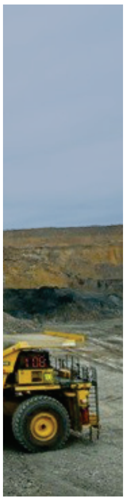
Cameby Downs Mine






Cameby Downs Continued Operations Project

Environmental Values Assessment

APPENDIX A

Surface Water Assessment

YANCOAL
兖煤澳大利亚有限公司

Cameby Downs Mine Continued Operations Project - Surface Water Assessment

Syntech Resources Pty Ltd

0928-07-G10, 11 September 2018

Report Title	Cameby Downs Mine Continued Operations Project - Surface Water Assessment
Client	Syntech Resources Pty Ltd Cameby Downs Mine Site Ryalls Road Miles Qld 4415
Report Number	0928-07-G10

Revision Number	Report Date	Report Author	Reviewer
0	11 September 2018	HM	SM

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Director

EXECUTIVE SUMMARY

Overview

Syntech Resources Pty Ltd (Syntech), has lodged an amendment application to the Cameby Downs Mine (CDM) Environmental Authority (EA) EPML00900113 in accordance with Section 224 of the Queensland Environmental Protection Act 1994 (EP Act) to approve the Cameby Downs Mine Continued Operations Project (the CDCOP). The CDM is owned and operated by Syntech and is managed by Yancoal Australia Ltd.

The CDM is located approximately 280 kilometres (km) west-north west of Brisbane in the Western Downs Regional Council (WDRC) local government area. The CDM has been operating for eight years, with excavation of overburden commencing in July 2010 and the first coal excavated in August of that year. The coal handling and preparation plant (CHPP) was commissioned in November 2010 with the first railing of coal occurring in December 2010.

The CDCOP involves the extension of operations within Mining Lease (ML) 50233 and into Mining Lease Applications (MLAs) 50258, 50259, 50260 and 50269. The run-of-mine (ROM) coal mining rate will increase from the currently approved 2.8 million tonnes per annum (Mtpa) to 3.5 Mtpa. The CDCOP life is for 75 years. The CDCOP water management system was modelled over four (4) mine stages using the mine disturbance footprints:

- Existing (Stage 0) - 10 years from 2018 to 2027 based on the existing mine footprint;
- Year 29 (Stage 1) - 20 years from 2028 to 2047 based on the Year 29 mine plan;
- Year 48 (Stage 2) - 20 years from 2048 to 2067 based on the Year 48 mine plan; and
- Year 75 (Stage 3) - 25 years from 2068 to 2092 based on the Year 75 Mine plan (completion of mining).

WRM has prepared this Surface Water Assessment (SWA) for the CDCOP in compliance with the Department of Environment and Science (DES) (formally Department of Environment and Heritage Protection) Guideline Application Requirements for Activities with Impact to Water (ESR/2015/837) (DES, 2018).

An integrated water management system has been developed for the CDCOP to manage water surpluses and deficits during distinct wet and dry seasons, as well as climatic variations from year-to-year. A daily water balance model was used to develop an annual site water balance and demonstrate that the proposed CDCOP can adequately accommodate the seasonal fluctuations and periodic significant shortfalls and surpluses expected over the life of the mine (LOM).

Surface Water Management Strategy

The proposed CDCOP surface water management strategy will use a number of existing surface water management measures as well as a number of additional surface water management measures that will be implemented during the different mine stages.

For surface water management purposes, the surface runoff generated at CDM is divided into three types based on water quality:

- 'Diverted' water – surface runoff from areas of the CDCOP where water quality is unaffected by mining operations. Diverted water includes runoff from undisturbed areas which is diverted around the mine site where possible;
- 'Surface' Water – surface runoff water and seepage from the CDCOP areas that are disturbed by mining operations such as overburden spoil dumps and roads. This runoff may contain silt and sediment but is unlikely to contain contaminant concentrations in excess of the CDM EA condition release limits and trigger levels for key water quality parameters. However, this runoff must be of suitable quality if discharge into receiving waters is required; and

- ‘Worked’ Water – surface runoff water and seepage from CDCOP areas affected by mining operations and potentially containing chemicals (e.g. hydrocarbons) of various types generated by mining operations. Areas where hazardous waste can potentially be generated include the open pit, service bays, fuel storage areas, and process areas. Runoff from these areas must be managed to avoid discharge of potentially contaminated water into the receiving waters. There are restrictions on the use and release of this water.

The surface water management system proposed for CDCOP mining operations includes:

- clean water drains to control ‘diverted’ runoff from undisturbed areas around disturbed areas, runoff from rehabilitated overburden and releases from sediment management structures;
- ‘surface’ water drains and sediment management structures to capture and manage sediment laden runoff from disturbed areas; and
- mine water storages to manage ‘worked’ runoff on-site.

The surface water management at CDM for the CDCOP are as follows;

- Separate ‘diverted’, ‘surface’ and ‘worked’ water runoff as much as possible;
- Minimise the area of surface disturbance, thus limiting the volume of ‘surface’ and/or ‘worked’ runoff and at the same time limit ‘external’ water supply requirements;
- Manage ’worked’ and ‘surface’ water on site via containment storages or sediment dam’s dependant on the quality of water likely to be generated;
- Release ‘surface’ water following sediment removal through a sediment management structure (e.g. sediment dams), provided water quality is within the CDM EA water quality release limits;
- Segregate, collect and contain all ‘worked’ water runoff as much as possible on site via adequately sized containment storages;
- Provide permanent pumping infrastructure to allow transfer of ‘worked’ water between containment storages as required, to limit the potential for worked water overflows to the receiving waters and build-up of water in active open pits; and
- Limit ‘diverted’ and ‘external’ water consumption and prioritise the reuse of ‘surface’ and ‘worked’ water within the mine site (e.g. for coal washing).

CDM propose to continue sourcing ‘external’ water from Queensland Gas Corporation’s (QGCs) Glen Eden Pond to meet shortfalls for the on-site water demands when they cannot be met by on-site sources. This ‘external’ water extracted during QGCs coal seam gas operations is supplied to CDM (via a pipeline from Glen Eden Pond).

Proposed Surface Water Management System

The proposed surface water management system has been designed and developed to achieve the surface water management objectives described above. The adopted water management measures include:

- Three proposed (3) new clean water drains to direct ‘diverted’ runoff around disturbed areas using diversion banks and drains;
- Sixteen (16) sediment dams around the perimeter of the active spoil dumps to manage surface runoff. Surface water drains will be constructed to capture and direct surface runoff into these sediment dams. Sediment dams have been sized to provide sufficient volume to capture runoff from the 5 Year average recurrence interval (ARI) 24-hour storm in accordance with CDM’s Plan of Operations;
- Use of up to twelve (12) existing and proposed new containment storages to collect and manage ‘worked’ water at the CDM site. The proposed containment storages will be classified as low, significant or high consequence storages, in accordance

with guidelines given in DEHP (2016). Design storage allowances (DSA) and Extreme Storm Storage (ESS) volumes for significant and high consequence storages have been calculated in accordance with guidelines given in DEHP (2016);

- Disposal of fine rejects in above ground rejects dams, in pit disposal and integrated waste landforms within the back filled open pit (Pit 1). The majority of fine rejects will be deposited in pit and coarse rejects will be placed in backfilled pit spoil throughout the life of the CDCOP;
- Operation of the proposed significant and high consequence storages such that the appropriate DSA volume is available on 1st November each year. This may be achieved by transferring water for makeup water in the CHPP or inactive pits. The worked water dams may provide part of the required DSA volume, if necessary;
- Provision of the DSA requirements for open pits within inactive pits during mining operations. When the combined open pit water inventory exceeds 50 ML, water will be pumped to a water management dam (WMD). Water stored in WMDs will then be used as on on-site water source; and
- Use of 'external' water to make up water shortfalls for on-site water demands when on-site sources cannot meet demand. This water will be pumped from QGS Glen Eden Pond to the worked water dams, as required.

Water Balance

The water balance model OPSIM was used with a daily-time step over the 75 year CDCOP period, using 128 years of climatic data to simulate the long-term behaviour of the proposed CDM water management system and determine the mine site water balance for existing and proposed CDCOP mining conditions. The model is based on the calibration undertaken previously by WRM (WRM, 2012).

All water demands for the CDCOP operations will be met through a combination of on-site water sources, water recycled from the fine rejects and water imported from QGCs Glen Eden Pond.

Two surface water management cases were assessed:

- Base case – 'external' water required when harvesting of on-site sediment dams is not possible; and
- Alternate case – 'external' water required in preference to harvesting from on-site sediment dams.

The water balance model results indicate that:

- The CDCOP will be, over the long-term, a net producer of water due to the significant overburden runoff volumes generated when compared to the site demands for the CHPP, dust suppression and miscellaneous water consumption. Under the base case, site only requires 'external' QGC water during Existing (Stage 0) and Year 29 (Stage 1) conditions for periods of low rainfall;
- Site will require a water management dam or inactive void to store excess 'worked' water generated on-site;
- Periodic releases of water from sediment dams would occur via the dam spillways. Any sediment dam releases are predicted to only occur during significant flow events in the receiving waters;
- The OPSIM model was used to assess the release (spill) scenarios from Sediment Dam 1 and MIA Dam against the proposed release conditions. No other dams are predicted to release. The release scenarios that were investigated include:
    - Scenario 1 – The highest EC release from Sediment Dam 1;
    - Scenario 2 – The highest flow rate release from Sediment Dam 1; and
    - Scenario 3 – The highest EC and flow rate release from MIA Dam.

Results show there are no release limit exceedances from sediment dams and MIA Dam or trigger level exceedances in downstream water quality for salinity for either case assessed; and

- The CDCOP will be a net producer of water for median climate conditions (50% confidence trace) for all mine stages. Under 90th percentile (dry) climate conditions, the site will require:
    - up to 283 ML/yr of 'external' water (annual maximum) during Existing (Stage 0).
    - up to 148 ML/yr of 'external' (annual Maximum) during Year 29 (Stage 1).

The water balance modelling results indicate that the proposed water management system is robust and has adequate storage capacity to manage surface water runoff generated within the CDCOP site for a wide range of possible climatic conditions, including extended wet and dry periods. The water balance modelling results also indicate the potential for 'worked' water at the CDCOP site overflowing into receiving waters is very low (greater than 100 year ARI (less than 1% AEP)).

Pumped releases to the environment from regulated mine water storages and sediment dams were not modelled for CDCOP operations at CDM. Notwithstanding this, pumped releases from these storages to the environment from mine water dams and sediment dams may be undertaken if the water quality is within the release limits and downstream receiving water trigger levels specified in the proposed Cameby Downs EA conditions, subject to its approval.

Potential Constraints to Proposed Mining Activities

This SWA has been developed using the available water quantity and quality data for QGC water at the time of preparing this report. It has been assumed that QGC water will be available to make up all water shortfalls during CDCOP operations. The future availability of water should be regularly monitored in the coming years to confirm the assumptions that have been made in this study and to make refinements to the proposed water management plan as required.

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1 INTRODUCTION

1.1 GENERAL

Syntech Resources Pty Ltd (Syntech), has lodged an application to amend the Cameby Downs Mine (CDM) Environmental Authority (EA) EPML00900113 in accordance with Section 224 of the Queensland Environmental Protection Act 1994 (EP Act) to approve the Cameby Downs Mine Continued Operations Project (CDCOP). The CDM is owned and operated by Syntech and is managed by Yancoal Australia Ltd. A locality plan of the CDM site is shown in Figure 1.1.

The CDM is located approximately 280 kilometres (km) west-north west of Brisbane in the Western Downs Regional Council (WDRC) local government area. The CDM has been operating for seven years, with excavation of overburden commencing in July 2010 and the first coal excavated in August of that year. The coal handling and preparation plant (CHPP) was commissioned in November 2010 with the first railing of coal occurring in December 2010.

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- Existing (Stage 0) - 10 years from 2018 to 2027 based on the existing mine footprint;
- Year 29 (Stage 1) - 20 years from 2028 to 2047 based on the Year 29 mine plan;
- Year 48 (Stage 2) - 20 year period from 2048 to 2067 based on the Year 48 mine plan; and
- Year 75 (Stage 3) - 25 year period from 2068 to 2092 based on the Year 75 Mine plan (completion of mining).

Full details of the CDCOP are provided in the Environmental Values Assessment (EVA).

Syntech is seeking approval of the CDCOP through a major amendment of the EA in accordance with Chapter 5, Part 7, Section 224 of the EP Act. The EA amendment application was lodged with the Department of Environment and Heritage Protection (DEHP) on 21 November 2016. DES subsequently made its Assessment Level Decision on 30 November 2016 that the proposed amendment is a major EA amendment application. DES issued an Information Request on 12 January 2017 to request additional information from Syntech to enable it to make a decision on the application.

Syntech has responded to DES's Information Request through an EVA. The EVA is required to assess the potential environmental impacts associated with the development of the CDCOP in accordance with the DES's Information Request. Table 1.1 shows the DES information request items addressed in this report, which have been prepared in support of the EVA.

Table 1.1 – DES information request items addressed

Information request Item	Request Details	Report Section
2 a) (i)	*Consideration of the requirements in the Departmental guideline: Application requirements for activities with impacts to water (ESR/2015/1837)*	
2 a) (ii)	*a description of the project surface water management system including clean and dirty water management and any proposed releases to the receiving environment*	Sections 5 and 7
2 a) (iii)	*revision of the existing site water balance model to include the proposed expansion*	Sections 8
2 a) (iv)	*an assessment of potential impacts of any release to the receiving environment*	Section 8
2 b) (i)	*Location of all proposed release points (latitude and longitude in decimal degrees, GDA94) including map detailing the locations*	Section 9
2 b) (ii)	*Description of the receiving environment at any proposed release point*	Sections 3 and 9
2 b) (iii)	*The source, quality and quantity of all proposed releases*	Sections 6 and 8
2 b) (iv)	*the source, quality and quantity of all mine affected water*	Sections 6 and 8
2 b) (v)	*An assessment of the potential impacts to environmental values from the additional release*	Section 8
2 b) (vi)	*An assessment of whether the additional release(s) will achieve the existing Cameby Downs Mine environmental authority water release conditions*	Section 8
2 b) (vii)	*the proposed containment, management and disposal systems for all mine affected water*	Sections 5 and 7

1.2 REPORT STRUCTURE

This report is structured as follows:

- Section 2 describes the regional and local catchment and drainage characteristics in and around the CDM site;
- Section 3 describes the available rainfall, evaporation and streamflow data for the CDM site;
- Section 4 presents the environmental values for the CDCOP;
- Section 5 describes the objectives of the surface water management strategy for the CDM site. The potential constraints to the proposed mining activities with respect to surface water management are also discussed;
- Section 6 describes the contaminant source study undertaken for the CDCOP;
- Section 7 describes the existing and proposed surface water management system at the CDCOP;
- Section 8 presents details and results of the water balance modelling undertaken for the CDCOP;
- Section 9 present the surface water monitoring requirements and cumulative impacts assessment for the CDCOP; and
- Section 10 provides a list of references.

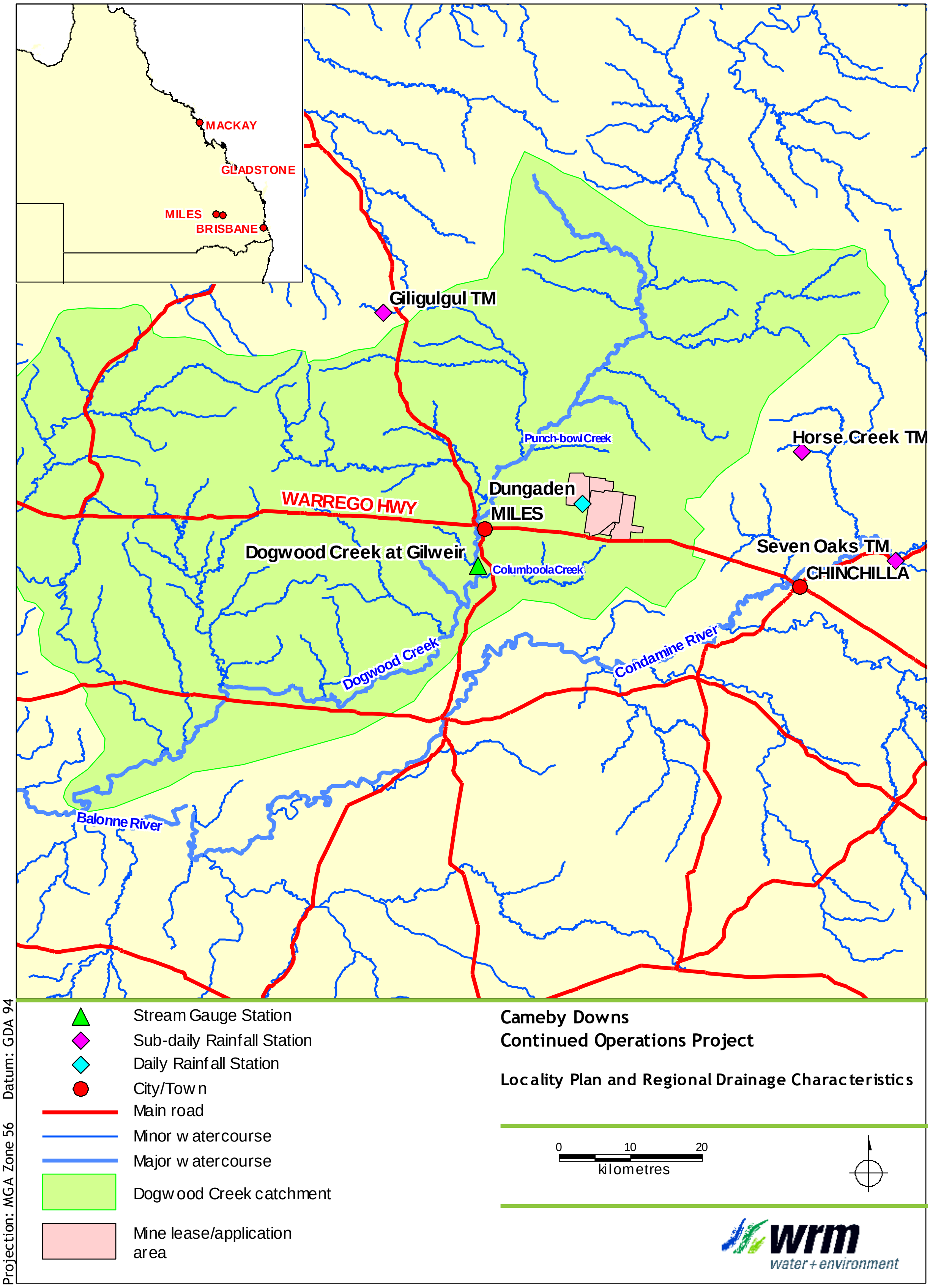

Figure 1.1 - Locality plan and regional drainage characteristics, Cameby Downs Mine

2 CATCHMENT AND DRAINAGE CHARACTERISTICS

2.1 OVERVIEW

The proposed CDCOP is located in the Surat Basin, approximately 360 km west-north west of Brisbane and near the township of Columboola, between Miles and Chinchilla. The CDCOP mine lease area covers approximately 69.5 km^2 and comprises several mining tenements including the existing Cameby Downs Coal Mine mining lease (ML) 50233 and additional mining lease applications (MLA) 50258, MLA 50259, MLA 50260 and MLA 50269. The CDCOP surface development limit within these ML and MLA's is approximately 69.5 km^2 in area. Figure 2.1 and Figure 2.2 show the local and regional drainage features respectively in the vicinity of CDM.

The existing land use within the catchment is primarily grassland (grazing) with some sparse areas of remnant vegetation and current Cameby Downs infrastructure and pit operation areas.

2.2 REGIONAL CATCHMENT CHARACTERISTICS

The CDCOP site is located within the Columboola Creek and Punch-bowl Creek catchments. These catchments are tributaries of Dogwood Creek, which is a major tributary of the Condamine River. The Condamine River drains in a southwesterly direction to the south of Chinchilla and Miles and becomes the Balonne River, a major tributary of the Murray-Darling Basin, approximately 20 km upstream of its confluence with Dogwood Creek.

Descriptions of these regional catchments are given below.

- The Condamine-Balonne River system is predominantly located in Southern Queensland, but also extends about 100 km into northwest New South Wales. This system has a catchment area of 136,642 km^2, representing around 13% of the total catchment area of the Murray-Darling Basin. The catchment of the Condamine River to its confluence with Dogwood Creek is 37,000 km^2. The flow conditions in the Condamine river are shown in Figure 2.3 and Figure 2.4. which indicate that The Condamine River flows less than 70% of the year.
- Dogwood Creek is an ephemeral creek that flows southwest to the west of the mining lease and drains to the Condamine River. Its confluence with Columboola Creek and the Condamine River are approximately 19 km and 85 km southwest of the CDCOP area respectively. The catchment area of Dogwood Creek to its confluence with the Condamine River is some 6,630 km^2. The flow conditions in Dogwood Creek are shown in Figure 2.5 and Figure 2.6 which indicate that Dogwood Creek is ephemeral and flows less than 40% of the year.
- Columboola Creek commences to the south of the CDCOP area and drains in a westerly direction to Dogwood Creek. It has a catchment area of approximately 432 km^2 to Dogwood Creek. The majority of the CDCOP area drains into Columboola Creek via three drainage features, named in this report as Drainage Line 1, Drainage Line 2, and Drainage Line 3. Another drainage feature, called Drainage Line 4, drains into Columboola Creek to the south of the CDCOP area (see Figure 2.1).
- Punch-bowl Creek drains in a westerly direction about 5 km to the north of the CDCOP and has a catchment area of 124.2 km^2 to its confluence with Dogwood Creek. The northern portion of the CDCOP area drains into Punch-bowl Creek via three headwater drainage features, named in this report as Drainage Line 5, Drainage Line 6 and Drainage Line 7 (see Figure 2.1).

2.3 LOCAL DRAINAGE CHARACTERISTICS

Figure 2.1 shows the local drainage features that cross the CDCOP area. The Queensland Department of Natural Resources, Mines and Energy (DNRME) have advised that the main drainage feature (Drainage Line 1) is not a watercourse as defined by the Water Act (2000). Therefore, it has been assumed that the smaller drainage features, which have similar characteristics, are also not watercourses. Description of these drainage features are as follows:

- Drainage Line 1 drains in an easterly and then in a southerly direction across the CDCOP site to Columboola Creek. Its catchment includes a number of other minor drainage features, which combine with Drainage Line 1, captures the majority of the CDCOP site. The upper headwaters of the catchment commence upstream to the east of the CDCOP site.
- Drainage Line 2 drains through the southwestern portion of the CDCOP to the southern mining lease boundary. It then continues in a southeasterly direction and discharges into Drainage Line 1 just upstream of the Western Railway and Warrego Highway. It has been diverted around the existing rail loop on the CDCOP.
- Drainage Line 3 drains through the southeastern portion of the CDCOP before discharging through the Warrego Highway and the Western Railway embankments (via bridges and culverts) and joins Drainage Line 1 about 1 km downstream of the CDM site.
- Drainage Line 4 drains in a southwest direction to the south of the CDCOP, the Western Railway and the Warrego Highway, where it joins Drainage Line 3. The catchment area of Drainage Line 4 is approximately 114.1 km^2.
- Drainage Lines 5, 6 and 7 drain the northern sections of the CDCOP to Punch-bowl Creek.

The upper reaches of the drainage features consist of scattered forest areas whereas the lower reaches have been cleared for grazing.

Table 2.1 summarises the catchment areas and the potential areas occupied by the CDCOP surface development limit within each of the catchments described above.

Table 2.1 - Catchment areas and areas occupied by CDCOP surface development limit

Receiving waters	Catchment area (km^2)	Area Occupied by CDCOP development limit (km^2)	Percent of catchment occupied by CDCOP surface development limit (%)
Condamine/Balonne River	37,000	78.4	0.2[a]
Dogwood Creek	6,630	74	1.2
Columboola Creek	432	61.3	14
Drainage Line 1	46.8	39.8	85
Drainage Line 2	12.5	2.8	22
Drainage Line 3	59.7	16.3	27
Punch-bowl Creek	124.2	12.7	10.2
Drainage Line 5	30.3	3.1	10.2
Drainage Line 6	19.1	7.1	37.2
Drainage Line 7	37.0	2.4	6.4

2.4 LOCAL DRAINAGE FLOW CHARACTERISTICS

Stream flows are recorded in both Drainage Line 1 and Drainage Line 2 at the locations shown in Figure 2.1. Figure 2.7 shows the flow duration relationship in Drainage Line 1 at WS1 and in Drainage Line 2 at WS3 for the period of 2014 to 2017. At WS1, flows were recorded or pooled water was present on approximately 60% of the days and has a 10th percentile flow rate of approximately 4.4 ML/day. At WS3, flows were recorded or pooled water was present on approximately 44% of the days and has a 10th percentile flow rate of approximately 4.7 ML/day.

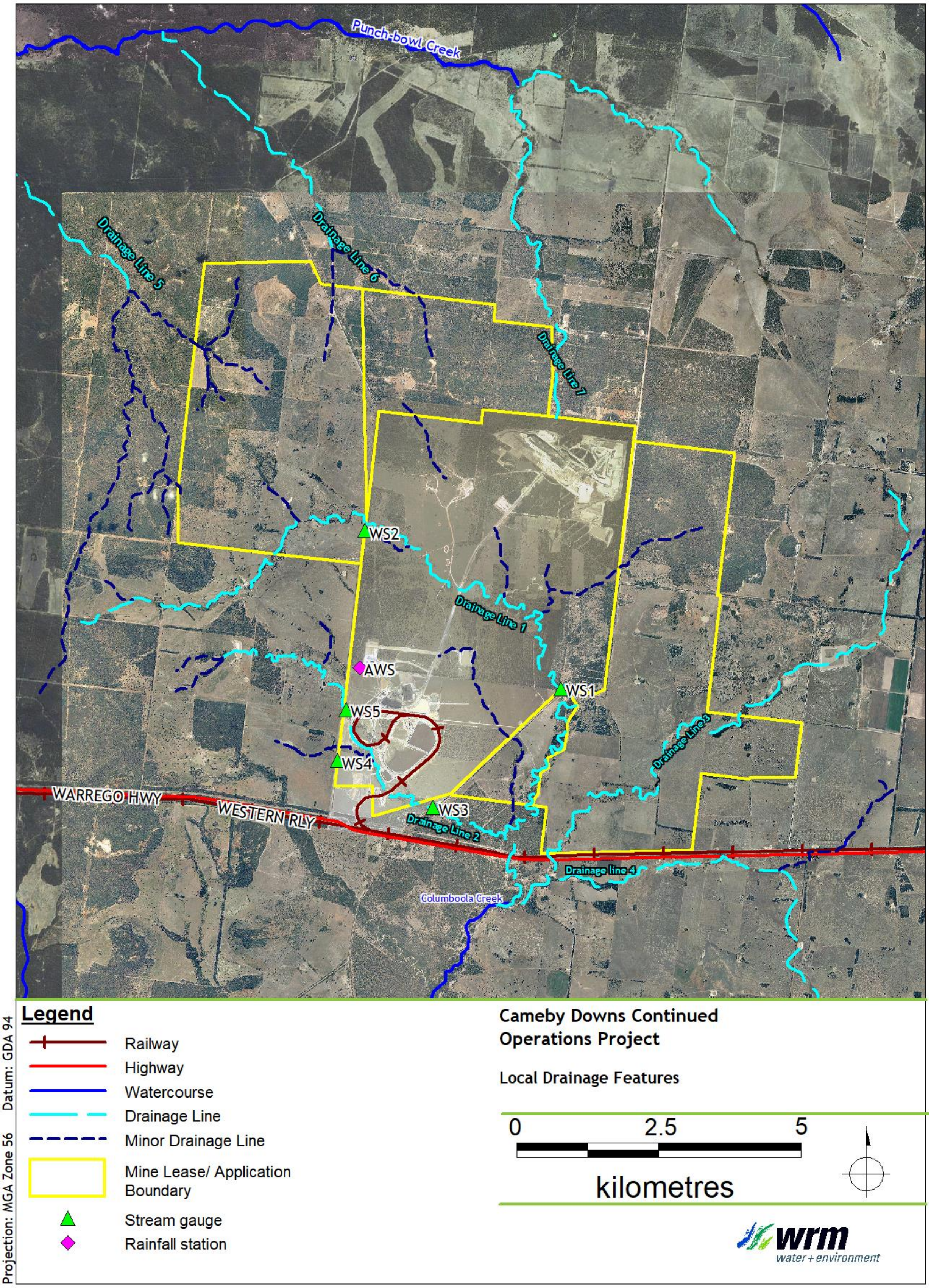

Figure 2.1 - Cameby Downs Mine local drainage features

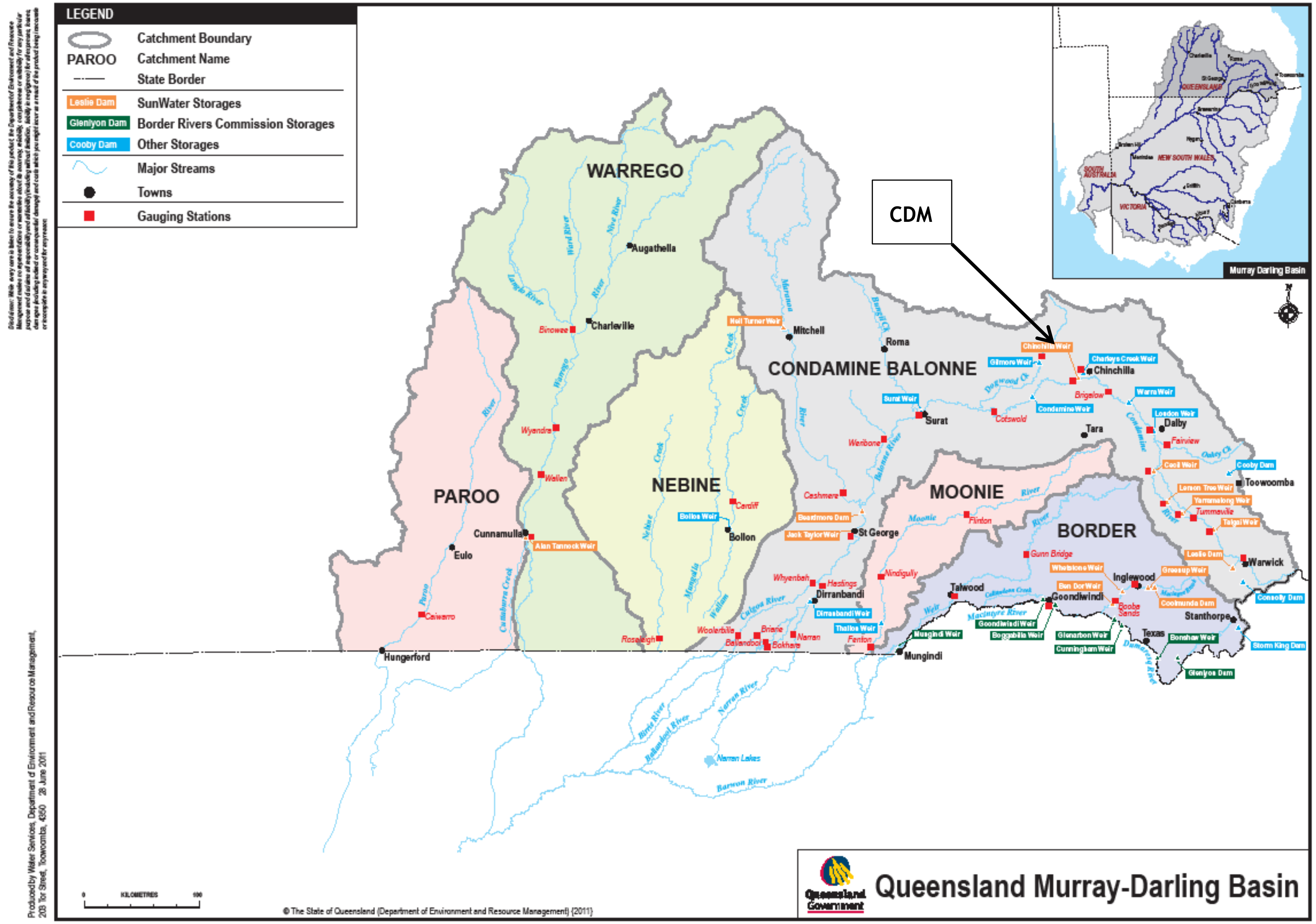

Figure 2.2 – Regional drainage features

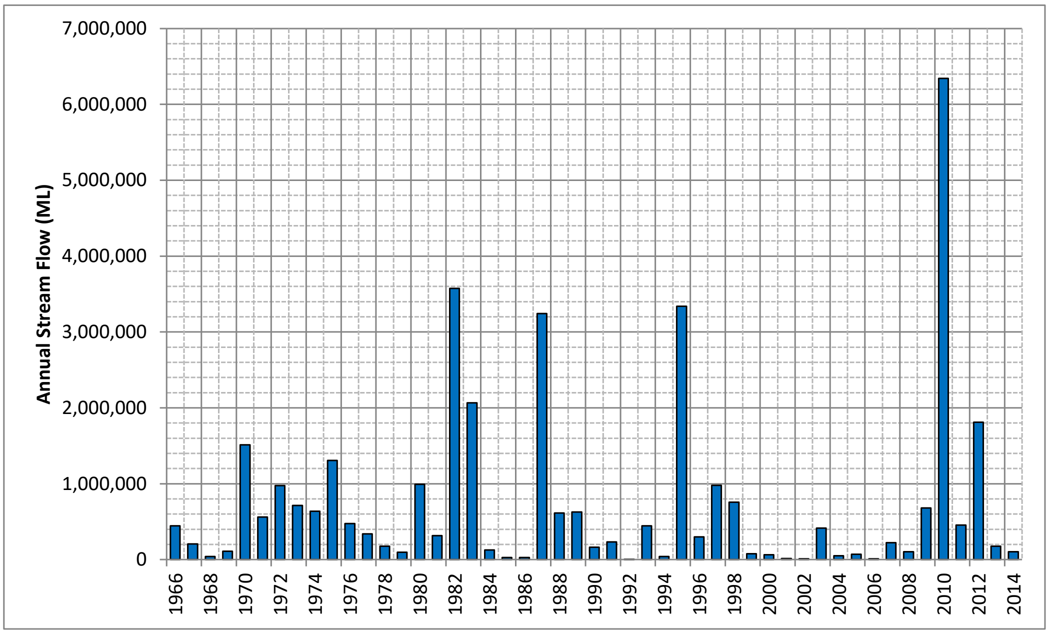

Figure 2.3 - Condamine River at Cotswold (No. 422325A) historical annual flow volumes (ML)

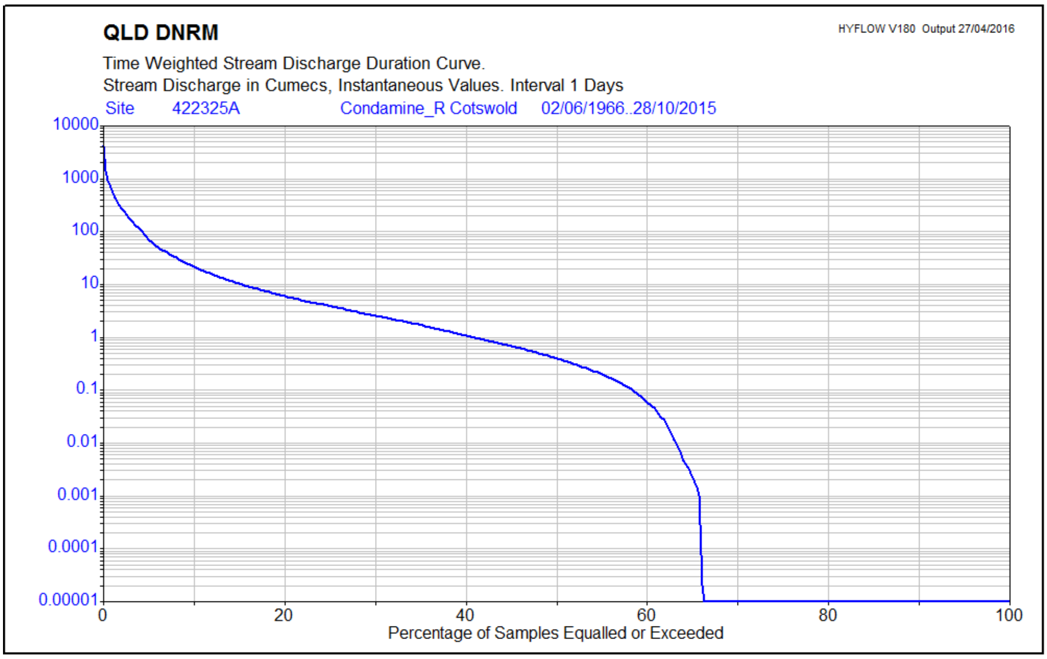

Figure 2.4 - Condamine River at Cotswold (No. 422325A) daily flow duration curve

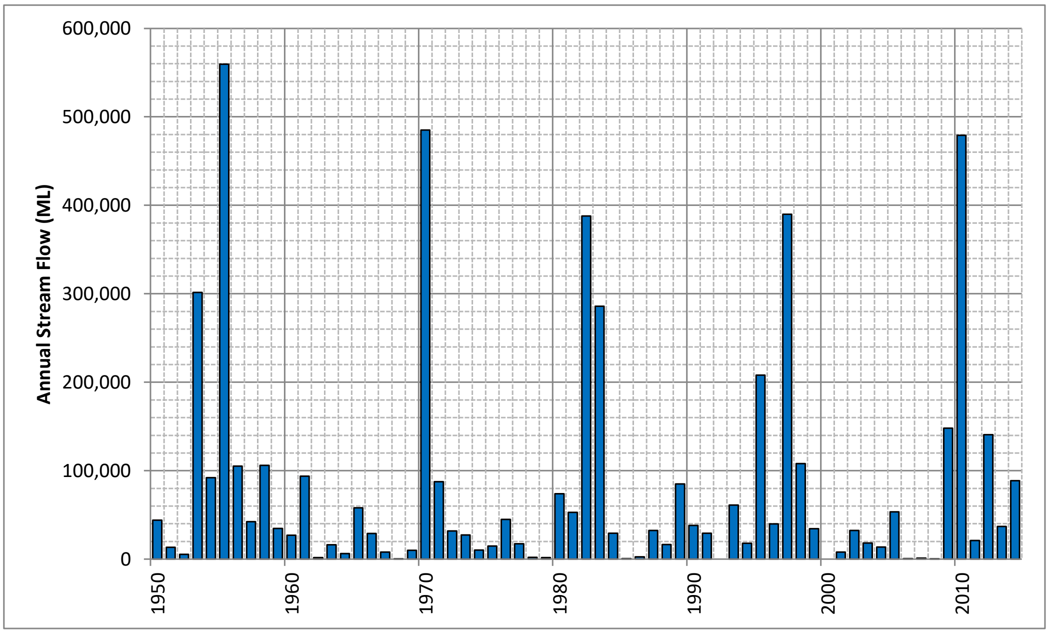

Figure 2.5 - Dogwood Creek at Gilweir (No. 422202A) historical flow volumes

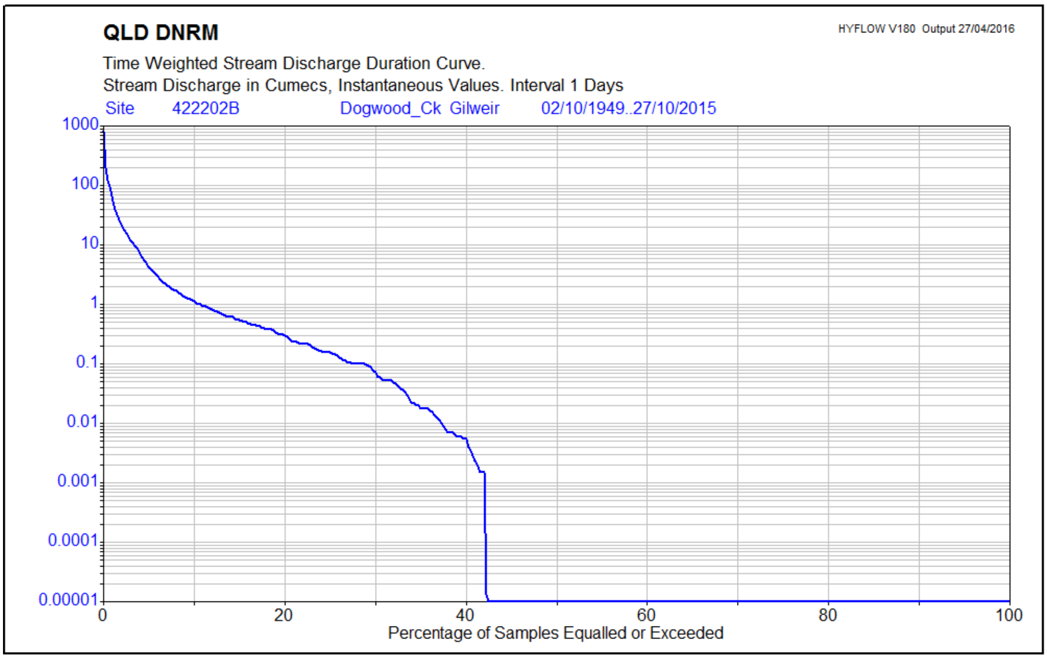

Figure 2.6 - Dogwood Creek at Gilweir (No. 422202A) daily flow duration curve

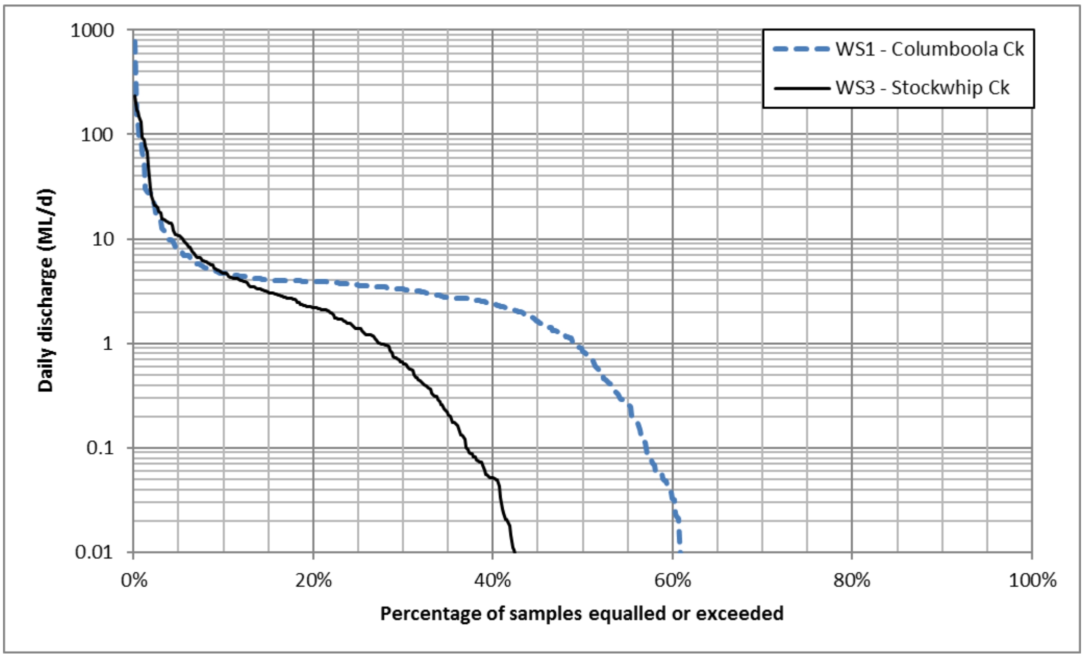

Figure 2.7 - Daily flow duration curves for Drainage Line 1 and Drainage Line 2 between 2014 and 2016

3 AVAILABLE DATA

3.1 CLIMATE DATA

The CDM site has a sub-tropical climate regime with distinct wet (October to March) and dry (April to September) seasons. The average daily minimum and maximum temperatures at Miles (near Cameby Downs) range between $4^{0}C$ (in July) and $33^{0}C$ (in January). The monthly and annual rainfall and evaporation variations at Cameby Downs are described below.

3.2 RAINFALL AND EVAPORATION

3.2.1 Available data

Table 3.1 shows summary details of rainfall recording stations located within the vicinity of CDM for the respective periods of record from the Commonwealth Bureau of Meteorology (BoM) and DNRME. The locations of the various stations are shown in Figure 1.1

In addition, synthetic rainfall data was available for the CDM site from the Queensland Climate Change Centre of Excellence (QCCCE) SILO Data Drill Service. The CDM site SILO Data Drill data have been derived by interpolation of recorded rainfall data between regional stations as described by Jeffreys et al. (2001). The Data Drill Service has provided a continuous daily rainfall data set over the 128 years between 1889 and 2017.

Evaporation data was also available for the CDM site from the SILO Data Drill Service.

Table 3.1 - Summary details of rainfall and stream gauging stations

Station ID (See Figure 1.1)	Station Number	Station Name	Station Type	Period of Record
1	42025	Horse Creek	Continuous	1999 - Current
2	41020	Seven Oaks	Continuous	1998 - Current
3	35029	Giligulgul	Continuous	1998 - Current
4	42109	Dungaden	Daily	1976 – 2013 (closed)
5	422202B	Dogwood Creek at Gilweir	Stream Flow	1949 - Current
6	042023	Mile Post Office	Daily	1989 - Current

3.2.2 Rainfall

Table 3.2 compares mean monthly and annual rainfalls recorded at the Miles Post Office daily rainfall station (No. 042023) with the SILO Data Drill data for the 128 year period of record (1889 - 2017). Annual values are shown for "water years", commencing in October.

The recorded mean monthly and annual rainfalls at Miles Post Office correlate well with the Data Drill data for the 128 year period of data. The average monthly rainfalls at CDM exhibit distinctly wet (October to March) and dry (April to September) seasons during the year, with a dry season low of 27.7 mm in August and a wet season high of 88.6 mm in December. The wet season average monthly rainfalls (54.2 mm to 88.6 mm) are significantly higher than the equivalent dry season monthly rainfalls (27.7 mm to 38.6 mm). The recorded mean annual rainfall at the Miles Post Office site over the period 1889 to 2017 is approximately 650 mm.

Figure 3.1 shows the variation of SILO Data Drill mean monthly rainfall and pan evaporation at the Cameby Downs site.

Table 3.2 - Mean monthly and annual rainfall and evaporation at the Cameby Downs site

Month	Mean Monthly Rainfall and Evaporation (mm) (1889 - 2017)		
	Mile Post Office (042023)	Data Drill Rain	Data Drill Pan Evaporation
October	53.4	54.2	192.7
November	64.5	64.0	213.6
December	91.2	88.6	233.9
January	96.1	88.2	231.3
February	73.6	72.7	192.0
March	59.7	58.9	182.3
April	36.2	33.7	134.5
May	38.8	36.9	94.6
June	39.3	38.6	70.4
July	36.5	35.5	79.5
August	29.5	27.7	110.3
September	32	31.4	149.5
Annual	**651 mm/yr**	**630 mm/yr**	**1885 mm/yr**

3.2.3 Evaporation

Table 3.2 also shows the mean monthly and annual (pan) evaporation values obtained from the Data Drill data for the 128 year period between 1889 and 2017.

The average annual pan evaporation at the CDM site is estimated to be approximately 1,885 mm, which is approximately 3 times the average annual rainfall. The evaporation rate is high throughout the year, with the highest evaporation rates occurring in the months between October and March. Evaporation rates are generally much higher than rainfall in all months.

3.3 STREAMFLOW DATA

CDM operates stream gauging stations on Drainage Line 1 at WS1 and Drainage Line 2 at WS3 located at the downstream boundary of the current ML boundary (see Figure 3.4). A DNRME stream gauging station (Stn. No. 422202B) is located on Dogwood Creek at Gilweir about 1.8 km upstream of its confluence with Columboola Creek and about 17.7 km southwest of the CDCOP area. The Dogwood Creek, Drainage Line 1 and Drainage Line 2 gauging stations provide an indication of the likely flow behaviour in the receiving environment downstream of the CDM site.

Figure 3.2 shows the variation in Dogwood Creek flows at Gilweir between 2003 and 2016. Dogwood Creek is an ephemeral creek that is dry (does not have recorded surface flows) for prolonged periods of time particularly during the dry season (between April and September). Based on the recorded data, Dogwood Creek remained effectively dry for a number of years during the major drought that occurred between 2006 and 2009.

Figure 3.3 shows the variation in the Drainage Line 1 and Drainage Line 2 flows at the ML boundary between 2014 and 2016. Drainage Line 1 and Drainage Line 2 are also ephemeral with significant flows ceasing soon after rainfall.

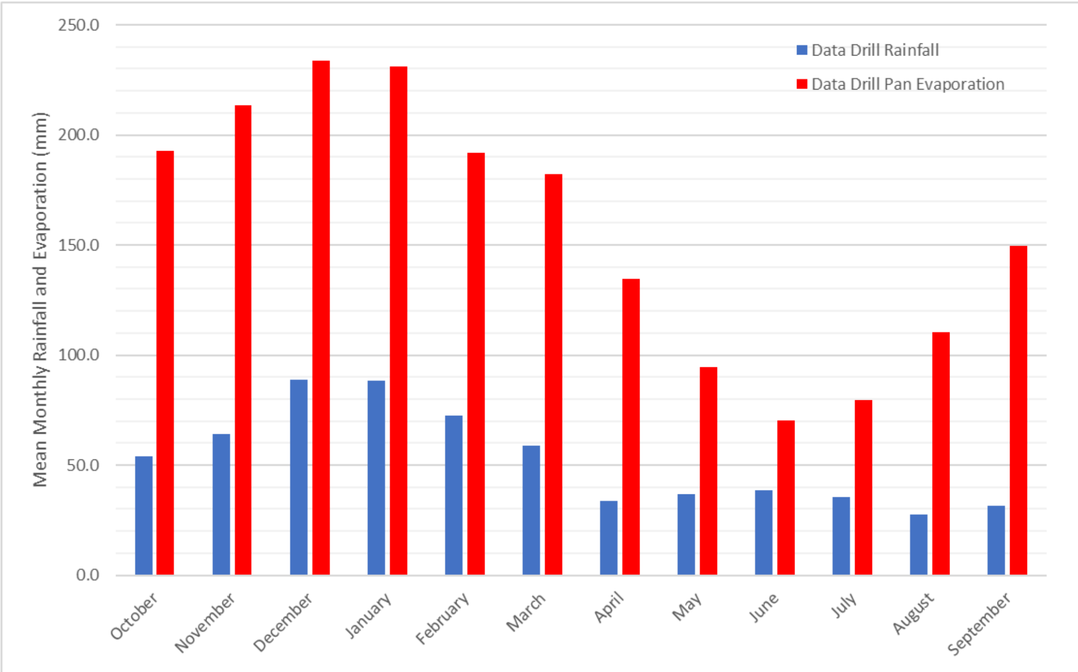

Figure 3.1 - Variation in SILO Data Drill monthly rainfall and evaporation at the Cameby Downs Mine, 1889-2017

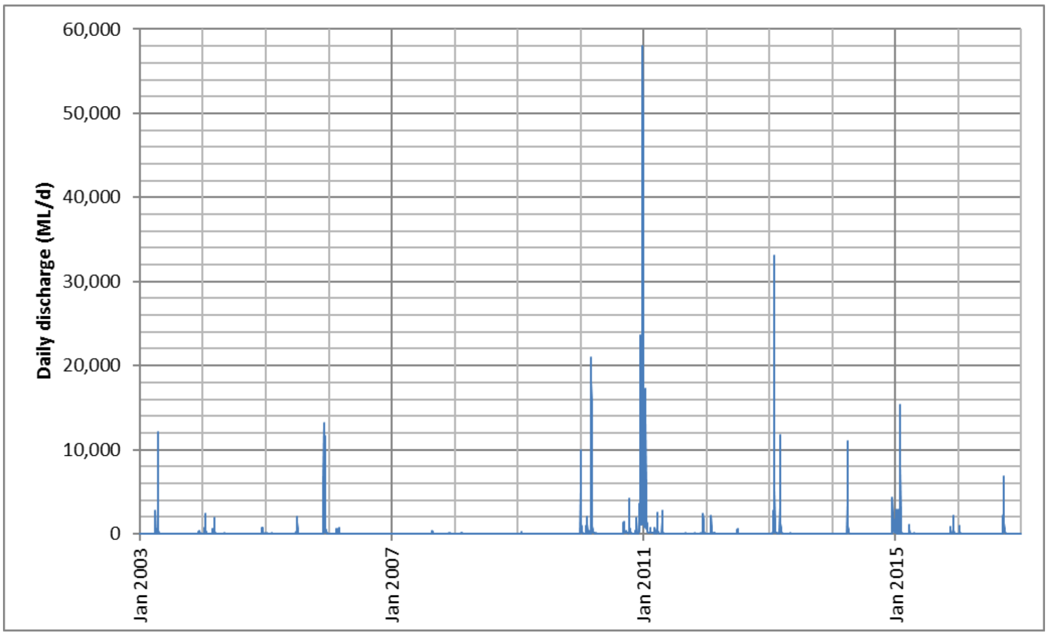

Figure 3.2 - Dogwood Creek flow variation at Gilweir between 2003 and 2016

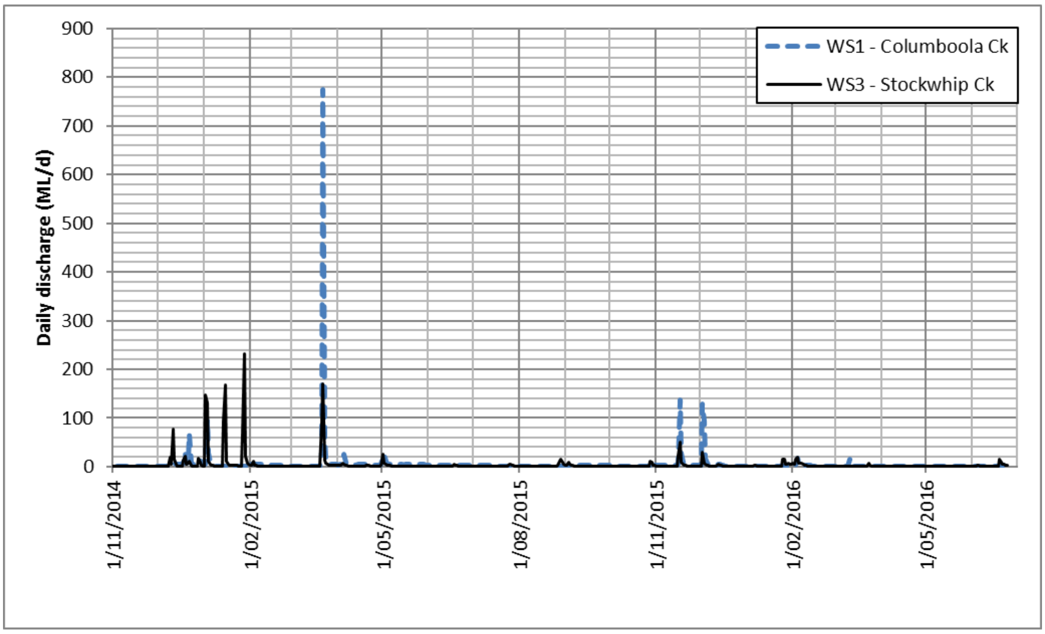

Figure 3.3 - Flow variations in Drainage Line 1 and Drainage Line 2 between 2014 and 2016

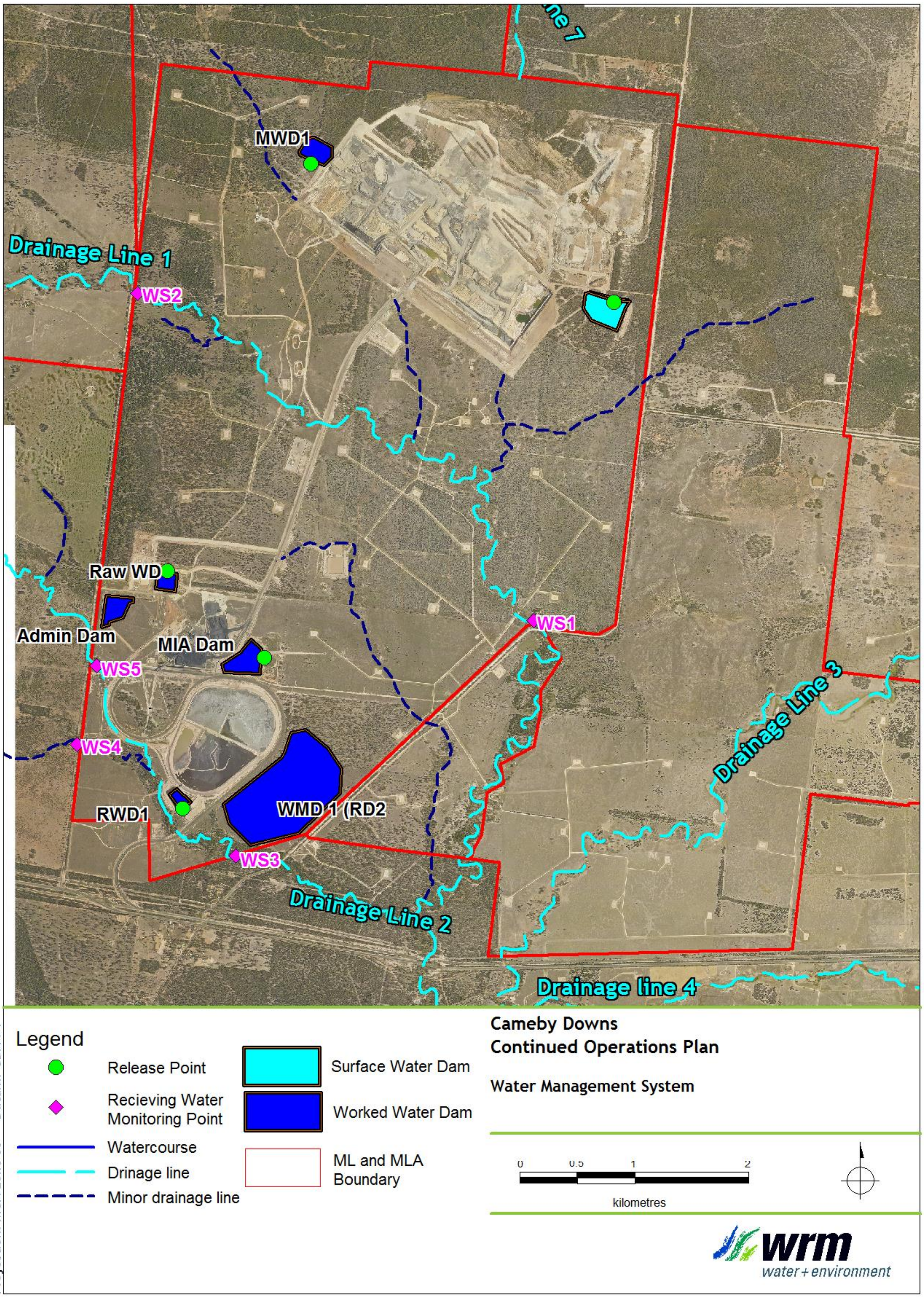

Figure 3.4 – Existing receiving water and end of pipe release monitoring points

3.4 SURFACE WATER QUALITY

3.4.1 Condamine River

Water quality in the Condamine River has been monitored at the DNRME stream gauge Cotswold (No. 422325A), which is located 28 km upstream of the Dogwood Creek confluence. Percentile water quality data (provided by Resource Strategies) for the Lower Condamine River base flow and event flow is shown in Appendix A (Table A.3 and Table A.4).

The Lower Condamine River water quality percentiles and a comparison against Table F5 of the Model Mine Conditions (MMC) trigger levels (guideline and locally derived levels) for receiving waters (see Table 5.3) and the default trigger levels for Environmental Values (ANZECC) (see Table 4.1) shows the following:

- pH
  - Median values are 7.8 and 7.3 for base and events flows respectively; and
  - 20th and 80th percentile values are 7.5 and 8.1 for base flows and 7.1 and 7.5 for event flows.
- EC
  - Median values are 376 and 243 µs/cm for base and events flows respectively; and
  - 80th percentile values are 650 and 262 µs/cm for base and event flows respectively.
- TSS
  - Median values are 51 and 675 mg/L for base and events flows respectively; and
  - 80th percentile values are 139 to 1130 for base and event flows respectively.
- Turbidity
  - Median values are 57 and 490 NTU for base and events flows respectively; and
  - 80th percentile values are 208 to 1058 for base and event flows respectively.
- Sulphate
  - 80th percentile values are 11 and 6 mg/L for base and flow events respectively.

The above water quality percentiles indicate that the background Lower Condamine River water quality is poorer than the default and MMC trigger levels. The water quality percentiles show:

- Base flows
  - 20th percentile pH values are above the default upper trigger level and all values are within the MMC trigger level range;
  - Median EC values are higher than the default trigger levels, but lower than the MMC trigger levels;
  - 80th percentile TSS values are lower than the MMC trigger levels;
  - Median Turbidity values are higher than the default trigger levels; and
  - 80th percentile sulphate values are below MMC and default trigger levels.
- Event Flow
  - pH values are within the default and MMC trigger level range;
  - 80th percentile EC values are within the default and MMC trigger level range;
  - Median TSS values are higher than the MMC trigger levels;

- Median Turbidity values are higher than the default trigger levels; and
- 80th percentile sulphate values are below the MMC trigger levels.

3.4.2 Dogwood Creek

Water quality in Dogwood Creek has been monitored at the DNRME stream gauge Gilweir (No. 422202B), which is located 2 km upstream of the Dogwood Creek confluence with Columboola Creek. Percentile water quality data (provided by Resource Strategies) for the Dogwood Creek base flow and event flow is shown in Appendix B (Table B.1 and Table B.2).

The Dogwood Creek water quality data and a comparison against Table F5 of the Model Mine conditions (MMC) trigger levels for receiving waters (see Table 5.3) and the default trigger levels for Environmental Values (ANZECC) (see Table 4.1) shows the following:

- pH
  - Median values are 7 and 6.8 for base and events flows respectively; and
  - 20th and 80th percentile values are 6.5 and 7.6 for base flows and 6.4 and 7.4 for event flows.
- EC
  - Median values are 113 and 100 µs/cm for base and events flows respectively; and
  - 80th percentile values are 145 and 121 µs/cm for base and event flows respectively.
- TSS
  - Median values are 48 and 70 mg/L for base and events flows respectively; and
  - 80th percentile values are 105 and 130 for base and event flows respectively.
- Turbidity
  - Median values are 145 and 195 NTU for base and events flows respectively; and
  - 80th percentile values are 270 and 410 for base and event flows respectively.
- Sulphate
  - 80th percentile values are 5 and 8.9 mg/L for base and flow events respectively, below the MMC trigger levels.

The above water quality percentiles indicate that the background Dogwood Creek water quality is poorer than the default and MMC trigger levels. The water quality percentiles show:

- Base flows
  - 80th percentile pH values for base flows are higher than the default upper trigger level, but within the MMC trigger levels;
  - 80th percentile EC values are within the default and MMC trigger levels;
  - 80th percentile TSS values are within the MMC trigger levels; and
  - Median Turbidity values are higher than the default trigger levels.
- Event Flow
  - 20th percentile pH values are lower than the MMC lower trigger levels, but within the default trigger levels;
  - 80th percentile EC values are within the default and MMC trigger levels;
  - 80th percentile TSS values are within the MMC trigger levels;

- Median Turbidity values are higher than the default trigger levels; and
- 80th percentile Sulphate values are within the MMC trigger levels.

3.4.3 Drainage Line 1/Drainage Line 2

The CDM has carried out a water quality monitoring program since 2010 in accordance with the CDM EA conditions. The monitoring program has included regular surface water quality sampling from drainage lines in the vicinity of the mine including Drainage Line 1 and Drainage Line 2. Surface water is currently sampled and tested at five locations (see Figure 3.4 for locations) for a range of physical and chemical parameters.

CDM has monitored water quality at stream gauging stations from December 2010 to October 2017. Background water quality has been monitored upstream of the CDM boundary in Drainage Line 1 (WS2) and Drainage Line 2 and its tributary (WS4 and WS5). Receiving water quality has been monitored in Drainage Line 1 (WS1) and Drainage Line 2 (WS3) downstream of CDM site. A summary of the water quality data for the background receiving water sites is provided in Appendix A, Table A.5 to Table A.7

A comparison of the Drainage Line 1 and Drainage Line 2 background site recorded water quality data and the combined data for both drainage lines are given below. The percentile values are compared against Table F5 of the MMC Receiving Waters Contaminant trigger levels (see Table 5.2) and the default trigger values (ANZECC) (Table 4.1) shows the following:

- pH
  - Drainage Line 1 80th and 20th percentile pH values of 6.5 and 6.9 respectively compared with Drainage Line 2 pH values of 6.4 and 6.9 respectively. Drainage Line 2 20th percentile pH is lower than the MMC lower trigger levels.
  - The combined data 80th and 20th percentile pH values are 6.4 and 6.9 which are within both the default and MMC trigger levels.
- EC
  - Drainage Line 1 80th percentile EC value is 80 µS /cm and this compares to a value of 67 µS /cm in Drainage Line 2. The 80th percentile values for both drainage lines are within the default and the MMC trigger levels; and
  - The combined data 80th percentile EC value is 67 µS /cm, which is within the default and MMC trigger levels.
- TSS
  - Drainage Line 1 80th percentile TSS value is 211 mg/L, compared to Drainage Line 2 TSS value of 222 mg/L; and
  - The combined data 80th percentile TSS value is 216 mg/L which is the proposed locally derived trigger level, for MMC.
- Turbidity
  - Drainage Line 1 80th percentile Turbidity value is 453 NTU, compared to Drainage Line 2 value of 632 NTU; and
  - The combined data 80th percentile Turbidity value is 571 NTU.
- Sulphate sampling has not been conducted to date in the receiving waters.
- Metals have been sampled in the receiving waters for total concentrations. The MMC and default trigger levels are based on dissolved concentrations. Analyses of total metals at CDM has identified that 4 metals (Chromium, Copper, Lead and Zinc) are elevated in the background receiving water sites. Further water quality monitoring at CDM receiving waters will be required to derive local trigger levels for Table F5 of the model mine conditions. Indicative locally derived dissolved metals concentrations for the CDM receiving waters are discussed further in section 3.4.4

Water quality monitoring of the background sites in the receiving waters of Drainage Line 1 and Drainage Line 2 has shown that the local water quality is poorer than the default and MMC trigger levels. Details on the proposed locally derived trigger levels for CDM are given in Section 5.

Table 3.3 - Summary of available receiving water quality data

Data Source	Site	Receiving waters	Location	Period of Record
CDM		Upstream Monitoring Points		
	WS2	Drainage Line 1	D/S of Ryalls Road crossing	Feb.'11 - Mar '17
	WS4	Drainage Line 2	D/S of Ryalls Road crossing	Jun.'11 - Oct '17
	WS5	Drainage Line 2	D/S of Ryalls Road crossing	Dec.'10 - Mar '17
		Downstream Monitoring Points		
	WS1	Drainage Line 1	U/S of Boort Koi Road crossing	Feb.'11 - Mar '17
	WS3	Drainage Line 2	U/S of Boort Koi Road crossing	Feb.'11 - Oct '17
DES	422325A	Condamine River	28 km U/S of Dogwood Creek confluence	Varies
	422202B	Dogwood Creek	2km U/S of Columboola Creek confluence	Varies

3.4.4 Indicative locally derived metal concentration trigger levels

Table A.7 in Appendix A shows the 80th percentile values in the combined data for the CDM receiving water. Figure A.5 to Figure A.11 shows the historical monitoring results of contaminant concentrations used to undertake the statistical results in Table A.7. Available historical monitoring data shows that four metals (Chromium, Copper, Lead and Zinc) have higher total concentrations in the receiving waters than the dissolved trigger levels given in the MMC (see Table 5.2).

Indicative dissolved to total concentration conversion factors were derived to provide estimation of the dissolved concentrations for CDM receiving waters based on available water quality data from other mine sites in Queensland. Table 3.4 shows the indicative locally derived dissolved metals concentrations based on the indicative conversion factors.

The results indicate the 80th percentile dissolved concentrations values for some metals in the receiving waters may be higher than the MMC default trigger values. Future monitoring of dissolved (field filtered) metals will be undertaken to determine suitable trigger values. The MMC values will be adopted until adequate monitoring data has been collected.

Table 3.4 - Indicative dissolved metal concentrations compared with Table F3 of the MMC trigger levels.

Parameter	MMC Trigger level (dissolved) (µg/L)	80th percentile total (µg/L)	Adopted conversion factor	Indicative 80th percentile dissolved concentration (µg/L)
Chromium	1	16.2	0.5	8.1
Copper	2	7.0	0.8	5.5
Lead	4	8.0	0.6	4.5
Zinc	8	30.0	0.5	15.0

3.5 GROUNDWATER QUALITY

A groundwater assessment at CDM was undertaken by Australasian Groundwater and Environmental (AGE) Consultants Pty Ltd (AGE, 2018). Groundwater at the CDM site is generally brackish to saline. AGE conducted a search of the DNRME groundwater database and found that nearby groundwater bores at similar depths to the Juandah Coal Measures (30 m – 125 m deep) were also typically brackish to saline.

AGE (2018) noted that the CDM site also overlies deeper, freshwater aquifers (which form part of the Great Artesian Basin) known as the Precipice Sandstone and Hutton Sandstone aquifers. However, they are hydraulically isolated from the Walloon Coal Measures by large thicknesses of low permeability strata, and that the subcrop/recharge area is well distant from the CDM site.

According AGE (2018):

- The coal seam aquifers in the area of the mine form poor aquifers due to highly brackish to saline water quality and low yields;
- Monitoring of the MA01 and MA02 seams found that groundwater in the coal seam aquifers have electrical conductivity ranging from about 700 µS/cm to 35,000 µS/cm; and
- The shallow alluvium aquifers in the area of the mine are highly variable in salinity ranging from brackish to potable. Generally silty to clayey sediments are associated with poor quality water, whereas clean sands and gravels are likely to yield better quality water.

4 ENVIRONMENTAL VALUES AND WATER QUALITY OBJECTIVES

4.1 OVERVIEW

The *Environmental Protection Act 1994* seeks to protect Queensland's water resources while allowing ecologically sustainable development through the *Environmental Protection (Water) Policy 2009* (EPP Water). The EPP Water achieves this within a framework that includes:

- Identifying environmental values (EVs) for aquatic ecosystems and for human uses; and
- Determining water quality guidelines (WQGs) and water quality objectives (WQOs) to enhance or protect the EVs.

4.2 ENVIRONMENTAL VALUES

EVs are the qualities of receiving waters to be protected from activities in the catchment. Protecting EVs aims to ensure healthy aquatic ecosystems and receiving waters that are safe and suitable for community use. EVs reflect the ecological, social and economic values and uses of the receiving waters (Such as stock water, swimming, fishing and agriculture).

The processes to identify EVs and determine WQGs and WQOs are based on the National Water Quality Management Strategy: Implementation Guidelines (NWQMS, 1998) and further outlined in the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC & ARMCANZ, 2000).

EVs and WQOs for the Maranoa-Balonne (and Lower Condamine) Sub-basin are currently being developed by the Queensland Department of Environment and Heritage Protection (DES). DES have been developing the EV's and WQO's in collaboration with the Queensland Murray Darling Committee (QMDC). DES have republished a draft report by QMDC entitled *Healthy Waters Management Plan Draft Environmental Values and Community Consultation Report* (DEHP, 2017). Although this document is only in draft form, it is likely to be used to inform the subsequent development of EV's, WQO's and future water quality guidelines under the EPP Water.

Based on DSITIA (2016), the receiving surface waters downstream of the CDM are located in the Dogwood Creek zone. The surface water EVs nominated for protection for this zone are:

- Aquatic ecosystems
- Irrigation
- Farm supply/use
- Stock water
- Human consumer
- Primary recreation
- Visual recreation
- Drinking water
- Cultural and spiritual values

4.3 DEFAULT TRIGGER VALUES

The indicators and water quality guidelines relevant to the above Surface Water EVs are listed in the Queensland WQGs and ANZECC & ARMCANZ (2000) and the *Draft Environmental values and water quality guidelines: Queensland Murray-Darling Basin* (DEHP, 2017). The conditions of receiving waters located in the vicinity of the CDM are classified as *Level 2: slightly to moderately disturbed ecosystems* under the Queensland WQGs (DERM, 2009).

The receiving waters of CDM enter Dogwood Creek, downstream of the gauging station at Gilweir. Dogwood Creek Combines with the Condamine River and becomes the Balonne River. The following factors were considered when defining local water quality objectives:

- Gilweir is a man-made weir and samples collected at this location may be impacted by the weir depending on where the sample is taken; and
- The Condamine River has similar characteristics to the CDM receiving water which is influenced mainly by agricultural landuse activities.

Comparison of the water quality triggers shown in Table 4.1 for the ANZECC default trigger levels and the local receiving waters indicates:

- The 80th percentile pH ranges in the receiving waters are generally within the range of the ANZECC trigger values, except lower Condamine River base flows, which have an upper value of 8.0.
- The 80th percentile EC in the receiving waters indicates:
    - The Dogwood Creek value is 130 µS/cm. This is lower than the ANZECC trigger value; and
    - The Condamine River values vary from 245 µS/cm (event flow) to 523 µS/cm (base flow). The event flows are lower than the ANZECC trigger value, while the base flows are higher.
- The turbidity in the receiving waters indicates:
    - The Dogwood Creek value is 190 NTU, this is higher than the ANZECC trigger value; and
    - The Condamine River value is 150 NTU (base flow) and 835 NTU (event flow). These values are higher than the ANZECC trigger value.
- The TSS in the receiving waters indicate:
    - There are no default TSS trigger levels;
    - The Dogwood Creek value is 70 mg/l; and
    - The Condamine River values range between 90 mg/l (base flow) and 940 mg/l (event flow).
- The nutrient concentrations (Total Nitrogen and Total Phosphorus) in the receiving waters are significantly higher than the ANZECC default trigger values.

CDM will adopt the Model Mine Conditions receiving waters trigger levels for metals (shown in Section 5), which are based on the values for ANZECC aquatic ecosystem protection shown in Table 4.1. There are no water quality guidelines for metals in the DEHP (2017) draft report.

It is noted that updated draft documentation has been released by the DES in 2018 and is currently the subject of final consultation under the *Environmental Protection (Water) Policy 2009* on the environmental values (EVs), aquatic ecosystem protection mapping and water quality objectives (WQOs) for all surface water and groundwater of the Queensland Murray-Darling Basin (QMDB). It is also understood that some ANZECC default trigger values for ecosystem protection are expected to be revised in a planned (yet to be released) update to the ANZECC & ARMCANZ (2000). As these draft EVs, mapping and WQOs are yet to be finalised, no further consideration is made in this report.

Table 4.1 - Default trigger and local values for CDM and surrounds

Parameter	Units	ANZECC Trigger Level	Dogwood Creek 80th percentile	Lower Condamine Base Flow 80th percentile	Lower Condamine Event Flow 80th percentile
pH	pH units	lower 6.0	lower 6.5	lower 7.5	lower 7.1
		upper 7.5	upper 7.4	upper 8	upper 7.4
Conductivity	µS/cm	350	130	523	245
Turbidity	NTU	25	190	150	835
Total Suspended Solids	mg/L	ID	70	95	940
Total Nitrogen	mg/L	0.25	1.83	1.3	ID
Nitrite + Nitrate	mg/L	0.015			
Total Phosphorous	mg/L	0.02	0.44	0.425	0.95
Metals (dissolved)					
Aluminium (pH>6.5)	mg/L	0.055			
Aluminium (pH<6.5)	mg/L	ID			
Arsenic (As III)	mg/L	0.024			
Arsenic (As V)	mg/L	0.013			
Boron	mg/L	0.37			
Cadmium	mg/L	0.0002			
Chromium (Cr VI)	mg/L	0.001			
Copper	mg/L	0.0014			
Lead	mg/L	0.0034			
Manganese	mg/L	1.9			
Mercury (inorganic)	mg/L	0.0006			
Nickel	mg/L	0.0011			
Selenium	mg/L	0.0011			
Silver	mg/L	0.00005			
Zinc	mg/L	0.008			

Notes: * ANZECC & ARMCANZ (2000) Trigger Values for 'Upland Streams' (above 150m AHD) in South-east Australia for protection of 95% of species. ID – Insufficient data.

5 SURFACE WATER MANAGEMENT OBJECTIVES

5.1 OVERVIEW

For surface water management purposes, the surface runoff generated in the CDCOP area is divided into three types based on water quality:

- **'Diverted'** – surface runoff from areas of the CDCOP where water quality is unaffected by mining operations. 'diverted' water includes runoff from undisturbed areas;
- **'Surface'** – surface runoff water and seepage from the CDCOP areas that are disturbed by mining operations such as overburden spoil dumps and roads. This runoff may contain silt and sediment but is unlikely to contain contaminant concentrations in excess of the CDCOP EA release limits for water quality parameters. However, this runoff must be of suitable quality if discharge into receiving waters is required; and
- **'Worked'** – surface runoff water and seepage from CDCOP areas affected by mining operations and potentially containing chemicals of various types generated by mining operations. Areas where hazardous waste can potentially be generated include the open pit, service bays, fuel storage areas, and process areas. Runoff from these areas must be managed to avoid discharge of potentially contaminated water into the receiving waters. There are restrictions on the use and release of this water.

The following type of water used at the CDM site is also of relevance to the proposed surface water management system based on its water quality:

- **'External'** - groundwater that has been extracted as part of the coal seam gas operations from the Queensland Gas Corporation (QGC) and supplied to Cameby Downs (via Glen Eden Pond). A proportion of this water undergoes reverse osmosis treatment by QGC prior to entering the CDM water management system. There are currently restrictions within the EA on the use of this water on ML50233.

5.2 RELEVANT GUIDELINES

The following legislation, plans, policies and regulations are relevant to the CDCOP for surface water management:

- Water Act 2000;
- Water Regulation 2002;
- Water Resource (Condamine and Balonne) Plan 2004;
- Environmental Protection Act 1994;
- Environmental Protection (Water) Policy 2009;
- QMDC Draft Environmental Values and Community Consultation Report for the Maranoa-Balonne (and Lower Condamine) (2017);
- Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (2016);
- Coal Seam Gas Water Management Policy (2012);
- Terms of Reference guidelines – Water (2016);
- Application requirements for activities with impacts to water (DES, 2018); and

- Waste Reduction and Recycling Act 2011.

5.3 MANAGEMENT OBJECTIVES

The key operational objectives of the CDM water management system include the following:

- Protect the integrity of local and regional water resources;
- Maintain separation between ‘diverted’ runoff and water generated from mine impacted areas;
- Operate in accordance with the requirements of this SWA and EA conditions; and
- Provide a reliable source of water for mining and CHPP processing.

To achieve these objectives, the following measures are taken:

- Separate ‘diverted’, ‘surface’ and ‘worked’ water runoff as much as possible;
- Minimise the area of surface disturbance, thus limiting the volume of ‘surface’ and/or ‘worked’ runoff and at the same time limit external water supply requirements;
- Manage ’worked’ and ‘surface’ water on site via containment storages or sediment dam’s dependant on the quality of water likely to be generated;
- Release ‘surface’ water following sediment removal through a sediment management structure (e.g. sediment dams), provided water quality is within the CDM EA water quality release limits;
- Segregate, collect and contain all ‘worked’ water runoff as much as possible on site via adequately sized containment storages;
- Provide permanent pumping infrastructure to allow transfer of ‘worked’ water between containment storages as required, to limit the potential for worked water overflows to the receiving environment and build-up of water in active open pits; and
- Limit ‘diverted’ and ‘external’ water consumption and prioritise the reuse of ‘surface’ and ‘worked’ water within the mine site (e.g. for coal washing).

5.4 CDCOP WATER QUALITY MANAGEMENT OBJECTIVES

Water quality monitoring of the water management system would prioritise sampling of water storages that are able to release water during wet periods. Available water quality data for Sediment Dam 1 and the MIA Dam (See Figure 3.4 for locations) indicate these are the only storages that can be regularly released from. These storages should be monitored frequently for pH and EC during the wet periods (October to March) to ensure water quality is within release limits. This sampling will enable site to establish a release strategy during wet periods.

Site would regularly monitor runoff from surface water catchments to ensure that water quality is below release limits. Identifying areas with affected runoff water quality will limit the risk of exceedances in release conditions and allow areas with unsuitable runoff water quality to be segregated from the ‘surface’ water system to prevent contamination of sediment dams.

5.4.1 Release limits

The MMC and former Department of Environment and Resource Management’s (DERM’s) Training Notes from the Industry Briefing (of 25th August 2011) (DERM, 2011c) were used to derive the proposed release conditions for the project. The proposed flow criteria parameters are listed in Table 5.1 below.

The proposed flow criteria for medium and high flows have been developed using the OPSIM water balance model. The OPSIM AWBM catchment parameters were calibrated to the Gilweir gauging station on Dogwood Creek, which is detailed in Section 8.4.

The approach presented in the industry briefing notes was adopted using the OPSIM daily flows in Drainage Line 1 – as illustrated in Figure 5.1. Using the DERM (2001) procedure, the proposed minimum medium flow criteria is 0.2 m^3/s, which is approximately the 30^{th} percentile of flows. The minimum high flow trigger is 1.0 m^3/s.

A mass balance for both EC and SO_4 was used to derive the flow criteria and associated maximum release rates and release limits. The following assumptions were used to derive the flow criteria and release limits are shown in Table 5.1:

- The assumed background water quality in the receiving waters for EC and SO_4 of 350 µS/cm and 10 mg/L respectively (these values are considered conservative as they are greater than the 80^{th} percentile values for the Condamine River event flows);
- For receiving waters:
  - Low flow criteria trigger levels for EC and SO_4 of 350 µS/cm and 250 mg/L respectively; and
  - Medium and high flow criteria trigger levels for EC and SO_4 of 1,000 µS/cm and 250 mg/L respectively.
- The maximum release rate was also conservatively derived assuming mine water release occurred at the maximum allowed release rate and EC concentrations at the same time:
  - The minimum receiving water flow rates for each flow criteria was adopted. For example;
  - The maximum release rate for the flow criteria that could achieve the water quality trigger levels in the receiving waters:
    - A maximum release rate of 0.1 m^3/s with an EC and SO_4 of 3,500 µS/cm and 1,200 mg/L respectively meets the receiving waters trigger limits for the medium flow criteria of 0.5 m^3/s and an EC and SO_4 of 1,000 µS/cm and 250 mg/L respectively; and
    - A maximum release rate of 0.4 m^3/s with an EC and SO_4 of 1,500 µS/cm and 500 mg/L respectively meets the receiving waters trigger limits for the medium flow criteria of 0.5 m^3/s and an EC and SO_4 of 1,000 µS/cm and 250 mg/L respectively.

The release criteria given in Table 5.1 was considered a number of release scenarios using the water balance model to demonstrate compliance with the proposed receiving waters trigger values. Details of this assessment are given in Section 8.10.10.

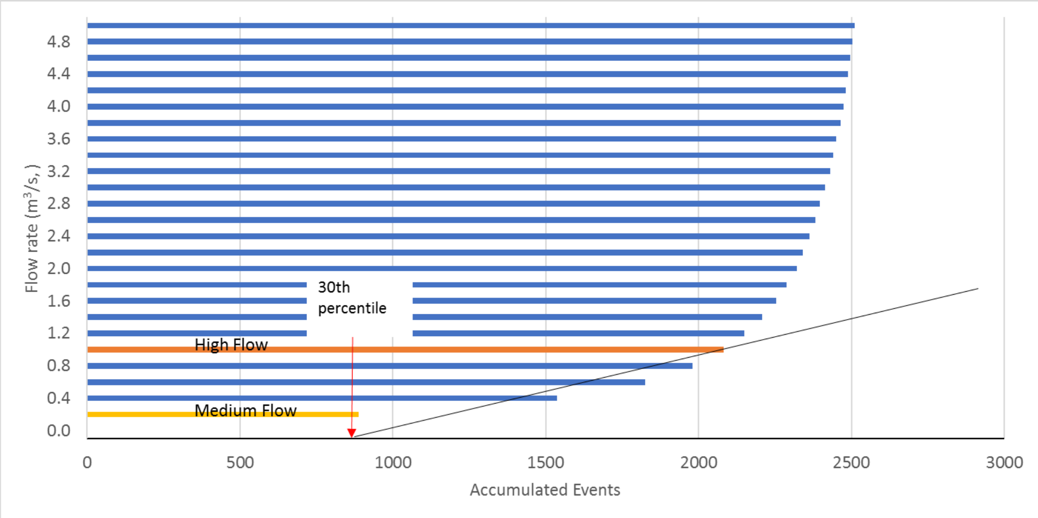

Figure 5.1 - Derivation of Drainage Line 1 minimum medium and high flow criteria

Table 5.1 – Table F2 mine affected water release limits

Flow Criteria	Receiving Water flow criteria for discharge (m^3/s)	Maximum release rate (for all combined RP flows) (m^3/s)	Electrical Conductivity and sulphate release limits	Receiving waters flow recording frequency
Low Flow	<0.2	<0.2	<350/250	Daily during release (within 2 hours of commencement
Medium Flow	>0.2	<0.2	<1,500/500	
	>0.5	<0.1	<3,500/1,200	
	>0.5	<0.4	<1,500/500	
	>0.9	<0.8	<1,500/500	
High Flow	>1.0	<0.2	<3,500/1,200	
	>1.7	<1.5	<1500/500	
	>2.5	<0.6	<3,500/1,200	
	>4	<0.2	<10,000/3,400	
pH (pH Unit)			6.5 - 9	
Turbidity (NTU)			TBA	

5.4.2 Release contaminant trigger investigation levels

Under Table F3 of the MMC, when a trigger level is exceeded in the release water, CDM is required to compare the results with water quality in the receiving waters (both downstream and background sites) in accordance with Condition F6 of the MMC. The water quality characteristics in Table F3 of MMC will therefore be monitored in the following locations during each release event:

- The release point at the end-of-pipe/spillway;
- At the downstream receiving water monitoring point; and
- At the upstream background receiving water monitoring point.

Table 5.2 shows the Table F3 MMC release contaminant trigger investigation levels, potential contaminants and monitoring frequencies. The table includes locally derived trigger levels for TSS.

Table 5.2 - Release contaminant trigger investigation levels, potential contaminants for Table F3 of the MMC and monitoring frequencies

Parameter	Units	Trigger Level	Frequency
Al	(µg/L)	55	Commencement of release and thereafter Weekly during release
As	(µg/L)	13	
Cd	(µg/L)	0.2	
Cr	(µg/L)	1	
Cu	(µg/L)	2	
Fe	(µg/L)	300	
Pb	(µg/L)	4	
Hg	(µg/L)	0.2	
Ni	(µg/L)	11	
Zn	(µg/L)	8	
B	(µg/L)	370	
Co	(µg/L)	90	
Mn	(µg/L)	1,900	
Mo	(µg/L)	34	
Se	(µg/L)	10	
Ag	(µg/L)	1	
U	(µg/L)	1	
Va	(µg/L)	10	
Ammonia	(µg/L)	900	
Nitrate	(µg/L)	1,100	
C9 - C9	(µg/L)	20	
C9 - C36	(µg/L)	100	
Fluoride	(µg/L)	2,000	
TSS		The higher value of 216[a] or +20% of background value	

[a] 80th percentile locally derived value

5.4.3 Receiving waters contaminant trigger levels

Table 5.3 shows the Table F5 of the MMC receiving waters contaminant trigger levels. CDM will monitor the parameters at the frequency shown in Table 5.3 in the receiving waters at the downstream sites and the upstream background sites.

The values adopted for Table F5 which are not prescribed in the MMC are based on:

- EC trigger values will depend on the flow conditions:
  - During low flow, a trigger level of 350 µS/cm will be adopted. This is in line with the ANZECC guideline and within the range of EC guideline values for the Lower Condamine River. Release events during low flow events will be from sediment dams only (in accordance with the site Erosion and Sediment Control Plan); and
  - During medium and high flow events, a trigger level of 1,000 µS/cm will be adopted. This is based on the mine being located less than 10 km from the top of the catchment for Dogwood Creek.
- A TSS concentration of 216 mg/l based on the 80th percentile locally derived value. The guideline values for the Lower Condamine River indicate that during flow

events, 80th percentile TSS concentration is 940 mg/l (DSITIA, 2017). The high TSS in the Lower Condamine River confirms disturbed catchments in the region generate high levels of sediment, which is also experienced at CDM.

Table 5.3 – Receiving waters contaminant trigger investigation levels for Table F5 of the MMC

Parameter	Units	Trigger Level	Frequency
pH	pH Unit	6.5 - 9	Daily during the release
EC low flow	µS/cm	350 [a]	
EC event flow	µS/cm	1,000	
TSS	(mg/L)	216	
Sulphate	(mg/L)	250	

[a] Source: ANZECC & ARMCANZ (2000)

5.5 POTENTIAL CONSTRAINTS OF PROPOSED CDCOP

The potential constraints to the CDCOP, in relation to surface water management, include the following:

- The available data appears to suggest that the quality of ‘external’ (QGC) water, which is a blend of raw (untreated) water and water treated by reverse-osmosis, is within acceptable water quality limits. It has been assumed that QGC water will be available to make up all water shortfalls during CDCOP operations;
- The potential of the CDM site for flooding from the Drainage Line 1, Drainage Line 2 and Drainage Line 3;
    - The mine infrastructure area, the rejects dams, mine water dams, water management dams, open pits and overburden dumps are located within the floodplains of the above drainage lines during different stages of mining. Without appropriate management measures, this infrastructure could potentially be susceptible to flooding from Drainage Line 1, Drainage Line 2 and/or Drainage Line 3 floodwaters; and
    - The proposed CDCOP surface water management system will include flood mitigation measures in the form of flood protection levees to mitigate the potential flooding risks to mining operations. The flood mitigation measures are addressed in detailed in the CDCOP flood study report (WRM, 2018).

6 CONTAMINANT SOURCES

6.1 OVERVIEW

Sources/activities at CDM which may potentially impact on the receiving environment by the introduction of contaminants have been identified as follows:

- Runoff from disturbed land (e.g. from stockpiles, overburden and open pit);
- Saline or acidic leachate from overburden dumps;
- Groundwater inflows to the pits;
- Coal washing/processing in the CHPP;
- Runoff from chemical or fuel/oil spills; and
- External Water.

Comments on the available water quality data of relevance (EC, pH, and TSS) to the above contaminant sources/activities are given in the following sections and detailed in Appendix A. Note recorded metal values are for total concentration, the MMC trigger values are dissolved (filtered) concentrations. Therefore, these values cannot be compared. Total metal concentration for each mine water storage have been provided in Appendix A.

6.2 RUNOFF FROM DISTURBED LAND

Disturbed land on the mining lease consists of roads, pits, overburden dumps, coal stockpiles, rejects facilities and the coal processing area. Runoff from these areas may contain lubricants, detergents, dissolved salts and particulate matter.

Sediment deposition into receiving waters may result in bed degradation, potentially altering flow parameters and increasing erosion potential within the receiving waters. The greatest risk of disturbed land impacts however, is in respect of particulate matter. Further to this, important consideration must also be given to associated impacts such as nutrients, heavy metals, acidity, alkalinity, sodicity, EC, chemical and other impacts.

Runoff from disturbed land at CDM is collected in the various site storages and pits. CDM has been monitoring water quality in the site storages and pits since 2010, at the locations presented in Figure 3.4 and over the period shown in Table 6.1. Appendix B shows the statistics of available mine site storage water quality data provided by Syntech.

Table 6.1 - Site storage water quality monitoring summary

Location	Period of Record
Sediment Dam 1	Dec.'10 to Mar '17
Raw Water Dam	Nov.'10 to Jun '16
Return Water Dam 1	Nov.'10 to Jun '16
MIA Dam	Nov.'10 to Jun '16
Mine Water Dam 1	Nov.'10 to Jun '16
Rejects Dam 1	Nov.'10 to Jun '16

Monitoring data provided by CDM in comparison to release limits in Table F2 of the MMC indicates the following:

- pH (field samples)

- Sediment Dam 1 10th and 90th percentile values are 6.1 and 6.8 respectively. The 10th percentile value is below the lower release limit.
- MIA Dam 10th and 90th percentile values are 6.7 and 8.4 respectively and they are within the release limits.
- The 10th and 90th percentile values of the Mine Water Dam, Raw Water Dam and Return Water Dam are generally within release limits.

- Electrical Conductivity (EC) (field samples)
  - 90th percentile values for Sediment Dam 1 are below the proposed release limit for low flow conditions of 500 us/cm.
  - Values for Raw Water Dam 1, Mine Water Dam 1 and MIA Dam, regularly exceed the release limits for medium flows (3,500 µs/cm) and high flows (10,000 µs/cm).
- Total Suspended Solids (TSS)
  - Median TSS in MIA Dam and Sediment Dam 1 is 80 mg/l and 700 mg/L respectively, which indicate that there is a high risk of exceedance from Sediment Dam 1.

6.3 SALINE / ACIDIC LEACHATE FROM OVERBURDEN DUMPS

A waste characterisation report produced by SRK Consulting (SRK, 2012) for CDM concluded that the majority of overburden could be managed as non-acid forming material. However, there is potential for existing salinity to be washed from the overburden in response to rainfall events. SRK noted, however that appropriate management strategies would be required for the carbonaceous units as variable proportions of this unit may have a capacity to generate acid.

The available Sediment Dam 1 water monitoring results indicate the following:

- 10th and 90th percentile pH values are 6.4 and 8.6 respectively (median value of 7.3);
- TSS ranges from 59 to 3,140 mg/L (median value of 700 mg/L); and
- EC (laboratory) ranges from 180 to 640 µs/cm (median value of 324 µs/cm).

On the basis of the recorded Sediment Dam 1 water monitoring results, runoff from overburden dumps in the past appear to have been generally neutral pH and not saline.

6.4 GROUNDWATER INFLOWS

The available groundwater monitoring results (AGE, 2018) indicate the following:

- pH ranges from 5.5 to 8.0; and
- EC ranges from 700 to 35,000 µs/cm.

6.5 COAL WASHING/PROCESSING

The fine rejects from the CHPP will be disposed via a pipeline into either the rejects dams, integrated waste landforms or in a final void. Rejects are in the form of a wet slurry composed of fine silt, clay, water and coal material. Coarse rejects are disposed of in-pit in backfilled spoil.

The available monitoring results in Rejects Dam 1 Cell 1 when active indicate the following:

- pH (field samples) ranges from 4.5 to 8.5; and
- EC (field samples) ranges from 1,870 to 3,890 µs/cm.

Seepage water quality from Rejects Dam Cell 1 is more concentrated, and therefore of poorer quality than the water stored in the dam and available monitoring data indicate the following:

- pH (field samples) ranges from 4.5 to 8.9; and
- EC (field samples) ranges from 6,540 to 29,700 µs/cm.

6.6 CHEMICAL STORAGE

Diesel and other hydrocarbon fuels are consumed by the haul trucks and other mobile equipment. Fuel storage facilities are located in designated areas.

Reagents are used in the coal preparation process and blasting process and are stored in bulk. Lubricants and solvents are also used on the mine. Waste lubricants and solvents are contained and transported off site for recycling or reuse.

Fuel storage areas at the mining workshop have been constructed and bunded in accordance with the relevant specification of AS1940 – Storage and Handling of Flammable and Combustible Liquids (AS1940). Fuel storage areas associated with the operation are inspected regularly and maintenance work completed on as-needs basis. Bunds filled with stormwater are drained (i.e. diesel/oil storage bunding at warehouse drains to oil sump and onto oil separator system) or pumped out by a licensed contractor as soon as practical to maintain the bund volume.

6.7 EXTERNAL WATER

CDM source 'external' water from Queensland Gas Corporation's (QGCs) Glen Eden Pond to meet shortfalls for the on-site water demands when they cannot be met by onsite sources. This 'external' water is extracted during QGCs coal seam gas operations and supplied to CDM (via a pipeline) and stored in the Raw Water Dam.

The quality of 'external' water, which is a blend of raw (untreated) 'external' water and water treated by reverse-osmosis, is monitored weekly during transfers to ensure that it is within acceptable water quality limits specified in the BUA.

The available water monitoring data indicate the following for the 'external' water:

- pH ranges from 8.5 to 9.7; and
- TDS ranges from 1,100 mg/L to 4,300 mg/L.

7 PROPOSED SURFACE WATER MANAGEMENT MEASURES

7.1 OVERVIEW

The CDCOP mining operations require changes to the existing surface water management system to accommodate the proposed changes to the mine site layout (e.g. increased open pit area and extended overburden spoil areas). The proposed CDCOP surface water management strategy will use a number of existing surface water management measures as well as a number of additional surface water management measures that will be implemented during both construction and operational phases.

This section details the proposed water management measures to separate 'diverted' runoff from the 'surface' and 'worked' runoff areas and the management measures proposed to manage 'surface' and 'worked' water at the CDM site during CDCOP operations.

Figure 7.1 to Figure 7.4 show the locations of the existing and proposed water storages and contributing catchment areas and land uses during CDCOP mining operations at four progressive stages of mining (Existing, Year 29, Year 48 and Year 75). Figure 7.5 shows a schematic of the proposed water circuit during CDCOP mining operations.

For reporting purposes, each mine stage is described as follows:

- Existing (Stage 0) – represents the existing (Year 1) mine plan.
- Year 29 (Stage 1) – represents the Year 29 mine plan.
- Year 48 (Stage 2) – represents the Year 48 mine plan.
- Year 75 (Stage 3) – represents the Year 75 EOM mine plan.

The following sections describe the various components of the CDM site surface water management system proposed for CDCOP mining operations. The behaviour and performance of the proposed water management system (including existing and proposed water storages) over the mine life have been investigated using a long-term historical simulation water balance model, as described in Section 8 of this report.

7.2 WATER MANAGEMENT STRATEGIES

7.2.1 'Diverted' water

'Diverted' water controls that divert runoff from external catchments away from disturbed areas will reduce erosion and the potential for contamination of diverted runoff. Figure 7.6 shows the key diverted water controls proposed for the CDCOP. It is noted that a section of Drainage Line 2 has previously been diverted to allow for mining activities.

Clean water drains are proposed to drain 'diverted' water around disturbed areas of the mine site during construction, operation and rehabilitation. Drainage Line 1 and three (3) new clean water drains (CWD1, CWD2 and CWD3) are proposed to manage 'diverted' runoff. In addition, 'surface' water drains constructed for surface water from overburden material, whose catchments have been fully rehabilitated will become clean water drains. These drains will only remain if the catchment is not able to shed runoff off site directly.

7.2.2 'Surface' water

'Surface' water at the CDM site will be managed by constructing sixteen (16) sediment dams around the perimeter of the active spoil dumps. 'Surface' water drains will be constructed to capture and direct 'surface' runoff into the proposed sediment dams. The sediment dam and drain locations have been selected taking into account the topography of the mine site and to provide the most sustainable locations for the life of CDCOP mining operations.

7.2.3 'Worked' water

'Worked' water at the expanded mine site will be managed by using the existing containment storages (Raw Water Dam, Return Water Dam 1, MIA Dam, Mine Water Dam 1 and Admin Dam currently under construction). In addition, the following new water storages are proposed:

- One (1) additional rejects Dam (RD2) to manage rejects from the CHPP;
- One (1) additional rejects return water dam (RWD2) to collect decant water from the proposed RD2;
- Two (2) additional water management dams to store excess water (WDM1 and WMD2). WMD1 will become RD2 during Year 29 (Stage 1); and
- Two (2) additional dams (MWD2 and MWD3) to transfer water from active open pits to the mine water management system for distribution.

Inactive open pit(s) will be used to store excess 'worked' water accumulated during very wet periods that can't be stored in the WMDs. Where possible, the 'sacrificial' inactive open pit will be strategically selected based on the proposed mine sequence to maximise the time an inactive pit can be used as a mine water storage and thereby minimise the need for regular water transfers when a pit is reinstated for active mining.

'Worked' water systems will be configured to limit the mixing of 'surface' and 'worked' water.

7.2.4 'External' water

'External' water supplied from QGC (via Glen Eden Pond) will be managed in Raw Water and Admin dams. 'External' water will be used to make up water shortfalls for on-site water demands when on-site sources cannot meet demand.

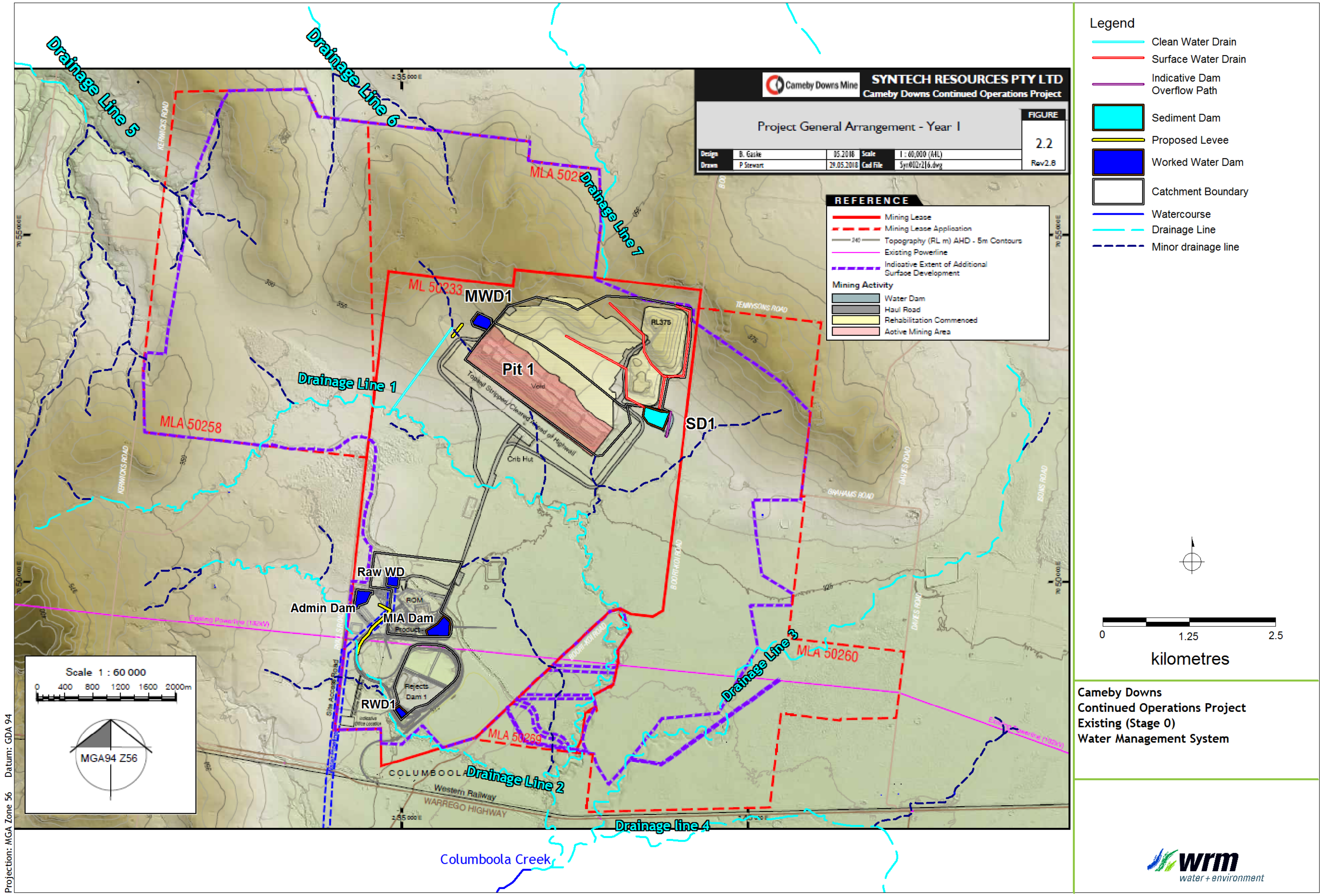

Figure 7.1 - Proposed water management system, Cameby Downs Continued Operations Project, Existing (Stage 0)

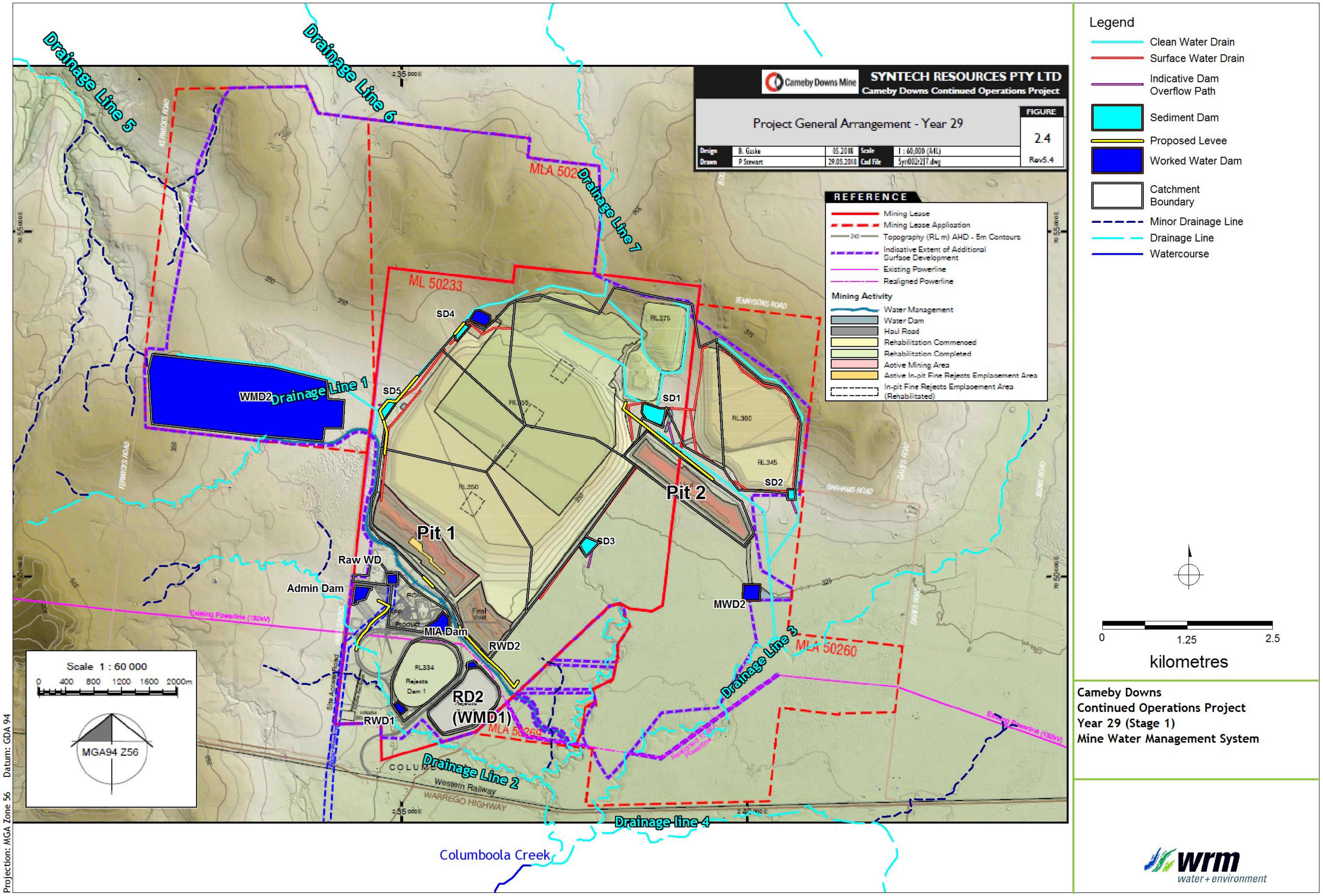

Figure 7.2 - Proposed water management system, Cameby Downs Continued Operations Project, Year 29 (Stage 1)

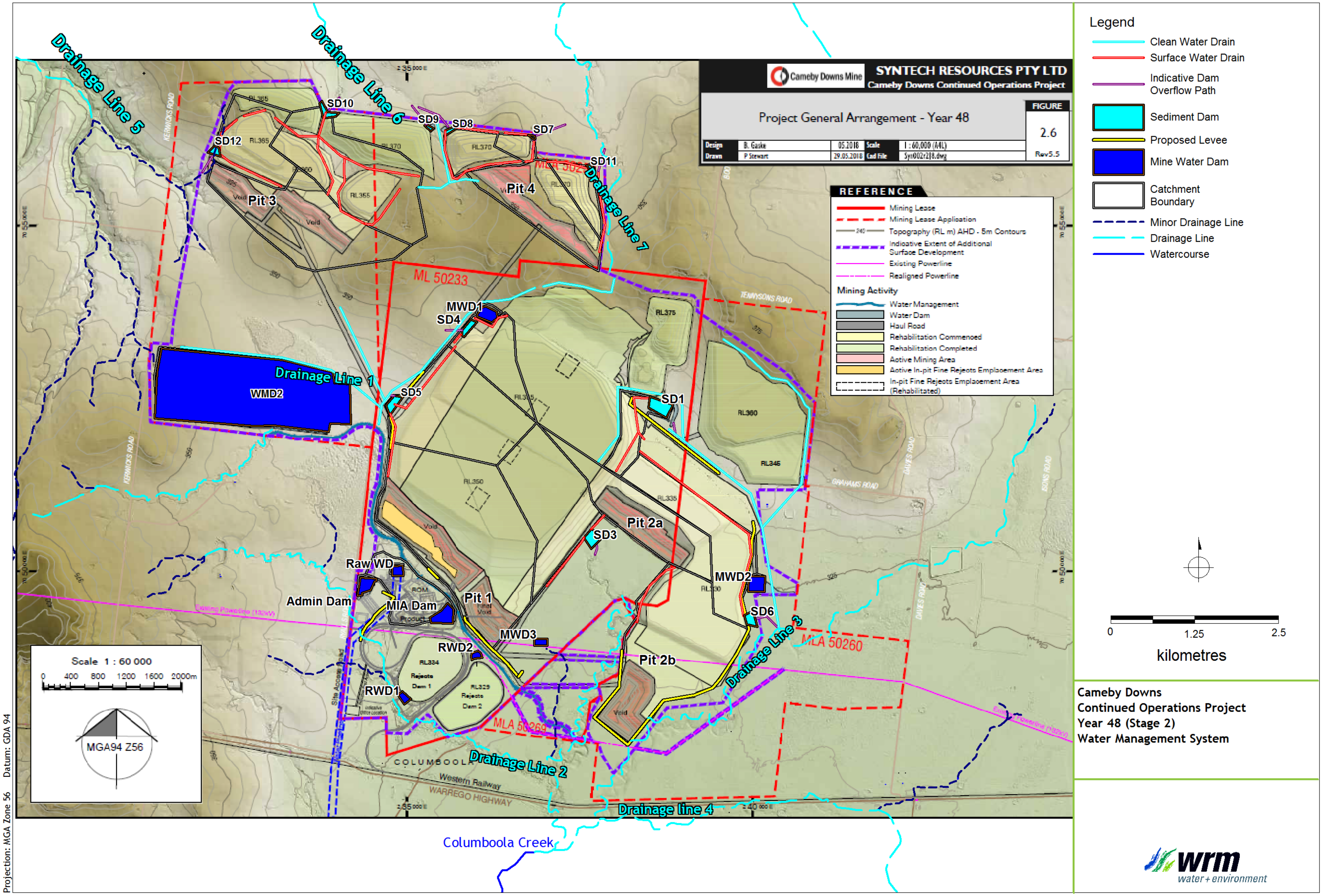

Figure 7.3 - Proposed water management system, Cameby Downs Continued Operations Project, Year 48 (Stage 2)

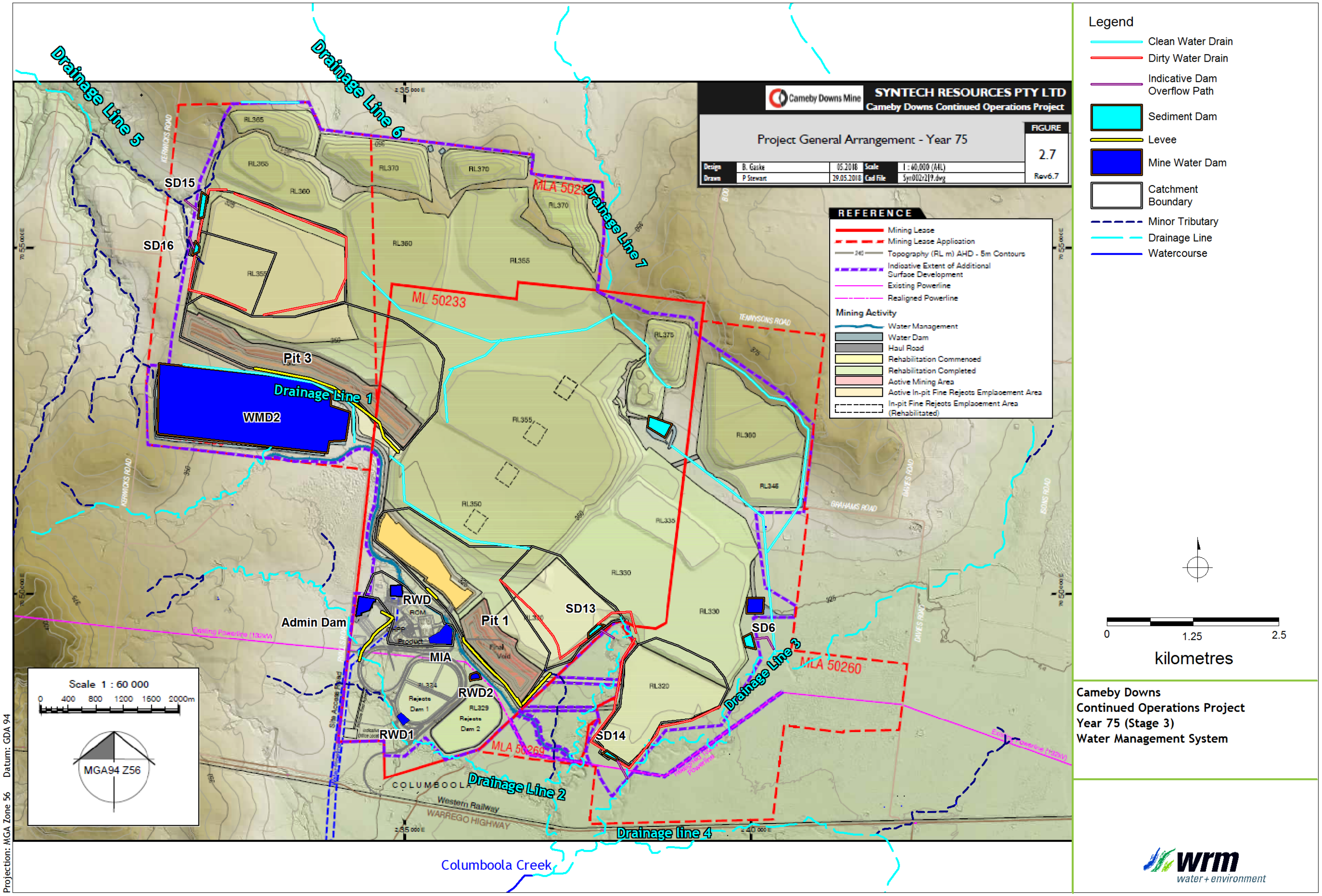

Figure 7.4 - Proposed water management system, Cameby Downs Continued Operations Project, Year 75 (Stage 3)

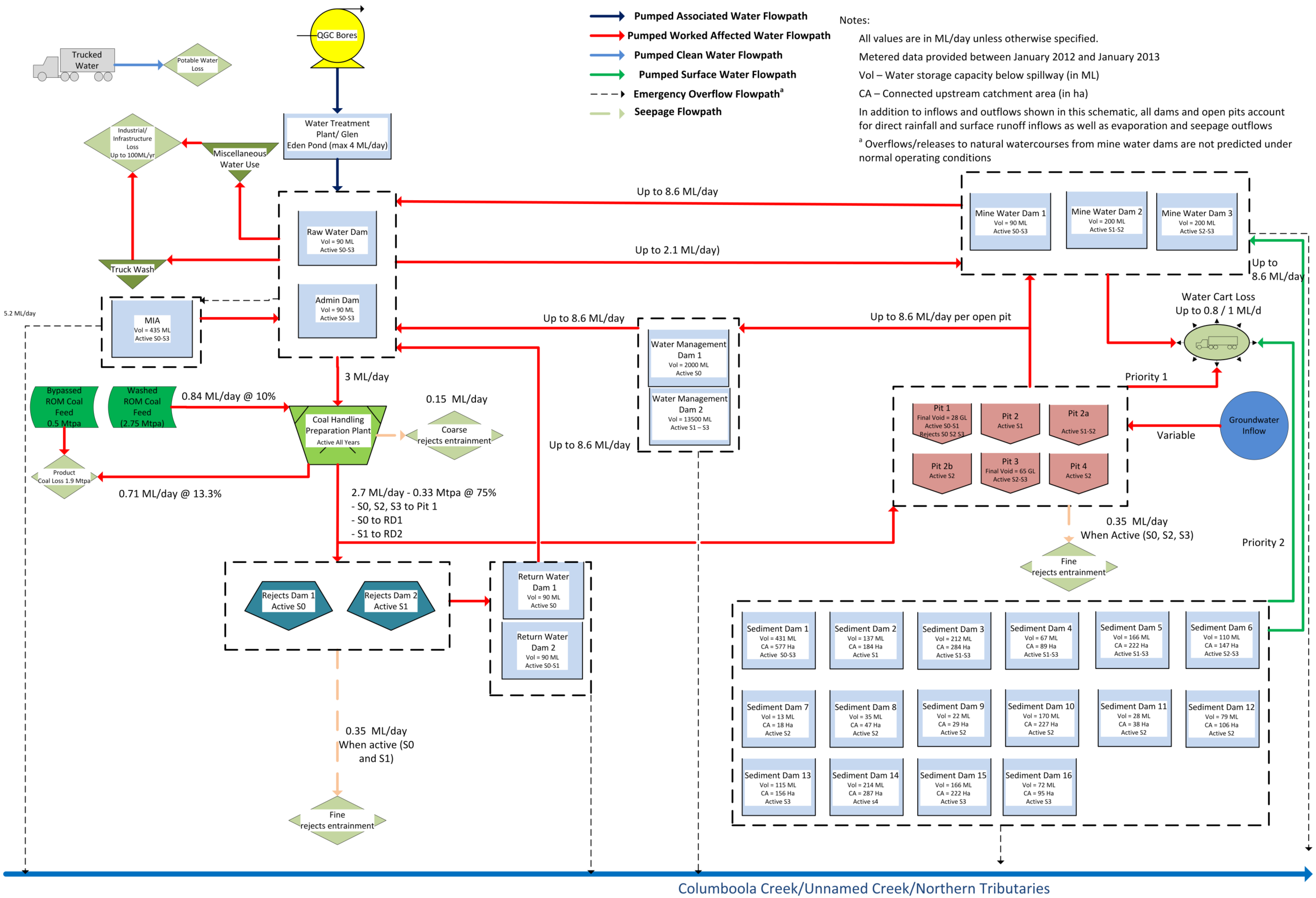

Figure 7.5 - Schematic of proposed Cameby Downs Mine water management system

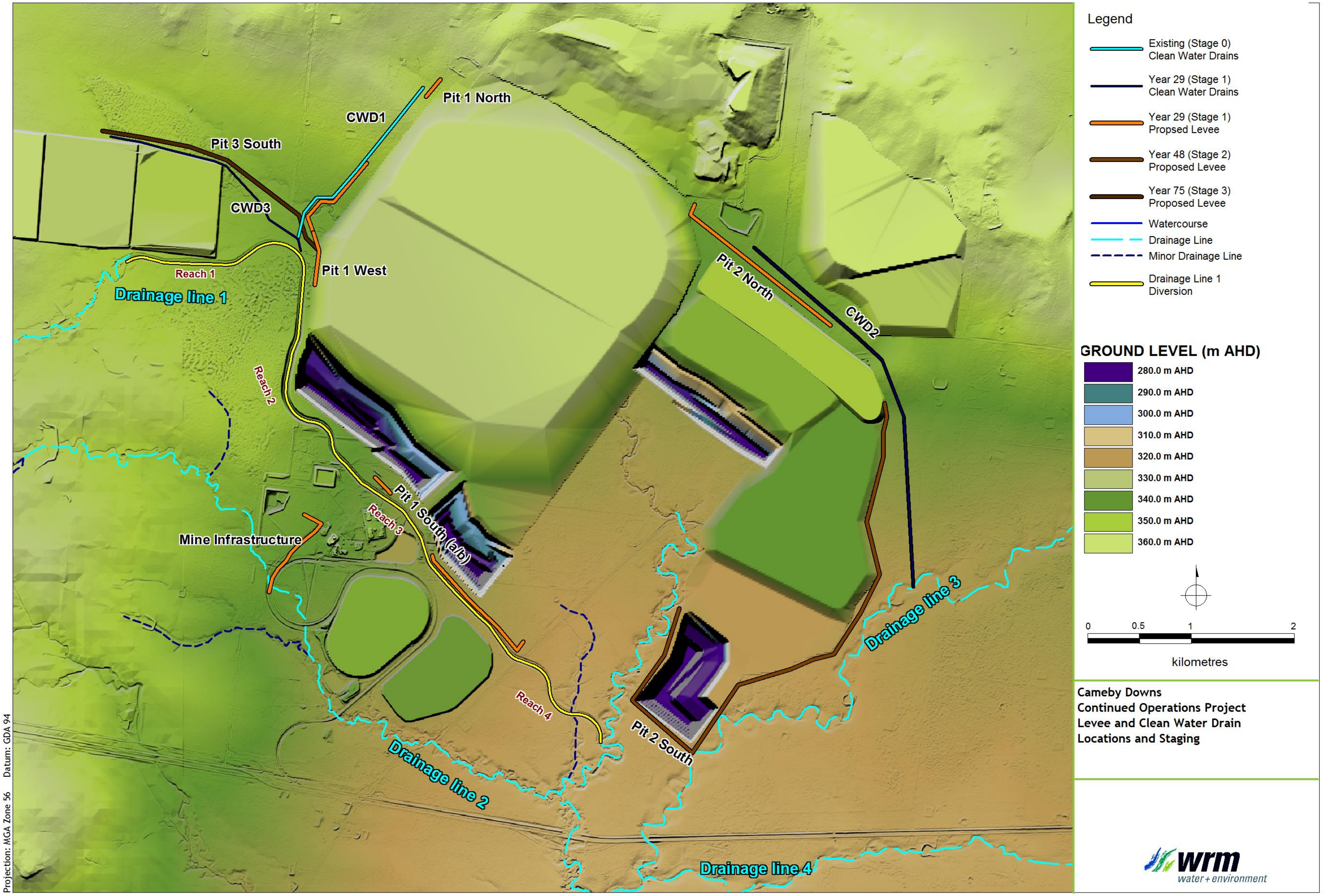

Figure 7.6 - Staging of levees and clean water drains

7.3 PROPOSED DRAINAGE LINE 1 DIVERSION

7.3.1 General

It is proposed to divert approximately 13.6 km of Drainage Line 1 through the CDCOP area to access the underlying coal. Figure 7.6 shows the locations of the Drainage Line 1 diversion. The objectives of the proposed diversion are to:

- Protect the open pits and mine infrastructure at CDM from flooding during events of at least up to 1,000 year ARI and 100 year ARI, respectively;
- Limit ponding upstream of the flood protection levees; and
- Provide a self-sustaining landform at the end of mine life so that the diversion channel behaves and functions like a natural stream similar to the hydraulic and geomorphic characteristics of the existing Drainage Line 1 channel within the CDCOP area.

Details on the design and assessment of performance of the proposed Drainage Line 1 diversion is documented elsewhere (WRM, 2017).

The Drainage Line 1 diversion will be constructed in three stages:

- By 2025 (Year 8) the mine is expected to reach the 1,000 year ARI Drainage Line 1 flood extent. The diversion will be commissioned prior to 2025 to allow for establishment of vegetation. It is suggested that the lower reaches of the diversion be constructed first as they will convey the largest flow.
- During 2025 (Year 8), the diversion of Drainage Line 1 will require the construction of a 1,000 year ARI flood protection levee (Pit 1 West) along the western boundary of Pit 1 along the existing Drainage Line 1 flow path. CWD1 will be required along this levee to direct ‘diverted’ water to the diversion.
- By EOM: The waterway corridor of the Drainage Line 1 diversion will be widened and landforms raised to ensure that Drainage Line 1 flood waters up to the probable maximum flood (PMF) event will be contained within the diversion without water overflowing into any open pit voids.

7.3.2 Diversion channel design notes

The following is of note with respect to the design of the proposed Drainage Line 1 diversion channel:

- The diversion is designed and assessed using the Australian Coal Association Research Program (ACARP) stream diversion design criteria (Fisher Stewart, 2002);
- The diversion is designed to mimic as much as possible the characteristics of the existing natural Drainage Line 1 channel that it would replace and the end of mine catchment area draining through the diversion;
- The diversion channel will have a base width of 5 m with 1(V):2(H) side slopes and a depth of 0.5m. The diversion floodplain will have a width of 50. The adopted channel design is based on the existing upper and middle Drainage Line 1 channel profiles to reflect the future reduction in catchment area draining to the diverted channel;
- Final voids will be immune from flooding from drainage lines for up to the Probable Maximum Flood (PMF). This will require the construction of “final landforms” in between the drainage lines and the pits;
- A monitoring program will be developed for the Drainage Line 1 diversion channel in accordance with the requirements given in the current Cameby Downs EA; and

- The confluence of the Drainage Line 1 diversion channel with the downstream receiving waters channel will be designed with consideration to:
  - Minimising the disruption to existing bank vegetation;
  - Ensuring the diversion outflows are not directed onto the banks of the receiving stream; and
  - Ensuring that the bed elevation at the downstream end of the diversion channel is the same as the receiving stream bed elevation so drop structures would not be required.

7.4 'DIVERTED' RUNOFF MANAGEMENT MEASURES

7.4.1 Flood protection levees

The flood protection levees will be used to protect key mine infrastructure such as open pits and infrastructure areas from inundation and to direct diverted runoff from undisturbed upstream catchments around potentially disturbed and/or contaminated areas.

Details of the design and assessment of the proposed flood protection levees are documented separately in the flood study report (WRM, 2018). The following sections provide a summary of the proposed flood protection levees.

7.4.2 Flood protection size requirements

Figure 7.6 shows the alignments of the proposed flood protection levees along the Drainage Line 1 diversions and around open pits. Figure 7.6 also shows three clean water drains (CWD1, CWD2 and CWD3) which are required to divert clean water catchments around levees. These CWDs need to be constructed at the same time as the levees. The clean water drains associated with levees are:

- CWD1 diverts water from behind Pit 1 North Levee and along Pit 1 West levee into the Drainage Line 1 diversion;
- CWD2 diverts water from Pit 2 North Levee to Drainage Line 3; and
- CWD3 diverts water along Rejects Dam 1 and Pit 3 South levee into Drainage Line 1 diversion.

Table 7.1 shows a summary of the 1,000 year ARI design flood depths along the proposed levees and the year by which each of the proposed levees would need to be commissioned. The proposed flood protection levees are designed to have 0.5 m freeboard above the appropriate design flood level.

Table 7.1 - Summary details of the proposed flood protection levees

Levee ID	Length (m)	Average 1,000 Year ARI Flood Depth (m)	Maximum 1,000 Year ARI Flood Depth (m)	Indicative Commissioning Year
Pit 1 North	250	0.75	1.4	Year 1
Mine Infrastructure Levee	1,000	0.7	1.6	Year 1
Pit 1 West	1,350	1.15	2.9	Year 8
Pit 1 South (a/b)	1,200/200	0.25	0.7	Year 20
Pit 2 North	1,750	1.2	2	Year 25
Pit 2 South	4,800	0.6	1.85	Year 35
Pit 3 South	2,250	0.7	1.85	Year 65

[a] – Average and maximum depths are for the 100 Year ARI flood event

7.4.3 Flood protection levee design notes

The following is of note with respect to the design of the proposed flood protection levees:

- Infrastructure areas (including process areas, site offices, mine water storage spillways, etc.) will be protected from inundation for flood events up to a 100 year ARI (1% AEP) during CDCOP operations;
- Flood protection levees around open pits will be constructed with crest levels at least above the 1,000 year ARI (0.1% AEP) level plus a suitable freeboard in accordance with DEHP (2016);
- Flood protection levees will be designed and constructed to appropriate engineering standards;
- Adequate erosion protection will be provided on the banks of the flood protection levee to withstand erosive forces generated by floodwaters from Drainage Line 1, Drainage Line 3 and local gullies and overland flow paths; and
- Flood protection levees will be constructed at least one year in advance of the open pit progression schedule during the dry season to minimise the potential risk of open pit inundation.

7.4.4 'Diverted' water drains

The proposed 'diverted' water drains will be used to direct 'diverted' runoff from undisturbed upstream catchments around potentially disturbed and/or contaminated areas. Figure 7.6 shows the locations of the three (3) drains proposed for the CDM site (denoted CWD1 to CWD3). Catchments that are fully rehabilitated will also be considered 'diverted' water catchments and be drained off site, not through sediment dams.

A number of other minor drains and bunds would be required to direct upslope 'diverted' runoff around areas of disturbance such as clay borrow pits, local roads and mine operations. These drainage works will be designed to suit local topographic conditions during the detail design conditions of the project.

7.4.5 'Diverted' water drain design requirements

The proposed CWDs were only conceptually designed for the CDCOP. It was assumed they would be able to convey 100% of flows and no water would enter the mine water management system. Figure 7.7 shows the standard design dimensions for diversion banks and catch drains that are recommended to be adopted for the proposed CWDs (Refer SD 5-

6 in Landcom, 2004 for construction). The following channel sizing calculations should be considered when designing CWDs:

- The Manning' Equation should be used to estimate design flow depths and velocities along the drains;
- A Manning's 'n' of 0.055 should be adopted for grass lined channels and 0.025 for unlined (bare earth) channels. It is recommended that all 'diverted' water drains be grass lined;
- 'diverted' water drains should be designed to contain the 100 year ARI (1% AEP) design discharge, which will maximise the diversion of clean water, preventing additional inflows to the site water management system; and
- Where possible, it is recommended clean water drains be designed to limit the peak velocity to 1.8 m/s or less for a 100 year ARI (1% AEP) design discharge and provide a minimum channel velocity of 0.6 m/s for a 1 year ARI (63% AEP) design discharge. These velocities prevent erosion during high flows and allow self-cleaning of the drains to minimise sediment build-up along the drains.

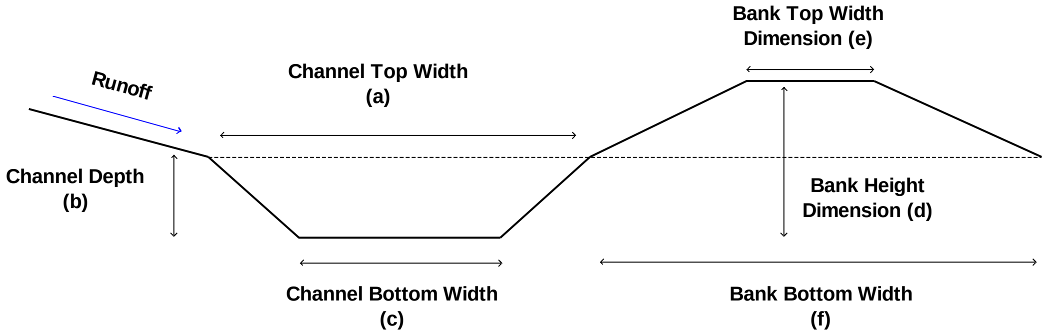

Figure 7.7 – 'Diverted' water drain configuration

7.4.6 'Diverted' water drain design notes

'Diverted' water drains should typically be designed and constructed with the following features:

- Trapezoidal channel.
- Channel batters 1:4 (V:H).
- Bank batters of between 1:3 (V:H) and 1:7 (V:H) depending on in-situ material.
- Bank bottom widths (f) will vary depending on the adopted bank batters.
- Where necessary rock check dams will be used to maintain specified channel grades.
- Diversion banks will be constructed to appropriate engineering standards.
- The channel outlet will be flared out to a minimum width of 1.5 x channel base width. Ground slopes below the channel outlet shall be less than or equal to the channel grade.
- Stable grass cover will be maintained in the bed and banks of the channel and below the channel outlets (as much as possible).
- Wherever practicable, cutting drains through dispersive soils will be avoided. If a drain must be located through dispersive soils, the channel bed and banks will be treated or buried with non-dispersive soils (0.1m minimum cover) before placing any revegetation or channel liner.

- All drainage structures will be inspected following significant storm events to ensure the structures have been able to sustain flow velocities without causing significant scour.
- Drains have been located based on existing topographic data and the proposed mine layout. If necessary, diversion drain locations may be adjusted during detailed design to accommodate finished site levels and grades.
- Drains will be designed and configured as part of detailed designs for the open pit and spoil dump progression.
- Rock check dams or cut and fill earthworks may be required to maintain channel grade.

7.5 'SURFACE' RUNOFF MANAGEMENT MEASURES

7.5.1 Sediment dams and 'surface' water drains

The proposed 'surface' water drains will direct runoff from active in-pit and out-of-pit spoil dumps towards sediment dams. Based on water quality data for the existing Sediment Dam 1, runoff from the existing out-of-pit spoil dump is of a quality that can be released to the receiving waters following removal of sediment in a sediment dam. Note that if runoff and/or seepage from future active spoil areas is found to be 'worked' water quality, active management measures and/or additional storage volume would be required to fully contain the 'worked' water on site.

It is expected that 'surface' water drains and sediment dams located within the project area will be operational (once constructed) until the active spoil dumps in the connected catchment area have been fully rehabilitated and it can be demonstrated (with water quality tests) that runoff from the catchment is of suitable quality to release to the downstream environment without active sediment removal management (i.e. 'diverted' runoff). Overflows from sediment dams will be directed into the receiving environment.

7.5.2 Sediment dam design

Sediment dams will have contributing catchment areas that are expected to generate 'surface' runoff such as disturbed catchment areas containing active spoil dumps. Sediment dams will be sized and configured during the detailed design conditions of the CDCOP.

Figure 7.8 shows a typical cross-section of a sediment dam to be used on the site. The following is of note:

- Sediment dams will have two zones: a settling zone to remove sediment from sediment laden water and a sediment storage zone to collect and store sediment that drops out of the water;
- The settling zone of the sediment dams will be sized to capture the required 5 year ARI 24-hour rainfall event from the contributing catchment area. The size of the sediment storage zone of the sediment dam will be an additional 50% of the settling zone;
- Where possible, sediment dams will be located in old drainage channels such as old or abandoned drainage channels that have been isolated due to mining activities to minimise the amount of excavation required for the storage and allow water to overflow/be pumped into a natural downstream channel after treatment;
- The sediment dams will be designed for a 10-day cycle whereby the sediment laden water fills the sediment dam, sediment is removed and then water be released to the downstream environment in accordance with the Cameby Downs EA conditions or pumped back into the mine water system within 10 days of a rainfall event to maintain storage capacity;

- De-silting of the sediment dams will be undertaken as required to maintain sufficient storage capacity;
- Sediment dams will be constructed with spillways designed to convey at least the 100 year ARI (1% AEP) discharge plus a 300 mm freeboard to the crest of the dam wall; and
- Adequate erosion protection will be required across and downstream of the spillway of the sediment dams.

The settling zone of the sediment dams will be sized using the following formula:

$$V_s = 10 \times R_{(5yr,24hr)} \times C_v \times A$$

where:

V_s = volume of the settling volume (m^3);

$R_{(5yr,24hr)}$ = 5 year ARI, 24-hour rainfall depth (99.6mm);

C_v = Volumetric runoff co-efficient (0.5 adopted); and

A = Catchment area connected to the sediment dam in hectares (ha).

Note that the total sediment storage volume required will be 1.5 times the V_s to account for the sediment storage zone.

Table 7.2 shows the adopted catchment areas, proposed storage capacity (below the spillway), FSL surface area and years when active spoil is within the connected catchment area based on the above design criteria.

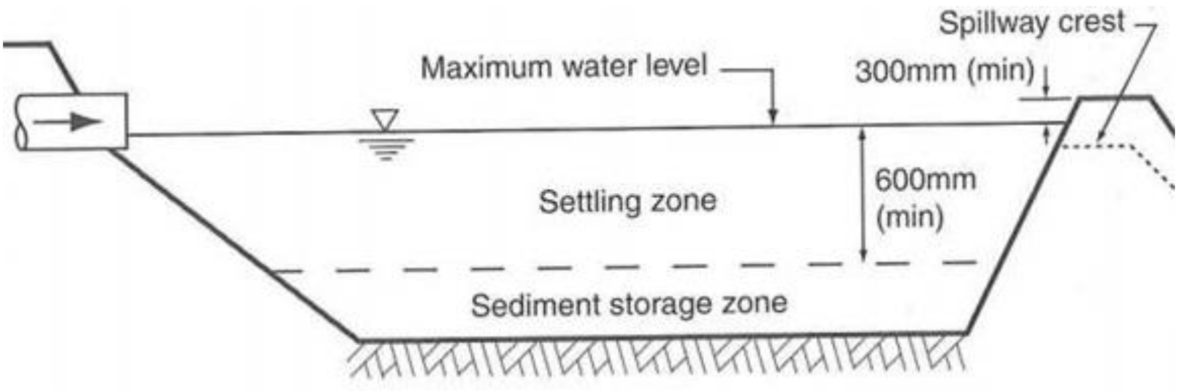

Figure 7.8 - Typical sediment dam cross-section (Source: IECA, 2008)

Table 7.2 - Estimated storage volumes and surface areas required for sediment dams and years of active spoil in the connected catchment

Sediment Dam ID	Maximum Connected Catchment Area (ha)	Total Storage Volume (Settling Zone + Sediment Storage Zone) (ML)	FSL Surface Area (ha)	Mine Stages When Active
SD 1	577	431	8.6	Existing (Stage 0) - Year 48 (Stage 3)
SD 2	184	137	2.7	Year 29 (Stage 1)
SD 3	284	212	4.2	Year 29 (Stage 1) - Year 48 (Stage 2)
SD 4	89	67	1.3	Year 29 (Stage 1) - Year 48 (Stage 2)
SD 5	222	166	3.3	Year 29 (Stage 1) - Year 48 (Stage 2)
SD 6	147	110	6.4	Year 48 (Stage 2)
SD 7	18	13	0.3	Year 48 (Stage 2)
SD 8	47	35	0.7	Year 48 (Stage 2)
SD 9	29	22	0.4	Year 48 (Stage 2)
SD 10	227	170	3.4	Year 48 (Stage 2)
SD 11	38	28	0.6	Year 48 (Stage 2)
SD 12	106	79	1.6	Year 48 (Stage 2)
SD 13	156	115	2.2	Year 75 (Stage 3)
SD 14	287	214	4.3	Year 75 (Stage 3)
SD 15	222	166	3.3	Year 48 (Stage 2) - Year 75 (Stage 3)
SD16	95	72	1.5	Year 48 (Stage 2) - Year 75 (Stage 3)

7.6 ‘WORKED’ WATER DAMS

7.6.1 General description

‘Worked’ water collected in the open pits and the infrastructure areas will be managed using five of the existing water storages (Raw Water Dam, Admin Dam, MIA Dam, Mine Water Dam, Return Water Dam). An additional three dams (Return Water Dam 2 (RWD2), Mine Water Dam 2 (MWD2) and Mine Water Dam 3 (MWD3)) will be constructed as part of the mine water management system.

Excess ‘worked’ water will be stored in WMD1 (Existing (Stage 0)) and WMD2 (Year 29 (Stage 1) to Year 75 (Stage 3)), or inactive pits. Figure 7.1 to Figure 7.4 show the locations of the ’worked’ water dams, together with contributing catchment areas. Table 7.3 shows the active stages, full storage level volumes, catchment areas and estimated preliminary consequence categories for ‘worked’ water storages assessed in Section 7.7.

7.6.2 Raw Water Dam and Admin Dam

Raw Water Dam and Admin Dam will be turkey’s nest storages with no external catchment area. These dams will be operated as a linked system. 'External' water will be pumped from the QGCs Glen Eden Pond at a maximum rate of up to 4 ML/d. MIA Dam will dewater into Raw Water Dam and Admin Dam prior to the wet season (1 November) each year to limit the risk of overflows to Drainage Line 1.

Raw Water Dam and Admin Dam will be the primary source of water for the CHPP water demand and all of the industrial / Infrastructure water demands. The combined storage capacity of Raw Water Dam and Admin Dam is approximately 180 ML. This will allow for storage of up to approximately 45 days of continuously pumped 'external' water inflows from the QGCs Glen Eden Pond. Potential overflows from RWD1 and RWD2 will be directed into MIA Dam.

7.6.3 MIA Dam

The MIA Dam catchment area consists of the coal stockpiles, CHPP, laydown areas and maintenance areas. The MIA dam catchment is considered to shed 'worked' water. The MIA dam transfers to the Admin Dam when above its operating capacity or used to meet CHPP demands at a rate of up to 8.6 ML/day.

7.6.4 Mine water dams 1, 2 & 3

MWD1, MWD2, and MWD3 will be turkeys nest dams with no external catchments. They will be used as open pit water storage and transfer dams. 'Worked' water collected in the open pits will be dewatered to MWDs. 'Worked' water will also be transferred to the MWDs from the Raw Water Dam and Admin Dam as required for dust suppression. The MWDs will transfer dewatered open pit water to the Raw Water Dam and Admin Dam at a combined rate of up to approximately 8.6 ML/d.

7.6.5 Return water dams 1 & 2

RWD1 and RWD2 will collect potentially 'worked' water that is decanted from the Rejects Dams. These dams are Turkey's nest dams with no external catchment areas. 'Worked' water will be transferred to either to meet the CHPP water demand or to the Raw Water Dam and Admin Dam at a combined rate of up to 4.6 ML/d. Each of these dams will be active at different stages, based on when the associated rejects dam is in operation. Once the associated rejects facility is rehabilitated, these dams will become inactive.

7.6.6 Rejects dams 1 & 2

RD1 & RD2 will collect fine rejects from the CHPP. RD1 will collect rejects during Existing (Stage 0) (Year 1 to 3) and RD2 will be operational during Year 29 (Stage 1) (Year 20 to 33), The following is of note with respect to the rejects water management system:

- Rejects slurry water has the potential to contain water that exceeds the contaminant concentration release limit. Hence, this water is considered 'worked' and appropriate management measures should be implemented to contain and reuse this water within the CDCOP mine water system;
- Return water from the rejects dams will be used for makeup water demand for in the CHPP and dust suppression, if required; and
- Active rejects dams will be designed to store its DSA requirement within the dam itself.

7.6.7 Water management dams 1 & 2

Additional 'worked' water dams are required in order to manage excess 'worked' water generated at CDM. Excess 'worked' water will predominantly be generated by rainfall and runoff into the pits.

WMD1 will be used as a storage during Existing (Stage 0) (Years 1 to 19). WMD1 will require an operational storage capacity of 2,000 ML (90% capacity). WMD1 will be converted to RD2 in Year 20.

WMD2 will be in the located at the southern end of the Western Pit. This dam will be used as a storage in Year 29 (Stage 1) to Year 75 (Stage 3) (Year 20 to 75). WMD2 will require an operational storage capacity of 12,000 ML (90% capacity).

The design and operation of the existing and proposed rejects dams will be undertaken in accordance with the relevant guidelines.

Table 7.3 - Mine water storage characteristics, catchment areas and preliminary consequence categories

Dam ID	Active Stage	FSL Volume (ML)	Catchment area (ha)	Preliminary Consequence Category
Raw Water Dam	Existing (Stage 0) - Year 75 (Stage 3)	75	3.5	Low
Admin Dam	Existing (Stage 0) - Year 75 (Stage 3)	75	4.1	Low
MIA Dam	Existing (Stage 0) - Year 75 (Stage 3)	435	89	Low
MWD1	Existing (Stage 0) - Year 48 (Stage 2)	90	4.0	Low
MWD2	Year 29 (Stage 1) - Year 48 (Stage 2)	170	4.0	Low
MWD3	Year 48 (Stage 2)	170	4.0	Low
RWD1	Existing (Stage 0)	75	1.4	Significant
RWD2	Year 29 (Stage 1)	75	1.4	Significant
RD1	Existing (Stage 0)	1,000	67	Significant
RD2	Year 29 (Stage 1)	2,000	61	Significant
WMD1	Existing (Stage 0)	2,000	61	Low
WMD2	Year 29 (Stage 1) - Year 75 (Stage 3)	12,000	252	Low

7.7 REJECTS MANAGEMENT

Coarse rejects will be disposed of in-pit for all stages. Syntech have advised fine rejects disposal will occur in the following locations/structures and years:

- RD1 for year 1 to 3;
- Integrated waste landforms within the backfilled Pit 1 from year 3 to 20;
- RD2 from year 20 to 33; and
- In Final Void (Pit 1) [Centre] from year 29 to year 75.

7.8 OPEN PIT WATER MANAGEMENT

Table 7.4 shows the adopted catchment areas for each open pit during the four stages of the CDCOP. It is proposed to provide DSA requirements for the open pits within the WMDs. When the combined open pit water inventory exceeds 50 ML, water will be pumped to the WMDs at an assumed dewatering rate of 8.6 ML/day for each open pit. In the unlikely event that the WMDs are full, excess water will be stored in an inactive open pit.

'Worked' water collected in the open pits will primarily be used in the water management system for use in the CHPP, industrial/infrastructure water demands and dust suppression.

Table 7.4 - Open pit total catchment area (ha) at different stages of the CDCOP

Pit ID	Existing (Stage 0)	Year 29 (Stage 1)	Year 48 (Stage 2)	Year 75 (Stage 3)
Pit 1	194	418	418	268
Pit 2	-	103	-	-
Pit 2a	-	-	142	-
Pit 2b	-	-	287	-
Pit 3	-	-	218	403
Pit 4	-	-	135	-

7.9 PRELIMINARY CONSEQUENCE ASSESSMENT OF 'WORKED' WATER STORAGES

7.9.1 General

A preliminary assessment of the consequence category of all 'worked' water dams and open pits was undertaken based on the procedures given in DEHPs *'Manual for Assessing Consequence Categories and Hydraulic Performance of Structures*' (DEHP, 2016). Figure 7.9 shows the adopted design configuration for significant and high consequence dams. Based on DEHP (2016), the following is of note:

- Mandatory Reporting Level (MRL) volume (Extreme Storm Storage (ESS)) is the minimum volume of airspace between the spillway and the stored water volume that is allowed in the storage before pumped inflows must cease. No water will be pumped into a storage that exceeds the MRL. The required airspace volume for the ESS has been calculated for significant consequence dams as:
  - 10 year ARI (10% AEP) 72-hour rainfall depth (158 mm) multiplied by the contributing catchment area (assuming no rainfall losses).
- Design Storage Allowance (DSA) volume is the minimum volume of airspace between the spillway and the stored water volume that must be provided for regulated dams on 1 November each year. The required airspace volume for the DSA volume has been calculated for significant consequence dams as:
  - 20 year ARI (5% AEP) 4-month rainfall depth (595 mm) multiplied by the contributing catchment area plus net inflows into the dam during a 4-month period.
- Full Storage Level (FSL) volume is the capacity of the storage from the base to the spillway of the dam;
- Dam spillway capacities for significant consequence dams will be appropriately sized to convey up to between the 100 year ARI (1% AEP) and 1,000 year ARI (0.1% AEP)) discharges plus wave run-up allowance for 10 year ARI (10% AEP) wind.
- The spillway capacity requirement depends on the potential implications of a failure to contain and/or dam break scenario. The appropriate dam spillway size will be determined during detailed design.

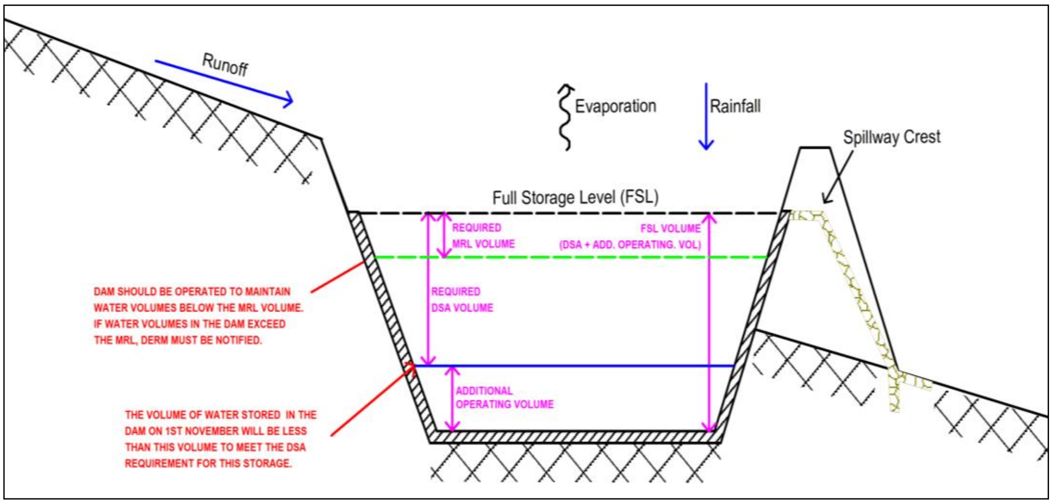

Figure 7.9 - Typical water management dam cross-section for regulated dams

7.9.2 'Worked' water dams

Table 7.3 shows the results of the preliminary consequence assessment for each existing and proposed dam for the CDCOP.

All proposed 'worked' water dams except for the rejects dams and their return water dams have been assigned a preliminary category of low consequence due to the low risk of significant consequence in the event of a failure to contain or dam break. The preliminary 'low' rating reflects the small pumped transfer rates and significant dam storage capacities compared with natural flows and low expected total suspended solid (TSS) concentrations.

Rejects Dams and their associated return water dam have been assigned at least a significant consequence category due to the potential cost of remediation and water quality impacts caused by the possible release of coal rejects in the event of a failure to contain (overflow) and dam break scenario. As a result, the rejects dams will likely require a DSA and ESS volume.

Table 7.5 shows the preliminary estimates of DSA and ESS volume requirements for each rejects dam and associated return water dam based on a significant consequence category.

The following is of note:

- The water quality of each 'worked' water dam will be monitored to confirm the appropriate consequence category for each dam.
- A failure to contain and dam break assessment will be undertaken at the detailed design stage to confirm the appropriate consequence category for each dam.
- The DSA and ESS preliminary estimates are based on the method of deciles, which assumes there are no losses in the system from evaporation or seepage. Other methods may be adopted if there is sufficient historical recorded water level/volume data for the 'worked' water dams.

Table 7.5 – Preliminary DSA/ESS requirements for mine water dams

Mine water dam	DSA/ESS (ML)	Active Stage
RD1 and RWD1	400/110	Existing (Stage 0)
RD2 and RWD2	360/100	Year 29 (Stage 1)

7.9.3 Open pits

Table 7.6 shows the total contributing catchment area and preliminary DSA requirement for the CDM site open pits. The DSA has been calculated based on a significant consequence category using the method of deciles, which assumes that there are no losses in the system from evaporation or seepage. Other methods may be adopted if there is sufficient historical recorded water level/volume data for the open pit.

Table 7.6 – Preliminary DSA requirement for open pits at different stages of the CDCOP

	Existing (Stage 0)	Year 29 (Stage 1)	Year 48 (Stage 2)	Year 75 (Stage 3)
Open pit catchment area (ha)	194	521	1,200	671
Preliminary estimate of wet season containment (DSA) requirement (ML)	1,170	3,100	7,200	4,030
Available storage in Pit 1 (not including rejects area) (ML)	1,600	25,600	25,600	25,600

8 MINE SITE WATER BALANCE

8.1 OVERVIEW

An OPSIM model (WS, 2016) was developed to simulate the long-term behaviour of the water management system at CDM and determine the mine site water balance for the proposed CDCOP mining operations.

The OPSIM model was run on a daily time step over 75 years (Jan 2018 – Dec 2092) to simulate the performance of the proposed water management system during the various mine stages. The model was configured for four stages of mining operations to represent the open pit progression over the mine life. Each stage is represented by a single mine footprint based on the following 4 mine plans:

- Existing (Stage 0) - 10 years from 2018 to 2027 based on the existing mine footprint;
- Year 29 (Stage 1) - 20 years from 2028 to 2047 based on the Year 29 mine plan;
- Year 48 (Stage 2) - 20 year period from 2048 to 2067 based on the Year 48 mine plan; and
- Year 75 (Stage 3) - 25 year period from 2068 to 2092 based on the Year 75 Mine plan (completion of mining).

The mine site water balance was assessed for the very dry (99th percentile), dry (90th percentile), median (50th percentile), wet (10th percentile) and very wet (1st percentile) traces for 75-year simulations based on predicted external water demand. The model was run for 128 separate sequences of daily rainfall and evaporation generated from 128 years (1889-2017) of Data Drill data (See Section 3.2). The use of such a long period of continual data provides a good indication of the behaviour of the various site storages at CDM over extended dry and wet periods.

The OPSIM model was used to determine:

- The long-term behaviour of the various on-site storages;
- The ability and reliability of the various on-site storages to supply the mine site water requirements;
- The frequency and volume of potentially 'surface' and/or 'worked' water overflows from various on-site storages and the impact on the receiving water quality (salinity);
- The predicted volume of water stored in open pit(s) and the WMDs;
- The frequency and volume of 'external' (QGC water) water required to meet shortfalls in mine water demands; and
- The overall site water balance.

The model was run for two different cases:

- Base Case – 'external' water required when harvesting on-site sediment dams is not possible; and
- Alternate Case – 'external' water required in preference to harvesting from on-site sediment dams.

8.2 MODELLING METHODOLOGY

The water balance model (OPSIM) represents the movements of water within the CDM surface water management system over time based on inputs and operating rules. It includes all inflows (e.g. rainfall, surface runoff, pumped inflows, groundwater inflows) and outflows (e.g. evaporation, entrainment, storage overflows, pumped outflows, site water usage, off-site releases) affecting the on-site storages.

A daily (time-step) simulation model was developed based on the schematisation of the CDCOP water management system for the mine site as shown in Figure 7.5 to include the proposed CDCOP water management system (as shown in Figure 7.1 to Figure 7.4) to assess the performance of the proposed water management system and determine its ability to manage water during a range of climatic conditions, including extended 'wet' and 'dry' periods.

In the absence of suitable recorded streamflow data for small local creek systems, an AWBM model (Boughton, 2003) for Dogwood Creek was developed and calibrated to recorded flows at the Gilweir stream gauging station. The calibrated AWBM model was then used to predict flows along Drainage Line 1 for the assessment of potential off-site water release opportunities from the CDM site.

A detailed water balance of the rejects dams as well as the integrated waste landform and the in-pit rejects areas was not undertaken as part of this study because there is no external catchment in the case of rejects dams and only the rejects areas receive pumped inflows from the CHPP. Integrated waste landforms and in-pit rejects areas have been included in the open pit catchments.

The active rejects areas were included in the water balance model as a static storage (i.e. ignoring rejects deposition) to account for rainfall into and evaporation from the rejects dams.

8.3 RAINFALL AND EVAPORATION

The SILO Data Drill rainfall and evaporation data obtained for the CDM site for the 128 year period 1889 to 2017 was used in the mine site AWBM and OPSIM models. This data is reviewed and discussed in Section 3.2 of this report.

8.4 CATCHMENT RUNOFF

8.4.1 Mine site runoff parameters

The AWBM model was used to represent the runoff characteristics of different land use types within local mine site catchments. AWBM uses a group of connected conceptual storages (3 surface storages and 1 groundwater storage) to represent a catchment. Water in the conceptual storages is replenished by rainfall and reduced by evapotranspiration. Simulated surface runoff occurs when these storages fill and overflow. The model parameters define the depth and relative area of each of the storages, as well as the rate of water flux between storages.

To accurately simulate the site water balance, it is necessary to define the runoff characteristics of the various catchment surface (land use) types. The following land use classifications were used:

- Natural - representing undisturbed area as well as rehabilitated areas;
- Industrial - representing areas disturbed by mining such as, haul roads and plant areas (including industrial and cleared areas);
- Spoil - representing uncompacted dumped overburden material;
- Pit - representing the open pit area; and
- Rejects – Representing active reject dams.

Table 8.1 shows the adopted AWBM parameters for the various catchment types at the mine site. The AWBM model parameters were determined on the basis of the OPSIM model calibration results and previous experience with similar catchments.

It is recommended that the runoff characteristics of the mine site catchments be monitored to verify the adopted runoff characteristics for active spoil dumps and natural catchments to confirm the accuracy of the predicted results.

Table 8.1 - Adopted AWBM parameters

Parameter	Parameter ID	Dogwood Ck	Site - Natural	Industrial	Active Spoil	Rehabilitated	Open Pit
Soil Store Depths (mm)	C1	90	90	12	15	90	12
	C2	150	150	21	40	150	38
	C3	280	280	0	120	280	0
Partial Areas	A1	0.134	0.134	0.1	0.134	0.134	0.1
	A2	0.433	0.433	0.9	0.433	0.433	0.9
Base flow index	BFI	0.25	0.25	0	0.3	0.25	0
Base flow recession constant	Kb	0.97	0.97	0	0.96	0.97	1
Surface flow recession constant	Ks	0.77	0.77	0	0	0.77	0

8.4.2 Receiving waters runoff AWBM model validation

The AWBM model was calibrated to the recorded daily Dogwood Creek flows at Gilweir station between October 1969 and December 2016, using the Rainfall Runoff Library (RRL) developed by the CRC for Catchment Hydrology (Podger, 2004). SILO Data Drill rainfalls for the CDM site were used for catchment rainfalls. The model was calibrated to achieve a daily flow duration curve similar to the recorded data. Figure 8.1 shows a comparison of the recorded and predicted daily flow duration curves (in ML/d) for Dogwood Creek at Gilweir station. Table 8.1 shows the validated AWBM model parameters.

8.4.3 Runoff water quality

The OPSIM model has been configured to use salinity (as EC) as an indicator of water quality, by assigning representative EC values to runoff from various catchment types and other inflow sources of water. EC for runoff from the various catchment types are largely based on monitoring data provided by CDM (see Section 3 and Section 5). Table 8.2 shows the EC values adopted for this assessment.

Table 8.2 - Adopted EC values for the CDCOP

Land use	Adopted EC (µS/cm)	Comment
Active Spoil	200	Recorded WQ data in Sediment Dam 1
Natural/Rehabilitation	100	Recorded WQ data in WS1 and WS3
Groundwater	7,500	Recorded WQ data in Open Pit
Rejects	1,500	Recorded WQ data in Rejects Dam 1
Industrial	2,000	Recorded WQ data in MIA Dam
External water	2,500	Recorded WQ data in Raw Water Dam

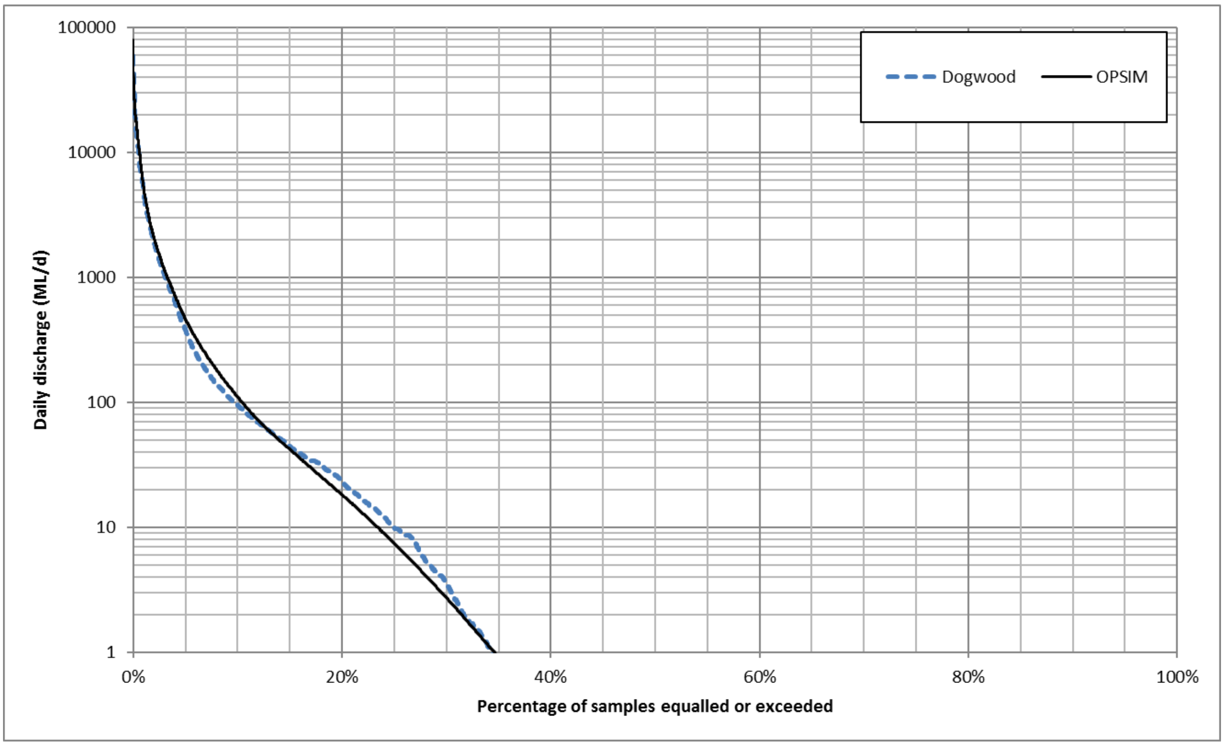

Figure 8.1 - Recorded vs predicted daily flow duration curves, Dogwood Creek at Gilweir Station

8.4.4 Model Catchments

Table 8.3 shows the adopted catchment areas of sediment dams for different stages of mining over the period of the mine life. Sediment dams with fully rehabilitated catchment areas were assumed to have 'diverted' runoff and were removed from the mine water management system. Sediment dam storage volumes were calculated based on the maximum catchment drainage to each sediment dam in any mine stage. Notwithstanding this, the catchment size reporting to each sediment dam was varied for each stage based on the mine plans shown in Figure 7.1 to Figure 7.4.

The catchments for the 'worked' water dams and the open pits were shown in Table 7.3 and Table 7.4.

Table 8.3 Sediment dam catchment areas for different stages of mining operations

Dam ID	Sediment Dam Catchment Area (ha)			
	Existing (Stage 0)	Year 29 (Stage 1)	Year 48 (Stage 2)	Year 75 (Stage 3)
SD 1	295	577	50	-
SD 2	-	184	-	-
SD 3	-	284	188	-
SD 4	-	89	84	-
SD 5	-	216	222	-
SD 6	-	-	147	-
SD 7	-	-	18	-
SD 8	-	-	48	-
SD 9	-	-	29	-
SD 10	-	-	227	-
SD 11	-	-	38	-
SD 12	-	-	106	-
SD 13	-	-	-	148
SD 14	-	-	-	287
SD 15	-	-	-	222
SD 16	-	-	-	100
Total	**295**	**1350**	**1157**	**757**

8.5 SITE WATER DEMANDS

The major water demands at the CDM site are for:

- Coal Handling and Processing Plant (CHPP) use;
- Dust suppression on haul roads; and
- Industrial and Infrastructure use (Such as vehicle wash-down).

Table 8.4 shows a summary of the adopted daily water demands for the CDM site for existing and proposed CDCOP mining conditions. Note that industrial and infrastructure water use have been combined into a single lumped demand.

Table 8.4 - Adopted daily water demands for the CDCOP

Water Demand	CDCOP (3.5 Mtpa ROM) (ML/day)
CHPP demand	2.8 to 3.1
Dust suppression demand	1.0
Industrial/Truck Wash Losses demand	0.3
Total Water Usage demand	4.1 to 4.4

8.6 COAL HANDLING AND PROCESSING PLANT

The proposed CDCOP mining operations will increase the ROM coal rate from approximately 2.8 Mtpa to up to 3.5 Mtpa. As a result, it is expected that product coal produced will be increased up to 2.7 Mtpa (bypass plus washed coal).

Table 8.5 shows the adopted moisture content for the CHPP coal streams. Table 8.6 shows the assumed annual washed coal tonnages into and out of the CHPP. Table 8.7 shows the corresponding assumed daily average CHPP water balance for each mining stage.

Table 8.5 - Adopted moisture contents for the CHPP for proposed CDCOP conditions

Coal type	Water Fraction (%w/w)
Washed ROM coal	10
Washed product coal	13.3
Fine rejects	75
Coarse rejects	10
Fines entrainment	19.1

Table 8.6 - Adopted solids rates for the CHPP for proposed CDCOP conditions

Description	Stage 0	Stage 1	Stage 2	Stage 3
Washed ROM coal dry tonnage (Mtpa)	2.7	2.8	2.8	2.8
Washed product coal dry tonnes (Mtpa)	1.71	1.70	1.65	1.69
Fine rejects (Mtpa)	0.29	0.33	0.34	0.33
Coarse rejects (Mtpa)	0.68	0.77	0.80	0.78

Table 8.7 - Adopted CHPP daily water balance for proposed CDCOP conditions

Description	Stage 0	Stage 1	Stage 2	Stage 3
Washed ROM coal (ML/day)	0.82	0.84	0.84	0.84
Washed product coal (ML/day)	-0.72	-0.71	-0.69	-0.71
Fines rejects slurry (ML/day)	-2.39	-2.66	-2.77	-2.68
Coarse and fine rejects entrainment (ML/day)	-0.50	-0.46	-0.48	-0.56
CHPP water demand (ML/day)	**2.8**	**3.0**	**3.1**	**3.1**

Negative values indicate a loss to the system

8.7 WATER SUPPLY SOURCES

8.7.1 QGC water

Water from the QGC gas field operations is supplied to the existing CDM site. Water is currently pumped to the Raw Water Dam from the Glen Eden Pond at a rate of up to 4 ML/d. Water stored in the Raw Water Dam is used for truck wash areas, industrial wash down areas and as a source of makeup water to the CHPP. This water may also be used for dust suppression in the event that all other mine water sources have been used up.

8.7.2 Potable water

Potable water is trucked to the CDM site. Note that water supplied to CDM for potable water needs was not explicitly modelled because potable water does not enter the water management system.

8.7.3 Groundwater inflows during the operational period

The predicted groundwater inflows for the CDCOP were provided by AGE (2018). A variable groundwater inflow rate is predicted over the life of the mine. The daily (annual averaged) inflow rates over the simulation period are shown in Figure 8.2.

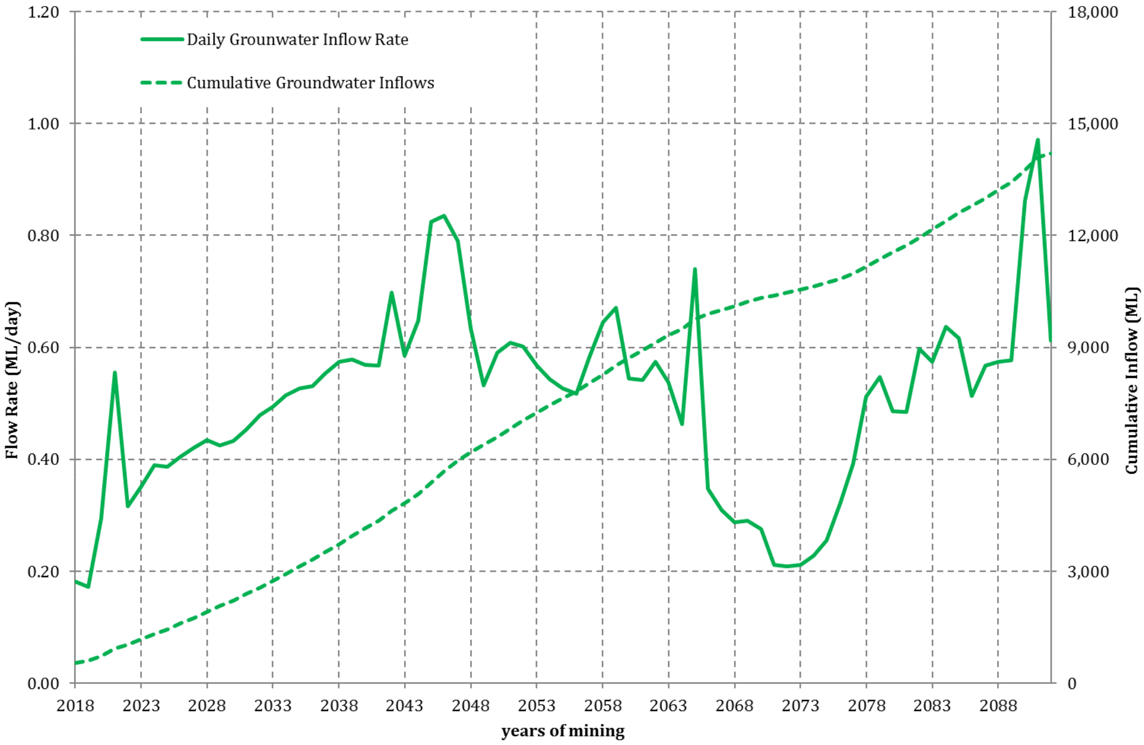

Figure 8.2 – Predicted groundwater inflows to open pits (figure source: AGE, 2018)

A proportion of the predicted groundwater inflows may be lost from the water balance as moisture in coal extracted from the seam (entrained water) and evaporation from exposed coal seams. AGE (2017) state that such losses are considered negligible in the context of the modelled annually averaged groundwater inflow rates provided. Hence, the potential groundwater losses from the exposed coal seam have been assumed negligible for the purposes of the site water balance and surface water assessments given that:

- possible evaporation losses from exposed coal seams would be many orders of magnitude lower than evaporation losses from mine water storages; and
- entrained water has been accounted in the site water balance as moisture in the ROM coal.

8.7.4 Groundwater inflows after closure.

The final void analyses assumed that the groundwater inflows and outflows are influenced by the water level in the voids post closure. Figure 8.3 shows the predicted stage-groundwater inflow/outflow relationship for final voids after closure. This relationship was provided by AGE (2018) and indicates that the voids will operate as groundwater sinks.

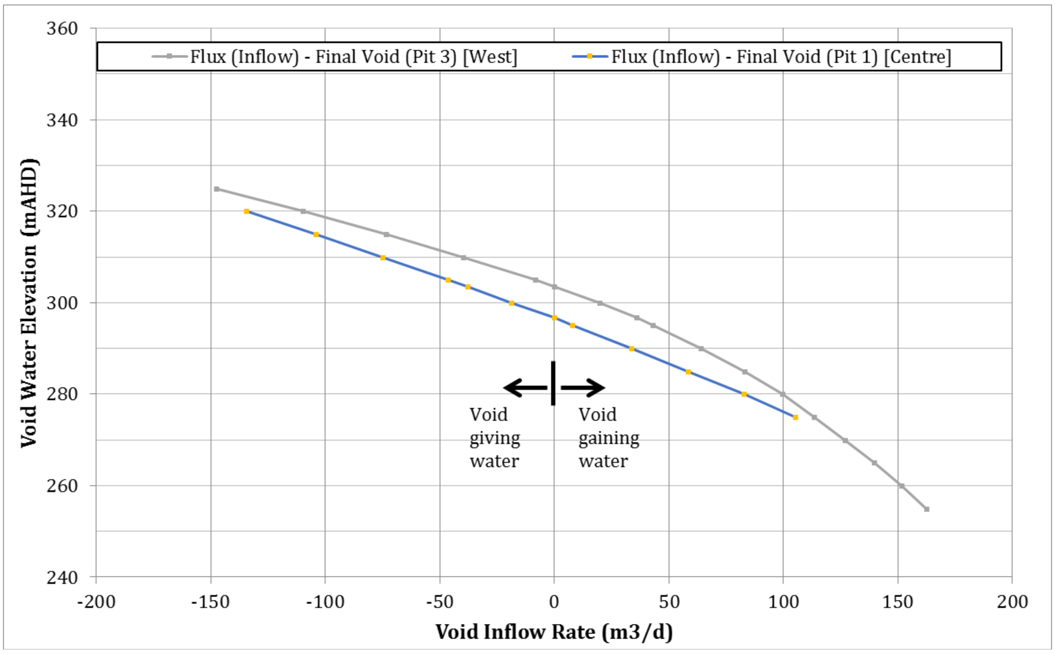

Figure 8.3 – Relationship between post closure final void groundwater inflow and outflow rates (Source: AGE, 2018)

8.8 CONTROLLED RELEASES

Controlled releases to the environment from 'worked' water storages and sediment dams were not modelled for CDCOP operations at CDM. Notwithstanding this, controlled releases from these storages to the environment from mine water dams and sediment dams can be undertaken if the water quality is within the release limits and downstream receiving water trigger limits specified in the proposed Cameby Downs EA conditions, subject to its approval (Section 5).

8.9 WATER BALANCE MODEL CONFIGURATION

Figure 7.5, which shows a schematic of the water balance model for all mine conditions, indicates when various storages are active and inactive. The following is of note with regards to the configuration of the CDCOP water balance model:

- Daily rainfall and evaporation data are described in Section 3.2;
- 'Worked' water storage configurations and operating rules are detailed in Section 7;
- Groundwater inflows to the open pits are described in Section 8.7.3;
- The open pit evaporation losses were factored by 0.7 (that is, the open pit has a reduced evaporation rate compared to surface evaporation from reduced sunlight and wind);
- Rejects moisture contents are described in Table 8.5. Coarse rejects are disposed in-pit and it is assumed 100% of the moisture is entrained (lost). Fine rejects are either deposited in-pit, an integrated waste landform or a rejects dam with an entrainment loss of 19.1%;
- The operational rules for all 'worked' water dams are the same through each mine stage;
- Dust suppression and miscellaneous water uses are the same for all stages; and
- Long-term groundwater inflows to the final voids after closure are described in Section 8.7.4.

8.10 PERFORMANCE OF THE PROPOSED CDCOP WATER MANAGEMENT SYSTEM – BASE CASE

8.10.1 Overview

The performance of the proposed water management system was assessed for five climatic conditions: very dry (99% confidence trace), dry (90% confidence trace), median (50% confidence trace), wet (90% confidence trace), and very wet (99% confidence trace) to provide a range of possible storage behaviours based on the 128 sequences of 75-year rainfall periods modelled. These confidence traces represent the following:

- The 99% confidence trace represents 'very dry' climatic conditions during CDCOP. There is a 1% chance that conditions will be this dry;
- The 90% confidence trace represents 'dry' climatic conditions during CDCOP. There is a 10% chance that conditions will be this dry;
- The 50% confidence trace represents 'median' climatic conditions during CDCOP and is the most likely scenario;
- The 10% confidence trace represents 'wet' climatic conditions during CDCOP. There is a 10% chance that conditions will be this wet; and
- The 1% confidence trace represents 'very wet' climatic conditions. There is a 1% chance that conditions will be this wet.

8.10.2 Mine site water balance

Table 8.8 to Table 8.10 present representative long-term mine site water balance results for different stages of mining based on simulation results for the dry (90th percentile), median (50th percentile) and wet (10th percentile) 75-year rainfall sequences. It should be recognised that rainfall, runoff, and evaporation of the water balance are highly variable from year to year because they are subject to climatic variability.

Note the difference in total rainfall over a 75-year period between the dry, median and wet climates is about 1 to 2%. Therefore, there is only a small difference in water balance tables for each climate condition. The result shown in later stages showing the difference between each stage is more relevant to the CDCOP operations.

The model results indicate that the CDCOP will be a net consumer of water during Existing (Stage 0) (up to year 2025) under dry and very dry conditions due to the higher water demand (CHPP, Dust suppression and Miscellaneous) compared with the volume of rainfall and runoff collected within the mine water system. From Year 29 (Stage 1) onwards, the CDCOP will be a net producer of water, due to the significant increase in the disturbance footprint. In general, mine water demands after Existing (Stage 0) will be met from combination of rainfall and runoff collected in water storages and 'external' QGC water will not be required. The following is of note with respect to the model results (over the period of mine life):

- The total 'external' QGC water requirement during CDCOP operations are approximately 0.42 GL, 0.94 GL and 0.49 GL for a dry, median and wet rainfall sequence, respectively. The majority of 'external' water is required during Existing (Stage 0);
- The total 'worked' rainfall and runoff inflows during CDCOP operations are approximately 153 GL, 161 GL and 173 GL for a dry, median and wet rainfall sequence, respectively;
- The predicted water supply from groundwater inflows (minus losses) during CDCOP operations is 13.8 GL; and
- The predicted water lost in rejects entrainment (fines and coarse) during CDCOP operations is 20.3 GL.

Table 8.8 - Representative long-term average annual water balance, median (50th percentile) rainfall sequence (realisation 99)

Component	Process	Volume (ML/yr)				
		Existing (Stage 0)	Year 29 (stage 1)	Year 48 (stage 2)	Year 75 (stage 3)	Total (75 years)
Inflows	Dirty Rainfall Runoff	106	912	1,293	602	60,209
	Potentially Contaminated Rainfall Runoff	726	1,917	3,292	1,978	160,887
	Net Groundwater	127	210	202	173	13,837
	QGC Water	94	-	-	-	935
	Washed ROM Moisture	299	308	308	308	23,011
	Total	**1,351**	**3,348**	**5,095**	**3,061**	**258,879**
Outflows	Evaporation	284	1,798	3,243	2,028	154,350
	Miscellaneous use	100	100	100	100	7,533
	Dust Suppression	365	365	365	20	18,763
	Washed Product Moisture	263	259	253	259	19,328
	Rejects moisture retention, seepage & evaporation	245	270	281	271	20,249
	Mine water releases	-	-	-	-	-
	Columboola Creek Sediment Dam Releases	26	506	800	324	34,489
	Total	**1,283**	**3,299**	**5,042**	**3,003**	**254,712**
	Change in Site Water Inventory	**69**	**49**	**53**	**58**	**3,809**

Table 8.9 - Representative long-term average annual water balance, dry (90th percentile) rainfall sequence (realisation 78)

Component	Process	Volume (ML/yr)				
		Existing (Stage 0)	Year 29 (stage 1)	Year 48 (stage 2)	Year 75 (stage 3)	Total (75 years)
Inflows	Dirty Rainfall Runoff	212	756	1,041	665	54,690
	Potentially Contaminated Rainfall Runoff	1,010	1,704	2,688	2,210	153,194
	Net Groundwater	127	210	202	173	13,837
	QGC Water	41	-	-	-	415
	Washed ROM Moisture	299	308	308	308	23,011
	Total	**1,690**	**2,978**	**4,240**	**3,356**	**245,147**
Outflows	Evaporation	554	1,540	2,637	2,327	147,240
	Miscellaneous use	100	100	100	100	7,533
	Dust Suppression	365	365	365	20	18,773
	Washed Product Moisture	263	259	253	259	19,328
	Rejects moisture retention, seepage & evaporation	245	270	281	271	20,249
	Mine water releases	-	-	-	-	-
	Columboola Creek Sediment Dam Releases	120	365	529	396	28,968
	Total	**1,646**	**2,901**	**4,165**	**3,373**	**242,091**
	Change in Site Water Inventory	**43**	**78**	**75**	**- 17**	**3,100**

Table 8.10 - Representative long-term average annual water balance, wet (10th percentile) rainfall sequence (Realisation 22)

Component	Process	Volume (ML/yr)				
		Existing (Stage 0)	Year 29 (stage 1)	Year 48 (stage 2)	Year 75 (stage 3)	Total (75 years)
Inflows	Dirty Rainfall Runoff	116	832	1,415	691	63,380
	Potentially Contaminated Rainfall Runoff	820	1,988	3,515	2,195	173,123
	Net Groundwater	127	210	202	173	13,837
	QGC Water	49	0	-	-	492
	Washed ROM Moisture	299	308	308	308	23,011
	Total	**1,411**	**3,339**	**5,440**	**3,366**	**273,843**
Outflows	Evaporation	437	1,830	3,184	2,400	164,636
	Miscellaneous use	100	100	100	100	7,533
	Dust Suppression	365	365	365	24	18,870
	Washed Product Moisture	263	259	253	259	19,328
	Rejects moisture retention, seepage & evaporation	245	270	281	271	20,249
	Mine water releases	-	-	-	-	-
	Columboola Creek Sediment Dam Releases	37	431	890	423	37,344
	Total	**1,447**	**3,255**	**5,073**	**3,477**	**267,960**
	Change in Site Water Inventory	**-36**	**84**	**367**	**-111**	**6,474**

8.10.3 Mine site salt balance

Table 8.11 to Table 8.13 present representative long-term mine site salt balance (TDS) results for different stages of mining based on simulation results for the dry (90th percentile), median (50th percentile) and wet (10th percentile) 75-year rainfall sequences.

Sources of salt inputs to the water management system include groundwater inflows, catchment runoff, direct rainfall, and external water. Salt inputs from direct rainfall was assumed to be zero.

Salt outputs from the water management system include salts which are lost through the process plant in the product material, site water demands (including dust suppression), offsite releases from the sediment dam system and runoff from rehabilitated/diverted catchments (there are no modelled offsite discharges of untreated mine water).

The results indicate the following:

- the largest contributor to the CDCOP salt load is groundwater inflows in median and dry years and ‘worked’ runoff in wet years. Washed ROM coal also contributes significant salt load; and
- The product coal contributes the greatest salt “loss” from the CDCOP.

An assessment of the water quality of sediment dam releases from CDCOP in the downstream receiving waters is provided in Section 8.10.9.

Table 8.11 – Representative long-term average annual total dissolved solids (TDS) balance, median (50th percentile) rainfall sequence (realisation 99)

Component	Process	Mass (Tonnes/yr)				
		Existing (Stage 0)	Year 29 (stage 1)	Year 48 (stage 2)	Year 75 (stage 3)	Total (75 years)
Inflows	Dirty Rainfall Runoff	15	212	292	96	12,626
	Potentially Contaminated Rainfall Runoff	920	1,539	2,180	1,680	125,571
	Net Groundwater	951	1,578	1,518	1,294	103,779
	QGC Water	234	-	-	-	2,338
	Washed ROM Moisture	747	770	770	770	57,527
	Total	**2,867**	**4,098**	**4,759**	**3,841**	**301,842**
Outflows	Evaporation	-	-	-	-	-
	Miscellaneous use	274	444	578	716	41,089
	Dust Suppression	1,194	1,468	1,290	39	68,088
	Washed Product Moisture	752	1,085	1,342	1,655	97,431
	Rejects moisture retention, seepage & evaporation	482	777	1,027	1,197	70,832
	Mine water releases	-	-	-	-	-
	Columboola Creek Sediment Dam Releases	6	172	261	123	11,796
	Total	**2,709**	**3,947**	**4,499**	**3,730**	**289,237**
	Change in Site Water Inventory	**157**	**152**	**261**	**111**	**12,605**

Table 8.12 – Representative long-term average annual total dissolved solids (TDS) balance, dry (90th percentile) rainfall sequence (realisation 78)

Component	Process	Mass (Tonnes/yr)				
		Existing (Stage 0)	Year 29 (stage 1)	Year 48 (stage 2)	Year 75 (stage 3)	Total (75 years)
Inflows	Dirty Rainfall Runoff	27	183	255	104	11,636
	Potentially Contaminated Rainfall Runoff	1,166	1,406	2,021	1,691	122,481
	Net Groundwater	951	1,578	1,518	1,294	103,779
	QGC Water	104	-	-	-	1,037
	Washed ROM Moisture	747	770	770	770	57,527
	Total	**2,995**	**3,937**	**4,564**	**3,860**	**296,460**
Outflows	Evaporation	-	-	-	-	-
	Miscellaneous use	280	435	489	749	40,015
	Dust Suppression	1,180	1,488	1,216	40	66,868
	Washed Product Moisture	762	1,069	1,160	1,725	95,333
	Rejects moisture retention, seepage & evaporation	488	766	888	1,247	69,154
	Mine water releases	-	-	-	-	-
	Columboola Creek Sediment Dam Releases	18	133	249	121	10,840
	Total	**2,728**	**3,891**	**4,002**	**3,883**	**282,211**
	Change in Site Water Inventory	**267**	**46**	**561**	**-23**	**14,249**

Table 8.13 - Representative long-term average annual total dissolved solids (TDS) balance, wet (10th percentile) rainfall sequence (realisation 22)

Component	Process	Mass (Tonnes/yr)				
		Existing (Stage 0)	Year 29 (stage 1)	Year 48 (stage 2)	Year 75 (stage 3)	Total (75 years)
Inflows	Dirty Rainfall Runoff	16	210	341	110	13,915
	Potentially Contaminated Rainfall Runoff	986	1,662	2,606	1,729	138,449
	Net Groundwater	951	1,578	1,518	1,294	103,779
	QGC Water	122	0	-	-	1,231
	Washed ROM Moisture	747	770	770	770	57,527
	Total	**2,823**	**4,220**	**5,235**	**3,903**	**314,901**
Outflows	Evaporation	-	-	-	-	-
	Miscellaneous use	298	476	468	905	44,493
	Dust Suppression	1,256	1,334	1,083	45	62,031
	Washed Product Moisture	799	1,140	1,108	2,047	104,125
	Rejects moisture retention, seepage & evaporation	512	817	848	1,480	75,427
	Mine water releases	-	-	-	-	-
	Columboola Creek Sediment Dam Releases	9	172	342	121	13,386
	Total	**2,875**	**3,939**	**3,849**	**4,598**	**299,461**
	Change in Site Water Inventory	**-52**	**281**	**1,386**	**-695**	**15,440**

8.10.4 Open pit storage behaviour

Figure 8.4 shows the predicted variation in open pit storage volumes for very dry (99% confidence trace), dry (90% confidence trace), median (50% confidence trace), wet (10% confidence trace) and very wet (1% confidence trace) years. Figure 8.5 shows the number of days per year that more than 50 ML would be stored in the open pits. The following is of note with respect to these results:

- Under very wet climate conditions (1% exceedance probability), open pits will have an inventory of:
  - up to 302 ML during Existing (Stage 0);
  - up to 911 ML during Year 29 (Stage 1);
  - up to 2,719 ML during Year 48 (Stage 2); and
  - up to 1,206 ML during Year 75 (Stage 3).
- Open pit inventory is greater than 50 ML under very wet climate conditions (1% exceedance probability) due to pumping capacity limitations for:
  - up to 130 days during Existing (Stage 0);
  - up to 308 days during Year 29 (Stage 1);
  - up to 365 days during Year 48 (Stage 2); and
  - up to 295 days during Year 75 (Stage 3).
- Under wet climate conditions (10% exceedance probability), open pits will have an inventory of
  - up to 172 ML during Existing (Stage 0);
  - up to 568 ML during Year 29 (Stage 1);
  - up to 1,014 ML during Year 48 (Stage 2); and
  - up to 604 ML during Year 75 (Stage 3).
- Open pit inventory is greater than 50 ML under wet climate conditions (10% exceedance probability) due to pumping capacity limitations for a maximum of:
  - 0 days during Existing (Stage 0);
  - up to 13 days during Year 29 (Stage 1);
  - up to 91 days during Year 48 (Stage 2);
  - up to 10 days during Year 75 (Stage 3).
- Under all other climate conditions considered, the open pits do not store water.

The above results assume that the active open pits will be fully dewatered to either the 'worked' water system to meet on-site water demands or to a WMDs to provide minimal disruption to mining operations. If adequate storage capacity is not made available to dewater the active open pits, excess water would have to be held in an active open pit(s) until spare storage becomes available or released to the receiving waters under the approved EA conditions. If water has to be held in an active open pit(s) for prolonged periods of time, this may cause interruptions to coal production.

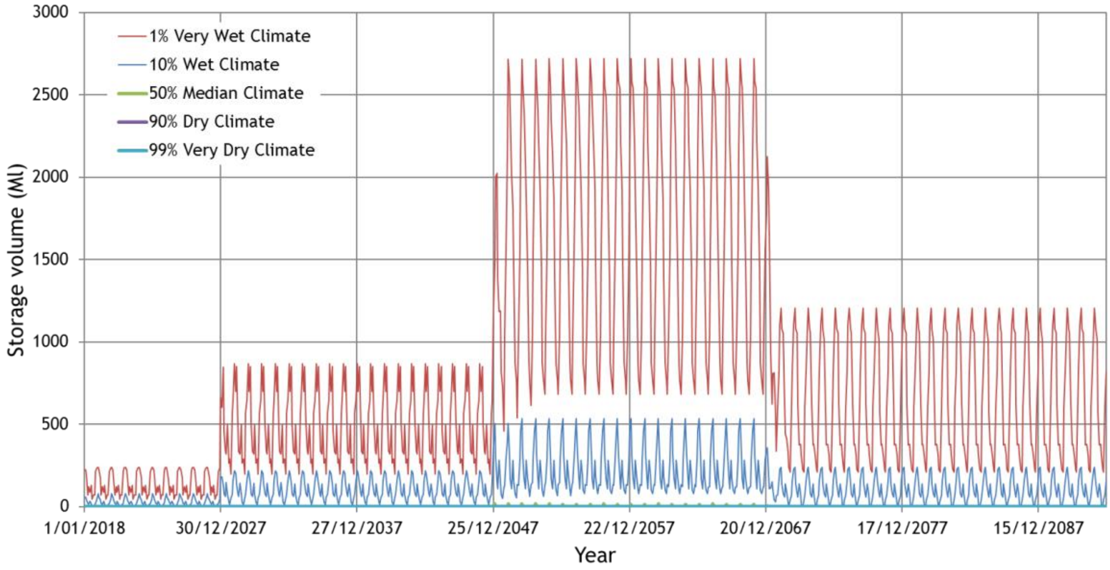

Figure 8.4 – Predicted variation in open pit storage volume

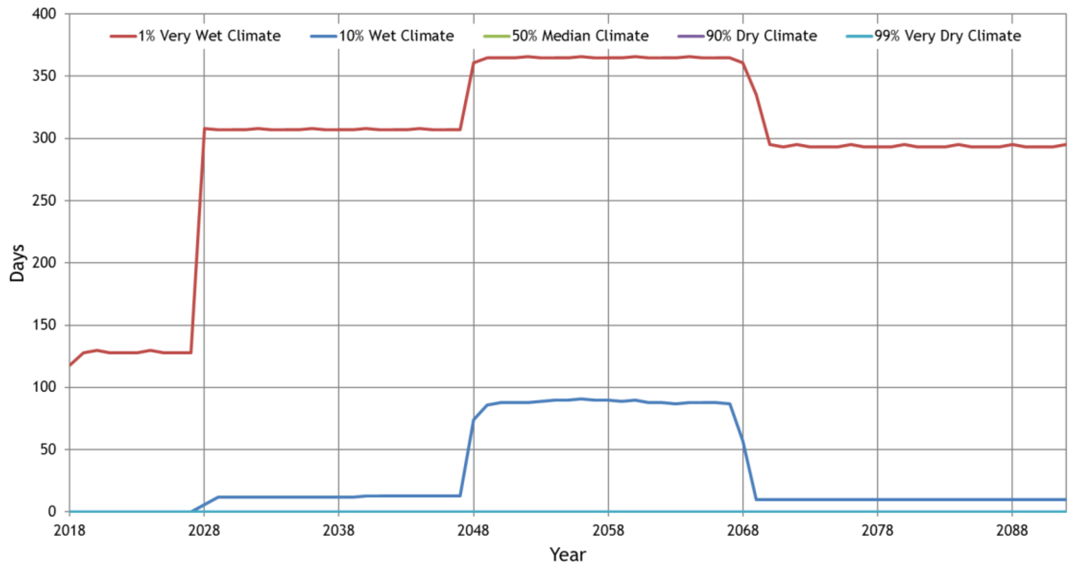

Figure 8.5 – Predicted maximum number of days per year the open pits have more than 50 ML of inventory

8.10.5 Water Management Dam performance

WMD1 will be operational during Existing (Stage 0) and WMD2 will be operational during Year 29 (Stage 1) to Year 75 (Stage 3). WDM1 and WMD2 have assumed operational capacities of 2,000 ML and 12,000 ML respectively plus an additional 10% freeboard to the spillway). Any excess water that is unable to be stored in WMDs will be held in the open pits.

Figure 8.6 shows the predicted variation WMD volumes for very dry (99% confidence trace), dry (90% confidence trace), median (50% confidence trace), wet (10% confidence trace) and very wet (1% confidence trace) years.

The following is of note with respect to the results:

- Under very wet climate conditions (1% exceedance probability), WMDs will have a maximum inventory of:
    - up to 1,986 ML during Existing (Stage 0);
    - up to 6,523 ML during Year 29 (Stage 1);
    - up to 12,238 ML during Year 48 (Stage 2); and
    - up to 7,829 ML during Year 75 (Stage 3).
- Under wet climate conditions (10% exceedance probability), WMDs will have a maximum inventory of:
    - up to 1,057 ML during Existing (Stage 0);
    - up to 3,563 ML during Year 29 (Stage 1);
    - up to 7,014 ML during Year 48 (Stage 2); and
    - up to 4,610 ML during Year 75 (Stage 3).
- Under median climate conditions (50% exceedance probability), WMDs will have a maximum inventory:
    - up to 447 ML during Existing (Stage 0);
    - up to 1,361 ML during Year 29 (Stage 1);
    - up to 2,321 ML during Year 48 (Stage 2); and
    - up to 1,996 ML during Year 75 (Stage 3).
- Under dry climate conditions (90% exceedance probability), WMDs will have a maximum inventory of:
    - up to 153 ML during Existing (Stage 0);
    - up to 607 ML during in Year 29 (Stage 1);
    - up to 958 ML during Year 48 (Stage 2); and
    - up to 936 ML during Year 75 (Stage 3).
- Under very dry climate conditions (99% exceedance probability), WMDs will have a maximum inventory of:
    - up to 71 ML during Existing (Stage 0);
    - up to 336 ML during Year 29 (Stage 1);
    - up to 589 ML during Year 48 (Stage 2); and
    - up to 542 ML during Year 75 (Stage 3).

The results indicate that the site will need WMDs for all climate conditions and during all mine stages. Under very wet climate (1% exceedance probability) conditions, the CDCOP may have to store water in inactive pits due to insufficient storage capacity during Existing (Year 0) and Year 48 (Stage 2).

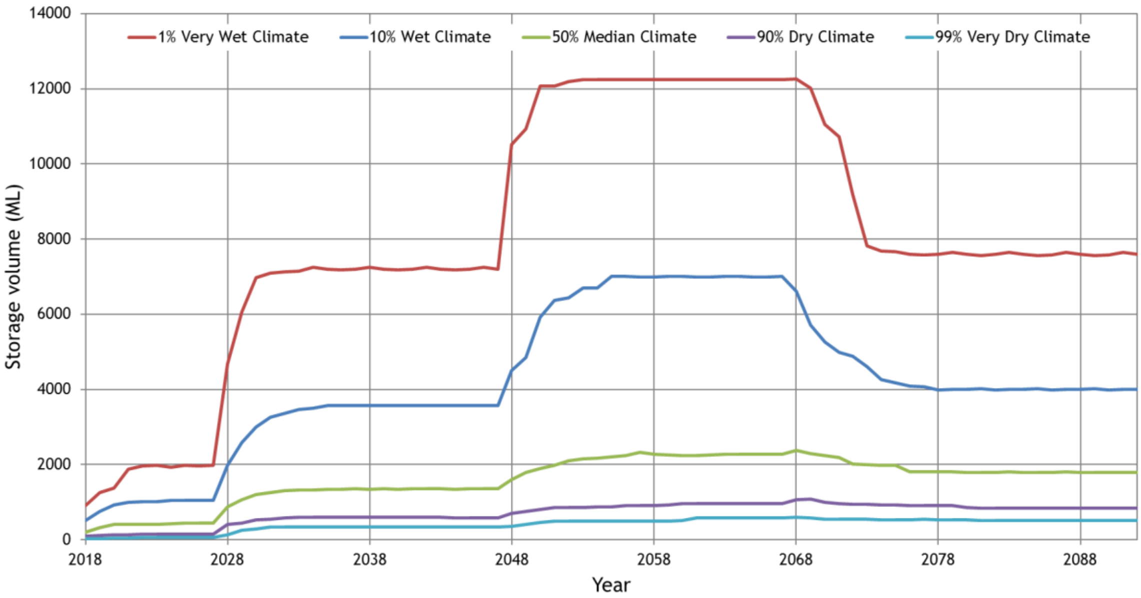

Figure 8.6 – Predicted variation in WMDs maximum storage volumes under different climate conditions (all realisations)

8.10.6 'External' (QGC) water supply requirements

The model results indicate that there would be no supply shortages from the 'external' QGC supply assuming the maximum available supply is 1,460 ML/yr (4 ML/day). The potential demand requirement from site are:

- Up to 456 ML/yr during Existing (Stage 0);
- Up to 381 ML/yr during Year 29 (Stage 1);
- No demand during Year 45 (Stage 2) and Year 75 (Stage 3); and
- A total of up to 1,588 ML during the CDCOP operations.

Figure 8.7 shows the predicted annual maximum volumes (in ML) of 'external' QGC water supply required to meet on-site water demands for the very dry (99% confidence trace), dry (90% confidence trace), median (50% confidence trace), wet (10% confidence trace) and very wet (1% confidence trace) years.

The following is of note with respect to the model results:

- There is at least a 50% chance that no water will be required from 'external' QGC in each year during all mine stages. There is at least a 90% chance no water will be needed each year during Year 48 (Stage 2) and Year 75 (Stage 3);
- There is a 90% chance each year that **less than** 283 ML and 148 ML of 'external' QGC water would be required during Existing (Stage 0) and Year 29 (Stage 1) respectively.
- There is a 99% chance each year that **less than** 456 ML and 381 ML of 'external' QGC water would be required during Existing (Stage 0) and Year 29 (Stage 1) respectively;
- The predicted total 'external' QGC water supply requirement ranges between 0 ML to 1,588 ML during CDCOP operations; and
- There is no external water demand during Year 48 (Stage 2) and Year 75 (Stage 3).

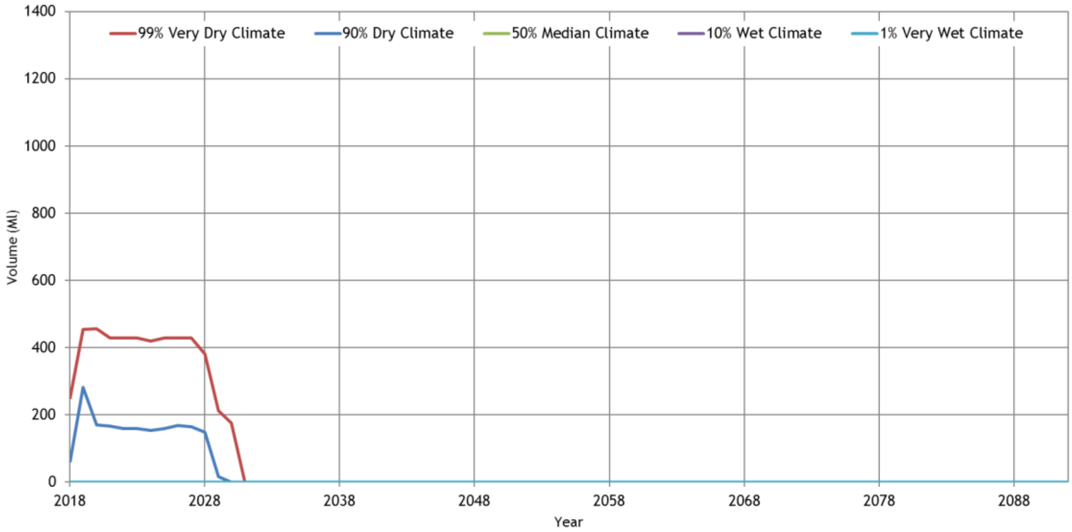

Figure 8.7 – Predicted requirement of annual volumes of 'external' QGC water (all realisations)

8.10.7 'Worked' water dam overflow frequencies and volumes

Figure 8.8 shows the predicted variation in annual maximum volume of water stored in MIA Dam during CDCOP operations for all climate conditions. The maximum operation level for the MIA dam based on its storage capacity (80% of storage capacity) ensures that the MIA dam has a 100 year ARI (1% AEP) spill risk. The MIA dam is predicted to spill up to 25 ML during very wet (1% confidence trace) year. There are no spills predicted from any other 'worked' water dams, as they are turkeys nest dams and are operated with sufficient freeboard in the model.

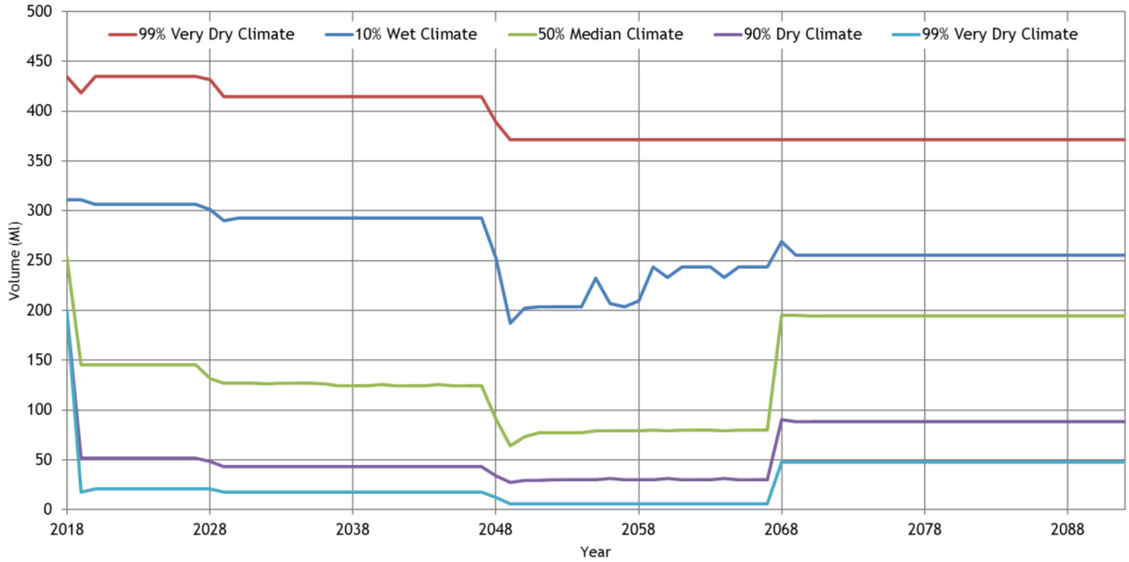

Figure 8.8 – Predicted variation in maximum annual inventory in MIA Dam during CDCOP operations

8.10.8 'Surface' water releases from sediment dams

Figure 8.9 shows the predicted variation in release volumes from sediment dams to the receiving waters during CDCOP operations for all climate conditions assessed. Figure 8.10 compares the total volume of inflows to sediment dams, total release volumes and total release volumes as a percentage of the total inflows during CDCOP operations for all 128 simulation sequences modelled.

The following is of note:

- Releases from sediment dams across their spillways have at least a 50% chance of occurring every year during the 75-year life of CDCOP operations. Given that the catchments draining to the sediment dams will be mainly benign spoil and rehabilitated areas, releases from sediment dams are expected to be of acceptable water quality following the removal of sediment. Based on the assessment undertaken in Section 8.10.9, there were no predicted exceedances in release limits or receiving waters EC trigger levels specified in the current CDM EA from sediment dam releases;
- It is predicted that between 45% and 60% of inflows to the sediment dams would overflow into the receiving waters during the 75-year life of CDCOP operations; and
- The frequency and volume of uncontrolled releases from the sediment dams are dependent on the 'worked' water management system demands. For example. A greater proportion of sediment dam water is used during Existing (Stage 0) and therefore the release probabilities during Existing (Stage 0) are less when compared to during Year 29 (Stage 1) and Year 48 (Stage 2).

The frequent releases from the sediment dams are due to the large catchment areas reporting to the sediment dams. These results highlight the need to manage overburden rehabilitation plans to limit the size of catchments with active spoil draining to sediment dams so that rehabilitated areas can be diverted around the water management system via clean water drains. It also highlights the need for implementation of robust erosion and sediment control and rehabilitation of spoil dumps.

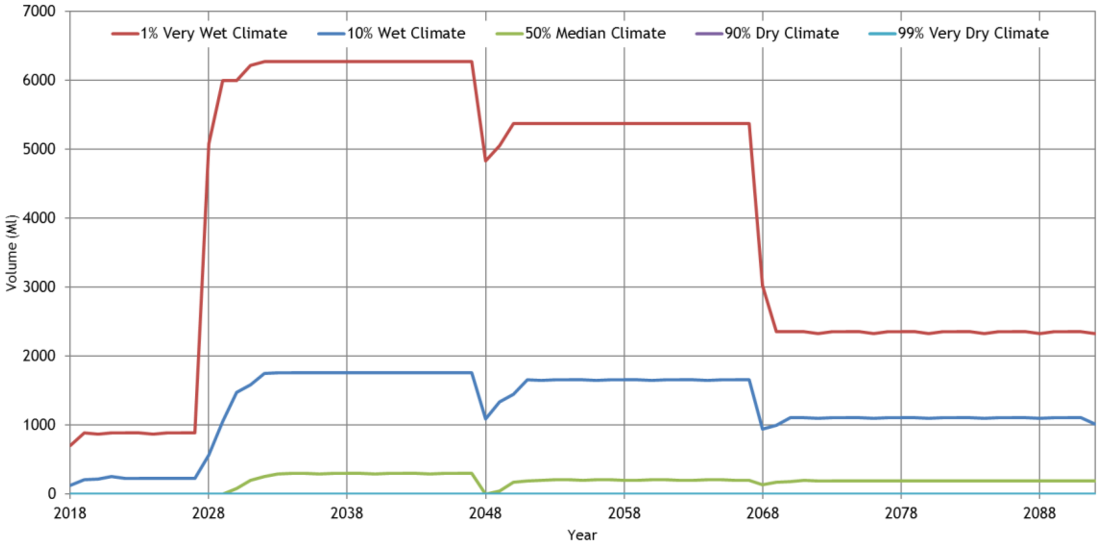

Figure 8.9 - Predicted annual spill volumes from sediment dams during CDCOP operations (all realisations)

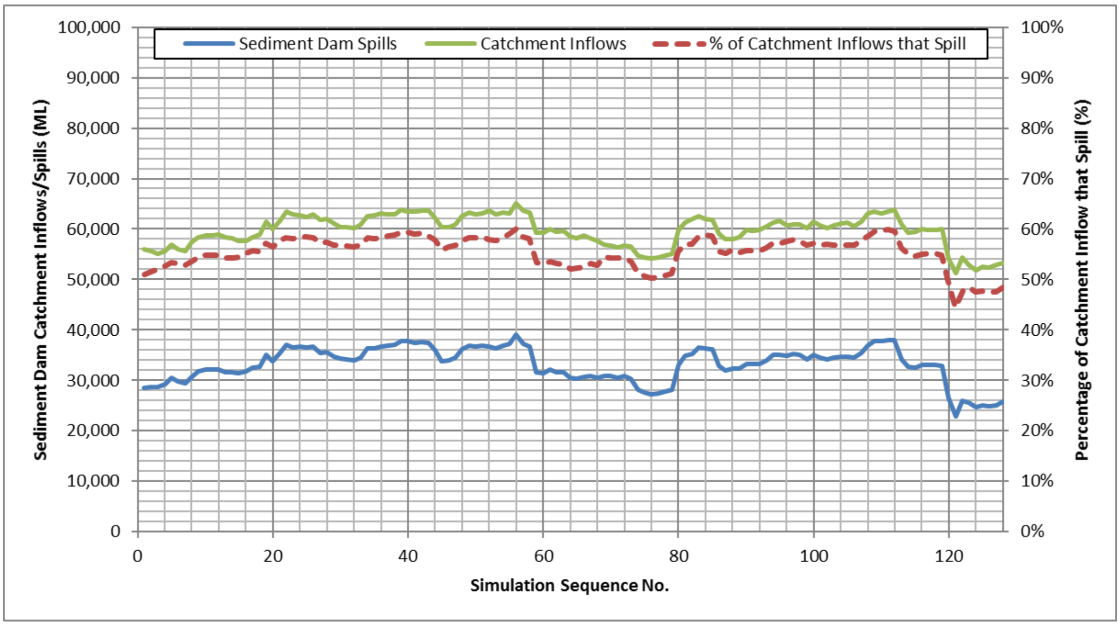

Figure 8.10 – Predicted total catchment inflows and spill volumes from sediment dams during CDCOP operations (all realisations)

8.10.9 Drainage Line 1 water quality

The two potential sources of receiving waters contamination from the water management system are releases from the sediment dams and releases (spills) from the 'worked' water dams. The MIA Dam is the only 'worked' water dam that has a predicted low risk of spilling (1% AEP). All other 'worked' water dams are not predicted to spill.

Potential impacts to EC in the receiving environment were assessed for Drainage Line 1 downstream of the CDCOP at monitoring point WS1 (see Figure 3.4). The potential impact of periodic 'surface' water releases (spills) from sediment dams on water quality in Drainage Line 1 was assessed for EC against the compliance criteria for release limits and receiving waters water quality trigger levels in the proposed CDM EA conditions given in Table 5.1 and Table 5.3. The EA water quality criteria that has been used for this assessment is discussed in Section 5.

Figure 8.11 shows that EC in Drainage Line 1 does not exceed the downstream EC event flow trigger level of 1,000 µs/cm during the CDCOP operations for all 122 realisations assessed. The results also show that releases from sediment dams have an EC generally less than 350 µs/cm with a maximum EC of approximately 515 µs/cm occurring during Year 48 (Stage 2).

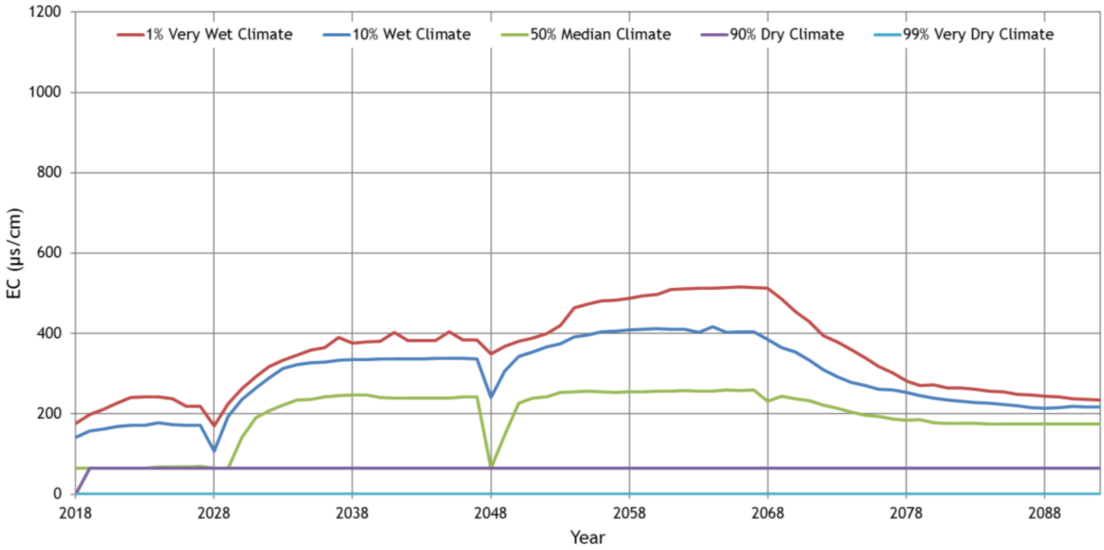

Figure 8.11 - Predicted Drainage Line 1 annual maximum EC variation at WS1 (all realisations) during CDCOP operations

8.10.10 Release scenarios

The OPSIM model was used to assess the release (spill) from scenarios Sediment Dam 1 and MIA Dam. No other dams are predicted to release. The release scenarios that were investigated include:

- Scenario 1 - The highest EC release from Sediment Dam 1;
- Scenario 2 - The highest flow rate release from Sediment Dam 1; and
- Scenario 3 - The highest EC and flow rate release from MIA Dam.

The release events were compared to the proposed flow criteria detailed in Table 5.1. The release scenarios were assessed against the following four conditions:

- Flow criteria - The flow criteria is based on the flow rate within the receiving waters. The flow criteria specify the maximum release rate and EC release limit for all release points;
- Maximum release rate - The maximum combined release rate from all release points for a given flow criteria;
- EC release limit - The maximum EC for releases from mine water dams for a given flow criteria; and
- EC receiving water limit - The maximum EC at the downstream monitoring point (WS1). The EC limit for the receiving waters at the downstream monitoring point (WS1) is 1,000 µS/cm for the medium and high flow criteria and 350 µS/cm for the low flow criteria.

For a release scenario to be in compliance, the maximum release rate, EC release limit and the receiving water EC trigger level must be below the specified corresponding flow criteria in Table 5.1.

8.10.10.1 Scenario 1 - Sediment Dam 1 highest EC

Sediment Dam 1 has a modelled highest release EC of 567 us/cm. Figure 8.12 and Figure 8.13 shows the release rate and EC from Sediment Dam 1 compared to the flow rate in Drainage Line 1. The proposed receiving water flow criteria and release conditions listed in Table 5.3 are also shown.

There are three different flow criteria and corresponding maximum release rates during the release:

- The medium flow criteria of greater than 0.9 m^3/s at the start of the release. This flow criteria allows a maximum release rate of 0.8 m^3/s with a maximum EC of 1,500 µS/cm;
- When the receiving waters flow rate declines below 0.9 m^3/s, the medium flow criteria “steps down” to 0.5 m^3/s. This flow criteria allows a maximum release rate of 0.45 m^3/s with a maximum EC of 1,500 µS/cm;
- When the receiving waters flow rate reduces below 0.5 m^3/s, the medium flow criteria “steps down” to 0.2 m^3/s. This flow criteria allows a maximum release rate of 0.15 m^3/s with a maximum EC of 1,500 µS/cm; and
- No release occurred from MIA during this release event.

The OPSIM model predicts that during Scenario 1 release, the release rate from Sediment Dam 1 would be compliant in terms of release rates and EC using the proposed flow criteria in the receiving waters (Table 5.3).

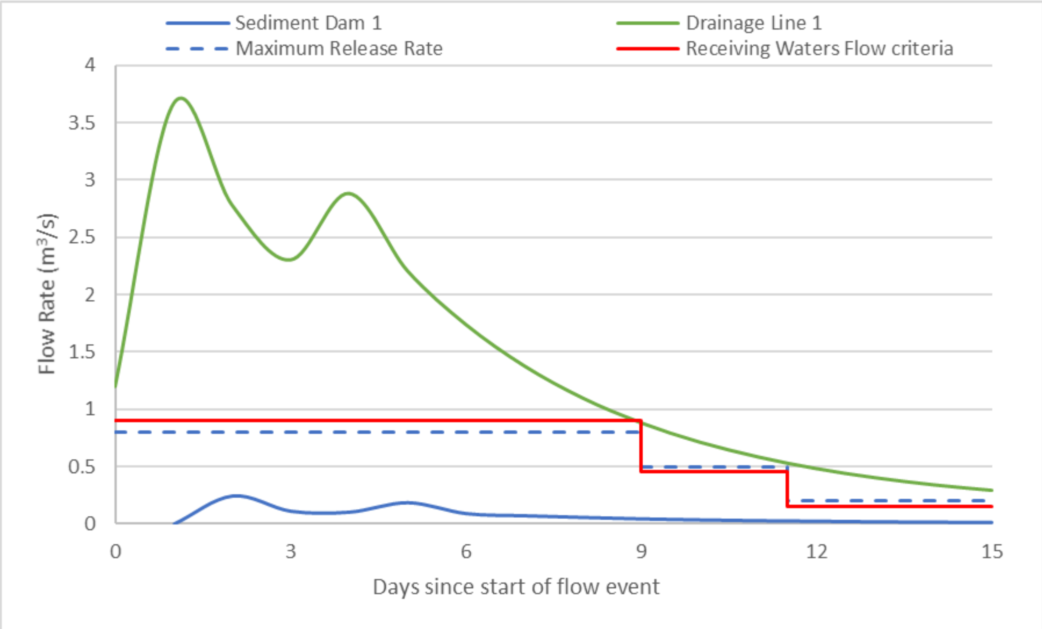

Figure 8.12 – Release rate from Sediment Dam 1 compared to flow rate in Drainage Line 1 and corresponding flow criteria and maximum release rate – Scenario 1

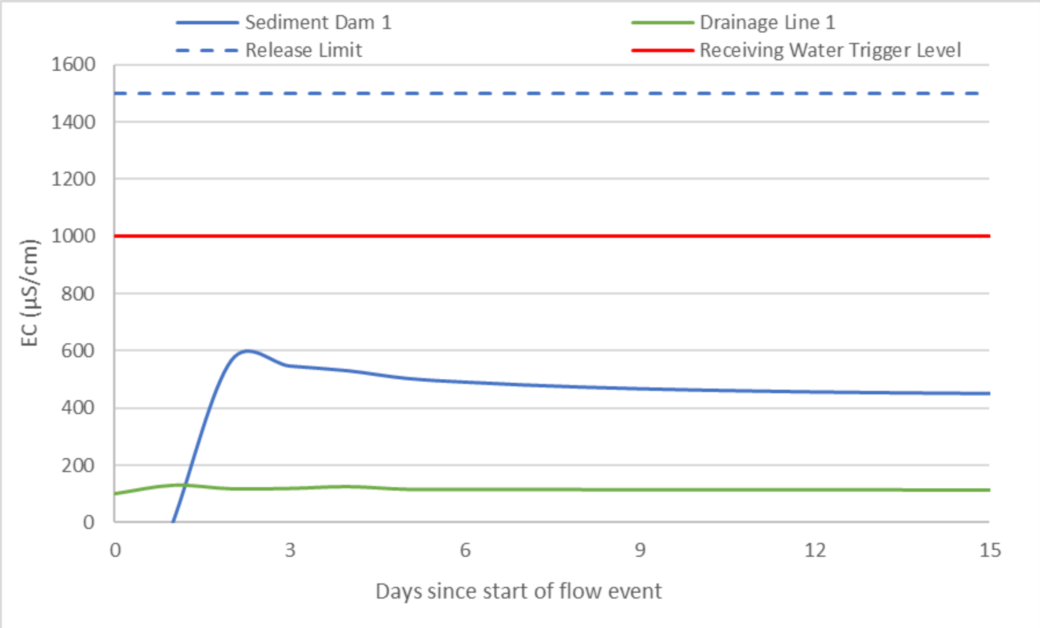

Figure 8.13 – EC from Sediment Dam 1 compared to EC in Drainage Line 1 and corresponding flow criteria and maximum release rate – Scenario 1

8.10.10.2 Scenario 2 – Sediment Dam 1 highest flow rate

The Scenario 2 highest release rate from Sediment Dam 1 rate is 1.46 m^3/s (daily averaged). Figure 8.14 Figure 8.15 shows the Scenario 2 release rate and EC from Sediment Dam 1 compared to the flow rate in Drainage Line 1. The proposed receiving water flow criteria and release conditions listed in Table 5.3 are also shown.

There are two different flow criteria and corresponding maximum release rates and EC triggers during the flow event:

- The high flow criteria of greater than 2.2 m^3/s at the start of the release allows for release EC of up to 1,500 µS/cm at a rate of less than 2 m^3/s; and
- When the flow rate reduces below 2.2 m^3/s, the high flow criteria “steps down” to the medium flow criteria of 0.9 m^3/s. This flow criteria allows a maximum release rate of 0.8 m^3/s with a maximum EC of 1,500 µS/cm.

The OPSIM model predicts that during release Scenario 2, the release rate from Sediment Dam 1 would be compliant in terms of flow rate and EC using the proposed flow criteria in the receiving waters (Table 5.3).

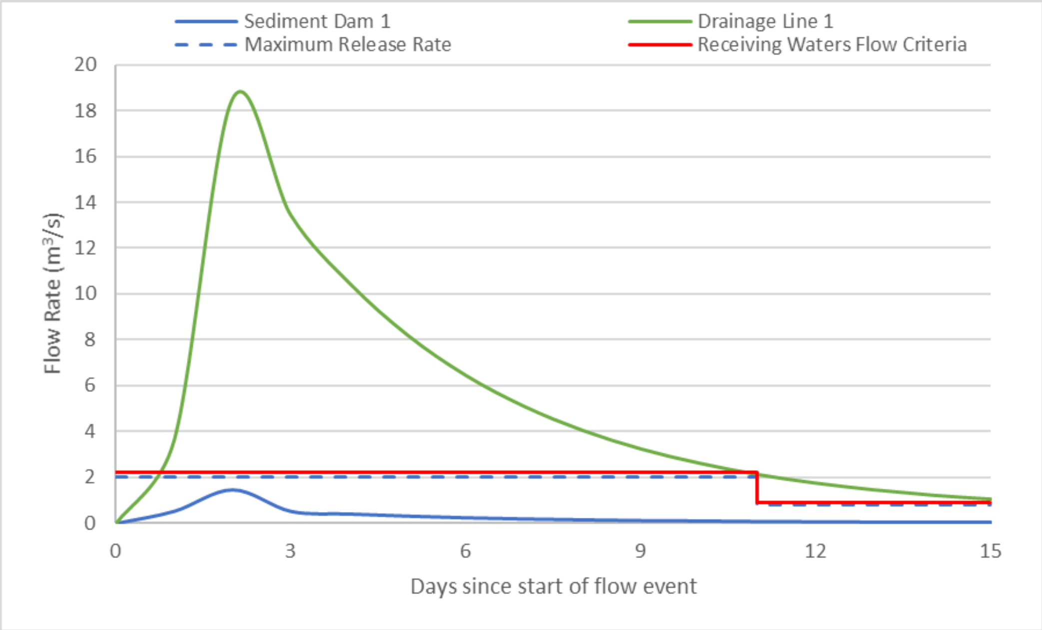

Figure 8.14 - Release rate from Sediment Dam 1 compared to flow rate in Drainage Line 1 and corresponding flow criteria and maximum release rate - Scenario 2

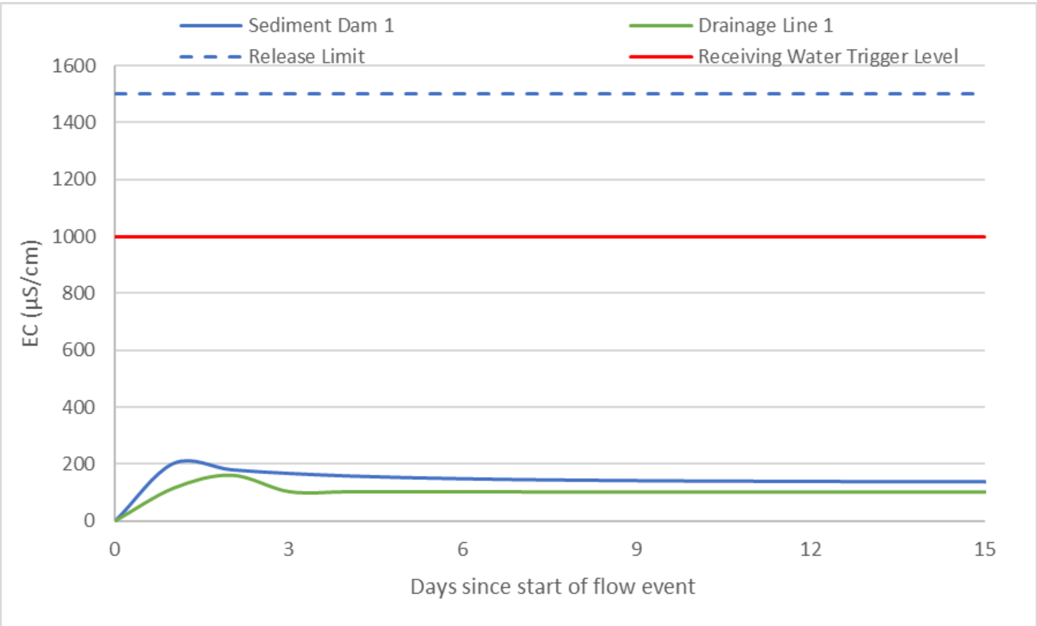

Figure 8.15 - EC from Sediment Dam 1 compared to EC in Drainage Line 1 and corresponding flow criteria and maximum release rate - Scenario 2

8.10.10.3 Scenario 3 – MIA Dam highest flow rate and EC

The highest release predicted by the OPSIM model for the MIA Dam is an EC (2,115 μS/cm) and release rate (0.5 m^3/s), which both occur in the same release. The modelled release from MIA Dam occurs at the same time as the Scenario 2 release from Sediment Dam 1.

Figure 8.16 shows the release rate from MIA Dam compared to the flow rate in Drainage Line 1. Figure 8.17 shows the EC from MIA Dam release compared to the EC in Drainage Line 1. The proposed receiving water flow criteria and release conditions listed in Table 5.3 are also shown.

The release from MIA Dam needs to comply with two flow criteria due to the spill occurring from Sediment Dam 1 at the same time:

- The high flow criteria of greater than 2.2 m^3/s in the Drainage Line 1 allows a maximum (combined) release rate of 2 m^3/s; and
- The high flow criteria of greater than 2.6 m^3/s in the Drainage Line 1 allows a maximum release rate of 0.6 m^3/s at 3,500 µS/cm.

The OPSIM model predicts that during the release event:

- The combined maximum release rate from MIA Dam and Sediment Dam 1 is 1.96 m^3/s, with an estimated combined EC of approximately 680 µS/cm, which complies with the high flow criteria for flows greater than 2.2 m^3/s in the Drainage Line 1 allows a maximum (combined) release rate of up to 2.0 m^3/s at less than 1,500 µS/cm;
- The MIA maximum release rate is 0.5 m^3/s with an EC of 2,112 µS/cm, which complies with the high flow criteria for flows greater than 2.6 m^3/s in the Drainage Line 1, which allows a maximum release rate of up to 0.6 m^3/s at less than 3,500 µS/cm; and
- The receiving waters of Drainage Line 1 has a maximum EC of 161 µS/cm, which is below the trigger limit of 1,000 µS/cm for medium and high flow criteria.

Based on the OPSIM model, the release Scenario 3 from MIA Dam would be compliant with the proposed flow criteria and EC trigger value if the release was assessed on its own, or in combination with Sediment Dam 1.

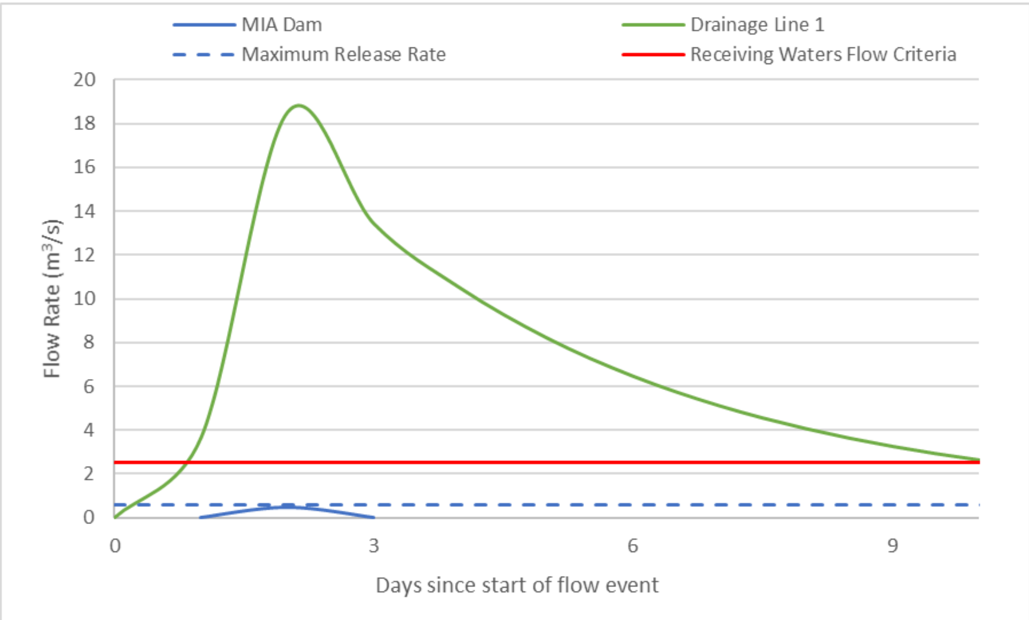

Figure 8.16 – Release rate from MIA Dam compared to flow rate in Drainage Line 1 and corresponding flow criteria and maximum release rate – Scenario 3

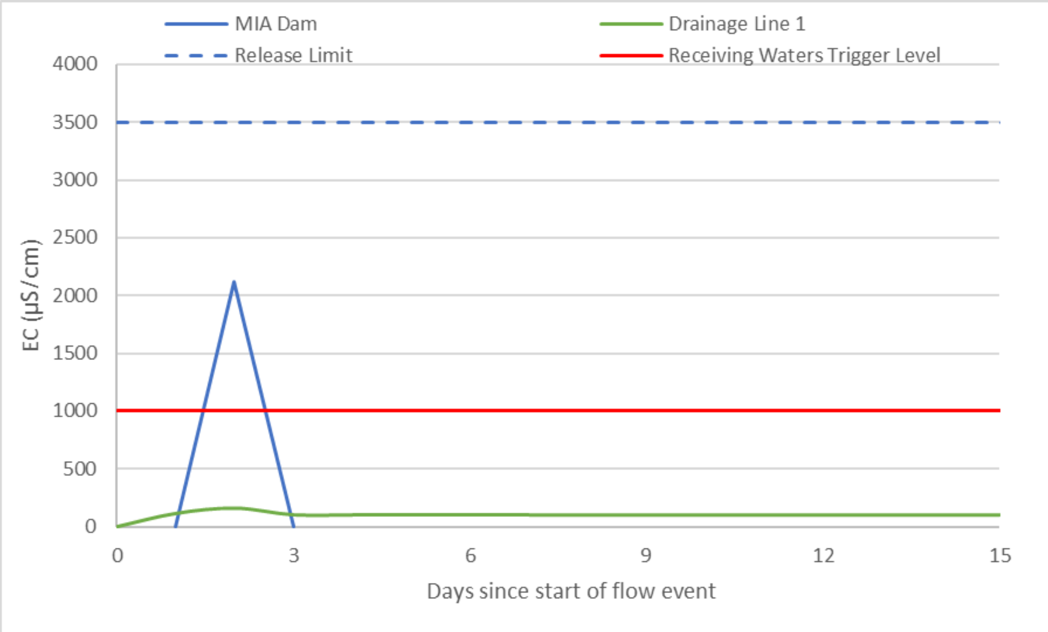

Figure 8.17 – EC from Sediment Dam 1 compared to EC in Drainage Line 1 and corresponding flow criteria and maximum release rate – Scenario 3

8.11 PERFORMANCE OF THE PROPOSED CDCOP WMS – ALTERNATIVE CASE

8.11.1 Overview

The water balance model was used to investigate an alternative case where sediment dam water is not used to make up mine water demands (e.g. CHPP, dust suppression etc). For the alternative case, the mine water system did not demand sediment dam water, instead demanded 'external' QGC water once the 'worked' water sources were depleted. The impact to open pit inventories, WMD performance, sediment dam releases and the demand on 'external' QGC water supply were assessed for this alternative case.

8.11.2 Open pit storage behaviour

Figure 8.18 shows the precited open pit storage volume behaviour for the alternative case under different climate conditions during the CDCOP operation. Comparing results shown in Figure 8.18 with Figure 8.4 for the base case indicate that the open pit inventories have remained basically unchanged for the alternative case when compared to the base case.

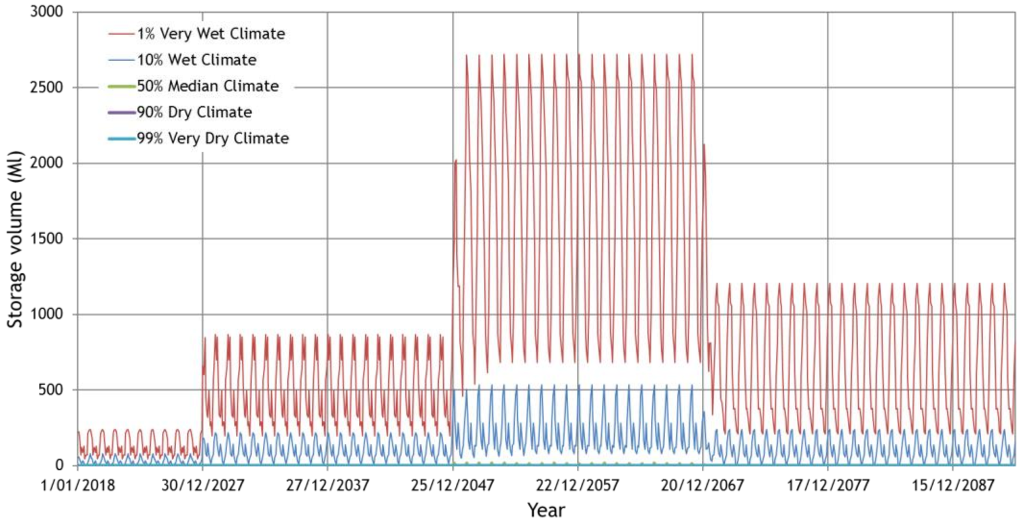

Figure 8.18 – Predicted variation in open pit storage volume for the alternative case (all realisations)

8.11.3 Water Management Dam performance

Removing sediment dam water from the CDCOP operational water supply has a negligible impact on the total water inventory in the WMDs as shown in Figure 8.19. The percentage change in maximum inventories in the WMDs for each mine stage is less than 1%.

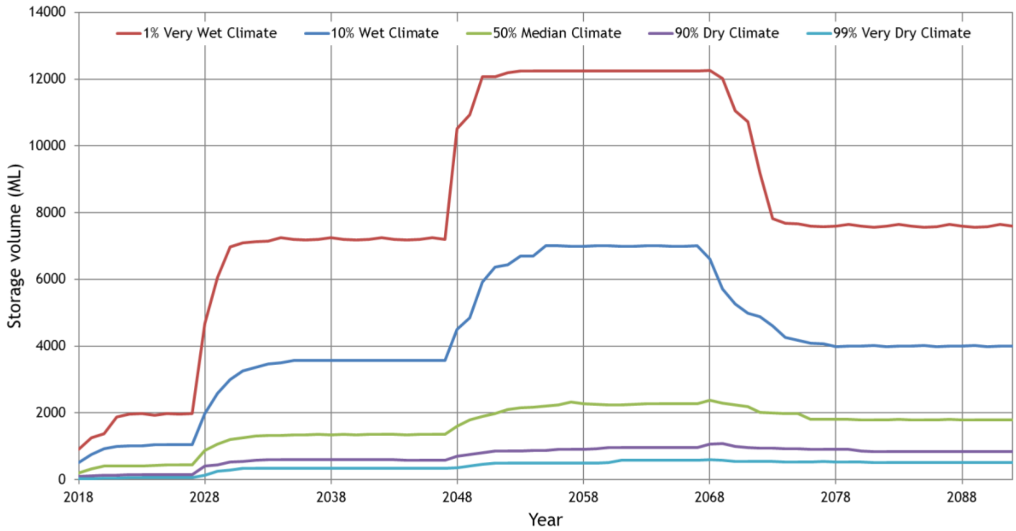

Figure 8.19 – Predicted variation in WMDs maximum storage volumes each year under different climate conditions (all realisations) for the alternative case

8.11.4 'External' QGC water supply requirements

'External' QGC water requirement is predicted to increase for the alternative case when compared with the base case. The following differences are of note:

- Under very dry climate conditions (99% confidence trace) there is a small increase in yearly demand:

- up to 485 ML during Existing (stage 0);
- up to 381 ML during Year 29 (Stage 1); and
- up to 120 ML during Year 48 (Stage 2).

- Under dry climate conditions (90% confidence trace) there is a small increase in yearly demand from:
  - up to 310 ML during Existing (stage 0): and
  - up to 148 ML during Year 29 (Stage 1).

The results indicate that during Year 75 (Stage 3), the CDCOP will not require any 'external' water supply for all climate conditions even after excluding sediment dam water.

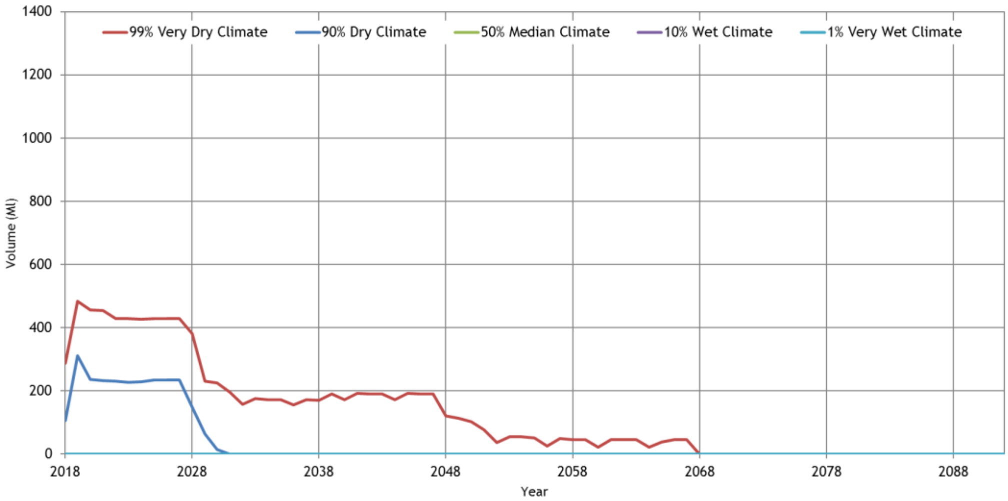

Figure 8.20 – Predicted requirement of annual volumes of 'external' QGC water (all realisations) for the alternative case

8.11.5 Releases from sediment dams

Sediment dam inflows and releases (spills) increase slightly for the alternative case. This is due to increased volumes of water stored in the sediment dams, which increases direct rainfall volumes and the resulting spill volume. Figure 8.21 shows the predicted variation in annual spill volumes from the sediment dams. Figure 8.22 shows the total volume of inflows to the sediment dams, totals spill volumes and the spill volumes as a percentage of the total inflows during the CDCOP operation for the alternative case. Based on these results, sediment dam releases have remained relatively the same, with negligible changes to the yearly release volume.

Table 8.14 shows the comparison in annual average spill volumes from the sediment dams between the base case and the alternate case. The following differences are of note:

- Under wet climate conditions (10% exceedance probability), the annual average spill volume increases by up to 28 ML/yr;
- Under median climate conditions (50% exceedance probability), the annual average spill volume increases by up to 10 ML/yr; and
- Under all other climate conditions, there is no change in annual spill volume.

The results indicate that use of sediment dam water during the CDCOP has a negligible impact on the site spill risk and spill volume from the sediment dams.

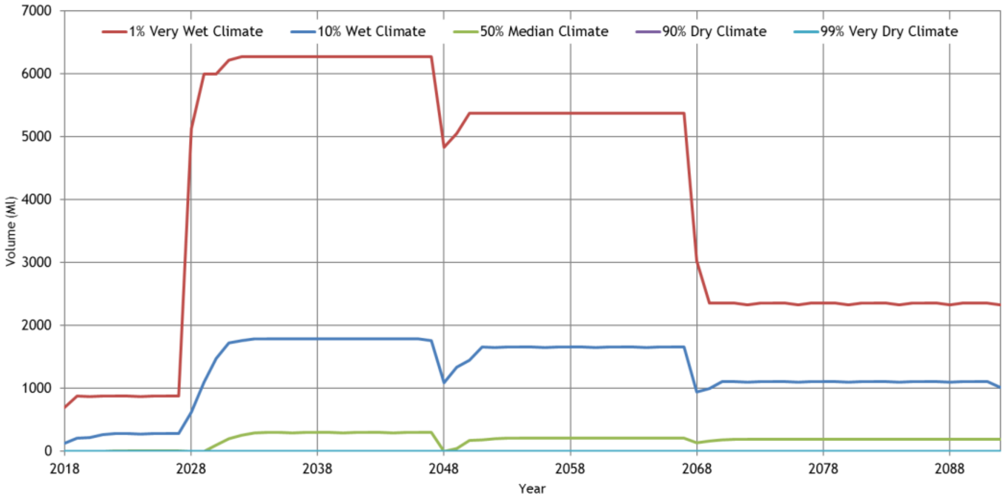

Figure 8.21 - Predicted annual spill volumes from sediment dams during CDCOP operations (all realisations) for the alternative case

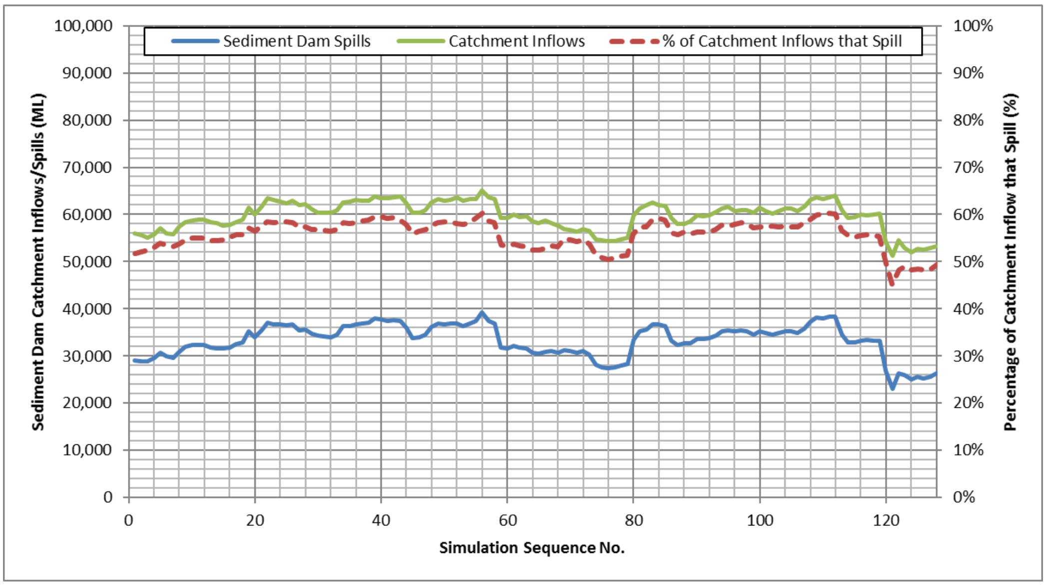

Figure 8.22 - Predicted total catchment inflows and spill volumes from sediment dams during CDCOP operation (all realisations) for the alternative case

Table 8.14 - Change in Sediment Dam annual spill volume for each mine stage and climate condition - Base case vs alternate case

Mine stage	Increase in annual average spill volume (ML/yr)				
	1% Very Wet Climate	10% Wet Climate	50% Median Climate	90% Dry Climate	99% Very Dry Climate
Existing (Stage 0)	0	28	10	0	0
Year 29 (stage 1)	0	25	0	0	0
Year 48 (stage 2)	0	0	0	0	0
Year 75 (stage 3)	0	0	0	0	0

8.11.6 Drainage Line 1 water quality

The results shown in Figure 8.23 indicate that EC values in Drainage Line 1 for the alternative case are slightly higher when compared to the base case. However, EC is not predicted to exceed the downstream water quality trigger level criteria (see section 5) during the CDCOP for all 122 realisations. Based on these results, the risk of exceeding the downstream trigger levels (if sediment dam water is not harvested) is low.

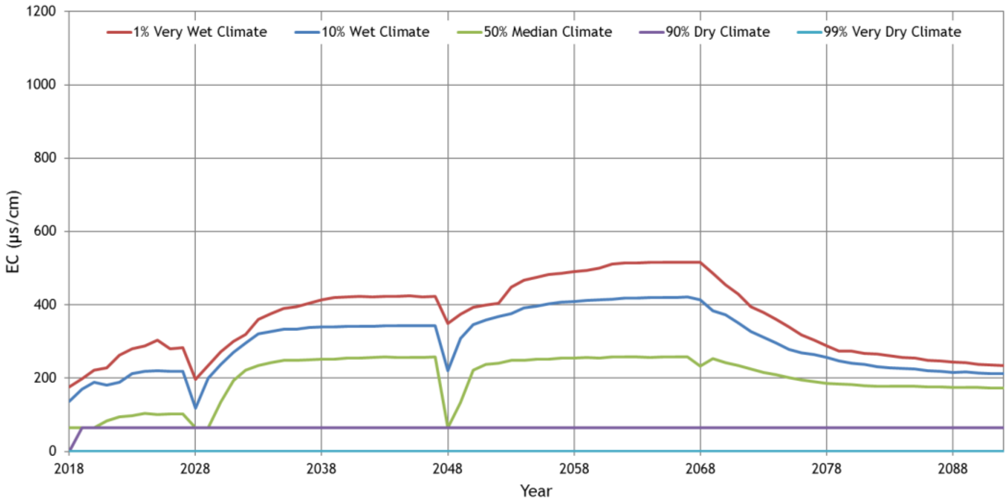

Figure 8.23 – Predicted Drainage Line 1 annual maximum EC at WS1 (all realisations) for the alternative case

8.11.7 Base case vs alternative case comparison

The results from the comparison of the two cases show that removing sediment dam harvesting impacts on the following areas of the water management system:

- Sediment dam spills as a percentage of total inflows increase slightly from 44% to 60% (for the base case) to 45% to 60% (for the alternative case). The slight increase in spills does not increase the predicted risk of exceedance of trigger levels for EC in the receiving waters.
- The maximum annual WMDs inventory change is negligible, and has no impact on the water management system during operations; and
- The duration for which the CDM may require 'external (QGC) water would increase by up to 35 years under very dry climate conditions (99% confidence trace). This may delay the ability for the CDCOP to be independent of 'external' (QGC) water supply.

8.12 FINAL VOID ASSESSMENT

8.12.1 Overview

The OPSIM model was run for a 500 year period from the end of mine to assess the long-term storage inventory and TDS concentrations in the final voids during post closure. The 128 years of SILO Data Drill rainfall and evaporation data was cycled four times to generate the 500 year climate sequence.

Variable groundwater inflow and outflow rates were provided by AGE (2018). Several iterations of the OPSIM model were run to converge with the stage groundwater inflow curve. The predicted groundwater flow rates for post closure as function of water elevation in the final voids are shown in Figure 8.3.

Final voids and open pits are assumed to have reduced evaporation due to the shading from the highwall. Two scenarios where modelled to assess the sensitivity of water inventory and TDS concentrations due to evaporation. The base case used an evaporation factor of 0.7 applied to the lake evaporation rate, which is the same factor used for open pits during operations.

The alternate case reduced the evaporation factor to a conservative value of 0.5.

8.12.2 Final void catchments and storage volumes

Figure 8.24 shows the final void catchment areas adopted for the assessment based on the end of mine (EOM) mine plan. The final landforms were assumed to be rehabilitated above natural surface and remaining as spoil below natural surface elevations. Based on the proposed final landforms, potentially large surface catchments will drain to Final Void (Pit 1) [Centre] and Final Void (Pit 3) [West] as shown in Table 8.15. Final Void (Pit 1) [Centre] was assumed to have a starting inventory of 5,000 ML to account for all the onsite dams being de-watered to the pit at closure.

Table 8.15 – Final void catchments and storage volumes

Void ID	FSL Volume (ML)	Catchment area (ha)
Final Void (Pit 1) [Centre]	25,600	188
Final Void (Pit 3) [West]	67,700	718

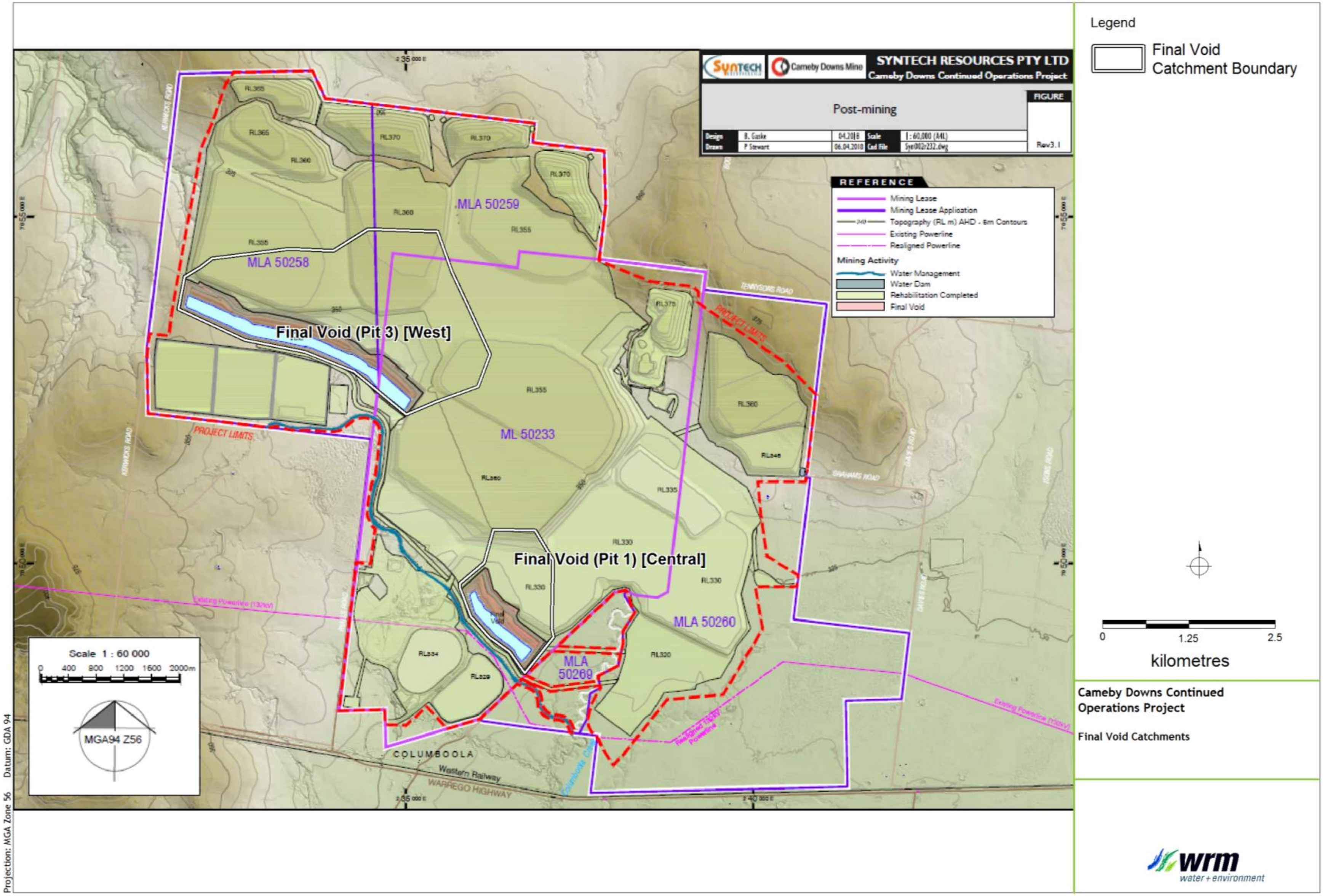

Figure 8.24 – Final void catchments for CDCOP

8.12.3 Results

Figure 8.25 shows that the TDS concentrations are predicted to increase past the end of the 500 year assessment period. Comparison of the maximum predicted TDS concentrations at the end of the simulation period between the base case and the alternate case show:

- Final Void (Pit 1) [Centre] maximum TDS decreased from approximately 23,000 mg/l (base case) to 6,700 mg/l; and
- Final Void (Pit 3) [West] maximum TDS decreased from approximately 21,000 mg/l (base case) to 5,500 mg/l.

The results indicate that a lower evaporation rate in the alternate case has a significant impact on the concentration of salts in the final voids.

Figure 8.26 and Figure 8.27 shows that the stored volumes in the final voids will increase until a balance is established between rainfall/groundwater inflows and evaporation outflows. The model results show that the final void water inventory in both pits is predicted to stabilise below half of the final void FSL volume within the first 200 to 300 years after mine closure for both the base case and the alternate case.

With respect to the predicted results, the following is of note:

- Final Void (Pit 3) [West] stabilises around 15% of its storage capacity in the base case which is the lowest inventory (as a percentage) of the final voids;
- The final void storage inventories shown in Figure 8.26 and Figure 8.27 follow a similar pattern albeit with different amplitudes. The amplitudes in final void behaviour are different because:
  - They have different stage-surface area-storage curves. Final Void (Pit 1) [Centre] is significantly smaller in surface area compared with Final Void (Pit 3) [West];
  - The final voids have different catchment areas as shown in Table 8.15; and
  - The final voids stage-groundwater inflow relationship curves vary significantly for each void. For example, at 275 mAHD Final Void (Pit 1) [Centre] groundwater inflow is 105 m^3/d and the equivalent Final Void groundwater inflow is 113.5 m^3/d.

There is very little recovery in Final Void (Pit 1) [Centre] and Final Void (Pit 3) [West] because the evaporation loss rates and rainfall runoff rates are significantly greater than the groundwater inflow rates. Therefore, the behaviour of these voids is dominated by surface hydrology rather than groundwater inflows and will continue to operate as groundwater sinks.

The alternate case increased the total storage inventory of both final voids. However, the storage inventory of the final voids is not predicted to exceed 50% of capacity over a 500 year period. Changing the evaporation factor had the following impacts on inventory:

- Final Void (Pit 1) [Centre] maximum storage inventory increased from approximately 7,370 ML to 11,340 ML; and
- Final Void (Pit 3) [West] maximum storage inventory increased from approximately 11,660 ML to 30,670 ML.

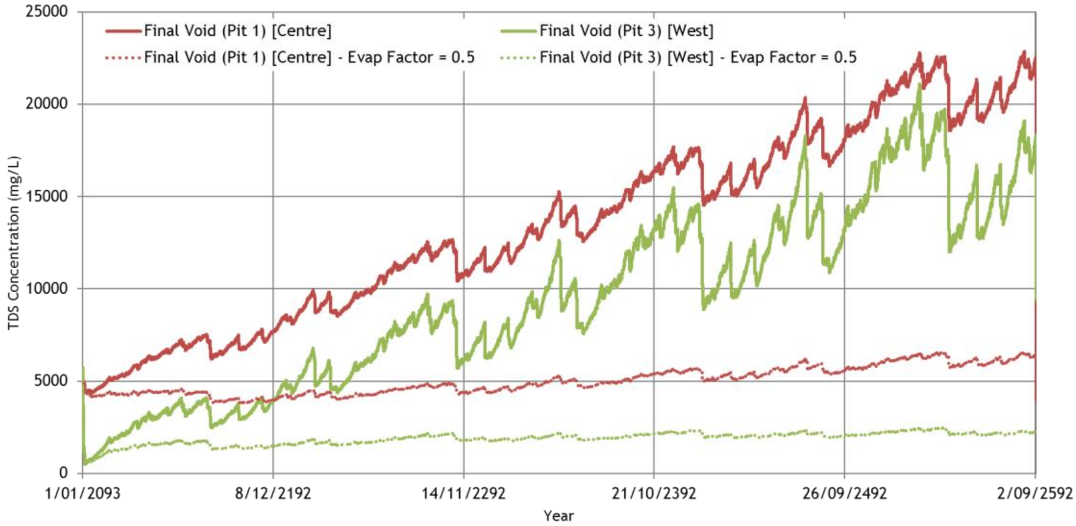

Figure 8.25 – Predicted Final Void TDS concentration for the base case and alternate case

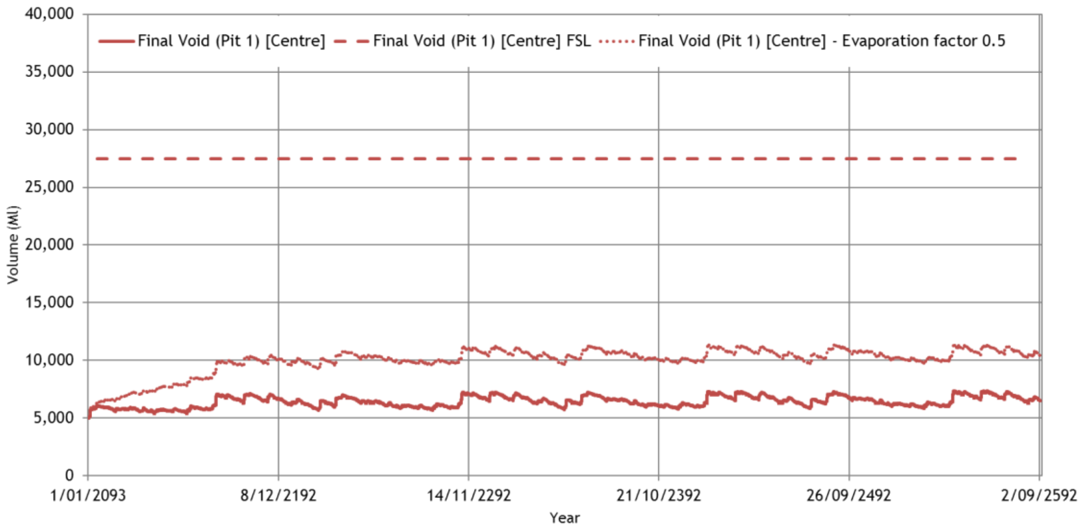

Figure 8.26 - Predicted Final Void (Pit 1) [Centre] inventory over 500 years

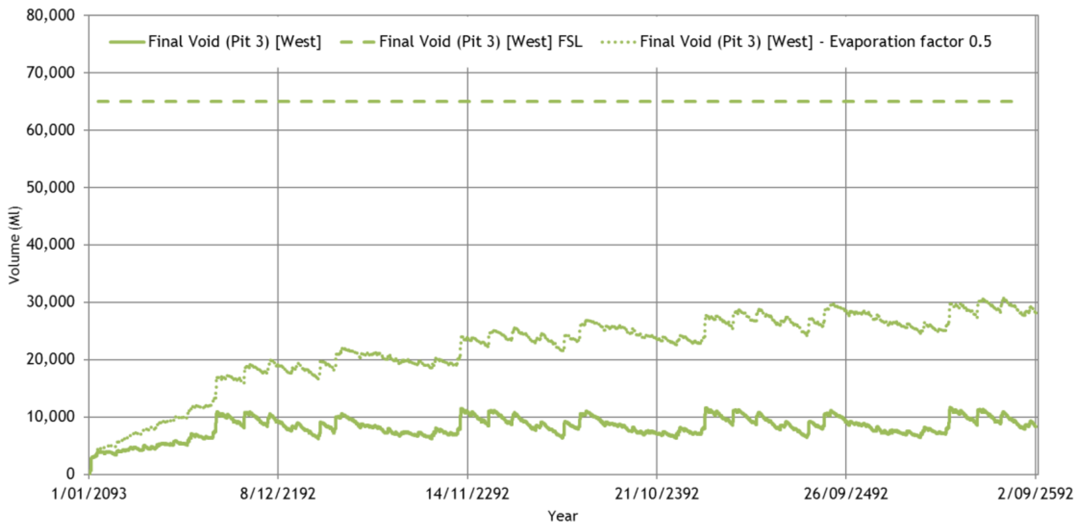

Figure 8.27 – Predicted Final Void (Pit 3) [West] inventory over 500 years

8.12.4 Climate Change Impact Assessment

The climate change impact assessment for the CDCOP was undertaken adopting the projections given in the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and the Commonwealth Bureau of Meteorology (BoM) report entitled "Climate Change in Australia Technical Report" (CSIRO, 2015). This report provides guidance on the possible projections of future climate for the Central Slopes based on a current understanding of the climate system, historical trends and model simulations of the climate response to changing greenhouse gas and decreasing aerosol emissions.

Projections are given for a number of climatic variables including (but not limited to) temperature, rainfall, solar radiation, wind speed, cyclones, potential evapotranspiration and sea levels for both short-term (2030) and long-term (2090) climate projections.

For this assessment, the Representative Concentration Pathway 8.5 (RCP8.5) emissions scenario was investigated as it appears to conservatively represent the impact of climate change based as it is the highest emissions scenario investigated by CSIRO (2015).

Based on the Climate Change Projections for the central slopes (CSIRO, 2015) the following changes are predicted at the CDCOP from 2090 onwards based on the RCP8.5 results:

- 80% of climate change models predicted that annual rainfall would change by between –23% (reduce by 145 mm) and 18% (increase by 113 mm); and
- 80% of climate change models predicted that annual evapotranspiration would change by between 9.8% (increase by 185 mm) and 18.1% (increase by 341 mm).

Based on the above CSIRO (2015) predictions, annual evaporation losses from the mine pit lake and its catchment will continue to be significantly higher than annual rainfall and groundwater inputs. Therefore, the potential effects of climate change on the behaviour of the final void lake is unlikely to be significant and the mine pit lakes are not expected to fill based on the CSIRO (2015) climate change predictions.

9 SURFACE WATER MONITORING

9.1 GENERAL

The CDM EA requirements are based on DEHP's "*Model Water Conditions for Coal Mines in the Fitzroy Basin*" (DEHP 2012b), which states that releases may only occur from designated release points when water quality is within defined release limits. CDM's EA imposes receiving waters trigger levels and release limits that would potentially constrain releases.

Monitoring of water quality is carried out in accordance with the Cameby Downs Mine EA and Environmental Monitoring Manual to demonstrate compliance with the CDM EA receiving waters trigger levels and release limits during a release event. The CDM Environmental Monitoring Manual outlines procedures for collecting environmental monitoring data and reporting requirements for compliance with the CDM EA.

9.2 EXISTING SURFACE WATER MONITORING LOCATIONS

CDM monitors water quality in the receiving waters at locations upstream and downstream of the CDM ML, as well as in water storages, piped 'external' QGC water and open pit water. Figure 3.4 shows the existing surface water monitoring locations at the CDM site. Table 9.1 and Table 9.2 specify the location and sampling frequency at each receiving waters and storage monitoring location during release events, as specified in the CDM EA.

Table 9.1 - Receiving water monitoring points - EA requirements

Monitoring location	Easting (GDA94)	Northing (GDA94)	Receiving waters	Monitoring Frequency
WS1	238,058	7,049,622	Drainage Line 1	At least once per flow event and in accordance with Table 5.2 and Table 5.3 during a release
WS2	234,571	7,052,378	Drainage Line 1	
WS3	235,712	7,047,317	Drainage Line 2	
WS4	234,087	7,048,329	Drainage Line 2 (South arm)	
WS5	234,243	7,049,229	Drainage Line 2 (north arm)	

Table 9.2 - Release point monitoring - EA requirements

Monitoring location	Easting (GDA94)	Northing (GDA94)	Receiving Waters	Monitoring Frequency
Sediment Dam 1	238,759	7,052,398	Tributary of Drainage Line 1	In accordance with Table 5.1 and Table 5.2 during a release.
Raw Water Dam	234,865	7,050,052	Drainage Line 1	
Return Water Dam	234,999	7,047,979	Drainage Line 2	
MIA Dam	235,709	7,049,294	Tributary of Drainage Line 1	
Mine Water Dam 1	236,449	7,053,166	Tributary of Drainage Line 1	

9.3 CUMULATIVE IMPACTS

9.3.1 Overview

The objective of this assessment is to identify the potential for impacts from the Project to have compounding interactions with similar impacts from other projects, including activities proposed, under development or already in operation within a suitable region of influence of the Project.

There are three levels at which cumulative impacts may be relevant:

- *Localised cumulative impacts* – These are the impacts that may result from multiple existing or proposed mining operations in the immediate vicinity of the project. Localised cumulative impacts include the effect from concurrent operations that are close enough to potentially cause an additive effect on the receiving environment.
- *Regional cumulative impacts* – These include the project's contribution to impacts that are caused by mining operations throughout the Surat Basin region or at a catchment level. Each coal mining operation in itself may not represent a substantial impact at a regional level; however, the cumulative effect on the receiving environment may warrant consideration.
- *Global cumulative impacts* – These includes impacts that the project might contribute to at a global scale. The only potential global scale impact for the project is greenhouse gas (GHG) emissions, and as such has not been addressed in this assessment.

9.3.2 Relevant Projects

There are no existing or planned projects located within the Columboola Creek catchment. The closest operating project is Kogan Coal Mine, located approximately 53 km southeast of the CDCOP. This project is located on the Condamine River, upstream of the CDCOP and therefore the CDCOP would have negligible, if any, impact on the receiving waters of the Kogan Coal Mine.

9.3.3 Water Quality

The project is located in the Columboola Creek catchment, which is a tributary within the Dogwood Creek catchment, which discharges into the Condamine River. The Columboola Creek's confluence with Dogwood Creek is downstream of the Miles township, therefore the is no potential impacts to Miles.

Mine affected water from the CDCOP will be managed through a mine water management system which is designed to operate in accordance with typical EA conditions and the model water conditions. That is, it will have discharge conditions and in-stream trigger levels aligned with the water quality objectives in the EPP (Water).

Using the CDCOP water balance model, an analysis has been undertaken on the ability of the proposed water management system to demonstrate compliance with the proposed EA conditions. The outcomes from this assessment is provided in Section 8.11.

The CDCOP predicted mine water releases will not exceed water quality limits for EC. Therefore, mine water releases are expected to have negligible cumulative impact on surface water quality and associated environmental values.

While the DES cumulative impact assessment of mining focused on salinity as the key water quality issue related to mining activities, surface disturbance associated with mining activities can result in erosion and increased sediment levels in surface waters.

Water quality data presented in Section 3.4 indicates that background suspended solids and turbidity in the Condamine River and local tributaries are in excess of water quality objectives. The water quality assessment undertaken for the CDCOP has identified that sediment inputs can be controlled through drainage, erosion and sediment control measures. On this basis, the proposed CDCOP is not expected to make any significant contribution to cumulative sediment loads in the Condamine River.

9.3.4 Loss of Catchment and Stream Flows in Columboola Creek

The CDCOP will result in a loss of catchment to Columboola Creek during operations and post-mining. The surface runoff volume lost from the catchment will generally be in proportion to the loss of catchment area. The CDCOP is approximately 14% of the catchment area of Columboola Creek, and 0.2% of the Condamine River. At the end of mining, the loss of catchment reporting to final voids is approximately 2% of the Columboola Creek catchment.

When taking into account potential discharges from the CDCOP in accordance with the proposed EA conditions, the overall loss of catchment area and associated stream flow is relatively small.

9.4 PROPOSED WATER QUALITY MONITORING

9.4.1 General

The proposed modification to water quality monitoring locations for the CDCOP include:

- The downstream monitoring location for Drainage Line 1 will be relocated to monitor receiving water quality downstream of the Drainage Line 1 diversion. It is recommended that the monitoring point is moved prior to the construction of the diversion to determine background conditions.
- Two (2) additional monitoring locations will be required on Drainage Line 3 upstream and downstream of the CDCOP to monitor receiving water quality during spills (releases) from sediment dams and spills from ‘worked’ water dams associated with Open Pit 2. It is recommended that Drainage Line 3 monitoring starts prior to the Open Pit 2 box cut to determine background conditions.
- One (1) additional monitoring location will be required downstream of Drainage Lines 5, 6 and 7 on Punchbowl Creek to monitor receiving water quality during spills (releases) from sediment dams and spills from ‘worked’ water dams associated with Open Pits 3 and 4. It is recommended that monitoring starts prior to Open Pit 3 box cut to determine background conditions.
- Additional release point monitoring locations will be required as structures are built throughout the mine life as proposed in Figure 7.1 to Figure 7.4.

9.4.2 Receiving waters monitoring

CDM currently monitor water quality in the receiving waters at the locations and frequencies described in Table 9.3. Additional receiving waters monitoring location will be implemented in advance of mining operations entering the catchment and will have the same routine monitoring requirements. Figure 9.1 shows the location of the existing and proposed receiving waters monitoring locations for the CDCOP.

The locations selected for additional monitoring include:

- A relocated monitoring location for WS1 on Drainage Line 1 (DS1 DS) located on the upstream side of the western railway bridge. The bridge crossing is a flow control for more reliable stream gauge monitoring;

- DL3 US is located on the ML boundary of Drainage Line 3;
- DL3 DS is located on the upstream side of the Western Railway Bridge on drainage Line 3. The bridge crossing is a flow control for more reliable stream gauge monitoring;
- A monitoring point on Punchbowl Creek (PB DS), located upstream of the confluence with Dogwood Creek at the Hookswood Pelham Rd creek crossing.

Table 9.3 - Receiving waters - routine monitoring

Monitoring location	Monitoring Frequency
WS1	At least once per flow event and in accordance with Table 5.2 and Table 5.3 during a release
WS2	
WS3	
WS4	
WS5	
Relocated Drainage Line 1 (downstream) - DS1 DS	
Drainage Line 3 (upstream) – DL3 US	
Drainage Line 3 (downstream) – DL3 DS	
Punch Bowl Creek (downstream) – PB DS	

9.4.3 'Worked' water storage monitoring

CDM currently monitor water quality in 'worked' water storages at the locations and frequencies described in Table 9.4. Additional 'worked' water management structures constructed throughout the mine life will have the same routine monitoring requirements.

Table 9.4 - 'Worked' water storages – routine monitoring

Monitoring locations	Monitoring Frequency
Raw Water Dam and Admin Dam	Quarterly or in accordance with Table 5.1 and Table 5.2 during a release
MIA Dam	
Return Water Dams 1 and	
Mine Water Dams 1, 2 and 3	
Water Management Dams 1 and 2	
Rejects Dam 1 and 2	
Sediment Dams	Quarterly or in accordance with Table 5.1 and Table 5.2 during a release
Open Pit 1, 2, 2a, 2b, 3, 4	Annually

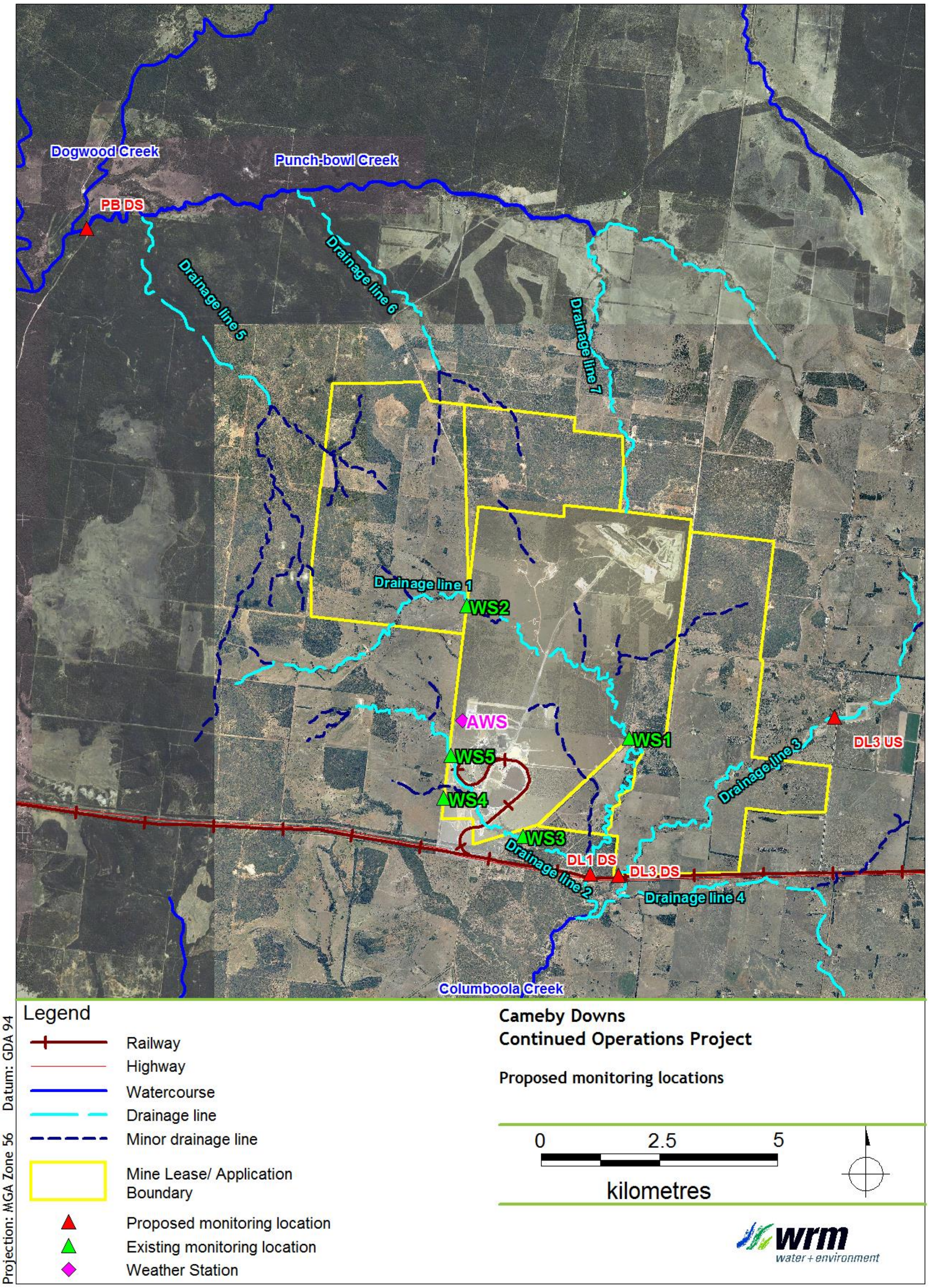

Figure 9.1 – Existing and proposed monitoring locations for the CDCOP

9.4.4 'Surface' water sample analysis

The standard field parameters measured and the laboratory analysis undertaken on surface water samples are listed in Table 9.5.

Table 9.5 - Water quality sample analysis

Laboratory Parameters	Field Readings
pH	pH
Electrical conductivity (EC)	Electrical conductivity (EC)
Total suspended solids (TSS)	Dissolved oxygen % saturation (DO)
Total dissolved solids (TDS)	Total dissolved solids (TDS)
Major cations: Ca, Mg, Na and K	Water temperature
Major anions: Cl, SO_4, and F	Turbidity (NTU)
Metals: Al, As, Cd, Cr, Cu, Fe, Pb, Hg, Ni, Zn, B, Co, Mn, Mo, Se, Ag, U and Va (Total and Dissolved (field Filtered))	
Nutrients: Ammonia, Nitrate	
Hydrocarbons C6-36	

9.4.5 'External' QGC water monitoring

The quality of 'external' QGC water is monitored weekly during the use of this water as a dust suppressant.

9.5 DRAINAGE LINE 1 DIVERSION MONITORING

Condition F21 of the CDM EA lists the monitoring requirements for the proposed Drainage Line 1 diversion. A monitoring program will be developed for the proposed Drainage Line 1 diversion within 12 months of approval from the regulator. It is recommended that a geomorphic characterisation of the existing Drainage Line 1 channel reach to be diverted is undertaken using the Index of Stream Diversion concept developed by the Australian Coal Association Research Projects (ACARP) (Project C8030). The ACARP projects established a set of key hydraulic, geomorphic and revegetation criteria for stream diversion design that was developed from natural streams.

9.6 MONITORING FOR IMPROVED WATER BALANCE MODELLING

The site water management plan and water balance modelling for CDM has been developed using the available water quantity and quality data. The accuracy of the OPSIM model should continue to be refined and validated so that it can be confidently used as a predictive tool for assessing compliance with the EA conditions. For continued refinement and validation of the model predictions, it is recommended to:

- Regularly monitor volume and water quality in all site storages;
- Record spill volumes and dates from all dams;
- Record the volumes of water which are pumped between storages; and
- Monitor dust suppression usage at all fill points.

10 REFERENCES

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Appendix A - Cameby Downs Mine receiving and regional water quality

Table A.1 - Water quality data summary for Dogwood Creek base flow

Percentiles	Ammonia (ug/L)	NOx (ug/L)	Turbidity (NTU)	TSS (mg/L)	pH	Conductivity (uS/cm)	Sulphate (mg/L)
80th	49	110	271	105	7.6	145	5.0
70th	42	99	190	71	7.4	130	4.3
50th	29	60	145	48	7.0	113	3.0
40th	25	18	119	34	6.9	106	2.6
20th	15	6	74	19	6.5	92	1.8
10th	14	4	55	14	6.4	82	1.4
No. of Samples	15	16	128	75	122	15	69

Table A.2 - Water quality data summary for Dogwood Creek event flow

Percentiles	Ammonia (ug/L)	NOx (ug/L)	Turbidity (NTU)	TSS (mg/L)	pH	Conductivity (uS/cm)	Sulphate (mg/L)
80th	20	270	410	130	7.4	121	8.9
70th	20	270	244	86	7.2	108	8.1
50th	20	270	195	70	6.8	100	6.2
40th	20	270	184	30	6.7	90	5.8
20th	20	270	155	10	6.4	71	1.8
10th	20	270	150	10	6.1	66	1.1
No. of Samples	1	1	12	11	15	19	12

Table A.3 - Water quality data summary for the Lower Condamine River base flow

Percentiles	Ammonia (ug/L)	NOx (ug/L)	Turbidity (NTU)	TSS (mg/L)	pH	Conductivity (uS/cm)	Sulphate (mg/L)
80th	25	339	208	139	8.1	650	11.0
70th	13	25	152	94	8.0	520	9.0
50th	6	35	57	51	7.8	376	5.3
40th	5	9	34	30	7.6	322	4.5
20th	3	2	14	13	7.5	237	3.1
10th	2	1	7	9.3	7.3	207	2.3
No. of Samples	84	87	395	284	348	503	306

Table A.4 – Water quality data summary for the Lower Condamine River event flow

Percentiles	Ammonia (ug/L)	NOx (ug/L)	Turbidity (NTU)	TSS (mg/L)	pH	Conductivity (uS/cm)	Sulphate (mg/L)
80th	131	748	1058	113	7.5	262	6.1
70th	62	622	835	940	7.4	243	4.4
50th	29	465	490	675	7.3	195	3.6
40th	24	396	393	532	7.2	180	3.4
20th	15	224	300	262	7.1	136	2.3
10th	11	130	204	160	6.9	118	1.6
No. of Samples	4	4	33	21	23	39	21

Table A.5 – Drainage Line 1 water quality data statistics at WS2 (2010 to 2017)

Statistic	pH	EC (µs/cm)	TSS (mg/L)	As (µg/L)	Cd (µg/L)	Cr (µg/L)	Cu (µg/L)	Ni (µg/L)	Pb (µg/L)	Zn (µg/L)	Hg (µg/L)
Min	5.6	29	16	1	0.1	1	1	1	1	6	0.1
20th percentile	6.5	37	50	1	0.1	4	2	2	2	10	0.1
Median	6.7	57	102	2	0.1	6	4	4	4	18	0.1
80th percentile	6.9	67	211	2	0.1	11	6	6	6	29	0.1
Max	7.2	126	941	7	0.4	61	56	31	72	167	1
No of Samples	61	27	56	61	61	61	61	61	61	61	61

Table A.6 – Drainage Line 2 water quality data statistics at WS4 and WS5 (2010 to 2017)

Statistic	pH	EC (µs/cm)	TSS (mg/L)	As (µg/L)	Cd (µg/L)	Cr (µg/L)	Cu (µg/L)	Ni (µg/L)	Pb (µg/L)	Zn (µg/L)	Hg (µg/L)
Min	5.5	22	12	1	0.1	1	1	1	1	5	0.1
20th percentile	6.4	42	44	1	0.1	8	3	3	3	12	0.1
Median	6.6	61	84	1	0.1	12	4	5	5	19	0.1
80th percentile	6.9	80	222	3	0.1	21	8	9	10	31	0.1
Max	7.2	202	1470	5	1.0	55	11	26	21	127	0.1
No of Samples	104	36	115	114	114	114	114	114	114	114	114

Table A.7 – Drainage Line 1 and Drainage Line 2 combined water quality data statistics (2010 to 2017)

Statistic	pH	EC (µs/cm)	TSS (mg/L)	As (µg/L)	Cd (µg/L)	Cr (µg/L)	Cu (µg/L)	Ni (µg/L)	Pb (µg/L)	Zn (µg/L)	Hg (µg/L)
Min	5.5	22	12	1.0	0.1	1.0	1.0	1.0	1.0	5.0	0.1
20th percentile	6.4	40	47	1.0	0.1	5.0	2.8	3.0	2.8	11.0	0.1
Median	6.6	59	88	2.0	0.1	10.0	4.0	5.0	4.0	19.0	0.1
80th percentile	6.9	67	216	2.0	0.1	16.2	7.0	7.0	8.0	30.0	0.1
Max	7.2	202	1470	7.0	1.0	61.0	56.0	31.0	72.0	167.0	1.0
No of Samples	165	63	171	175	175	175	175	175	175	175	175

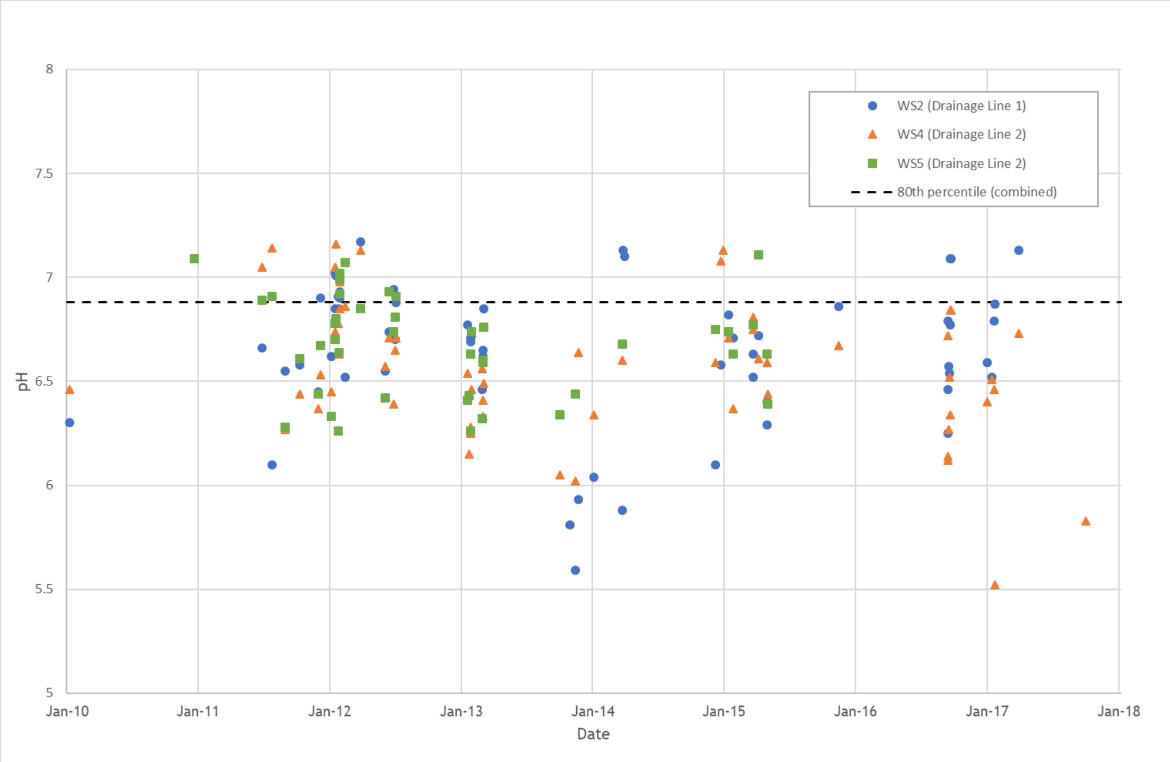

Figure A.1 - Drainage Line 1 and Drainage Line 2 recorded pH (lab) (2010-2017)

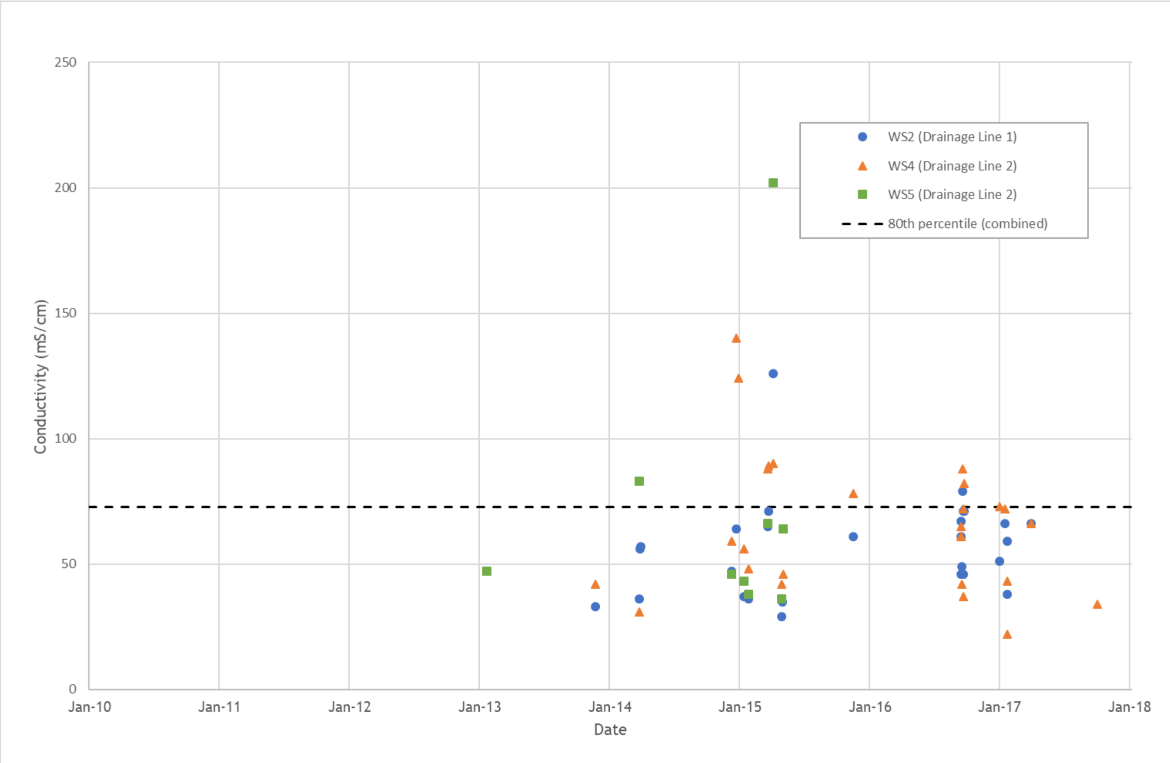

Figure A.2 - Drainage Line 1 and Drainage Line 2 recorded electrical conductivity (lab) (2010-2017)

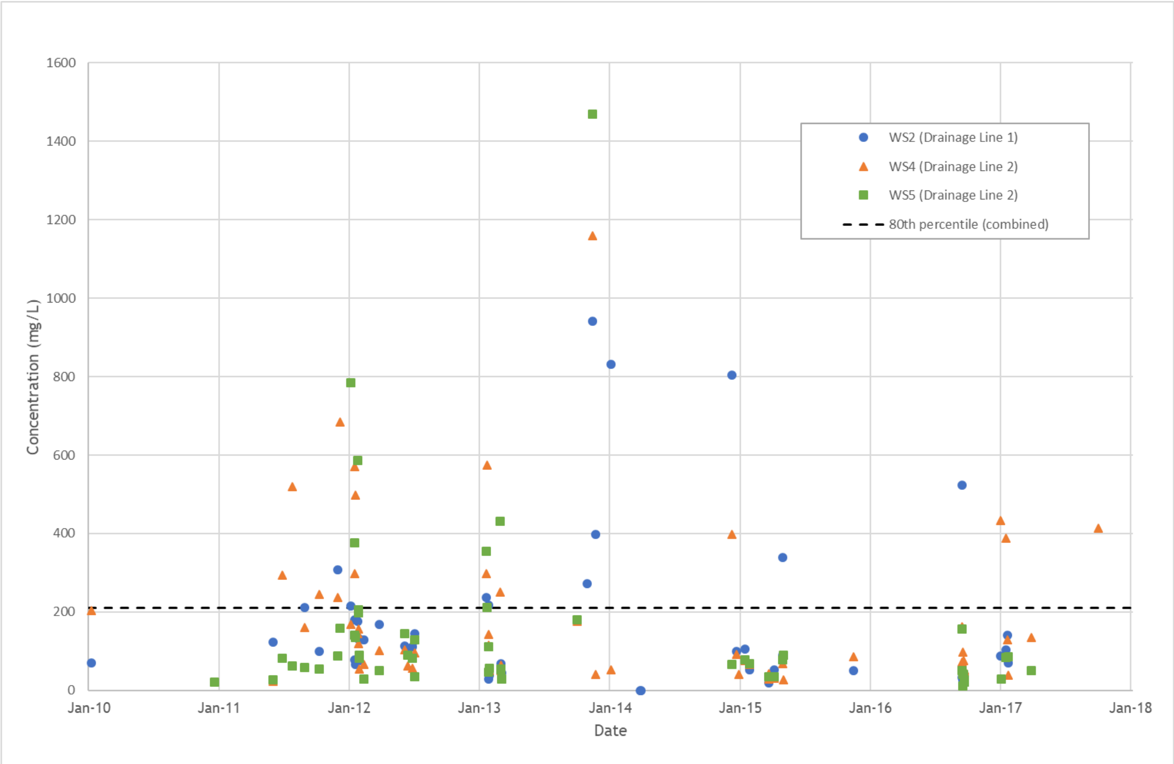

Figure A.3 - Drainage Line 1 and Drainage Line 2 recorded total suspended solids (2010-2017)

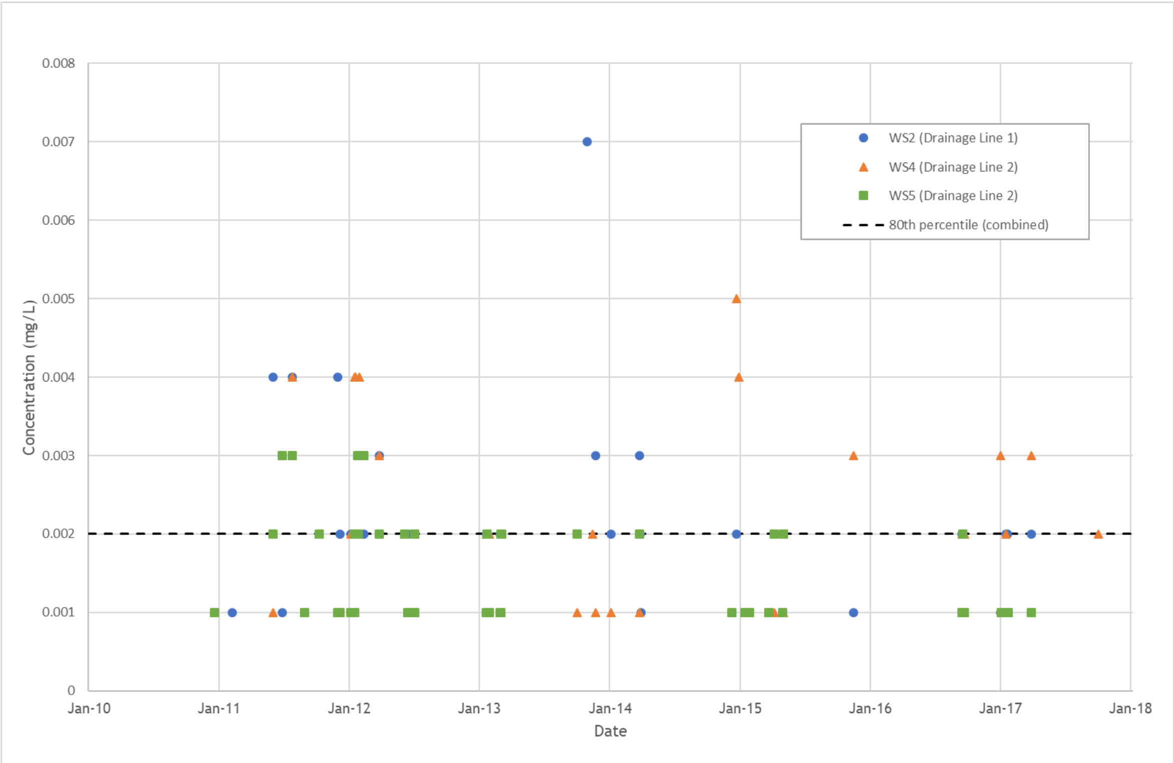

Figure A.4 - Drainage Line 1 and Drainage Line 2 recorded Arsenic (2010-2017)

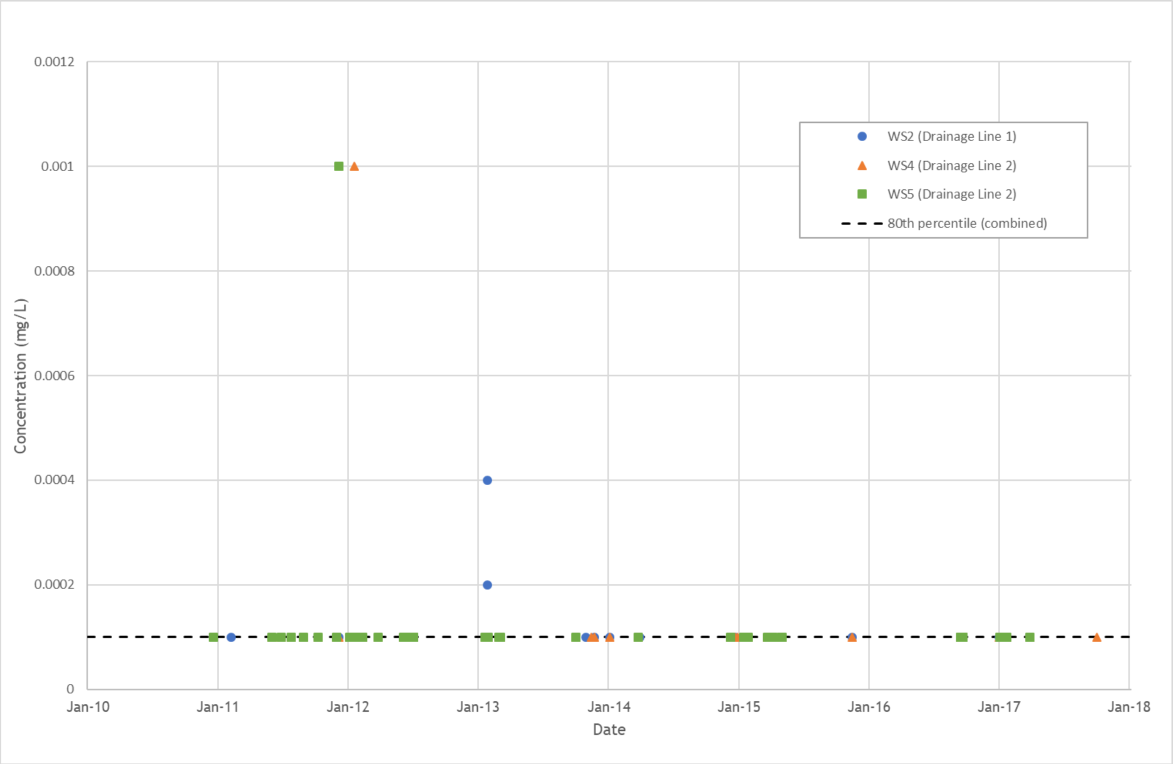

Figure A.5 - Drainage Line 1 and Drainage Line 2 recorded Cadmium (2010-2017)

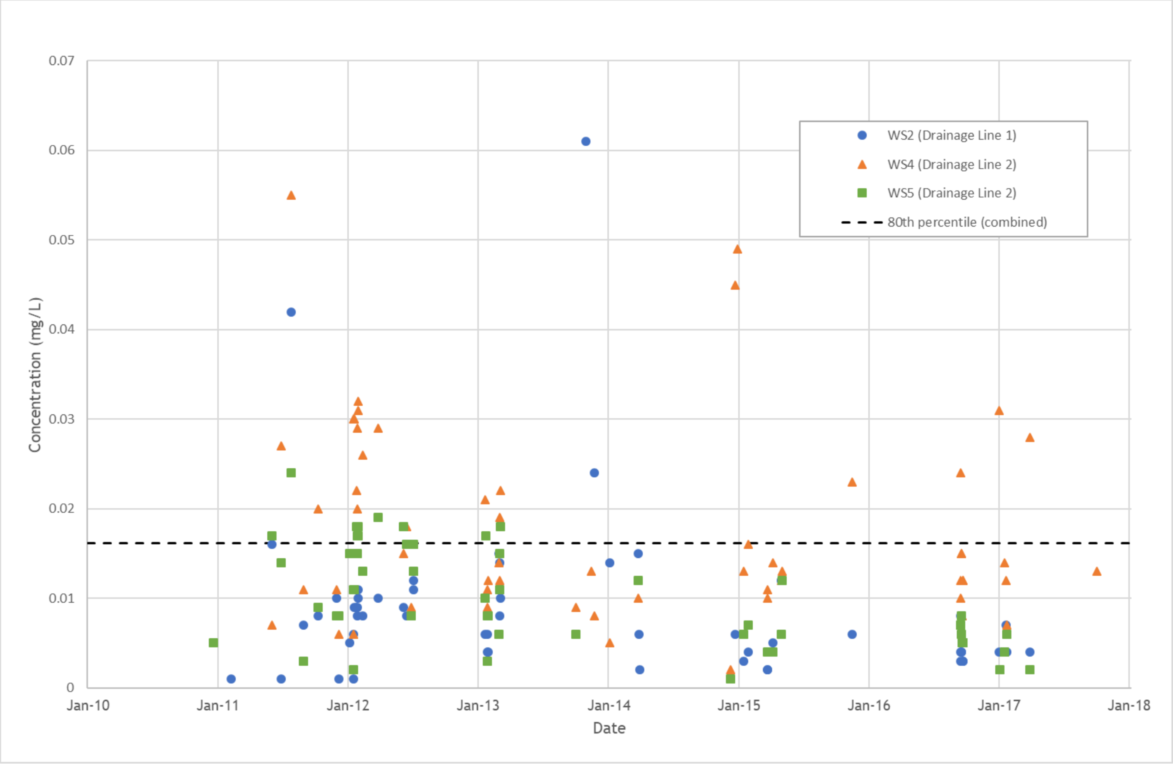

Figure A.6 - Drainage Line 1 and Drainage Line 2 recorded Chromium (2010-2017)

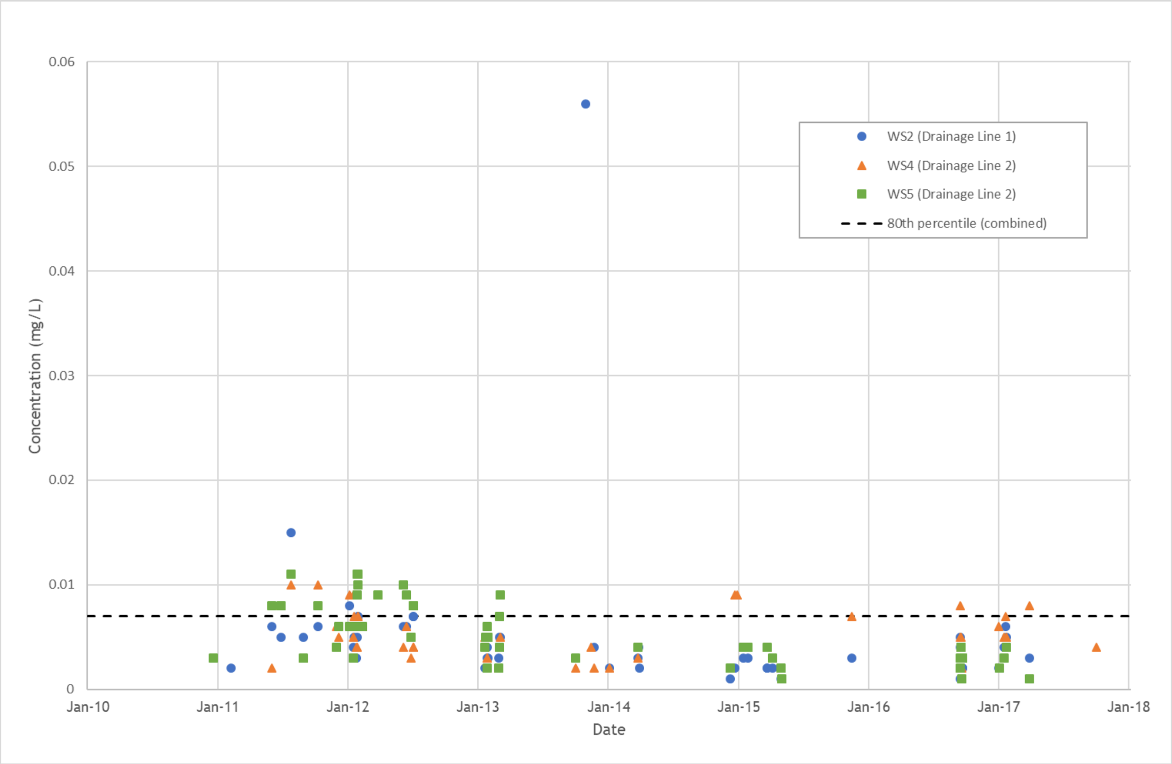

Figure A.7 - Drainage Line 1 and Drainage Line 2 recorded Copper (2010-2017)

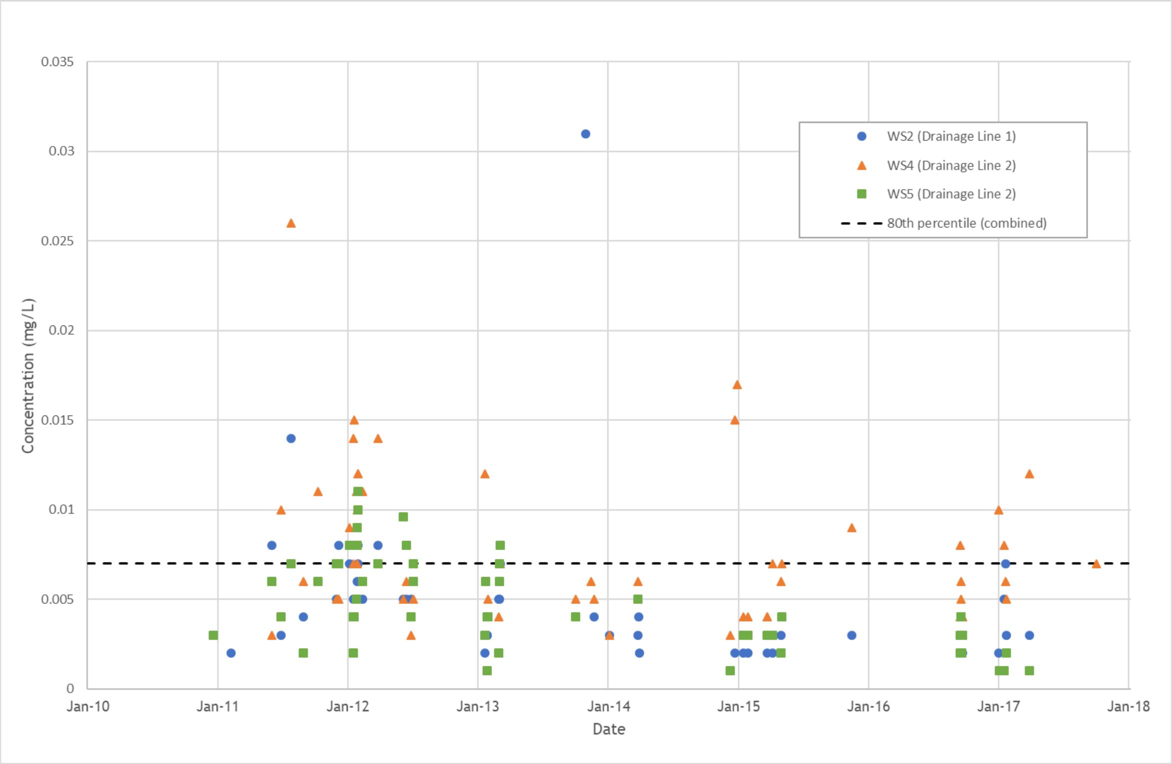

Figure A.8 - Drainage Line 1 and Drainage Line 2 recorded Nickel (2010-2017)

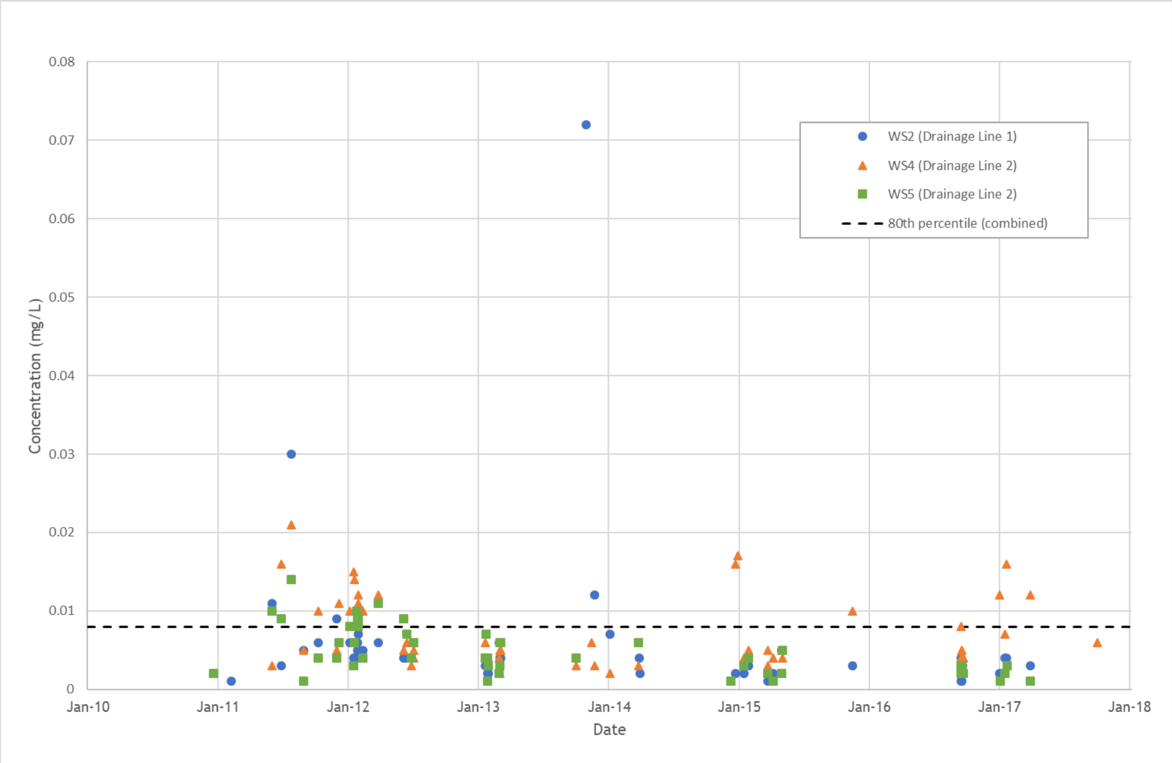

Figure A.9 - Drainage Line 1 and Drainage Line 2 recorded Lead (2010-2017)

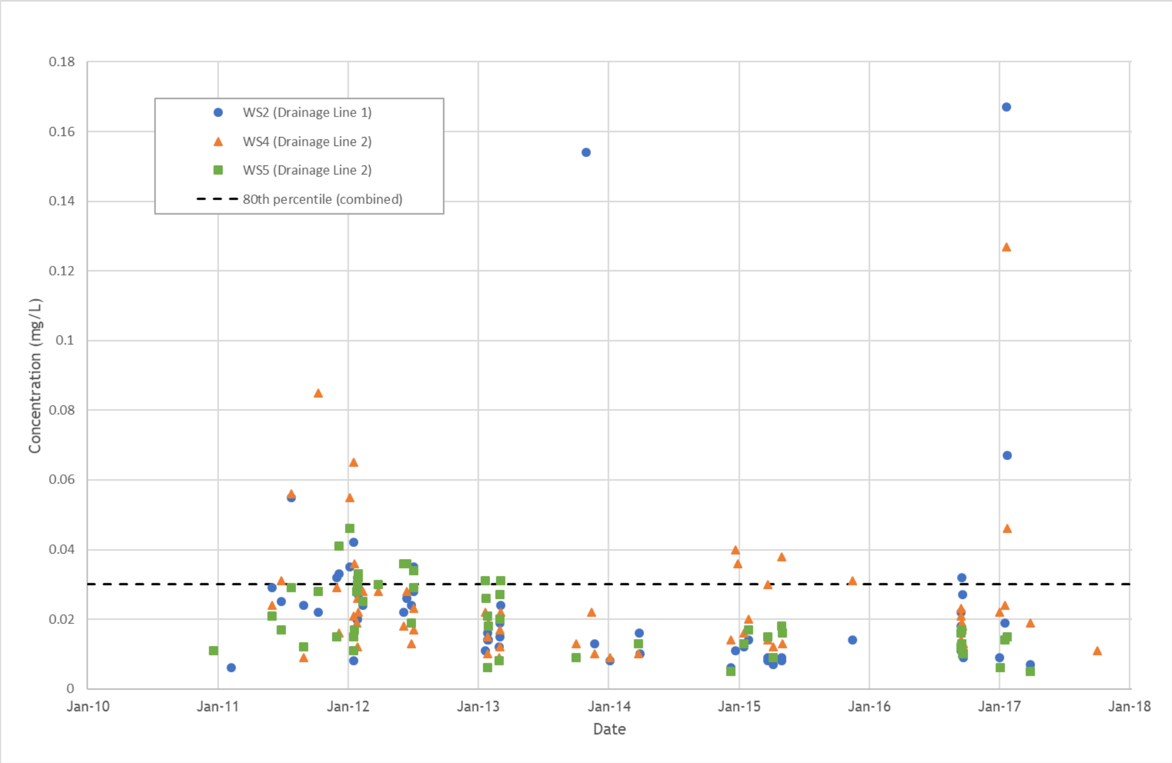

Figure A.10 - Drainage Line 1 and Drainage Line 2 recorded Zinc (2010-2017)

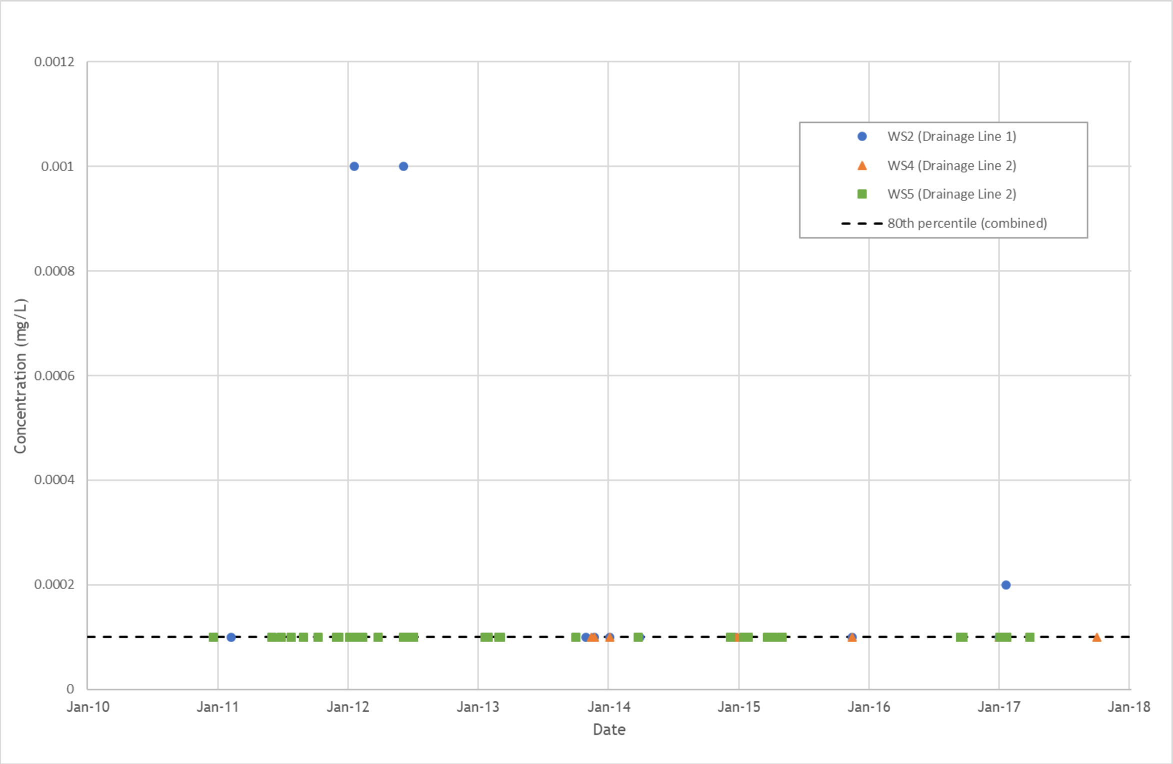

Figure A.11 - Drainage Line 1 and Drainage Line 2 recorded Mercury (2010-2017)

Appendix B - Cameby Downs Mine storage water quality

Table B.1 - Water Quality Data Summary (2010-2017) - Sediment Dam 1

Parameter	Unit	No. of Samples	Min.	10%ile	Median	90%ile	Max
pH (lab)		41	6.0	6.1	6.4	6.8	9.2
pH(field)		47	5.8	6.4	7.3	8.6	9.2
Conductivity (lab)	µS/cm	40	180	208	324	422	640
Conductivity (field)	µS/cm	45	7	122	317	437	1300
TSS	mg/L	26	59	235	700	2210	3140
Total Metals							
Arsenic	mg/L	37	0.001	0.003	0.004	0.011	0.017
Cadmium	mg/L	37	0.0001	0.0001	0.0002	0.0003	0.0030
Chromium	mg/L	37	0.001	0.012	0.033	0.064	0.808
Copper	mg/L	37	0.0001	0.0196	0.0440	0.0644	0.1030
Nickel	mg/L	37	0.002	0.014	0.023	0.031	0.094
Lead	mg/L	37	0.001	0.016	0.038	0.051	0.098
Zinc	mg/L	37	0.005	0.062	0.122	0.187	0.327
Mercury	mg/L	37	0.00005	0.0001	0.0001	0.0001	0.0005

Table B.2 - Water Quality Data Summary (2010-2017) - Raw Water Dam

Parameter	Unit	No. of Samples	Min.	10%ile	Median	90%ile	Max
pH (lab)		27	5.4	7.9	8.6	9.1	9.3
pH(field)		33	7.3	8.2	8.5	8.9	9.0
Conductivity (lab)	µS/cm	26	1630	1990	4765	10950	13200
Conductivity (field)	µS/cm	19	1798	2574	3170	5704	6752
TSS	mg/L	15	6	14.4	25	67	1030
Total Metals							
Arsenic	mg/L	27	0.0004	0.001	0.002	0.003	0.003
Cadmium	mg/L	27	0.0001	0.0001	0.0001	0.0001	0.003
Chromium	mg/L	27	0.001	0.001	0.001	0.0104	0.808
Copper	mg/L	27	0.0001	0.001	0.002	0.0048	0.014
Nickel	mg/L	27	0.001	0.002	0.003	0.0076	0.021
Lead	mg/L	27	0.001	0.001	0.001	0.0072	0.034
Zinc	mg/L	27	0.005	0.005	0.009	0.0366	0.083
Mercury	mg/L	27	0.0001	0.0001	0.0001	0.0001	0.0001

Table B.3 – Water Quality Data Summary (2010-2016) – Return Water Dam 1

Parameter	Unit	No. of Samples	Min.	10%ile	Median	90%ile	Max
pH (lab)		31	7.4	7.9	8.3	8.9	9.4
pH(field)		32	6.5	7.9	8.4	8.8	9.2
Conductivity (lab)	µS/cm	25	2010	3080	5770	11600	15000
Conductivity (field)	µS/cm	30	689	751	3814	7436	9940
TSS	mg/L	14	5	11.9	23.5	66	87
Total Metals							
Arsenic	mg/L	31	0.001	0.001	0.002	0.004	0.005
Cadmium	mg/L	31	0.0001	0.0001	0.0001	0.0002	0.004
Chromium	mg/L	31	0.001	0.001	0.001	0.028	0.03
Copper	mg/L	31	0.001	0.001	0.002	0.012	0.014
Nickel	mg/L	31	0.001	0.002	0.004	0.016	0.023
Lead	mg/L	31	0.001	0.001	0.001	0.015	0.017
Zinc	mg/L	31	0.005	0.005	0.008	0.036	0.072
Mercury	mg/L	31	0.0001	0.0001	0.0001	0.0001	0.0005
*Filtered Metals **							
Aluminium	mg/L	1			<0.01		
Arsenic	mg/L	1			<0.001		
Cadmium	mg/L	1			<0.0001		
Chromium	mg/L	1			<0.001		
Cobalt	mg/L	1			<0.001		
Copper	mg/L	1			<0.001		
Lead	mg/L	1			<0.001		
Manganese	mg/L	1			<0.001		
Molybdenum	mg/L	1			0.007		
Nickel	mg/L	1			0.002		
Selenium	mg/L	1			<0.01		
Silver	mg/L	1			<0.001		
Uranium	mg/L	1			<0.001		
Vanadium	mg/L	1			<0.01		
Zinc	mg/L	1			<0.005		
Boron	mg/L	1			0.06		
Iron	mg/L	1			<0.05		
Mercury	mg/L	1			<0.0001		
*Nutrients **							
Ammonia as N	mg/L	1			0.02		
Nitrite as N	mg/L	1			<0.01		
Nitrate as N	mg/L	1			0.07		
Nitrite + Nitrate as N	mg/L	1			0.07		

* sample taken on 2 March 2018

Table B.4 - Water Quality Data Summary (2010-2016) - MIA Dam

Parameter	Unit	No. of Samples	Min.	10%ile	Median	90%ile	Max
pH (lab)		32	6.5	6.7	7.4	8.4	9.3
pH(field)		32	6.6	7.3	8.1	8.7	9.3
Conductivity (lab)	µS/cm	25	262	314	1080	2978	3690
Conductivity (field)	µS/cm	30	247	381	1322	2256	3990
TSS	mg/L	14	5	16	80	831	913
Total Metals							
Arsenic	mg/L	32	0.001	0.0011	0.003	0.005	0.009
Cadmium	mg/L	32	0.0001	0.0001	0.0001	0.0001	0.0003
Chromium	mg/L	32	0.001	0.0031	0.0315	0.052	0.072
Copper	mg/L	32	0.001	0.0032	0.014	0.0229	0.039
Nickel	mg/L	32	0.001	0.0051	0.0165	0.0257	0.034
Lead	mg/L	32	0.001	0.0032	0.0235	0.0326	0.052
Zinc	mg/L	32	0.005	0.0183	0.0695	0.1058	0.204
Mercury	mg/L	32	0.0001	0.0001	0.0001	0.0001	0.0005

Table B.5 - Water Quality Data Summary (2010-2016) - Mine Water Dam

Parameter	Unit	No. of Samples	Min.	10%ile	Median	90%ile	Max
pH (lab)		25	6.6	7.2	8.2	8.9	9.3
pH(field)		45	7.4	7.8	8.3	9.0	9.7
Conductivity (lab)	µS/cm	24	459	1000	2225	7063	9860
Conductivity (field)	µS/cm	42	130	1251	3800	8575	9141
TSS	mg/L	13	16	23	57	291	1790
Total Metals							
Arsenic	mg/L	25	0.001	0.001	0.001	0.004	0.006
Cadmium	mg/L	25	0.0001	0.0001	0.0001	0.00016	0.0003
Chromium	mg/L	25	0.001	0.001	0.002	0.029	0.046
Copper	mg/L	25	0.001	0.001	0.002	0.011	0.064
Nickel	mg/L	25	0.002	0.002	0.003	0.013	0.280
Lead	mg/L	25	0.001	0.001	0.001	0.014	0.046
Zinc	mg/L	25	0.005	0.005	0.010	0.042	0.185
Mercury	mg/L	23	0.0001	0.0001	0.0001	0.0001	0.0001

Table B.6 – Water Quality Data Summary (2010-2016) – Rejects Dam (all cells)

Parameter	Unit	No. of Samples	Min.	10%ile	Median	90%ile	Max
pH (lab)		13	4.5	6.7	8.3	8.8	8.9
pH(field)		23	2.4	6.9	8.4	8.9	10.3
Conductivity (lab)	µS/cm	13	1870	2332	3920	16100	29700
Conductivity (field)	µS/cm	17	2230	2360	4860	11260	16800
TSS	mg/L						
Total Metals							
Arsenic	mg/L	21	0.001	0.002	0.004	0.037	0.763
Cadmium	mg/L	17	0.0001	0.0001	0.0003	0.02084	0.0401
Chromium	mg/L	14	0.001	0.001	0.002	0.054	0.117
Copper	mg/L	23	0.001	0.002	0.004	0.320	2.730
Nickel	mg/L	16	0.001	0.001	0.009	0.253	2.000
Lead	mg/L	4	0.000	0.000	0.001	0.002	0.003
Zinc	mg/L	23	0.002	0.003	0.009	0.356	1.390
Mercury	mg/L	16	0.0001	0.006	0.026	6.01	18.7