,860	920	2,090
Ground Water Inflow	Pit	175	36	350	1,107	257
	TOTAL	1,159	2,889	3,312	3,137	3,462
OUTFLOWS						
Evaporation	All Water Storages	60	47	39	70	37
Overflows	RWD & Sed. Dams	20	9	11	18	18
Pumped Off site	Highwall Dams	0	88	81	28	0
CHPP Demand	RWD	176	1,379	1,544	808	1,652
	MWD	625	1,006	1,054	1,790	953
	Total	802	2,384	2,598	2,598	2,605
Dust Supp Demand	RWD	15	181	223	22	347
	MWD	65	147	230	467	227
	Total	80	328	453	489	574
Washdown Demand	RWD	91	91	91	91	91
	TOTAL	1,053	2,948	3,273	3,294	3,326

5.10.2 Makeup Water Requirements

Figure 5.6 shows the range of annual volumes of makeup water required from the Namoi River pipeline, based on the minimum, median and maximum for each year of operation from the 89 climate scenarios. In very wet years, it may be possible to obtain all water required for mine operations from local runoff and groundwater inflows. However, on average, it is likely that annual volumes of the order of 1,000 to 1,800 ML will be required. Typical makeup water volumes required in dry years are likely to be of the order of 2,000 to 2,500 ML. The maximum simulated volume for any year was 2,730 ML which is less than Aston Resources' existing high security licence volume (3,000 ML).

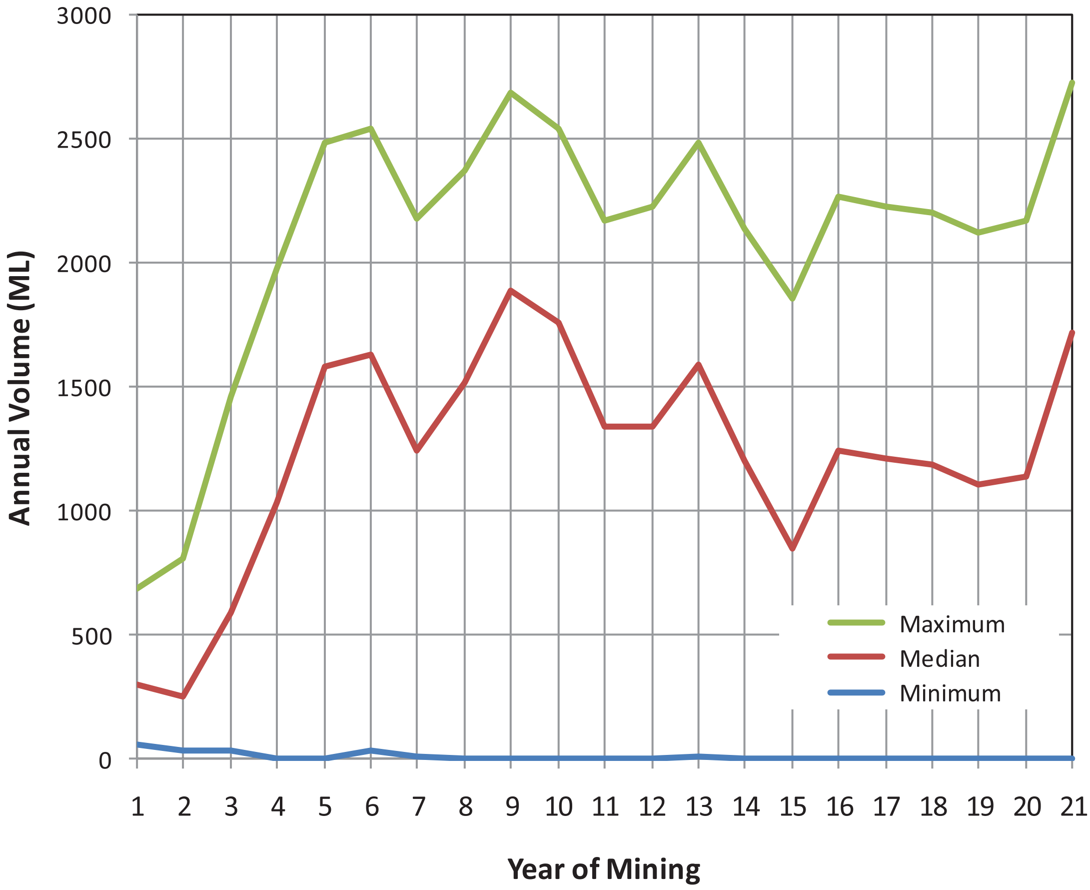

Figure 5.6 Annual Volume of Makeup Water Required From Namoi Pipeline

5.10.3 Storage Behaviour – Mine Water Dam

Figure 5.7 shows a summary of the simulated stored volume in the Mine Water Dam, based on the distribution of model results from the 89 climate sequences over the mine life. The median of the 89 simulations indicates that stored volumes are likely to be less than 200 ML. However, the model results indicate that the Mine Water Dam stored volume is sensitive to climatic conditions. If relatively wet conditions occur, the Mine Water Dam will reach its maximum operating volume of 890 ML.

Figure 5.8 shows a ranked plot of stored volume in the Mine Water Dam for two discrete climate sequences; one with median catchment runoff and the other with 99th percentile (wettest) catchment runoff. Both climate sequences indicate that the Mine Water Dam will be full for about 1.5 years over the mine life (7% of 21 year mine life).

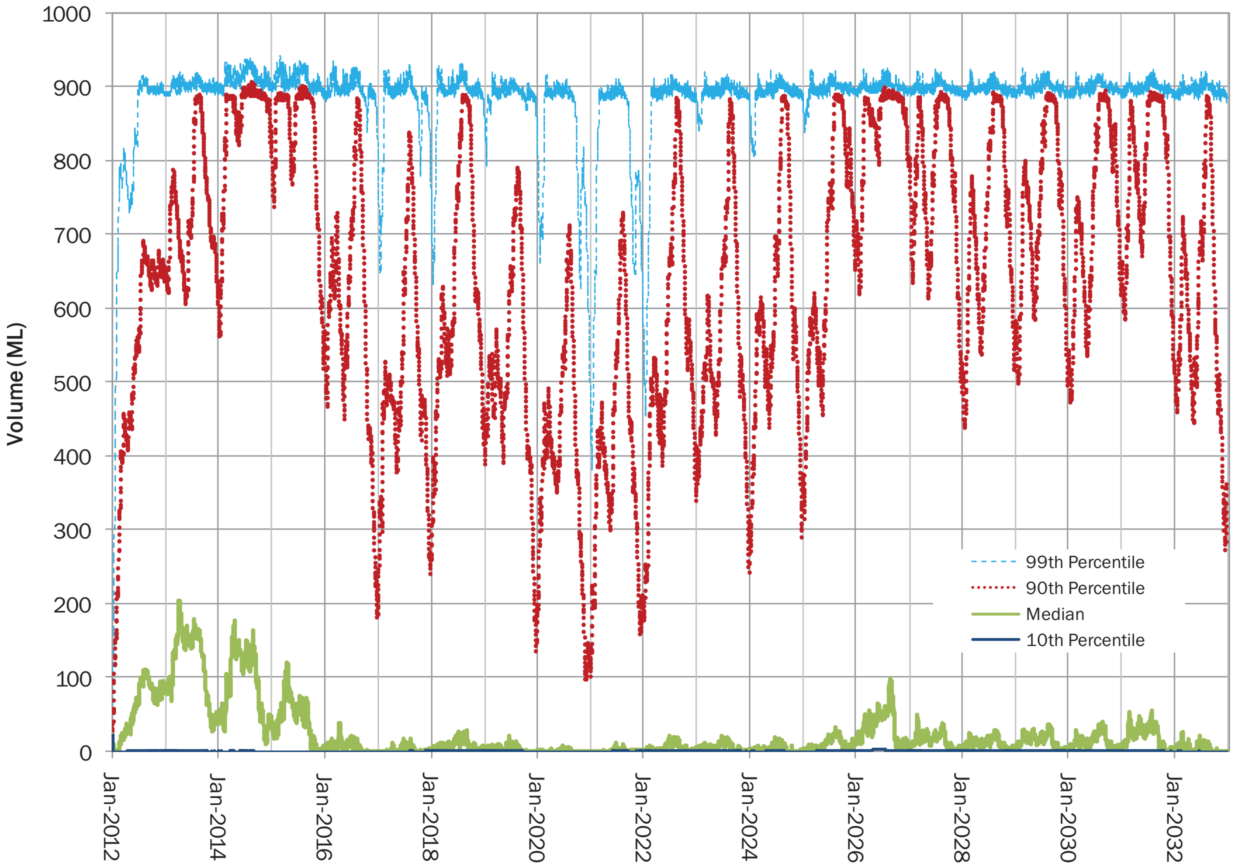

Figure 5.7 Mine Water Dam Stored Volume, Summary of 89 Climate Sequences

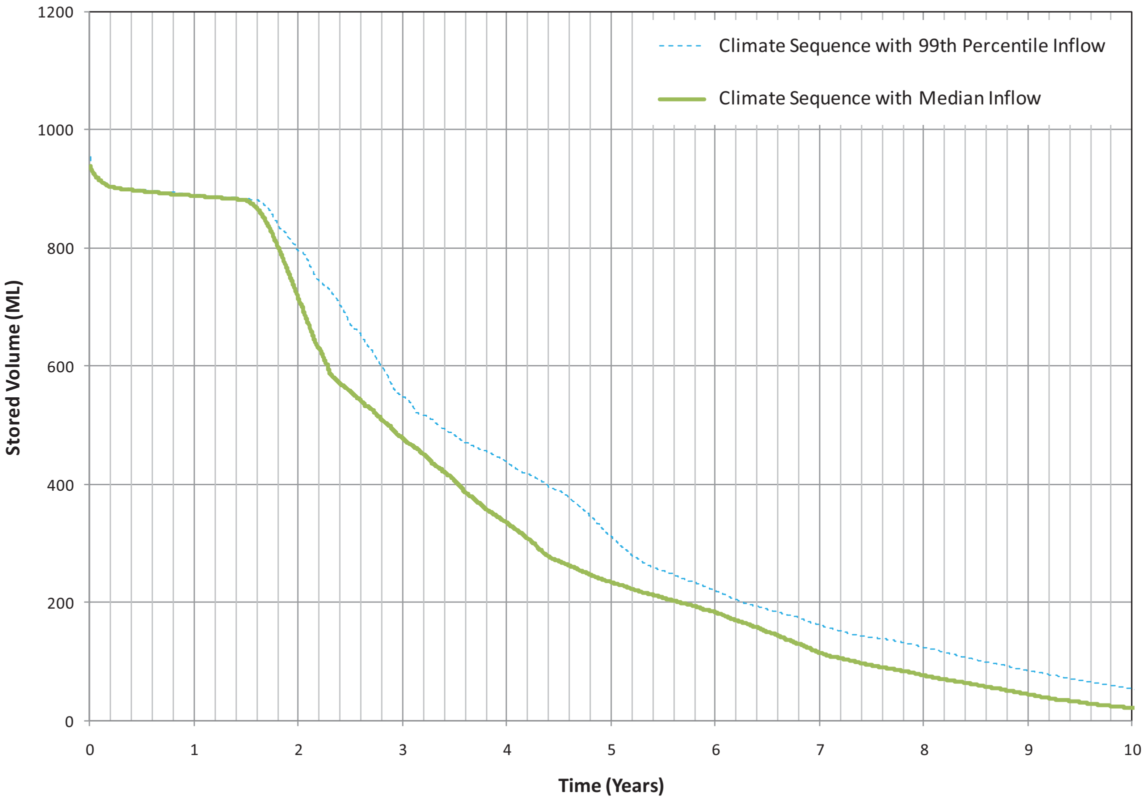

Figure 5.8 Distribution of Mine Water Dam Stored Volume Over Mine Life

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5.10.4 Storage Behaviour – Open Cut Pit

Figure 5.9 shows the shows a summary of the simulated stored volume in the Open Cut Pit, based on the distribution of model results from the 89 climate sequences over the mine life. The median of the 89 simulations indicates that the proposed pumping strategy should be effective in dewatering the pit. However, if wet conditions occur, there is the potential for significant volumes of water to collect in the pit, potentially affecting coal production.

Figure 5.10 shows a ranked plot of stored volume in the Mine Water Dam for two discrete climate sequences; one with median catchment runoff and the other with 99th percentile catchment runoff. The results for the median inflow climate sequence indicate that the water volume in the Open Cut Pit may exceed 200 ML about 5% of the time over the mine life (1 year out of the 21 year mine life). With very wet climatic conditions, the water volume stored in the Open Cut Pit may exceed 600 ML about 5% of the time over the life of the mine.

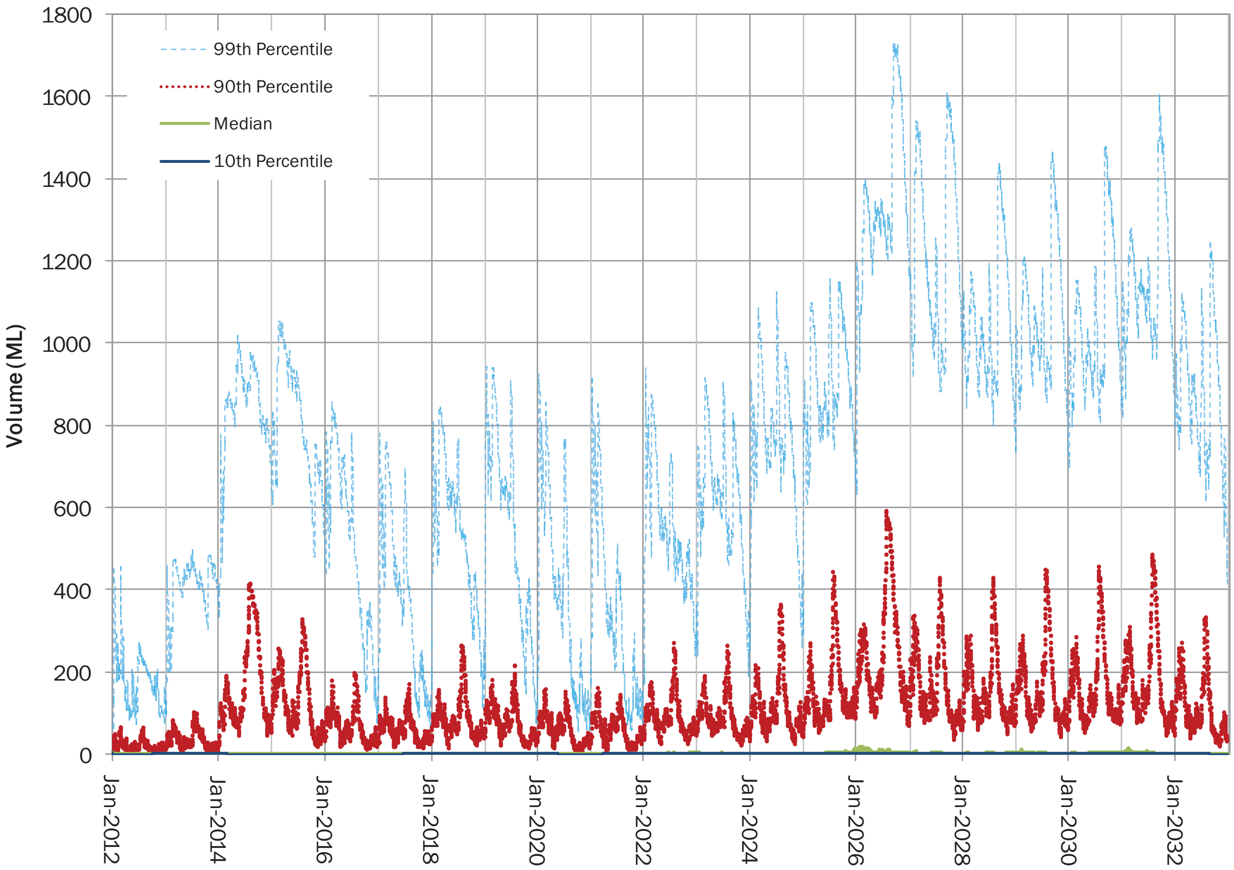

Figure 5.9 Open Cut Pit Stored Volume, Summary of 89 Climate Sequences

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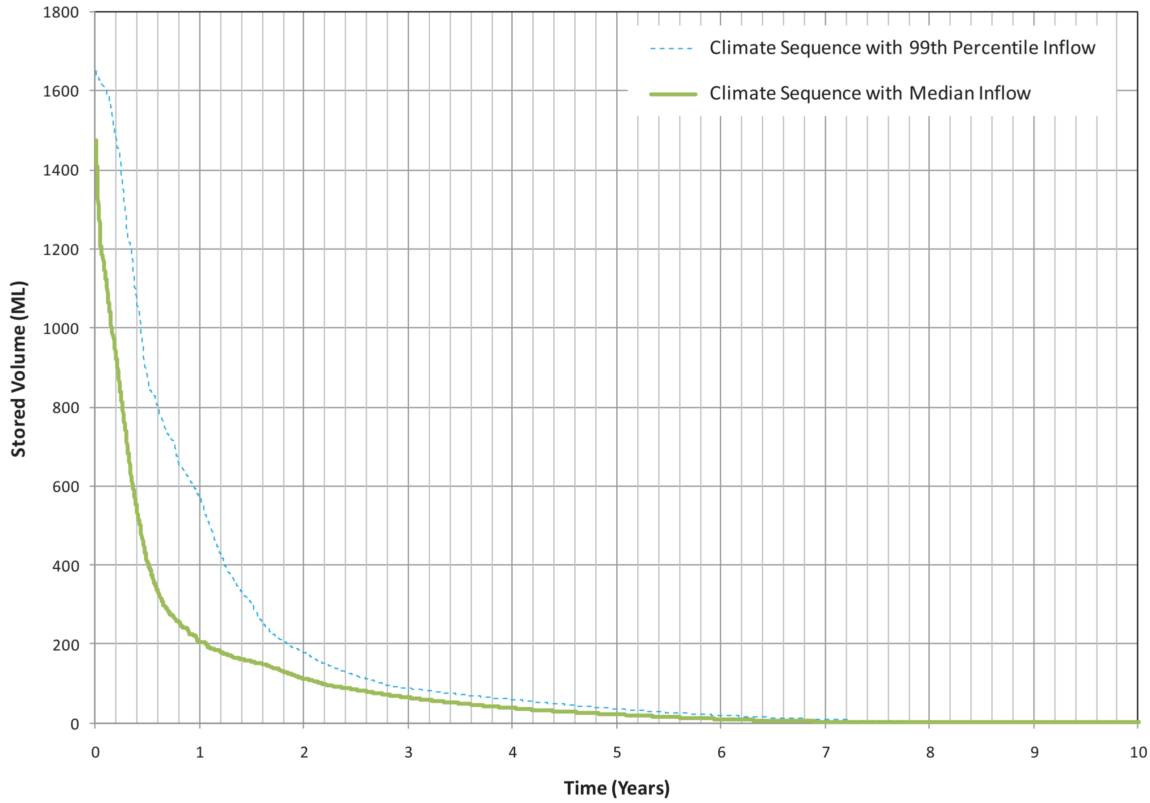

Figure 5.10 Distribution of Open Cut Pit Stored Volume Over Mine Life

5.11 FINAL VOID WATER BALANCE

5.11.1 Input Data

A water balance of the Final Void was undertaken to assess the likely long term water levels within the Final Void. The adopted configuration of the Final Void is shown in Figure 4.1. The analysis was undertaken on a monthly timestep over a period of 1,000 years. Input data used in the analysis consisted of:

- Rainfall from the SILO Data Drill (see Section 5.9.2) for the period 1889 to 2010. A synthetic 1,000 year rainfall sequence was derived by repeating the 121 year rainfall sequence.
- Open water evaporation, obtained using Morton's lake evaporation (see Section 5.8). A reduction factor was applied to the open water evaporation to account for the reduction in evaporation at depth in the Final Void. The adopted reduction factor varied linearly from 0.7 at a water surface elevation of 100 mAHD, to 1.0 at 300 mAHD.
- A stage-area-volume relationship for the Final Void derived from design elevation data for the final landform. The adopted stage-area volume relationship is provided in Table 5.10.
- Estimated long term groundwater inflows. The adopted groundwater inflows, provided by the Project groundwater consultants, AGE, are shown in Figure 5.11.
- Surface runoff inflow estimated using the AWBM model (see Section 5.9) from the synthetic 1,000 year rainfall sequence. Catchments draining to the Final Void were separated into four types:

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– Water surface. Area varies with elevation based on stage-area relationship.

– Surface runoff only (40 ha). Internally draining catchments outside the Open Cut Pit footprint.

– Infiltration only (247 ha). Externally draining catchments within the Open Cut Pit footprint.

– Surface runoff and infiltration (847 ha minus the water surface area). Internally draining catchments within the Open Cut Pit footprint.

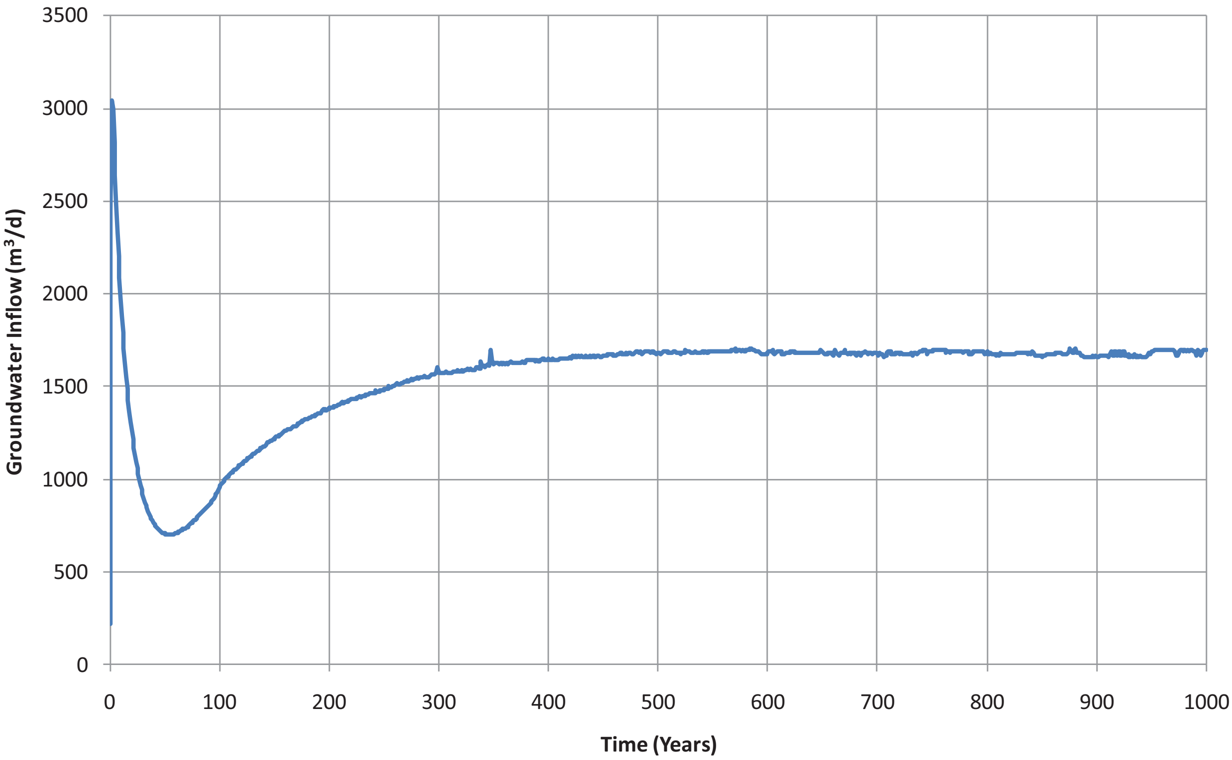

Figure 5.11 Final Void Groundwater Inflows

Table 5.10 Final Void Stage-Area-Volume Relationship

Elevation (mAHD)	Area (ha)	Volume (ML)
100	0.0	-
105	0.6	14
110	1.4	63
115	2.2	154
120	3.2	289
125	4.4	477
130	6.0	735
135	7.8	1,078
140	10	1,523
145	18	2,285
150	25	3,348
155	36	4,822
160	56	7,073
165	66	10,103
170	77	13,652
175	86	17,707
180	95	22,221
185	104	27,199
190	114	32,661
195	123	38,587
200	131	44,936
205	141	51,743
210	151	59,040
215	159	66,800
220	168	74,985
225	176	83,584
230	184	92,578
235	192	101,966
240	200	111,748
245	212	122,036
250	226	132,989
255	236	144,534
260	245	156,537
265	253	168,962
270	261	181,788
275	269	195,019
280	277	208,669
285	287	222,773
290	297	237,364
295	306	252,444
300	317	268,019
305	327	284,104
310	338	300,717
315	348	317,865
320	359	335,553
325	371	353,809
330	384	372,671
335	403	392,387
340	422	413,000
345	448	434,772

5.11.2 Results

Figure 5.12 shows the predicted water level variation in the Final Void over the 1000 year simulation. The model results indicate that over the first few years after mine closure, the Final Void water level will rise quickly to a depth of about 60 m (160 mAHD). The rate of water level rise will slow as evaporation from the water surface comes closer to average inflows. The final steady-state water level of about 210 to 220 mAHD will not be reached for another 300 to 400 years. The simulated long-term water level is consistent with the equilibrium water level of 225 mAHD derived by AGE (2011) using a groundwater model. The steady state water level is more than 100 m below the overflow level of about 340 mAHD. Hence, based on the estimated inflows and outflows, water will not spill from the Final Void.

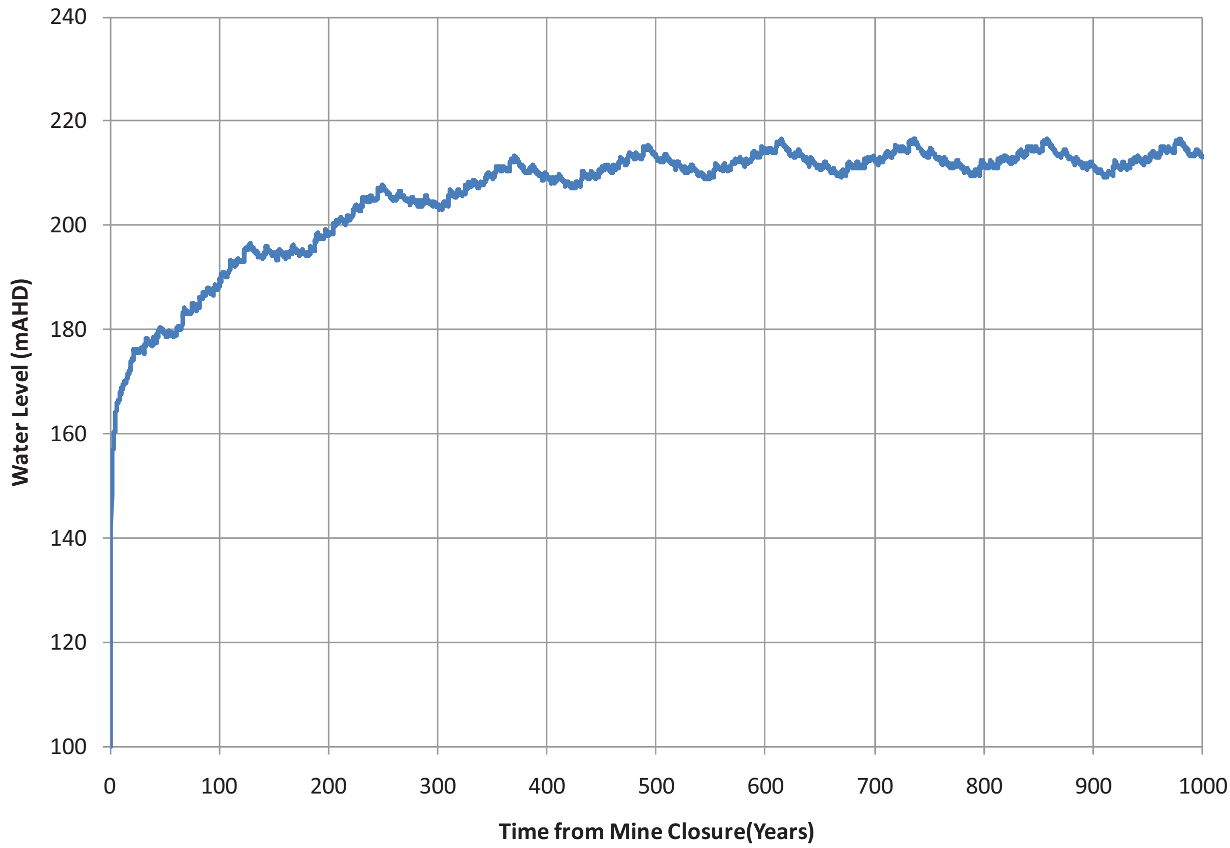

Figure 5.12 Simulated Final Void Water Levels

5.12 FINAL VOID WATER QUALITY

A salt balance was undertaken to assess the likely change in water quality within the Final Void over time. The salt balance was undertaken by assigning a representative concentration of TDS to the various inflows to the final void, including direct rainfall, surface runoff, infiltration and groundwater. The analysis assumed instantaneous full mixing of water from all sources and assumed no loss of salt mass from the Final Void.

The adopted TDS concentrations of the various inflows are summarised as follows:

- Direct rainfall onto the water surface in the final void was assumed to have a TDS concentration of zero.
- Infiltrated surface runoff leaching through the overburden (20% of simulated total runoff – see Section 5.9.3) was assigned a representative concentration based on kinetic leach column tests on overburden material (RGS, 2011). The mean EC of 21 measurements on overburden samples was 142 µS/cm. This was converted to an approximate equivalent TDS concentration of 85 mg/L by multiplying by 0.6 (DPI, 2010).
- Surface runoff was assigned a representative TDS concentration of 100 mg/L based on surface water sampling from site catchments undertaken in the 1980s (LMJ, 1986). A summary of the results of the surface water sampling program is provided in Table 2.6.
- Groundwater was assigned a representative concentration of 958 mg/L, based on EC measurements from groundwater sampling (AGE, 2011) using a conversion factor of 0.6.

The results of the simulation indicate that the salinity in the Final Void will gradually increase over time. Due to the relatively low salinity of leachate and surface runoff, TDS will increase at a relatively slow rate of about 900 mg/L per 100 years. It will take more than 500 years to reach a salinity of 5,000 mg/L. The rising salinity level in the Final Void will have no adverse impact on surface water because the long-term equilibrium water level is more than 100 m below the overflow level. Groundwater will not be affected because the Final Void will act as a sink, with net outflow of groundwater due to evaporation (AGE, 2011).

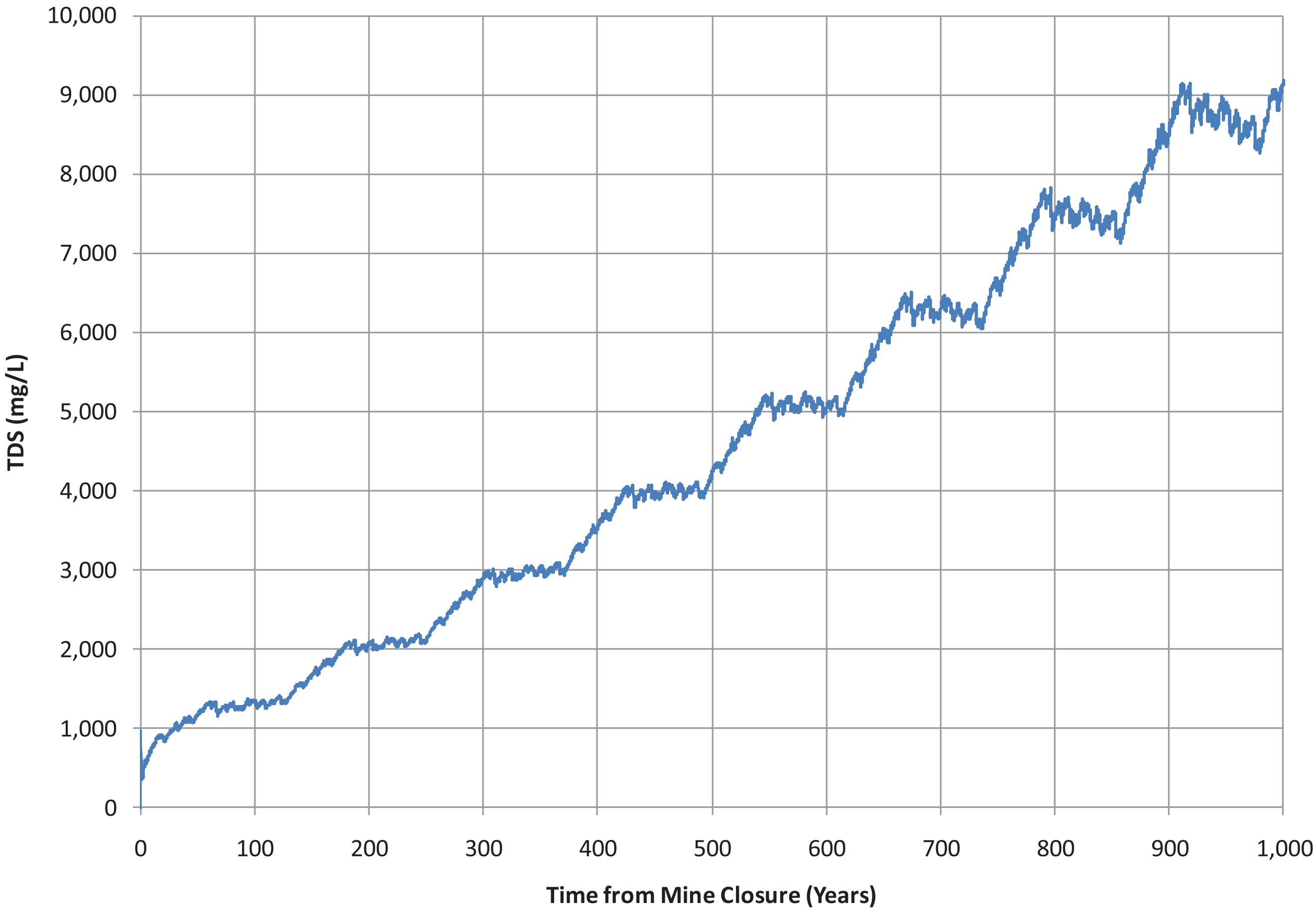

Figure 5.13 Simulated Final Void Salinity

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5.13 MINE WATER BALANCE SUMMARY

Overall, the results of the water balance modelling show that:

- Makeup water requirements from the Namoi River pipeline are expected to average less than 2,000 ML per year, which is less than Aston Resources' existing high security water allocation of 3,000 ML per year.
- Even under extremely dry conditions, the maximum makeup water required is less than the existing Namoi River allocation.
- The proposed operating rules for the mine water management system will ensure that all mine water is contained on site.
- Under average climatic conditions, the volume of water stored in the Open Cut Pit should be less than 200 ML for 95% of the time.
- Simulation of the water balance for the Final Void indicates that the water level will take several hundred years to reach an equilibrium level. The long term equilibrium level is more than 100 m below the spill level for the Final Void.

6 MITIGATION AND MANAGEMENT MEASURES

6.1 OVERVIEW

The impacts of the Project on surface water resources will be mitigated through the implementation of the following measures:

- A **mine site water management system** to control the flow and storage of water of different qualities across the site;
- A **sediment control plan** to reduce sediment loads from disturbed area runoff; and
- A **surface water monitoring program** to ensure that the site water management system is meeting its objectives of no adverse impact on receiving waters.

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

6.2 MINE SITE WATER MANAGEMENT SYSTEM

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

- Diversion of clean surface water runoff away from areas disturbed by mining activities;
- Collection of dirty water runoff in sediment dams for control of suspended sediment prior to discharge from site or reuse in the mine water management system;
- Transfer of mine water (groundwater inflows and surface runoff) from within the Open Cut Pit to the Mine Water Dam for reuse as a water supply;
- Collection of contaminated water from industrial areas for treatment in an oil and grease separator prior to recycling in the mine water management system;
- Minimisation of fresh water usage by recycling water from the mine water system before taking additional water from the mine's water allocation from the Namoi River; and
- Release of runoff from rehabilitated catchments once rehabilitation is fully established.

The proposed water management infrastructure for the site is shown in Figures 3.1 to 3.5. Details of the operation of the mine water management system are provided in Section 5.

6.3 SEDIMENT CONTROL PLAN

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

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

Figures 3.1 to 3.5 show the proposed sediment control measures for the site. A small sediment dam (SD 1) will be required to collect surface runoff from the mine infrastructure area. In the initial stages of mining, the existing dam on the property will be converted to a sediment dam (SD 2) for the northern overburden emplacement area. Once the footprint of the northern overburden emplacement area extends north past SD 2, two additional sediment dams (SD 3 and SD 4) will be required along the northern extent of the northern overburden emplacement area. Another sediment dam (SD 5) will be required adjacent to the Open Cut Pit to collect runoff from the outer face of the proposed in-pit overburden emplacement. Sediment dams SD 6 and SD 7 will be required in the later stages of mining to collect runoff from overburden emplacements draining to small gullies near the south-western extent of the Open Cut Pit.

Preliminary estimates of sediment dam sizes are provided in Table 6.1. Sediment dam sizes and locations will be confirmed during detailed design. The preliminary estimates are based on the following design standards and methodology:

- "Type F" sediment basins consistent with SD 6-4 (page 6-19, Landcom 2004);
- Sediment basin spillway capacity of 50 year ARI peak discharge;
- Total sediment basin volume = settling zone volume + sediment storage volume. The sediment storage volume is the portion of the basin storage volume that progressively fills with sediment until the basin is de-silted. The settling zone volume is the minimum required free storage capacity that must restored within 5 days after a runoff event;
- Sediment basin settling zone volume based on 90th percentile 5-day duration rainfall (35.9 mm) with an adopted volumetric event runoff coefficient for disturbed catchments of 0.35; and
- Sediment storage volume = 50% of settling zone volume.

The proposed sediment dams should be dewatered within 5 days after a runoff event to provide free storage capacity of at least the Settling Zone Volume shown in Table 6.1. Where TSS concentration in sediment dams after a runoff event is less than the selected water quality objective, sediment dams may be dewatered to receiving waters. Where TSS exceeds the water quality objective, water in basins must be either:

- Flocculated to reduce TSS to less than the water quality objective;
- Pumped to another water storage with available capacity; or
- Pumped in to the mine water management system.

Results from a previous surface water quality monitoring program (LMJ, 1986) indicate that Back Creek may have naturally high TSS levels. Hence, the water quality objective for releases from sediment dams will be established based on updated water quality sampling for Back Creek to be undertaken prior to commencement of the Project. This updated sampling will establish a relevant baseline TSS concentration for Back Creek.

Table 6.1 Sediment Dam Preliminary Sizing

Sediment Dam	Catchment Area (ha)	Settling Zone Volume (ML) [a]	Sediment Storage Volume (ML)	Minimum Total Design Dam Volume (ML)
SD 1	25	3.3	1.7	5
SD 2	349	48	23	71
SD 3	184	25	12	37
SD 4	220	30	15	45
SD 5	182	25	12	37
SD 6	29	3.9	1.9	6
SD 7	53	7.1	3.5	10

[a] Settling Zone Volume = minimum required free storage capacity that must be restored within 5 days after a runoff event.

6.4 SURFACE WATER MONITORING PROGRAM

Monitoring of surface water quality both within and external to the Project Boundary will form a key component of the surface water management system. Monitoring of upstream, on site and downstream water quality will assist in demonstrating that the site water management system is effective in meeting its objective of no adverse impact on receiving water quality.

Figure 6.1 shows proposed stream monitoring locations. Details of the proposed monitoring locations, including sample collection frequency and key water quality parameters to be monitored, are shown in Table 6.2. Table 6.2 also shows the proposed water quality monitoring program for water storages on site. All samples should be collected in a manner consistent with the Approved Method for Sampling and Analysis of Water Pollutants in NSW (DEC, 2004).

Table 6.2 Surface Water Quality Monitoring Program

Location		Parameters	Frequency
Maules Creek	SW1	Suite 1	Monthly if flowing Daily during runoff events
Namoi River	SW7 SW8	Suite 1	Monthly
Back Creek	SW3 SW10	Suite 2	Daily during runoff events
	SW9	Water level	Continuous
		Suite 2	Daily during runoff events
Site Clean Water Discharge Point	SW11	Suite 2	Daily during runoff events
Mine Water Dam		Suite 2	Monthly
Raw Water Dam & Sediment Dams		Suite 2	Monthly until baseline established, then quarterly
Dam overflows		Suite 1	Daily during overflows

Suite 1 = pH, EC, TSS, TDS, Turbidity
Suite 2 = Suite 1 + Major Anions, Major Anions, Alkalinity, Metals

6.5 RESIDUAL IMPACTS

Residual impacts of the Project will include:

- If mining ceases after Year 21 of the Project, a permanent loss of catchment area of about 887 ha from Back Creek. This represents about 14% of the Back Creek catchment area to the downstream Project Boundary.
- Creation of a permanent Final Void lake that is likely to increase in salinity over time. The water level of the lake will take hundreds of years to stabilise at a level about 100 m below the surrounding ground level.

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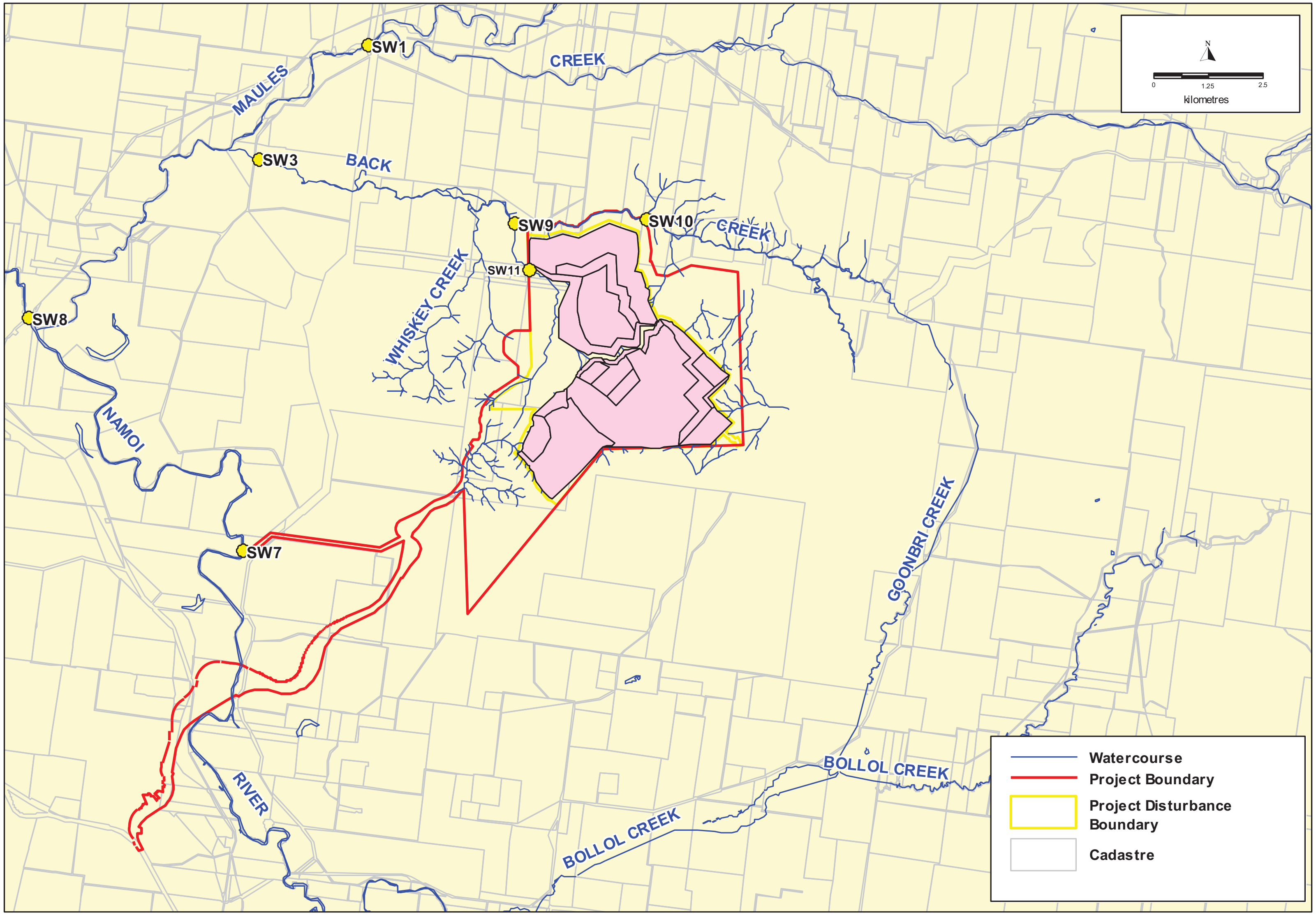

Figure 6.1 Proposed Stream Water Quality Monitoring Locations

7 SUMMARY OF FINDINGS

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

- Net water demand for the operation of the mine can be met through an existing high security water licence held by Aston Resources. This high security allocation is an existing entitlement which is allowed for in the Water Sharing Plan. Hence, water taken by the mine will not reduce the entitlements of other water users accessing the Lower Namoi Water Source;
- The Project will have no impact on flood behaviour along Back Creek for flood event up to 100 year Average Recurrence Interval;
- The proposed water management system will ensure the separation of clean and dirty water on the site and that no spills occur from the Mine Water Dam which is likely to contain water with elevated concentrations of salt and other pollutants; and
- Simulation of the water balance for the Final Void indicates that the water level will take several hundred years to reach an equilibrium level. The long term equilibrium level is more than 100 m below the overflow level of the Final Void.
- Simulation of water quality in the Final Void indicates that salinity will gradually increase over time. Due to the low salinity of leachate and surface runoff, salinity will increase at a very slow rate. The rising salinity level in the Final Void will have no adverse impact on surface water or groundwater because the Final Void will never spill and groundwater will flow into, rather than out of, the Final Void.

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