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Surface Water Impact Assessment

BYLONG COAL PROJECT
Environmental Impact Statement

Hansen Bailey
ENVIRONMENTAL CONSULTANTS

Bylong Coal Project -

Surface Water and Flooding Impact Assessment

Hansen Bailey Pty Ltd

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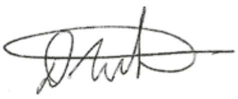

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1 Introduction

1.1 BACKGROUND

In December 2010, KEPCO Bylong Australia Pty Ltd (KEPCO) acquired Authorisations (A) 287 and 342. Since this time, extensive exploration and mine planning work has been undertaken to determine the most socially responsible and economically viable mine plan to recover the known coal resources within the two Authorisations.

In August 2014, KEPCO commissioned WorleyParsons Services Pty Ltd (WorleyParsons) to manage the Project exploration activities, mine feasibility study planning, environmental approvals and ongoing environmental monitoring for the Bylong Coal Project (the Project).

The Project is located wholly within A287 and A342 which are located within the Mid-Western Regional Council (MWRC) Local Government Area (LGA). The closest regional centre is Mudgee, located approximately 55 km south-west of the Project Boundary. The Project is approximately 230 km by rail from the Port of Newcastle. Figure 1.1 illustrates the locality of the Project within New South Wales (NSW). Figure 1.2 shows the regional locality of the Project in relation to the neighbouring town centres, mining authorities, major transport routes and reserves.

KEPCO is seeking State Significant Development Consent under Division 4.1 of Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) for the development and operation of the Project. The State Significant Development Application will be supported by an Environmental Impact Statement (EIS) which is being prepared by Hansen Bailey.

This report, which forms part of the EIS, presents the methodology and results of an assessment of the impacts of the Project on surface water resources.

1.2 PROJECT DESCRIPTION

The Project life is anticipated to be approximately 25 years, comprising a two year construction period and a 23 year operational period, with underground mining operations commencing in Year 7. Various rehabilitation and decommissioning activities will be undertaken during both the course of, and following the 25 years of the Project. It is noted that further mineable coal resources exist within both A287 and A342.

The Project is to be developed on land within the Project Boundary as illustrated on Figure 1.3. Key features of the Project are conceptually shown on Figure 1.3 and include:

- The initial development of two open cut mining areas with associated haul roads and Overburden Emplacement Areas (OEAs), utilising a mining fleet of excavators and trucks and supporting ancillary equipment;
- The two open cut mining areas will be developed and operated 24 hours a day, 7 days a week over an approximate 10 year period and will ultimately provide for the storage of coal processing waste from the longer term underground mining activities;
- Construction and operation of administration, workshop, bathhouse, explosives magazine and other open cut mining related facilities;
- Construction and operation of an underground coal mine operating 24 hours a day, 7 days a week for a 20 year period, commencing mining in around year 7 of the Project;
- A combined maximum extraction rate of up to 6.5 Million tonnes per annum (Mtpa) Run of Mine (ROM) coal;
- A workforce of up to approximately 800 during the initial construction phase and a peak of 470 full-time equivalent operations employees at full production;

- Underground mining operations utilising longwall mining techniques with primary access provided via drifts constructed adjacent to the rail loop and Coal Handling and Preparation Plant (CHPP);
- The construction and operation of facilities to support underground mining operations including personnel and materials access to the underground mining area, ventilation shafts, workshop, offices and employee amenities, fuel and gas management facilities;
- Construction and operation of a CHPP with a designed throughput of approximately 6 Mtpa of ROM coal, with capacity for peak fluctuations beyond this;
- The dewatering of fine reject materials through belt press filters within the CHPP and the co-disposal of dewatered fine and coarse reject materials within OEAs and final open cut voids (avoiding the need for a coarse and fine reject materials emplacement);
- Construction and operation of a rail loop and associated rail load out facility and connection to the Sandy Hollow to Gulgong Railway Line to facilitate the transport of product coal;
- The construction and operation of surface and groundwater management and water reticulation infrastructure including diversion drains, dams (clean, dirty and raw water), pipelines and pumping stations;
- The installation of communications and electricity reticulation infrastructure;
- Construction and operation of a Workforce Accommodation Facility (WAF) and associated access road from the Bylong Valley Way;
- The upgrade of Upper Bylong Road and the construction and operation of a Mine Access Road to provide access to the site facilities;
- Relocation of sections of some existing public roads to enable alternate access routes for private landholders surrounding the Project; and
- Infilling of mining voids, progressive rehabilitation of disturbed areas, decommissioning of Project infrastructure and rehabilitation of the land progressively following mining operations.

1.3 OVERVIEW OF SURFACE WATER ISSUES

The Project is located within the catchment of the Bylong River, a tributary of the Goulburn River, which in turn is a tributary of the Hunter River. The proposed open cut mining areas and OEAs are located adjacent to the main channel of the Bylong River and Lee Creek, a tributary of the Bylong River. The proposed Underground Extraction Area is located in the catchment of Dry Creek, a tributary of the Bylong River, which joins the river channel downstream of the open cut mining areas (see Figure 1.3). Underground mining beneath the Dry Creek catchment will not require extensive land clearing activities or disturbance of soils (with the exception of small areas of mine infrastructure), but will result in the subsidence of the land surface which may lead to surface cracking.

The potential surface water impacts of the Project relate to possible changes in water quality and quantity in the Bylong River, Lee Creek and Dry Creek catchments. Impacts on the Bylong River and Lee Creek may be caused by land disturbance, construction of mine infrastructure, storage of mine-affected water and taking water from surface and underground sources for use in mine operations. The impacts in the Dry Creek catchment relate primarily to potential changes in drainage patterns and flow behaviour caused by subsidence.

This surface water impact assessment quantifies these potential impacts of the Project and presents the proposed mitigation and management measures that will be implemented to protect the environmental values of receiving waters.

1.4 REPORT STRUCTURE

This report is structured as follows:

- Section 2 provides an overview of the regulatory framework with respect to surface water resources;
- Section 3 describes the existing surface water environment;
- Section 4 describes the proposed water management system;
- Section 5 provides a description of the site water balance model used to simulate the performance of the water management system over the life of the Project;
- Section 6 presents the results of the site water balance assessment;
- Section 7 provides an assessment of flood behaviour in the Bylong River catchment under existing conditions and with proposed mine infrastructure in place;
- Section 8 provides an assessment of flood behaviour in the Dry Creek catchment under existing conditions and following land subsidence caused by underground mining;
- Section 9 assesses the impacts of the Project on surface water resources;
- Section 10 presents an assessment of potential cumulative impacts of the Project in combination with existing and proposed mining operations in the region;
- Section 11 outlines the proposed mitigation and management measures to minimise surface water impacts;
- Section 12 presents a summary of the conclusions of the surface water impact assessment; and
- Section 13 provides a list of references.

This report also includes several attachments:

- Attachment 1 contains maps of flood model results for the Bylong River catchment for existing conditions;
- Attachment 2 contains maps of flood model results for the Bylong River catchment including proposed Project infrastructure;
- Attachment 3 contains maps of flood model results for the Dry Creek catchment for existing conditions;
- Attachment 4 contains maps of flood model results for the Dry Creek catchment for post-subsidence conditions.

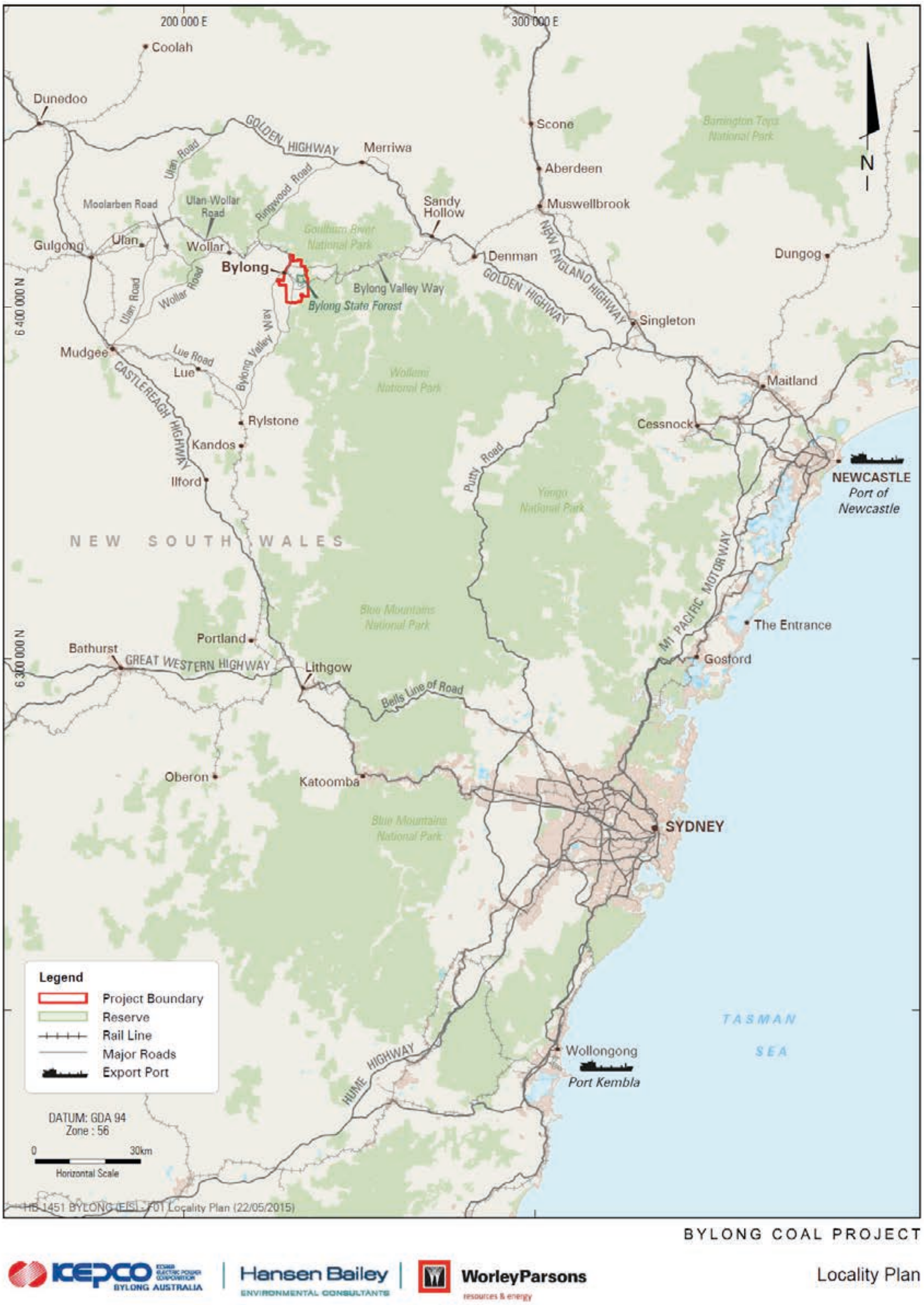
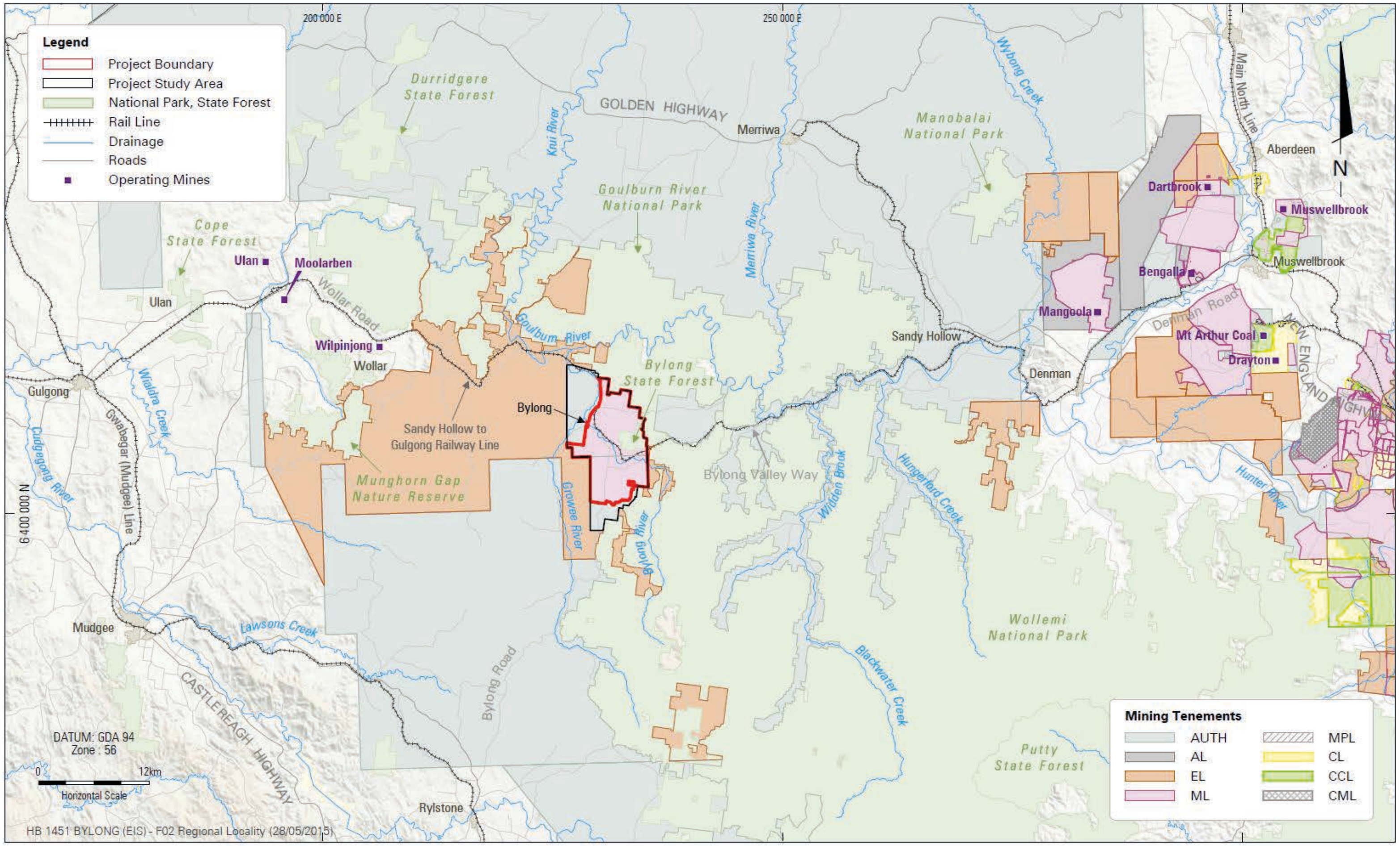


Figure 1.1 – Locality plan



BYLONG COAL PROJECT

Regional Locality

Figure 1.2 – Regional locality plan

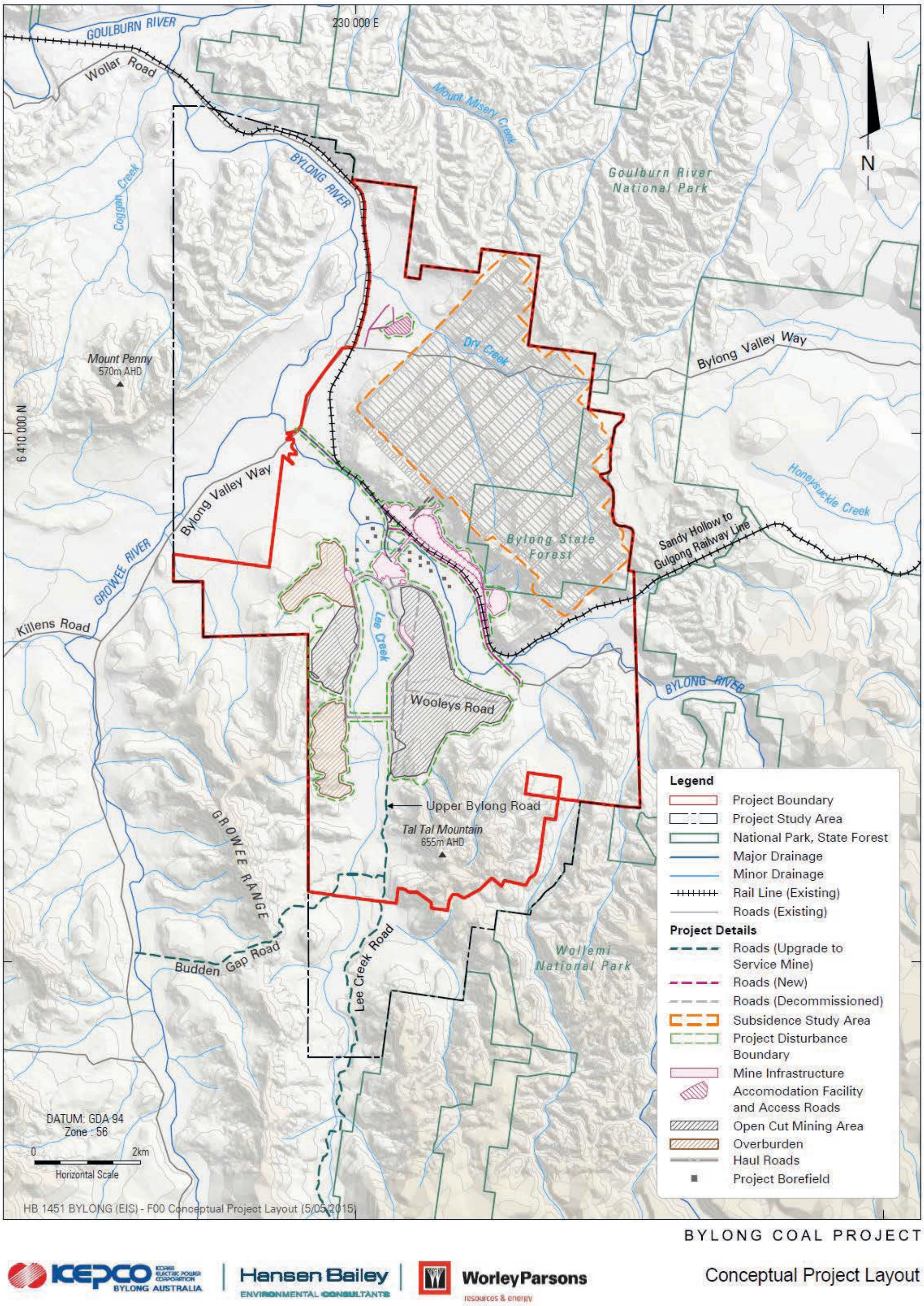


Figure 1.3 - Proposed Project layout

2 Regulatory Framework

2.1 OVERVIEW

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

- Strategic Regional Land Use Policy, which considers potential impacts on agricultural land;
- *Water Management Act 2000* (WM Act), *Water Act 1912* (Water Act) and associated water sharing plans (WSP), which relate to the sustainable management of water resources;
- *National Water Quality Management Strategy: Australian Guidelines for Fresh and Marine Water Quality* (ANZECC/ARMCANZ, 2000) and the NSW Government Water Quality and River Flow Objectives, which provide information on the environmental values of receiving waters and the definition of protection level based on ecosystem condition;
- Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), which considers impacts on Matters of National Environmental Significance (MNES), including water resources. The Australian Government established the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development (the IESC) under the EPBC Act in 2012 to provide scientific advice on mining proposals. The IESC has published information guidelines that outline the information necessary for the IESC to provide advice to government regulators;
- *Dams Safety Act 1978* (Dams Safety Act), which relates to the design, construction, monitoring and management requirements of any prescribed dams on the site or in the surrounding area;
- *Managing Urban Stormwater Soils and Construction – Volume 2E Mines and Quarries*, (DECC, 2008) and *Managing Urban Stormwater, Soils and Construction*, (Landcom, 2004), which provides guidelines on suitable management measures for erosion and sediment control;
- *Protection of the Environment Operations Act 1997* (POEO Act), which relates to the minimisation of pollution from the mine water management systems and discharge criteria; and
- NSW Flood Prone Land Policy and the Mid-Western Regional Local Environmental Plan which aim to minimise flood risks and impacts.

The design of infrastructure for the Project has considered the requirements of the above legislation, plans, policies and regulations. Further discussion on the regulatory framework with respect to surface water is provided in the following sections.

2.2 STRATEGIC REGIONAL LAND USE POLICY

The Strategic Land Use Policy aims to identify, map and protect valuable residential and agricultural land from the impacts of mining. Implementation of the policy includes a Gateway process to closely examine the potential impacts of new mining proposals on strategic agricultural land and equine and viticulture critical industry clusters. The Project description and impact assessment methodology has been refined to address recommendations provided within the Mining and Petroleum Gateway Panel's Gateway Certificate on the Project (MPGP, 2014).

2.3 WATER MANAGEMENT ACT 2000 & WATER ACT 1912

The Water Act and WM Act establish licensing regimes for the management of water resources in NSW. The licensing and approvals provisions of the WM Act apply to water sources that are the subject of a WSP. The Water Act continues to apply to water sources that are not the subject of a WSP.

The objective of the WM Act is the sustainable and integrated management of the State's water for the benefit of both present and future generations. The WM Act provides clear arrangements for controlling land based activities that affect the quality and quantity of the State's water resources. It provides for four types of approval:

- Water use approval – which authorise the use of water at a specified location for a particular purpose, for up to 10 years;
- Water management work approval;
- Controlled activity approval; and
- Aquifer interference activity approval – which authorises the holder to conduct activities that affect an aquifer such as approval for activities that intersect groundwater, other than water supply bores and may be issued for up to 10 years.

Water use, water management work and controlled activity approvals are not required for a State Significant Development approved under Division 4.1 of the EP&A Act.

For aquifer interference activities, the WM Act requires that the activities avoid or minimise their impact on the water resource and land degradation, and where possible the land must be rehabilitated. The Aquifer Interference Policy (AIP) (Department of Primary Industries, 2012) states that a water licence is required for the aquifer interference activity regardless of whether water is taken directly for consumptive use or incidentally. Activities may induce flow from adjacent groundwater sources or connected surface water. Flows induced from other water sources also constitute take of water. In all cases, separate access licences are required to account for the take from all individual water sources. Further information on the AIP is provided in the EIS Groundwater Impact Assessment (AGE, 2015).

With respect to surface water, the Project has the potential to impact on the Bylong River Water Source under the WM Act, as identified in the *Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009* (HUAWSP).

2.3.1 Water Sharing Plan for the Hunter Unregulated and Alluvial Water Sources 2009

The HUAWSP commenced on 1 August 2009. The plan area comprises 39 water sources in the Hunter River catchment. The water sources of the Goulburn Extraction Management Unit (EMU) of the Hunter Unregulated and Alluvial Water Sources, including the Bylong River Water Source, are shown in Figure 2.1.

The WSPs allow for some extraction of water from the river and groundwater without a Water Access Licence to provide basic landholder rights, which include domestic and stock rights as well as Native Title rights.

All water extraction that is not for basic landholder rights must be authorised by a Water Access Licence. Each Water Access Licence specifies a share component. The share components of specific purpose licences, such as town water supply, stock and domestic are expressed as megalitres per year (ML/yr). The share components of high security, general security and supplementary Water Access Licences are expressed as a number of unit shares. Table 2.1 shows the categories of access licences in the relevant Water Sources and their total share components at the start of the HUAWSP (NOW, 2009).

Extractions from the Bylong River are subject to Total Daily Extraction Limits which limit the daily extraction volume depending upon the river flow rate.

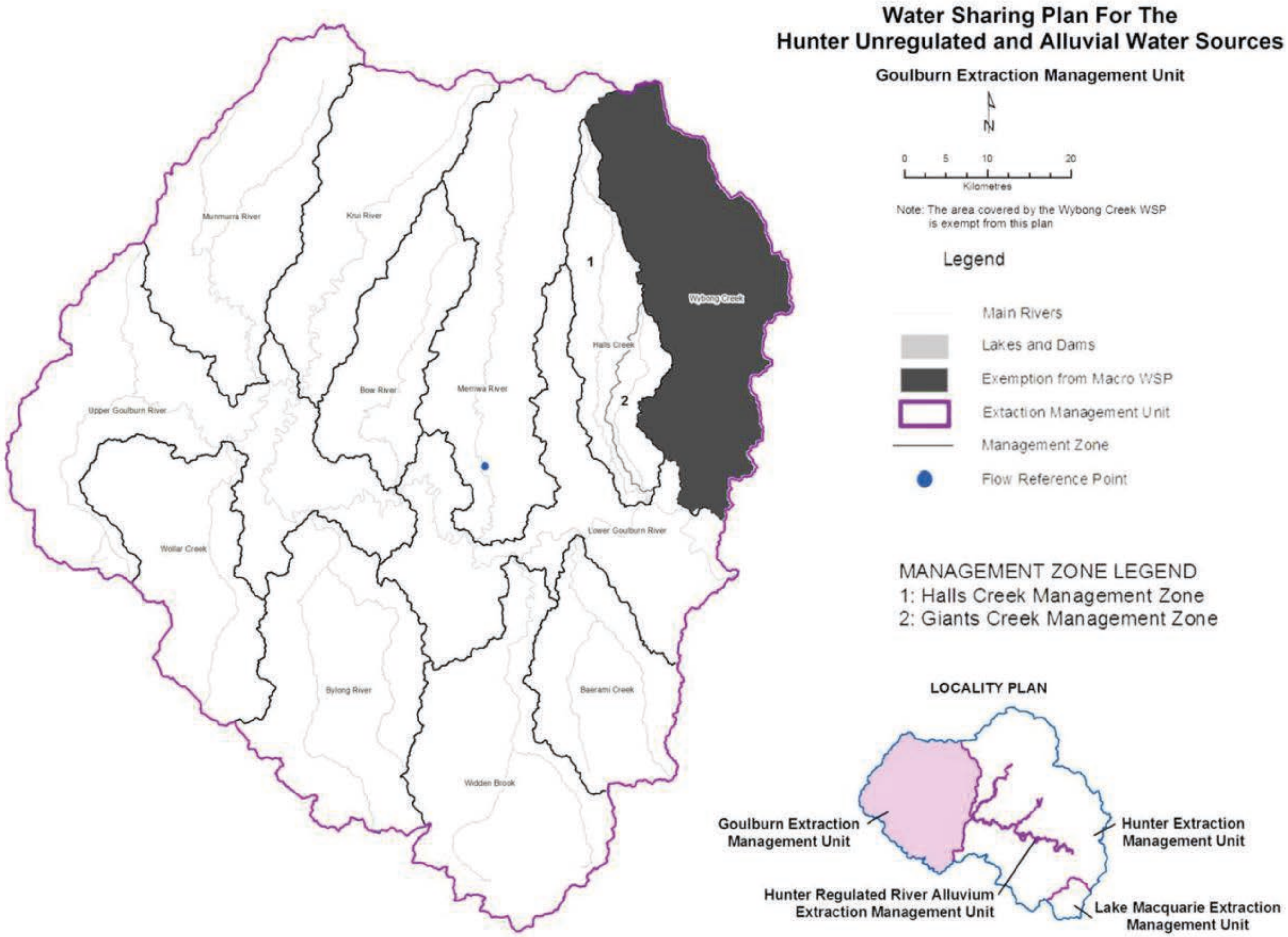


Figure 2.1 – Hunter unregulated and alluvial water sources (Source: NOW, 2009)

Table 2.1 – Bylong River water source share components for different licence categories

Access Licence Category	Bylong River Water Source Share Component Zone 1	Total Share Component in the Hunter Unregulated and Alluvial Water Source Zone 2
Domestic & Stock Access (ML/yr)	0	736.5
Unregulated River Access (Unit Shares)	65	80,619
Aquifer Access (Unit Shares)	5,843	80,400
Local Water Utility (ML/yr)	0	5,597
Major Utility (ML/yr)	0	346,700

2.4 AUSTRALIAN GUIDELINES FOR FRESH AND MARINE WATER QUALITY

The Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) have prepared a guideline for water quality management for use throughout Australia and New Zealand based on the philosophy of ecologically sustainable development (ESD). The guideline is called the *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC and ARMCANZ, 2000) and is often referred to as the 'ANZECC guideline'.

The NSW Department of Environment and Climate Change and Water (now the Office of Environment and Heritage (OEH)) published online the *NSW Water Quality and River Flow Objectives* that provide guidance to technical practitioners with applying the ANZECC guidelines in NSW. The guideline defines the 'environmental values' of receiving waters as those values or uses of water that the community believes are important for a healthy ecosystem. Specific environmental values and water quality objectives for uncontrolled streams in the Hunter River catchment are provided in Section 3.7.1.

2.5 COMMONWEALTH ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999

The EPBC Act prescribes the Commonwealth's role in environmental assessment, biodiversity conservation and the management of protected areas.

The EPBC Act is administered by the Department of the Environment (DoE) (formerly the Department of Sustainability, Environment, Water, Populations and Communities (SEWPaC)) and provides protection for listed MNES. There are currently nine MNES:

- World heritage properties;
- National heritage places;
- Wetlands of international importance;
- Listed threatened species and ecological communities;
- Migratory species;
- Nuclear actions;
- Commonwealth marine areas;
- The Great Barrier Reef Marine Park; and

- Water resources in relation to coal seam gas development and large coal mining development.

The Project is not within a World heritage property or place, does not have wetlands of international importance, does not relate to nuclear actions, and is not within either Commonwealth marine areas or the Great Barrier Reef Marine Park.

The MNES of potential relevance to the Project with respect to the surface water impact assessment is water resources.

A referral including a supporting assessment of significance for each threatened species and community must be made to DoE to obtain confirmation of whether or not a project constitutes a "controlled action". A controlled action is a proposed development or activity that will have, or is likely to have, a significant impact on MNES. Similarly, the referral is likely to require the inclusion of information on the potential impacts that the project may have upon water resources to confirm whether or not the project constitutes a controlled action. The Project was deemed a controlled action on 12 March 2014.

The EPBC Act establishes an environmental assessment and approval process for controlled actions. The Commonwealth Minister for the Environment has the power to accredit the Environmental Impact Assessment process under the NSW EP&A Act to meet the assessment requirements of the EPBC Act. On 20 December 2013, the Commonwealth Minister for the Environment reached a Bilateral Agreement with the NSW Government which accredits the NSW planning approvals system for the assessment of a controlled action and its impacts upon MNES. However, the ultimate approval authority remains with the Commonwealth Minister for the Environment. The controlled action cannot be carried out until the Minister has granted approval under Section 133 of the EPBC Act.

The surface water impact assessment is consistent with the requirements of the IESC '*Information Guidelines for Independent Expert Scientific Committee advice on coal seam gas and large coal mining development proposals*' (April 2014).

2.6 DAMS SAFETY ACT 1978

The Dams Safety Act establishes the role of the Dams Safety Committee (DSC) to ensure the safety of dams in NSW, including surveillance of prescribed dams, which are those listed in Schedule 1 of the Act. The DSC is empowered with various enabling functions under the Dams Safety Act and *Mining Act 1992*. The DSC has a general responsibility for the safety of all dams, and a special responsibility for prescribed dams. Determination of whether a dam is a prescribed dam is based on an assessment of its consequence category, which considers potential downstream impacts of dam failure. Detailed design of proposed dams for the Project will include assessment of consequence categories to determine whether any of the dams are required to be prescribed under the Dams Safety Act.

2.7 MANAGING URBAN STORMWATER SOILS AND CONSTRUCTION

Managing Urban Stormwater: Soils and Construction (Landcom, 2004) provides guidance on best practice management measures for erosion and sediment control during construction and other land disturbance activities. A specific volume (2E: Mines and Quarries) provides specific advice on appropriate measures and design standards for mining operations. The design of erosion and sediment control measures for the Project has been based on the recommended approaches and design criteria from these documents.

2.8 PROTECTION OF THE ENVIRONMENT OPERATIONS ACT 1997

The POEO Act is the key piece of environment protection legislation administered by the NSW Environment Protection Authority (EPA). The Act enables the government to set protection of the environment policies that provide environmental standards, goals, protocols and guidelines. The Act also establishes a licensing regime for pollution generating activities in NSW. Under section 48, an environment protection licence (EPL) is required for “scheduled activities”, which includes coal mining. Accordingly, an EPL for the Project will be sought by KEPCO. The Act also includes a duty to notify relevant authorities of pollution incidents where material harm to the environment is caused or threatened.

2.9 FLOOD PRONE LAND POLICY

The primary objective of the NSW Flood Prone Land Policy is to reduce the impact of flooding and flood liability on owners and occupiers of property and to reduce private and public losses resulting from floods. Similarly, the Mid-Western Regional Local Environmental Plan aims to minimise flood risk and to ensure development of flood-prone land is compatible with flood hazard and does not adversely affect other properties or the environment through increased flooding, erosion or siltation.

The design of the Project has been carefully considered to minimise flood impacts. The design of the key Project infrastructure has considered the flood extent for the 100 year average recurrence interval (ARI) flood event and is designed around this constraint. The Project also includes appropriate measures to protect proposed infrastructure from flood damage. The results of detailed flood impact modelling are included in Section 7 and Section 8.

2.10 SECRETARY’S REQUIREMENTS

The Secretary’s Environmental Assessment Requirements (SEARs) for the Project were issued on 23 June 2014 (SSD14_6367). An amendment to the SEARs was issued on 11 November 2014 in light of some minor amendments to the Project. This surface water impact assessment has been prepared in accordance with the SEARs related to surface water, as well as the various agency requests which supported the SEARs. Table 2.2 lists the SEARs that are relevant to this assessment and the sections of this report in which they are addressed.

This report only addresses the surface water aspects of these SEARs. The groundwater aspects are addressed within the EIS Groundwater Impact Assessment.

Table 2.2 – Secretary's Environmental Assessment Requirements relevant to surface water

Issue / Agency	SEARs relevant to surface water	Location where addressed in Surface Water Impact Assessment
NSW Government Planning & Environment	The EIS must include an assessment of the likely impacts of the development on the environment, focussing on the specific issues identified below, including:	
	– a description of the existing environment likely to be affected by the development, using sufficient baseline data;	Section 3
	– an assessment of the likely impacts of all stages of the development, including any cumulative impacts, taking into consideration any relevant laws, environmental planning instruments, guidelines, policies, plans and industry codes of practice;	Section 9, 10
	– a description of the measures that would be implemented to mitigate and/or offset the likely impacts of the development, and an assessment of: • whether these measures are consistent with industry best practice, and represent the full range of reasonable and feasible mitigation measures that could be implemented; • the likely effectiveness of these measures; and • whether contingency plans would be necessary to manage any residual risks;	Section 11
	– a description of the measures that would be implemented to monitor and report on the environmental performance of the development if it is approved.	Section 11.5
NSW Office of Water	The EIS must address the following specific issues:	
	– an assessment of the likely impacts of the development on the quantity and quality of the region's surface and groundwater resources, having regard to the Mining & Petroleum Gateway Panel's, EPA's, Department of Primary Industries' and (Commonwealth) Department of the Environment's requirements;	Section 9
	– an assessment of the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure, and other water users; and	Section 9
	– an assessment of the likely flooding impacts of the development.	Section 9.5
MNES, EPBC Act	Consideration of:	
	– potential for increased turbidity and sedimentation resulting in impacts to water quality downstream (the Bylong River and associated tributaries);	Section 9.3
	– potential for additional demands on existing water sources;	Section 9.2
	– changes to the catchment areas, with consequent impacts on catchment yields and drainage downstream of the site;	Section 9.4

– potential impacts to other licensed users of surface water sources;	Section 9.2.1
– requirement for discharge of surplus water, with potential consequent impacts on downstream water quality and quantities;	Section 9.3
– post-mining surface water impacts on catchment yields, water quality and quantity;	Section 9.4
– cumulative impacts.	Section 10
A description of the important water resources within the site and in surrounding areas, which is consistent with the most recent version of the Independent Expert Scientific Committee on Coal Seam Gas and Large Coal Mining Development's *Information Guidelines for Proposals Relating to the Development of Coal Seam Gas and Large Coal Mines where there is a Significant Impact on Water Resources*.	Section 3
A description of water related assets that are dependent on any important water resources, including an estimation of the water requirements of those assets (ie. regional water use).	Section 2.3
A description of all of the relevant impacts of the action on MNES. Impacts during the construction, operational and (if relevant) the decommissioning phases of the project must be addressed, and the following information provided:	
– a description of the relevant impacts of the action;	Section 9
– a detailed analysis of the nature and extent of the likely direct, indirect and consequential impacts relevant to MNES, including likely short-term and long-term impacts;	Section 9
– a statement whether any relevant impacts are likely to be unknown, unpredictable or irreversible;	Section 9.1
– any technical data and other information used or needed to make a detailed assessment of the relevant impacts.	Section 3, 5
The EIS must provide information on proposed avoidance and mitigation measures to manage the relevant impacts of the action on MNES.	Section 11
The EIS must include and substantiate specific and detailed descriptions of the proposed avoidance and mitigation measures, based on best available practices and must include the following elements: a) a consolidated list of avoidance and mitigation measures proposed to be undertaken to prevent, minimise or compensate for the relevant impacts of the action on MNES, including: i. a description of proposed avoidance and mitigation measures to deal with relevant impacts of the action, including mitigation measures proposed to be taken by State/Territory governments, local governments or the proponent; ii. assessment of the expected or predicted effectiveness of the mitigation measures, including the scale and intensity of impacts of the proposed action and the on-ground benefits to be gained through each of these measures; iii. a description of the outcomes that the avoidance and mitigation measures will achieve; iv. any statutory or policy basis for the mitigation measures; and v. the cost of the mitigation measures.	Section 11

	b) a detailed outline of a plan for the continuing management, mitigation and monitoring of relevant MNES impacts of the action, including a description of the outcomes that will be achieved and any provisions for independent environmental auditing;	Section 11.5
	c) where appropriate, each project phase (construction, operation, decommission) must be addressed separately. It must state the environmental outcomes, performance criteria, monitoring, reporting, corrective action, contingencies, responsibility and timing for each environmental issue;	Section 11.1
	d) the name of the agency responsible for endorsing or approving each mitigation measure or monitoring program.	Section 11.1
	The EIS must provide details of the likely residual impacts on MNES that are likely to occur after the proposed activities to avoid and mitigate all impacts are taken into account, including reasons why avoidance or mitigation of impacts is not reasonably achieved, and identify the significant residual impacts on MNES.	Section 11.7
Department of Primary Industries	Fisheries NSW has serious concerns about connectivity between the pit and the river through this aquifer and requires that the surface water management assessment must include the interaction with the groundwater assessment to assess this risk and the potential reduction in delivery of water downstream to the receiving waters including the Goulburn River.	Section 5.5
NSW Office of Water	NSW Office of Water recommend that the EIS be required to include:	
	– Assessment of any water licensing requirements (including those for ongoing water take post-closure).	Section 9.2
	– Details of water proposed to be taken (including through inflow and seepage) from each water source as defined in the relevant Water Sharing Plan.	Section 6.3
	– The identification of an adequate and secure water supply for the life of the mine. Confirmation that water can be sourced from an appropriately authorised and reliable supply. This is to include an assessment of the current market depth where water entitlement is required to be purchased and will need to demonstrate consistency with the rules of the relevant Water Sharing Plan. It is recommended consideration be given to the potential for the project to trigger a reduced Available Water Determination in the water source and the associated impact to existing users and the project.	Section 6.3.2
	– Assessment of impacts on surface and ground water sources (both quality and quantity), watercourses, riparian land, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts. This is to include an assessment to meet the requirements of the NSW Aquifer Interference Policy (2012).	Section 9
	– Proposed surface and groundwater monitoring.	Section 11.5
	– A detailed and consolidated site water balance.	Section 6
	– Details surrounding the final landform of the site, including final void management and rehabilitation measures.	Section 9.4.2
	– Consideration of relevant policies and guidelines.	Section 2
	The EIS is required to:	
	– Demonstrate how the proposal is consistent with the relevant rules of the WSP including rules for access	Section 9.2

	licences, access licence dealings, distance restrictions for water supply works and rules for management of local impacts in respect of surface water and groundwater sources, ecosystem protection, water quality and surface-groundwater connectivity.	
	– It is recommended consideration be given to the potential for the project to trigger a reduced Available Water Determination in the water source and the associated impact to existing users and the project.	Section 9.2
	– Provide a description of any site water use (amount of water from each water source) and management including all sediment dams, clear water diversion structures with detail on the location, design specification and storage capacities for all the existing and proposed water management structures.	Section 5, 6
	– Provide an analysis of the proposed water supply arrangements against the rules for access licences and other applicable requirements of any relevant WSP.	Refer to EIS Groundwater Impact Assessment
	– Provide a detailed and consolidated site water balance.	Section 6
	– Identify water requirements for the life of the mine in terms of both volume and timing.	Section 6
	– Detail the water supply sources for the proposal including any proposed surface water and groundwater extraction from each water source as defined in the relevant Water Sharing Plan/s and all water supply works to take water.	Section 6
	– Explanation of how the required water entitlements will be obtained (ie. through a new or existing licence/s, trading on the water market, controlled allocations etc).	Section 9.2.5
	– Information on the purpose, location, construction and expected annual extraction volumes including details on all existing and proposed water supply works which take surface water (pumps, dams, diversions etc).	Refer to EIS Groundwater Impact Assessment
	– Details on all bores and excavations for the purpose of investigation, extraction, dewatering, testing and monitoring. All predicted groundwater take must be accounted for through adequate licensing.	Refer to EIS Groundwater Impact Assessment
	– Details on existing dams/storages (including the date of construction, location, purpose, size and capacity) and any proposal to change the purpose or existing dams/storages.	Section 4.3
	– Details on the location, purpose, size and capacity of any new proposed dams/storages.	Section 5
	Water allocation account management rules, total daily extraction limits and rules governing environmental protection and access licence dealings also need to be considered.	
	Provide details on all watercourses potentially affected by the proposal including:	
	– Geomorphic assessment of water courses including details of stream order (Straher System), river style and energy regimes both in channel and on adjacent floodplains.	Section 3
Resources and Energy	Outcomes of the surface and groundwater assessments in relation to the likely final water level in the void. This should include an assessment of the potential for fill and spill along with measures required to be implemented to minimise associated impacts to the environment and downstream water users.	Section 6

	Surface water flow and flooding regimes and how these will be impacted and mitigated by the project both during and after mining has ceased. This is to include an evaluation of potential impacts from the final void on both surface and groundwater quality and flow regimes.	Section 9, 11
EPA	The environmental outcomes of the project in relation to water should be that:	
	– There is no pollution of waters (including surface and groundwater); and	Section 9
	– Polluted water (including process/tailings waters, wash down waters, polluted stormwater or sewerage) is captured onsite and collected, treated and beneficially reused, where safe and practical to do so.	Section 9
	The EIS should document the measures that will achieve the above outcomes in the construction, operation and post operations phases of the project. Construction activities will need to demonstrate best practice sediment and erosion control and management in accordance with the reference document Managing Urban Stormwater: Soils and Construction (NSW Landcom)	Section 11
	The EIS should:	
	1. Describe the Project including position of any intakes and discharges, volumes, water quality and frequency of all water discharges.	Section 6
	2. Demonstrate that all practical options to avoid discharge have been implemented and environmental impact minimised where discharge is necessary.	Section 6, 11
	3. Include a water balance for the including water requirements (quantity, quality and source(s)) and proposed storm and wastewater disposal, including type, volumes, proposed treatment and management methods and re-us options.	Section 5, 6
	4. Describe existing surface and groundwater quality. An assessment needs to be undertaken for any water resource likely to be affected by the proposal.	Section 3
	5. Describe any drainage lines, creeks lines etc that will be impacted by the project.	Section 3
	6. State the Water Quality Objectives for the receiving waters relevant to the proposal. These refer to the community's agreed environmental values and human uses endorsed by the NSW Government as goals for ambient waters (http://www.environment.nsw.ciov.au/ieo/index.htm). Where groundwater may be impacted the assessment should identify appropriate groundwater environmental values.	Section 3.7
	7. State the indicators and associated trigger values or criteria for the identified environmental values. This information should be sourced from the ANZECC (2000) Guidelines for Fresh and Marine Water Quality (http://www.mincos.gov.au/publications/australian and new Zealand guidelines for fresh and marine water Quality).	Section 3.7
	8. State any locally specific objectives, criteria or targets which have been endorsed by the NSW Government.	Section 3.7
	9. Describe the nature and degree of impact that any proposed discharges will have on the receiving environment.	Section 9
	10. Whether the project will significantly adversely affect the environment or cause avoidable erosion, siltation,	Section 9

	destruction of riparian vegetation or a reduction in the stability of river banks or watercourses.	
	11. Identify potential impacts on watercourses and the management and mitigation measures that will be implemented where mining activities occur in proximity to or within a watercourse.	Section 9
	12. Assess impacts against the relevant ambient water quality outcomes. Demonstrate how the proposal will be designed and operated to: • protect the Water Quality Objectives for receiving waters where they are currently being achieved; • contribute towards achievement of the Water Quality Objectives over time where they are not currently being achieved.	Section 9.3
	13. Assess impacts on groundwater and groundwater dependent ecosystems,	Refer to EIS Groundwater Impact Assessment
	14. Describe in detail how stormwater will be managed both during and after construction	Section 5, 9.3
	15. Provide detailed water management strategies for all disturbance areas, paying particular attention to the waste rock emplacement areas and potential impacts on groundwater and offsite surface water resources including particular reference to the management of channel and overland flows into and within the disturbance area.	Section 4
	16. Provide plans for any proposed relocation/realignment of all creeks and/or drainage lines including design, timelines and completion criteria and sufficient evidence to demonstrate that the proposed plans are achievable, reasonable and feasible in the short and the long term.	No proposal for creek realignment
	17. Describe how predicted impacts will be monitored and assessed over time.	Section 11
	18. The proponent should develop a water quality and aquatic ecosystem monitoring program to monitor the responses for each component or process that affects the Water Quality Objectives that includes, for example: • adequate data for evaluating compliance with water quality standards and/or Water Quality Objectives • measurement of pollutants identified or expected to be present in any discharge.	Section 11
	19. Water quality monitoring should be undertaken in accordance with the Approved Methods for the Sampling and Analysis of Water Pollutant in NSW (2004) (http://www.environment.nsw.flov.au/resources/legislation/approvedmethods-water.pdf)	Section 11.5
Office of Environment and Heritage	The EIS should clearly detail the quantity and source of water to be used, and the expected quality, temperature and quantity of water being released.	Section 6
	OEH also has concerns regarding effects on water quality and sedimentation on Goulburn River National Park, downstream of the Bylong Coal Project. The EIS will need to demonstrate how the movement of sediment and wastewater (including discharges from mining operations, the accommodation facility and associated infrastructure) will be controlled so as to avoid impacts on the aquatic and riparian habitats of the park.	Section 6

3 Existing Surface Water Environment

3.1 DRAINAGE NETWORK

The Project is located within the catchment of the Bylong River, a tributary of the Goulburn River, which in turn is a tributary of the Hunter River. The drainage network in the area of interest is shown in Figure 3.1. The Bylong River drains generally northwards, from the south-east, and passes between the Open Cut Mining Area and the Mine Infrastructure Area. A number of tributaries feed into the Bylong River in the vicinity of the Project, including:

- Wattle Creek,
- Cousins Creek,
- Lee Creek,
- Growee River,
- Dry Creek, and
- Coggan Creek.

The primary areas of disturbance for the Project are in the Dry Creek catchment, where underground mining will occur, and along a short reach of Lee Creek and the Bylong River where mine infrastructure and open cut pits are located. The remaining tributaries are not affected by the Project.

The headwaters of the catchment are typically steep and well vegetated and include areas of State Forest, such as the Nullo Mountain State Forest. In the lower portions of the catchment, extensive vegetation clearing has occurred for agricultural use, particularly in alluvial areas adjacent to the river channel.

The Strahler stream order (Strahler, 1952) of the various watercourses and tributaries located within the Bylong River catchment is shown in Figure 3.2. In the vicinity of proposed Project infrastructure, the Bylong River is a fourth order stream. Dry Creek is a third order stream in its lower reaches.

3.2 DRAINAGE CHARACTERISTICS – BYLONG RIVER CATCHMENT

The drainage network in the Bylong Valley, in which the Project is located, varies from steep headwater gullies to wide, flat, alluvial floodplains.

Figure 3.4 shows photographs of various reaches of Lee Creek (see Figure 3.3 for locations of photographs). The lower reaches of Lee Creek consist of a wide, flat floodplain, with a small, poorly defined low-flow channel. Extensive clearing of the floodplain has been undertaken as part of farming activities, with complete removal of riparian vegetation along substantial reaches. Significant bank erosion is evident in the mid-reaches of Lee Creek.

Photographs of the Bylong River, which has similar characteristics to Lee Creek, are shown in Figure 3.5.

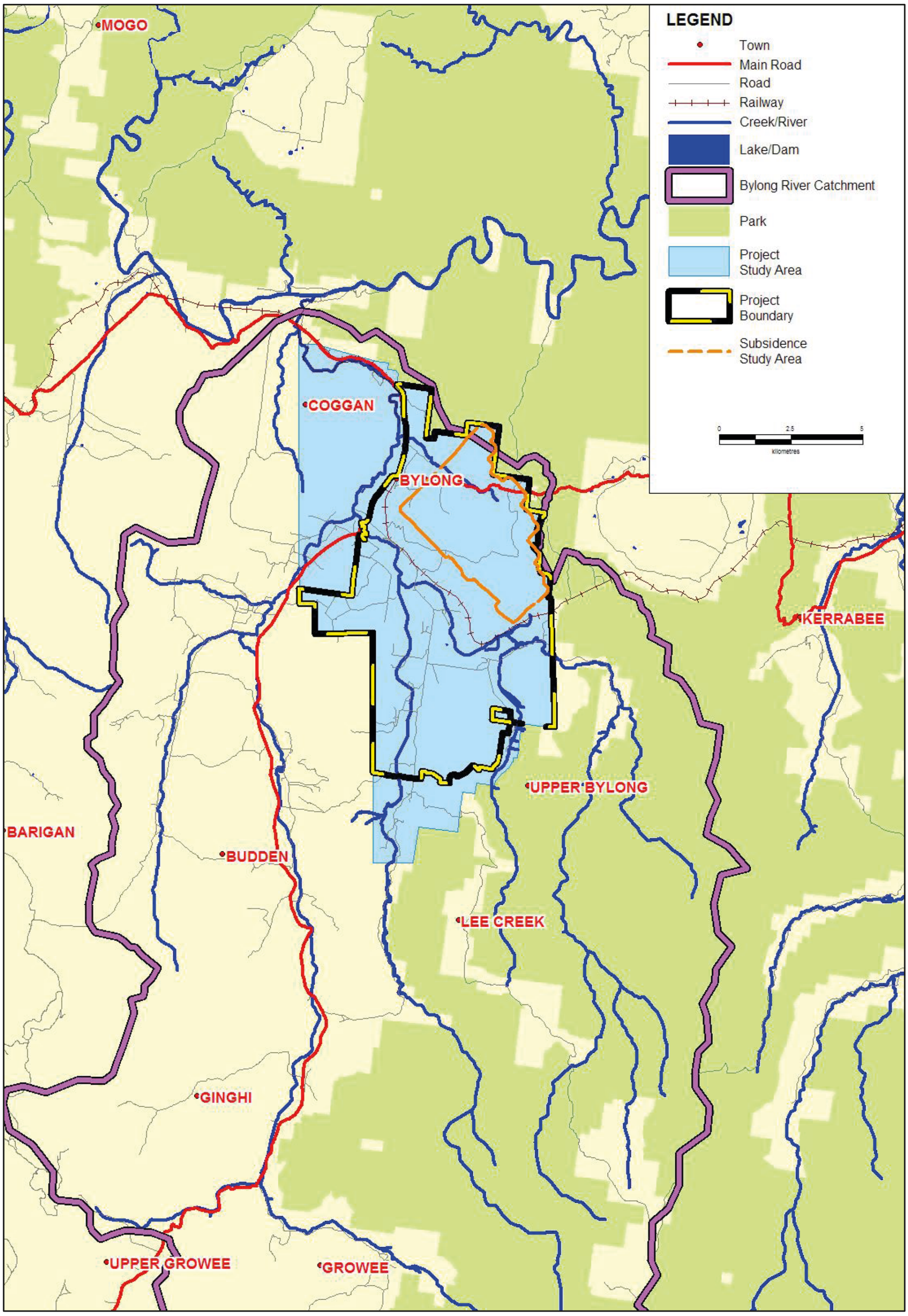


Figure 3.1 – Drainage network

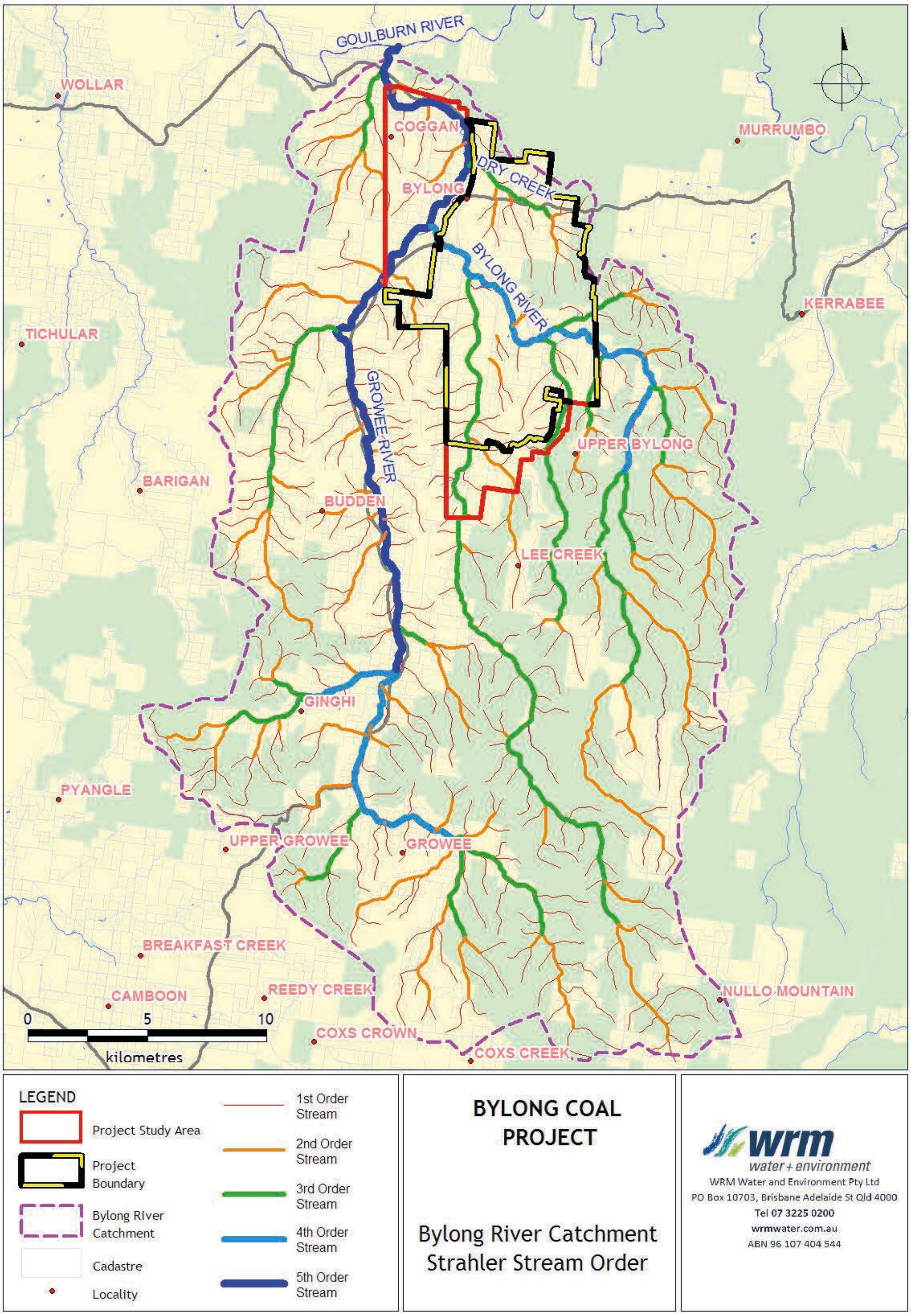


Figure 3.2 – Bylong River catchment stream order

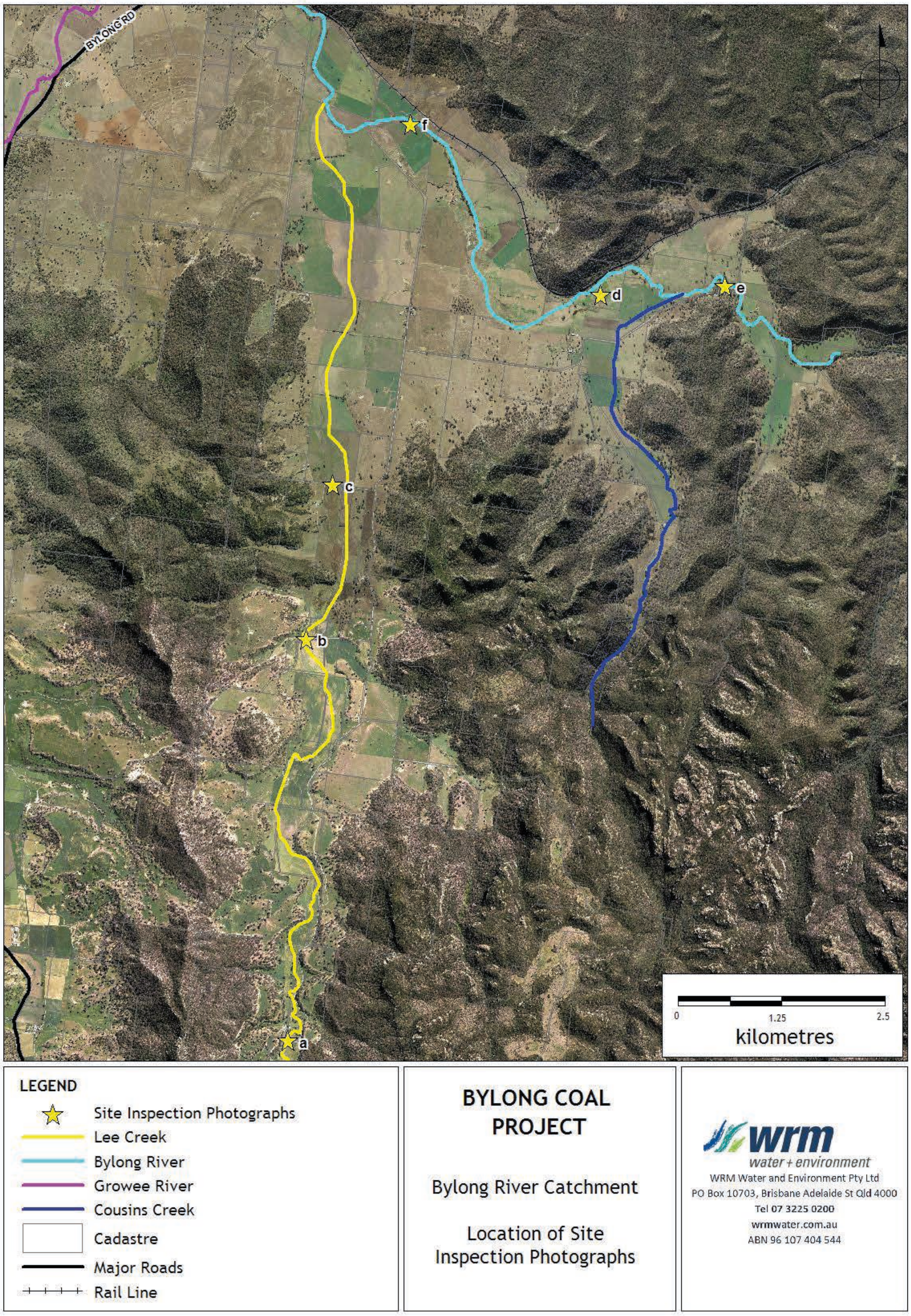


Figure 3.3 - Location of photographs, Bylong River catchment

Figure 3.4 – Photographs showing Lee Creek (a) Main channel in the upper catchment, (b) Main channel and floodplain mid-catchment, (c) Poorly defined main channel in lower catchment

(d)

(e)

(f)

Figure 3.5 - Photographs showing Bylong River (d) Floodplain near Cousins Creek confluence, (e) Main channel near Monitoring Point SW1, (f) Main channel immediately upstream of Lee Creek confluence

3.3 DRAINAGE CHARACTERISTICS – DRY CREEK CATCHMENT

Dry Creek is a tributary of the Bylong River and flows in a general easterly direction before entering the Bylong River approximately 3.1 km north-east of the junction of Bylong Valley Way and Upper Bylong Road. The upper reaches of Dry Creek are located in the Bylong State Forest. Dry Creek is intersected by numerous first and second order streams and is a third order stream for much of its length (see Figure 3.2). Dry Creek is discontinuous with intermittent flow and sections of the creek have no discernible channel. The tributaries of Dry Creek are incised with minimal riparian vegetation due to clearing for agricultural use.

Figure 3.6 shows the location of photographs taken to illustrate the key drainage characteristics of Dry Creek and its tributaries. The photographs are shown in Figure 3.7 to Figure 3.19. A summary of the existing drainage characteristics of Dry Creek is provided below:

- Large sections of the downstream reach of Dry Creek show severe bank erosion (see Figure 3.7) and extensive vegetation clearing (see Figure 3.8) which contributes to reduced soil stability.
- Tributaries of Dry Creek are typically incised with steep bed grades. This has resulted in bank scour and degradation of riparian vegetation (see Figure 3.9 and Figure 3.17).
- A large section of Dry Creek is located in close proximity to Bylong Valley Way. In this section (see Figure 3.11) there is no discernible southern bank. The northern bank is steep and eroded with large sections of exposed rock present (see Figure 3.12). The bed material in much of this section consists of exposed rock and gravel (see Figure 3.13).
- Extensive clearing combined with cattle grazing have resulted in some degradation of the banks and bed of the tributaries of Dry Creek (see Figure 3.14, Figure 3.16 and Figure 3.19). In several locations, headward erosion is evident (see Figure 3.17).
- Clearing and grazing has resulted in widespread bank erosion downstream of Bylong Valley Way (see Figure 3.18). In some areas, wombat burrows have also contributed to the erosion of tributary banks.
- An analysis of the channel slope of Dry Creek and its three main tributaries indicates that Dry Creek has an average bed slope of 1.3% whereas the tributaries have average bed slopes of approximately 2.3%. These steep gradients of the natural landform, combined with the effects of riparian vegetation clearing have resulted in the creek channel being in generally poor condition. Figure 3.20 shows longitudinal section plots of the channel invert levels of Dry Creek and its tributaries.

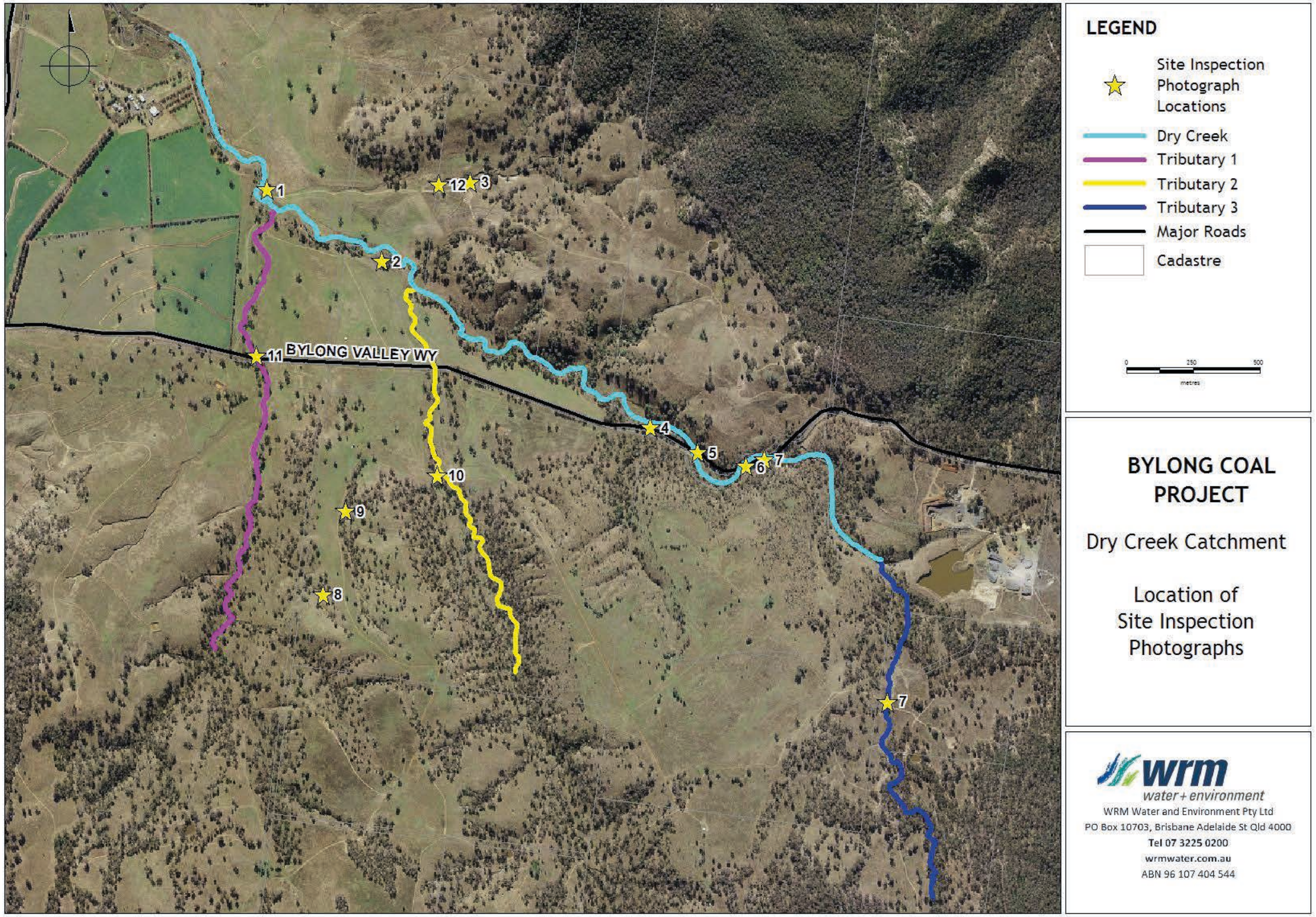


Figure 3.6 – Location of photographs, Dry Creek catchment

Figure 3.7 – Photograph 1 showing eroded bank in downstream section of Dry Creek

Figure 3.8 – Photograph 2 showing extensive clearing adjacent to Dry Creek

Figure 3.9 – Photograph 3 showing degraded first order tributary of Dry Creek

Figure 3.10 – Photograph 4 showing Dry Creek adjacent to Bylong Valley Way

Figure 3.11 - Photograph 5 showing Dry Creek adjacent to Bylong Valley Way

Figure 3.12 – Photograph 6 showing rock material on northern bank of Dry Creek

Figure 3.13 - Photograph 7 showing rock material in the channel bed of Dry Creek

Figure 3.14 - Photograph 7 showing second order tributary with exposed rock in channel bed

Figure 3.15 – Photograph 8 showing steep, incised channel in Dry Creek tributary

Figure 3.16 – Photograph 9 showing severely eroded first order stream

Figure 3.17 - Photograph 10 showing extensive headward erosion in Dry Creek tributary

Figure 3.18 - Photograph 11 showing extensive degradation and erosion of a second order tributary of Dry Creek

Figure 3.19 - Photograph 12 showing impacts of cattle grazing

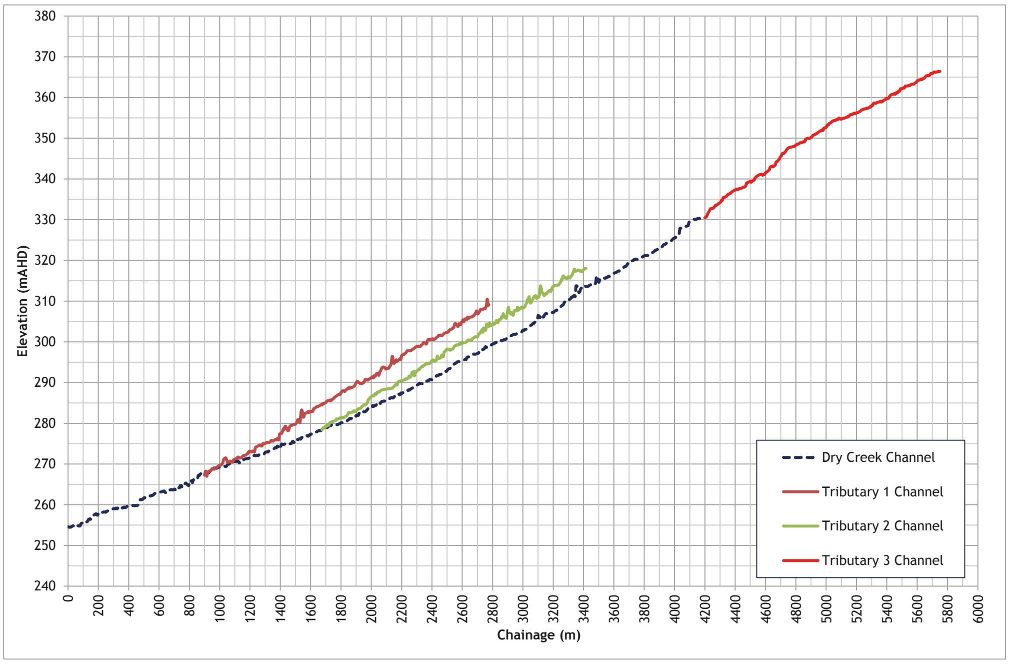


Figure 3.20 - Longitudinal sections of Dry Creek and its tributaries

3.4 ASSESSMENT OF RIVER CONDITION

An assessment of a River Condition Index, based on the National Water Commission's *Framework for the Assessment of River and Wetland Health* (Norris et al, 2007), has been undertaken for the Hunter River catchment, including the Bylong River, by the National Water Commission (Hamstead, 2010). The index was based on the following four components:

- River Styles condition assessment to develop a Geomorphic Condition Index;
- Riparian vegetation cover assessment to create a native Riparian Vegetation Index;
- A hydrologic stress rating; and
- A river biodiversity condition.

The results of application of the component assessments to the Bylong River catchment (rated from 0 = poorest, to 1 = best) are summarised as follows:

- The Geomorphic Condition Index across the catchment ranged from a minimum of about 0.4 in the northern portion of the catchment to 0.8 in the eastern forested portion of the catchment.
- The Native Riparian Vegetation Index ranged from about 0.1 in the north-western portion of the catchment to 0.7 in the forested eastern portion.
- The Hydrologic Stress Index was classified as Very High Stress for the entire Bylong River catchment (the same rating was given to about 80 of the Hunter River catchment).
- The River Biodiversity Condition Index was generally high, with assigned values of 0.8 to 1 across the catchment.

Based on these inputs, the River Condition Index for the Bylong River catchment was assigned a "Moderate" condition across most of the catchment, with the exception of the forested eastern catchment, located to the southeast of the Project Boundary, which was considered to be in "Good" condition. The mapped River Condition Index across the Hunter River catchment and Bylong River catchment is shown in Figure 3.21.

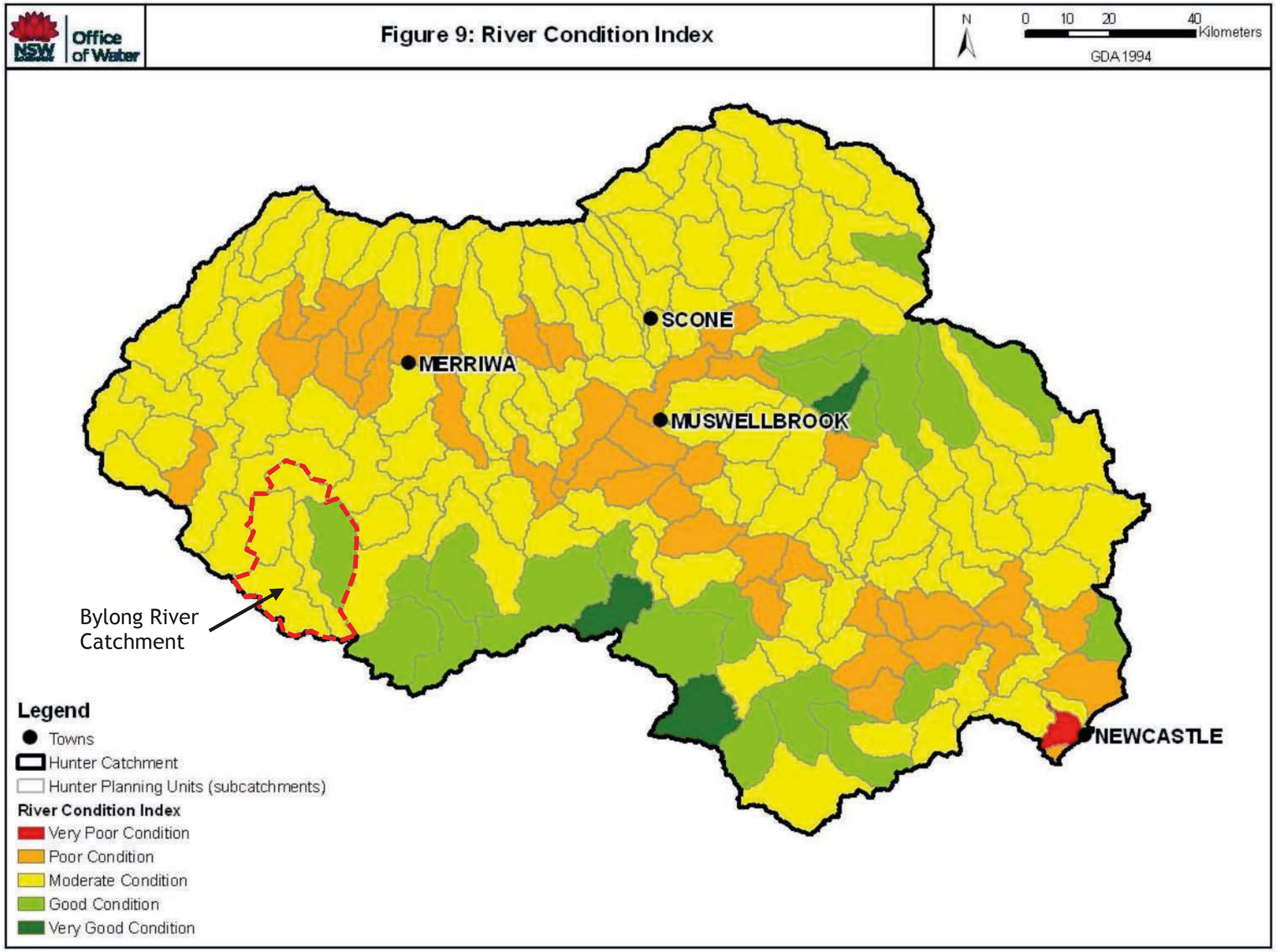


Figure 3.21 – River Condition Index (Source: Hamstead, 2010)

3.5 RAINFALL AND EVAPORATION

Table 3.1 shows summary details of the rainfall stations in the area. Daily rainfalls have been recorded at Kerrabee (Murrumbo) (BoM Station No. 062046), approximately 10 km east of the Project Boundary, since 1951. Rainfall data recorded at this station would be representative of rainfall in the vicinity of the Project. Table 3.2 shows summary rainfall statistics for the Kerrabee (Murrumbo) station. Mean annual rainfall is 657 mm with the highest monthly rainfalls occurring in the summer. The highest annual rainfall at this station (1,207.8 mm) was recorded in 1990.

The Bylong (Heatherbrae) rainfall station (BoM Station No. 062080), located near the northern end of the Project Boundary, has recorded daily rainfall between 1968 and 2008. A comparison of the mean monthly rainfalls for the common period of record at the Bylong (Heatherbrae) and Kerrabee (Murrumbo) rainfall stations is provided in Table 3.3. Recorded rainfalls at both stations are relatively consistent, with a difference in mean annual rainfall of about 4%.

A local weather station near the township of Bylong (Bylong Weather Station - details in Table 3.1) has been operated by KEPCO since 2011. A comparison of the mean monthly rainfalls with the Kerrabee (Murrumbo) stations for the common period of record is provided in Table 3.3. The comparison shows the Bylong rainfalls to be more than 10% lower than the Kerrabee (Murrumbo) rainfalls. However, the comparison period is relatively short and can be significantly influenced by individual events. For example, on 28 and 29 January 2014, 96 mm of rainfall was recorded at the Kerrabee (Murrumbo) gauge and less than 1 mm was recorded at the Bylong Weather Station. The difference in rainfall for this event contributes significantly to the observed difference in mean January rainfall at the two gauges (see Table 3.3).

Table 3.1 – Rainfall station details

Station No.	Station Name	Elevation (mAHD)	Latitude	Longitude	Distance from site (km)	Opened	Closed
062046	Kerrabee (Murrumbo)	260	32.41°S	150.24°E	12	1951	-
062080	Bylong (Heatherbrae)	230	32.36°S	150.10°E	12	1968	2008
4118	Bylong Weather Station	260	32.41°S	150.12°E	3	2011	-

Table 3.2 - Mean rainfall statistics, Kerrabee (Murrumbo) (BoM Station No. 062046), 1951-2014

Statistic	Monthly Rainfall												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean	85.3	74.9	53.8	35	43	36.9	38.1	43.4	39.2	56.3	59.7	71.2	656.8
Lowest	3	0	0	0	0	0	0	0	0	0	5.1	0	286.1
5th %ile	13.6	1.9	0.6	0	2.4	0.9	4.2	2.5	2.4	1.5	12.6	9.3	428
10th %ile	31.1	6.4	3.9	4.8	6.9	3.3	9.1	6.7	6.9	9.4	15.1	17.7	474.3
Median	63.2	63.2	34.2	25.1	32.7	29.2	31.9	38.6	34.3	55.3	53.2	64.6	664
90th %ile	161.8	137.6	131	68.3	107.5	71.2	69.9	82	78.7	100.6	124.2	137.4	815.7
95th %ile	204.5	205.8	135.7	94.8	118.7	90.7	80.1	116.7	92	106.2	139.9	160.4	880.6
Highest	260.5	388.9	183.4	153.6	162.9	217	150.8	129	102.4	187.6	154.6	266.1	1207.8

Table 3.3 – Monthly rainfall comparison

Month	Mean Monthly Rainfall (mm) 1968-2008		Mean Monthly Rainfall (mm) Sep 2011 – Dec 2014	
	Kerrabee (Murrumbo) 062046	Bylong (Heatherbrae) 062080	Kerrabee (Murrumbo) 062046	Bylong Weather Station 4118
Jan	89	76	71	32
Feb	70	72	83	86
Mar	52	49	112	127
Apr	35	35	32	19
May	46	39	20	24
Jun	37	43	38	38
Jul	42	40	37	21
Aug	44	38	14	12
Sep	43	42	45	39
Oct	56	63	19	14
Nov	64	58	75	74
Dec	69	68	62	43
Total	**648**	**623**	**608**	**530**

In order to extend the rainfall dataset for the simulation of the site water balance over the widest range of locally relevant climatic conditions, a synthetic rainfall dataset was also obtained for the Project from the Queensland Department of Science, Information Technology, Innovation and the Arts (DSITIA) Data Drill service (Jeffrey et al. 2001). The Data Drill accesses grids of data "derived by interpolating the Bureau of Meteorology's stations records. Interpolations are calculated by splining and kriging techniques. The data in the Data Drill are all synthetic. There are no original meteorological station data left in the calculated grid fields. However, the Data Drill does have the advantage of being available for any set of coordinates in Australia" (DSITIA, 2013). The key advantage of adopting the Data Drill data is that it has been adjusted to remove accumulated totals over multiple days and to fill periods of missing data using rainfall from nearby stations.

A comparison of mean monthly rainfall for the Data Drill data and the Kerrabee (Murrumbo) station over the period 1951 to 2013 (the period of coincident rainfall) is presented in Table 3.4, which shows that the simulated rainfall data set is within a few percent of the recorded data.

Table 3.4 – Mean monthly rainfall comparison – Kerrabee (Murrumbo) and Data Drill (mm/month)

Month	Kerrabee (Murrumbo) 062046	SILO DataDrill
Jan	85.3	82.0
Feb	74.9	75.2
Mar	53.8	54.5
Apr	35.0	39.5
May	43.0	44.1
Jun	36.9	41.6
Jul	38.1	41.1
Aug	43.4	44.6
Sep	39.2	43.7
Oct	56.3	60.5
Nov	59.7	63.2
Dec	71.2	67.0
Total	**656.8**	**642.6**

Table 3.5 shows mean monthly evaporation (based on Class A pan evaporation) recorded at Jerrys Plains Post Office (BoM Station No. 061086), located some 75 km to the east of the Project Boundary. Table 3.5 also shows interpolated pan evaporation and Morton's Lake evaporation obtained from the Data Drill service for Bylong. Mean annual evaporation is approximately 2.4 times greater than mean annual rainfall.

Figure 3.22 shows the annual distribution of monthly rainfall and evaporation. Evaporation is greater than rainfall in all months, but is much greater than rainfall in the warmer months. The rainfall pattern shows higher monthly rainfall occurring during summer.

For water balance modelling, Morton's lake evaporation was used to estimate evaporation loss from storages. Soil moisture evapotranspiration losses in the rainfall runoff model (AWBM) were estimated using Morton's lake evaporation with an evapotranspiration factor selected to match Morton's wet environment areal evapotranspiration.

Figure 3.23 shows the distribution of average annual rainfall over the Bylong River catchment, based on data obtained from the BoM (BOM, 2009). Average annual rainfalls are similar across the alluvial plains (of the order of 600 to 700 mm), but are significantly higher across the ranges that form the southern and eastern boundary of the Bylong River catchment. Average annual rainfalls on the ranges to the south and east are approximately 750 to 1,000 mm.

Table 3.5 - Mean monthly evaporation (mm/month)

Month	Jerrys Plains Post Office 061086 Pan evaporation (10 years of data)	Data Drill (1889 - 2013)	
		Pan Evaporation	Morton's Lake Evaporation
January	220	223	191
February	170	177	154
March	155	157	135
April	120	106	90
May	90	67	56
June	60	47	38
July	71	53	45
August	81	76	68
September	111	107	99
October	164	150	141
November	195	182	166
December	205	224	192
Total	**1,641**	**1,569**	**1,375**

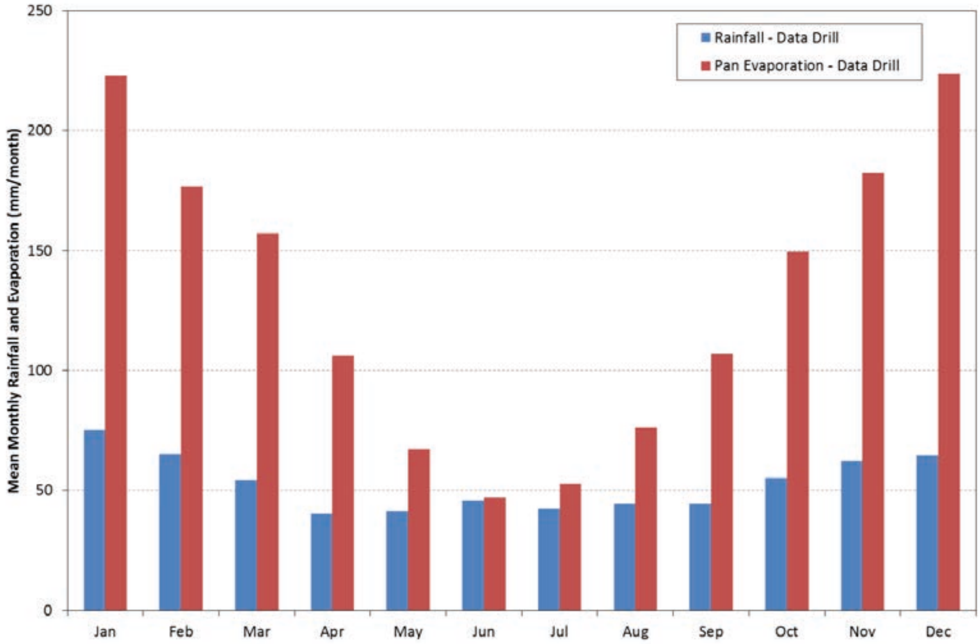


Figure 3.22 - Distribution of monthly rainfall and evaporation (SILO DataDrill)

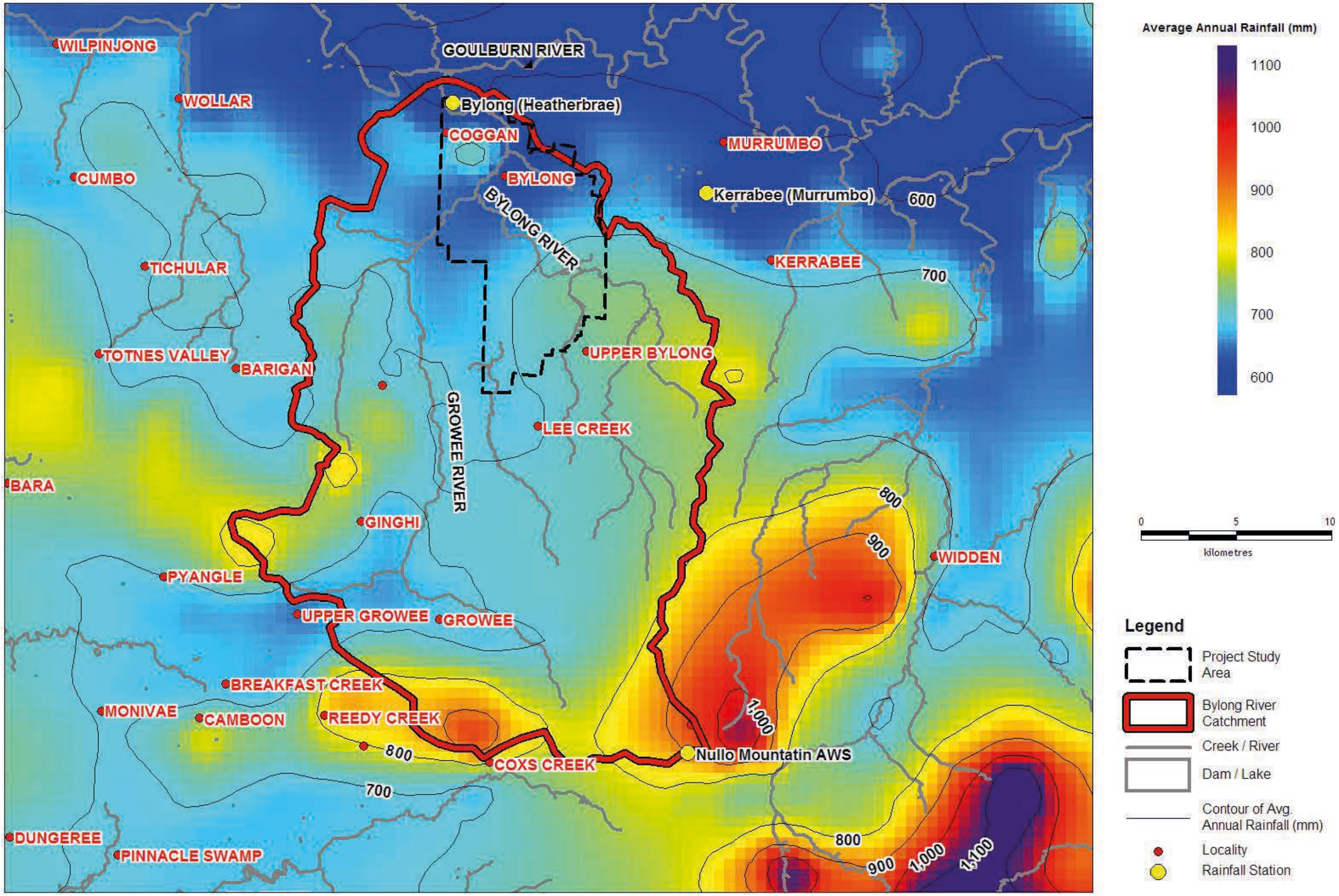


Figure 3.23 – Spatial distribution of average annual rainfall, Bylong River catchment

3.6 STREAMFLOW

Streamflow data for the Bylong River is available at Bylong No.2 (Station No. 210062) from November 1969 to April 1979. This stream gauge is located approximately 8.5 km upstream of the confluence with the Goulburn River, as shown in Figure 3.24, and has a catchment area of approximately 660 km^2. The gauge record includes significant periods of missing data, as shown in Figure 3.25.

Additional streamflow data for the Bylong River was available from the Environmental Monitoring Program for the Project, however due to the relatively short period of record (from mid-2012) and the relatively dry climatic conditions over the period of record, the recorded data was not sufficient for meaningful analysis or calibration of streamflow models.

Due to the missing data at Bylong No.2 gauge, the streamflow record was not suitable to calibrate rainfall runoff model parameters for the Bylong River catchment. Longer periods of stream flow record were available for adjacent catchments at the Wollar Creek (#210082) and Widden Brook at Widden (#210034) stream gauges, as shown in Figure 3.26 and Figure 3.27, respectively. The locations of these adjacent catchments are shown in Figure 3.24.

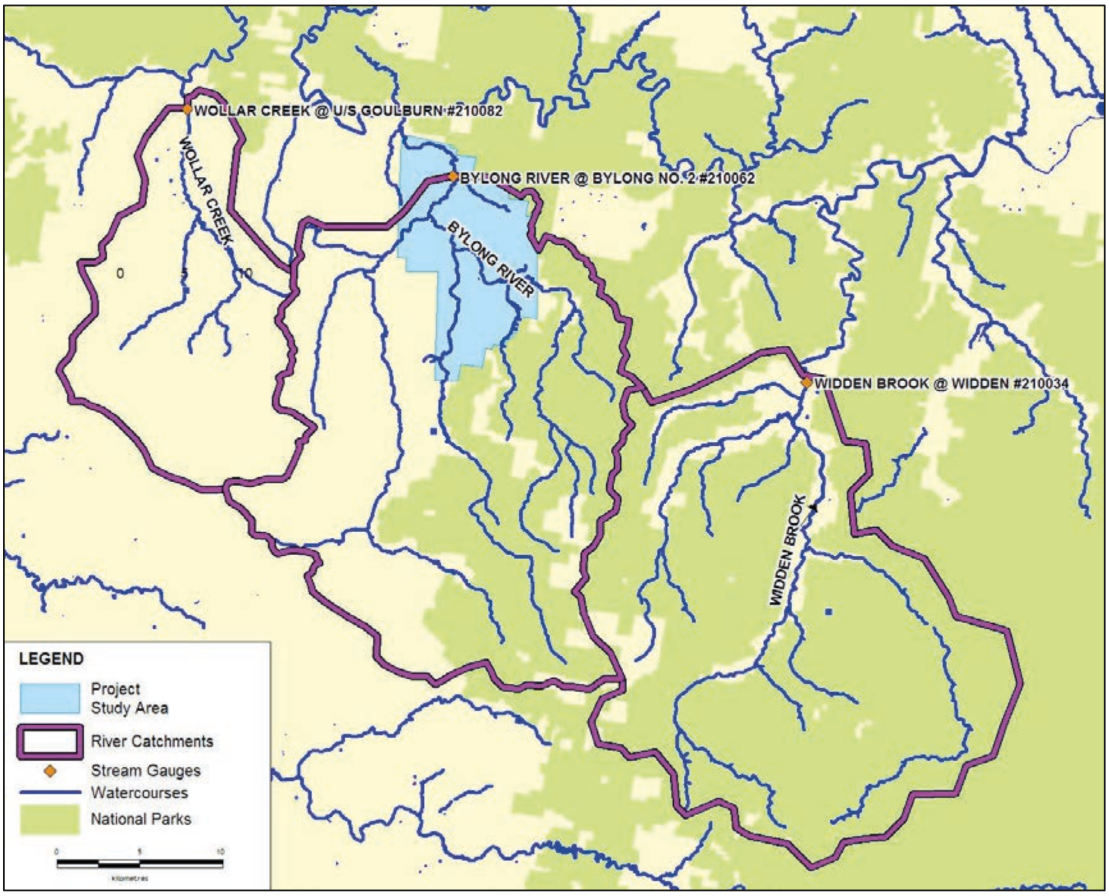


Figure 3.24 – Gauged catchments in the vicinity of the Project

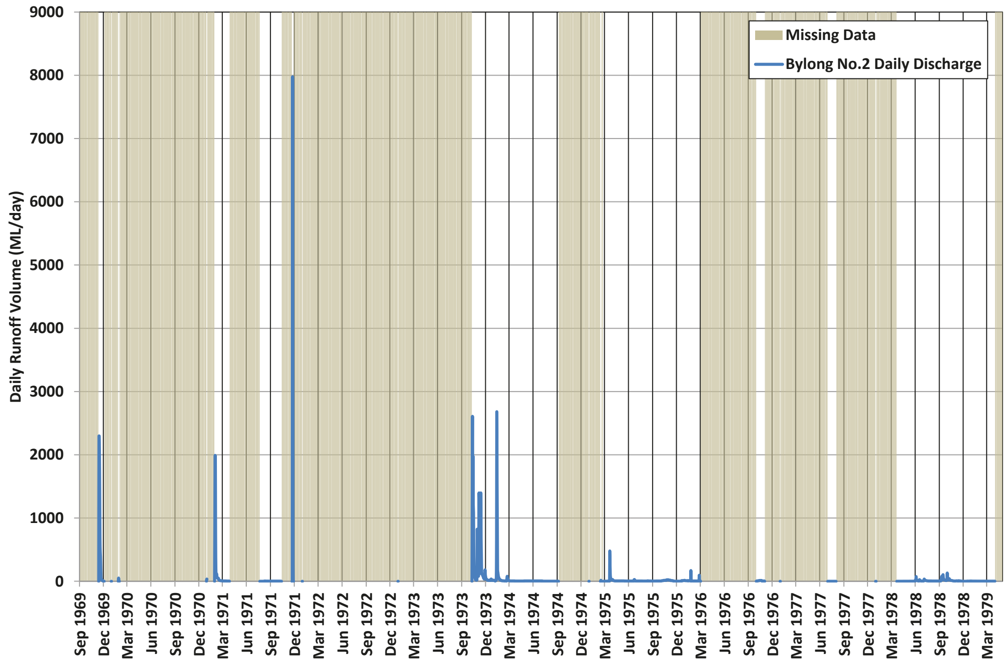


Figure 3.25 – Bylong River daily runoff volume at Bylong No.2 stream gauge (#Station No.10062)

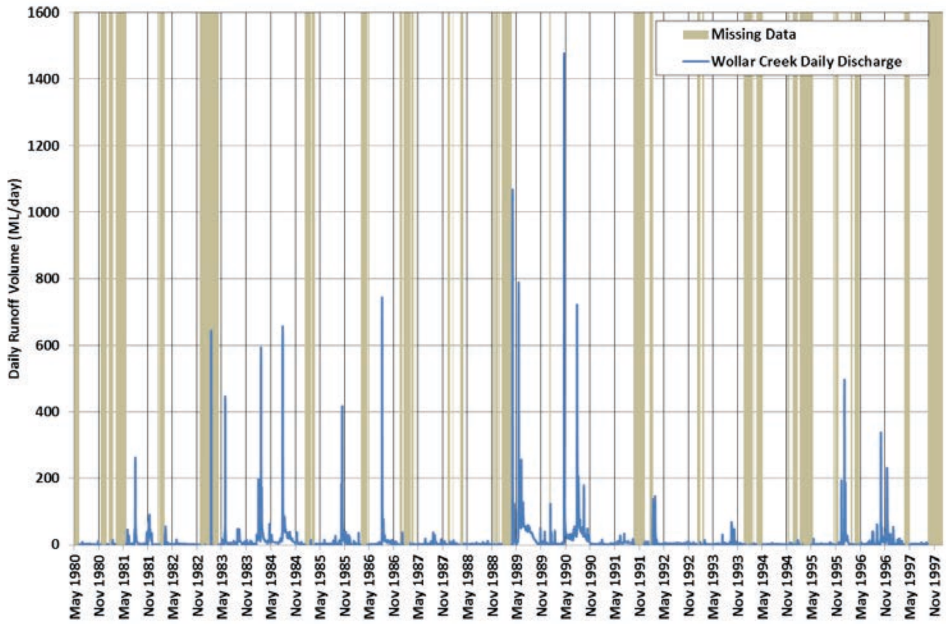


Figure 3.26 – Wollar Creek daily runoff volume at U/S Goulburn River stream gauge (Station No. 210082)

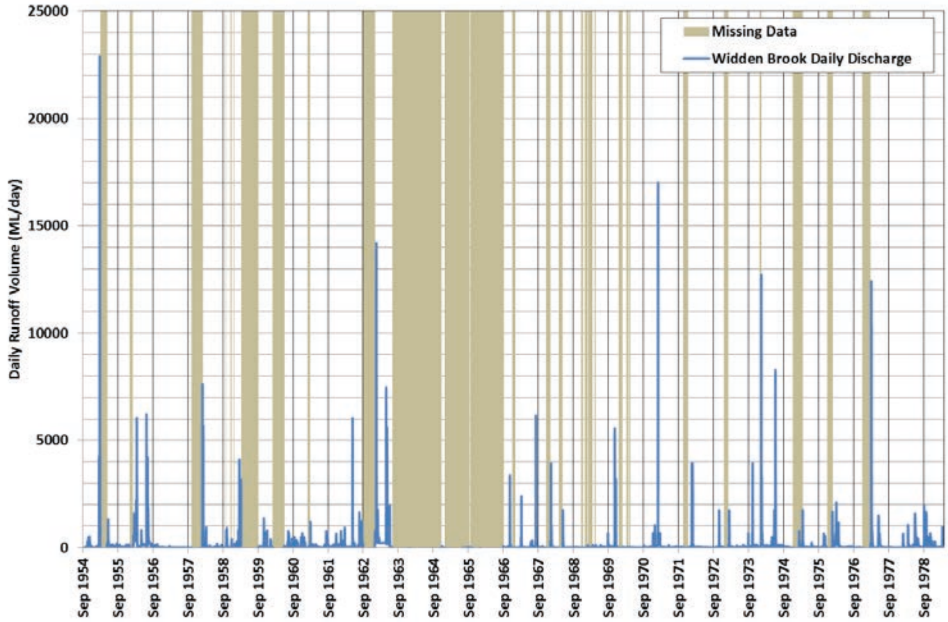


Figure 3.27 – Widden Brook daily runoff volume at Widden stream gauge (Station No. 210034)

Estimates of the long term volumetric runoff coefficient for these adjacent Wollar Creek and Widden Brook catchments were calculated based on the following:

- Long term synthetic rainfall datasets were obtained from the Data Drill service (Jeffrey et al, 2001) for locations near the catchment centroid for each gauge; and
- Rainfall and runoff volumes were calculated for the common period of recorded rainfall and runoff at each gauge.

The catchments draining to the Wollar Creek gauge (Station No. 210082) and the Widden Brook gauge (Station No. 210034) were found to have long term volumetric runoff coefficients of approximately 2% (1980 to 1997) and 10% (1954 to 1978), respectively.

3.7 WATER QUALITY

3.7.1 Environmental Values

Environmental values for uncontrolled streams in the Hunter River catchment, which include the Bylong River, are published by the OEH (NSW Water Quality and River Flow Objectives). The identified environmental values for water quality are protection of:

- Aquatic ecosystems;
- Visual amenity;
- Secondary contact recreation;
- Primary contact recreation;
- Livestock water supply;
- Irrigation water supply;
- Homestead water supply;

- Drinking water at point of supply-Disinfection only;
- Drinking water at point of supply-Clarification and disinfection;
- Drinking water at point of supply-Groundwater; and
- Aquatic foods (cooked).

River flow objectives are:

- Protect pools in dry times;
- Protect natural low flows;
- Protect important rises in water levels;
- Maintain wetland and floodplain inundation;
- Maintain natural flow variability;
- Manage groundwater for ecosystems; and
- Minimise effects of weirs and other structures.

Default trigger values for water quality indicators relevant to the various environmental values are shown in Table 3.6.

Table 3.6 – Water Quality Trigger Values

Parameter	Unit	Trigger Value						
		Irrigation	Livestock drinking	Ecosystem*[d]	Recreation	Homestead Water Supply	Drinking Water for Disinfection	Aquatic Foods
pH	pH	6.0 - 9.0	-	6.5 - 8.0	5.0 - 9.0	6.5 - 8.5	6.5 - 8.5	-
EC (uncompensated)	µS/cm	1,000 *[a]	-	-	-	-	-	-
EC (25C)	µS/cm	-	-	30-350	-	-	<1500	-
DO (% Saturation)		-	-	90-110	-	-	-	-
Total Dissolved Solids (TDS)	mg/L	-	2,000*[a]	-	1,000	<500 - 1000	-	-
Turbidity	NTU	-	-	2 - 25	6	5	-	-
Calcium (Ca)	mg/L	-	1000	-	-	-	-	-
Sodium (Na)	mg/L	115*[c]		-	300	-	-	-
Magnesium (Mg)	mg/L	-	2,000*[b]	-	-	-	-	-
Sulphate as SO4	mg/L	-	1000	-	400	-	-	-
Chloride as Cl	mg/L	175*[c]	-	-	400	-	-	-
Aluminium	mg/L	5*[f]	5	-	0.2	-	-	-
Arsenic	mg/L	0.1*[f]	0.5*[a]	0.013*[ae]	0.05	-	-	-
Barium	mg/L	-	-	-	1	-	-	-
Beryllium	mg/L	0.1*[f]	-	-	-	-	-	-
Cadmium	mg/L	0.01*[f]	0.01	0.0002*[e]	0.005	-	-	-
Chromium	mg/L	0.1*[f]	1	0.001*[e]	0.05	-	-	-
Cobalt	mg/L	0.05*[f]	1	-	-	-	-	-
Copper	mg/L	0.2*[f]	0.4*[a]	0.0014*[e]	1	-	-	0.005
Iron	mg/L	0.2*[f]	-	-	0.3	-	-	-
Lead	mg/L	2*[f]	0.1	0.0034*[e]	0.05	-	-	-
Manganese	mg/L	0.2*[f]	-	1.9*[e]	0.1	-	-	-
Mercury	mg/L	0.002*[f]	0.002	0.0006*[e]	0.001	-	-	0.001
Nickel	mg/L	0.2*[f]	1	0.011*[e]	0.1	-	-	-
Selenium	mg/L	0.02*[f]	0.02	0.011*[e]	0.01	-	-	-
Vanadium	mg/L	0.1*[f]	-	-	-	-	-	-
Zinc (Zn)	mg/L	2*[f]	20	0.008*[e]	5	-	-	0.005
Ammonia	mg/L	-	-	0.013	-	-	-	-
Total phosphorus (Total P)	mg/L	0.05*[f]	-	0.02	-	-	-	-
Total nitrogen (Total N)	mg/L	5*[f]	-	0.25	-	-	-	-
NOx	mg/L	-	-	0.015	-	-	-	-
Nitrate-N	mg/L	-	400	0.7*[e]	10	-	-	-
Nitrite-N	pH	-	30	-	1	-	-	-

Notes: - No Trigger Value recommended
*[a] Lowest recommended value
*[b] Cattle (insufficient information on other livestock)
*[c] Sensitive crops
*[d] Upland River
*[e] 95% of species protected
*[f] Long term Trigger Value

3.7.2 Regional Water Quality

There is limited historical baseline regional water quality data available for the Bylong River catchment; however some information is available for the Goulburn River in the vicinity of the Project.

Water quality data is available from the NSW Office of Water (NOW) for two Goulburn River locations:

- Goulburn River at Coggan (Station No. 210006) from May 2012, located just downstream of the Bylong River confluence (catchment area = 3,340 km^2).
- Goulburn River at Kerrabee (Station No. 210016) from July 2002, located further downstream from the Bylong River confluence (catchment area = 4,950 km^2).

A summary of the available Goulburn River electrical conductivity (EC) data is provided in Table 3.7 and shown in Figure 3.28, along with a comparison to trigger values for protection of aquatic ecosystems and irrigation water supply. The following is of note:

- The 20th percentile EC records at both gauges exceed the upper trigger value for ecosystem protection;
- The median EC at both stations is close to the trigger value for irrigation water supply; and
- The 80th percentile EC value at both locations exceeds the trigger value for irrigation water supply.

Table 3.7 – Goulburn River surface water quality monitoring data

Water Quality Parameter		Sampling Site	
		Goulburn River at Kerrabee #210016 (2002-2013)	Goulburn River at Coggan #210016 (2012-2013)
EC (μs/cm)	20th %ile	752	885
	Median	990	1,004
	80th %ile	1,221	1,202
	N	79,541	40,310

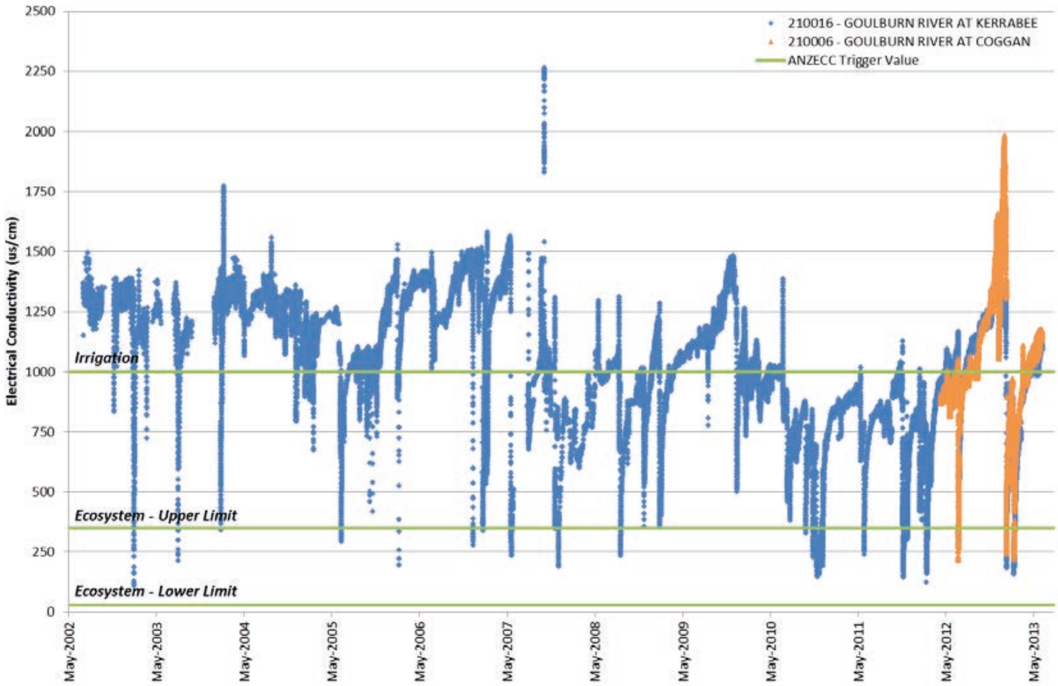


Figure 3.28 - NOW surface water quality monitoring - Electrical Conductivity

3.7.3 Baseline Water Quality Monitoring

Baseline surface water quality monitoring at nine sites has been undertaken by Douglas Partners Pty Ltd from February 2012 to August 2014 and then recommenced in December 2014. Figure 3.29 shows the baseline surface water monitoring locations. Sampling has been undertaken generally on a monthly basis, subject to climate conditions, for salinity, pH, temperature, Dissolved Oxygen, turbidity, alkalinity as well as a number of metals and organic compounds. Note that monitoring location SW5 which is located on the Growee River was dry on all sampling occasions. The results of the water quality monitoring program are summarised in Table 3.8.

Table 3.6 shows the recorded baseline monitoring data with the water quality trigger values. Ecosystem protection trigger values used in the comparison are for upland rivers with a level of protection of 95% of species. If ANZECC indicated a range of trigger values, the lowest value has been used for comparison. Both dissolved and total metals have been compared to the ANZECC trigger values; however most monitoring sites have only sampled the total metals once.

The surface water quality in the Bylong River at SW1, 2, 4, 6 and 8 may be characterised as follows:

- slightly alkaline, with median field and laboratory measured pH values ranging from 7.3 to 8.4;
- salinity varying from fresh in the upper Bylong River draining the national park to brackish downstream of the Growee River confluence. Median EC values downstream of the Growee River exceed irrigation trigger levels. Figure 3.30 shows a plot of baseline salinity at the various monitoring locations. There is a distinct difference in salinity between upstream locations on Lee Creek and the Bylong River (SW1, SW7, SW9), where salinity is generally below 400 µS/cm and downstream of

the Growee River (SW4, SW6) where salinity is generally in the range 1,800 to 2,200 µS/cm;

- mostly within the acceptable turbidity range for ecosystem protection, with median field and laboratory measured turbidity values ranging from 2.6 to 17.5 Nephelometric Turbidity Units (NTU);
- total phosphorous above the ecosystem protection trigger value and above the irrigation trigger value on a number of occasions;
- sodium below the recreational trigger value on all occasions and above the irrigation trigger value a number of times at the downstream gauges, SW 4 and 6;
- chloride below the recreational trigger value except for one occasion at the downstream gauge, SW6, and below the irrigation trigger value at the upstream monitoring sites SW1, SW2 and SW8. Mostly above the irrigation trigger value at the downstream monitoring sites, SW4 and SW6;
- ammonia mostly above the ecosystem protection trigger value;
- dissolved aluminium and chromium below the ANZECC trigger values;
- total aluminium below the livestock and irrigation trigger values and above the recreation trigger value;
- total chromium below the livestock, irrigation and recreational trigger values and above the ecosystem protection trigger value;
- both dissolved and total copper below the livestock, irrigation and recreational trigger values and above the ecosystem protection trigger value on many occasions for dissolved copper and one occasion for total copper;
- dissolved iron mostly below the trigger values and total iron always above the trigger values;
- dissolved manganese below the ecosystem protection trigger value and above the recreational and irrigation trigger values on many occasions;
- total manganese below the trigger values;
- dissolved cadmium below the livestock, irrigation and recreational trigger values and above the ecosystem protection trigger on a number of occasions;
- total cadmium below the trigger values;
- dissolved zinc below the livestock, irrigation and recreational trigger values and mostly exceeds the ecosystem trigger value;
- below the trigger values for total zinc; and
- below the ANZECC trigger values for calcium, magnesium, sulphate and for both dissolved and total arsenic, barium, beryllium, cobalt, lead, mercury, nickel, selenium and vanadium.

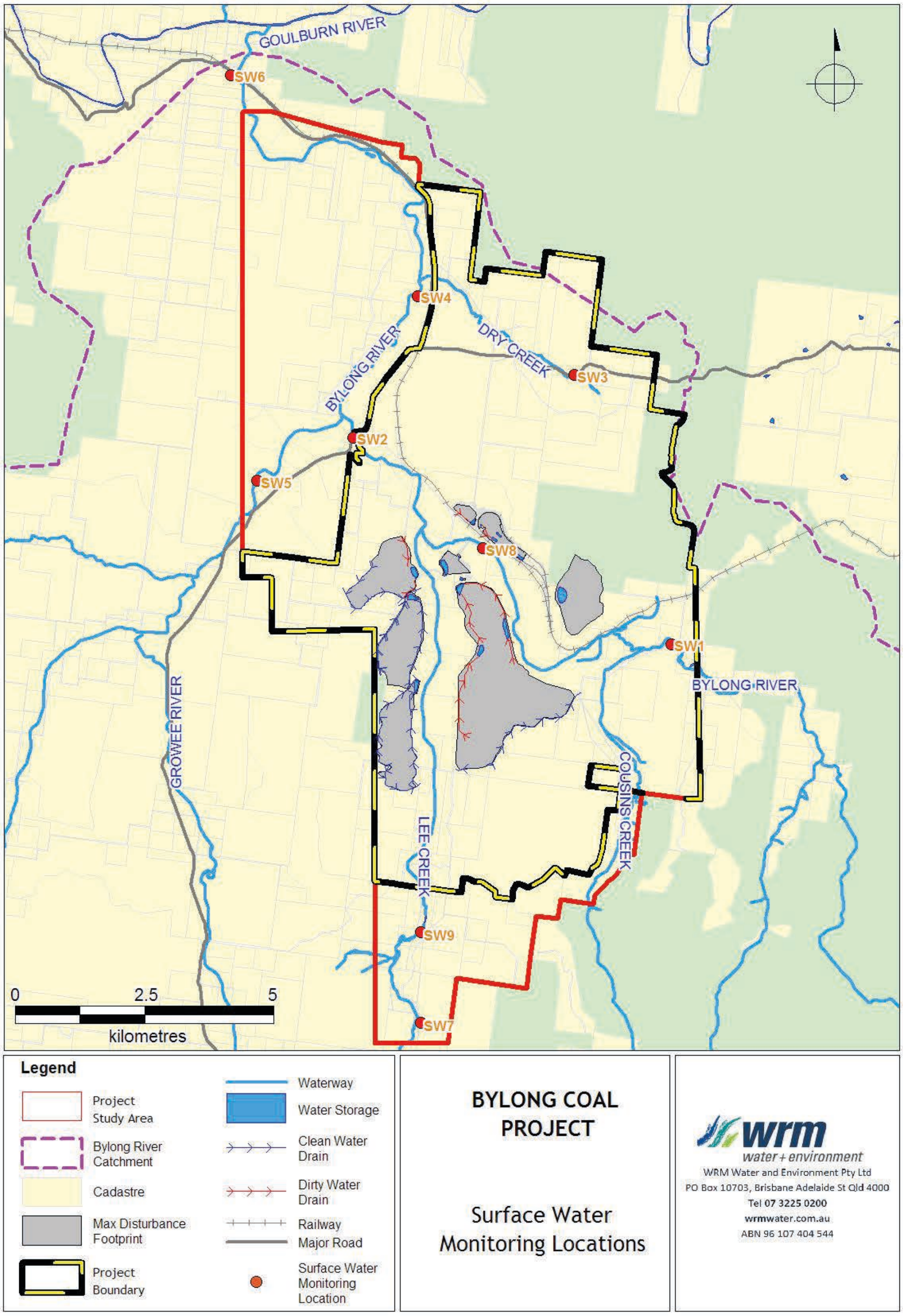


Figure 3.29 – Baseline surface water quality monitoring locations

The surface water quality in Lee Creek at SW7 and SW9 is:

- slightly alkaline, with median field and laboratory measured pH values ranging from 7.4 to 8.2;
- fresh, with field and laboratory measured EC ranging from 180 to 385 µS/cm, with a median value between 270 and 343 µS/cm;
- mostly within the acceptable turbidity range for ecosystem protection;
- total phosphorous above the ecosystem protection trigger value and above the irrigation trigger value (SW9 only);
- mostly above the ecosystem protection trigger value for ammonia;
- below the ANZECC trigger values for dissolved aluminium and chromium;
- below the livestock and irrigation trigger values and above the recreation trigger value for total aluminium;
- below the livestock, irrigation and recreational trigger values and above the ecosystem protection trigger value for total chromium;
- below the livestock, irrigation and recreational trigger values for both dissolved and total copper;
- above the ecosystem protection trigger value on a number of occasions for dissolved copper and below the ecosystem protection trigger for total copper;
- below the recreational trigger value and mostly above the irrigation trigger value for dissolved iron;
- above the trigger values for total iron;
- below the ecosystem protection trigger value and mostly above the recreational trigger value for dissolved manganese;
- above the irrigation trigger value for dissolved manganese at SW9 and below the irrigation trigger value at SW7 which is located further upstream;
- below the trigger values for total manganese;
- below the livestock, irrigation and recreational trigger values and exceeds the ecosystem trigger value on a few occasions for dissolved zinc;
- below the trigger values for total zinc; and
- below the ANZECC trigger values for calcium sodium, magnesium, sulphate, chloride and for both dissolved and total arsenic, barium, beryllium, cadmium, cobalt, lead, mercury, nickel, selenium and vanadium.

The surface water quality in Dry Creek at SW3 is:

- slightly alkaline, with median field and laboratory measured pH values ranging from 8.2 to 8.5;
- fresh to brackish, with field and laboratory measured EC ranging from 418 to 1,202 µS/cm, with a median value between 968 and 995 µS/cm;
- mostly within the acceptable turbidity range for ecosystem protection;
- above the ecosystem protection trigger value for total phosphorous and above the irrigation trigger value on a few occasions;
- below the recreational trigger value for sodium on all occasions and mostly above the irrigation trigger value;
- below the recreational and the irrigation trigger value for chloride;
- mostly below the ecosystem protection trigger value for ammonia;

- mostly below the ANZECC trigger values for dissolved aluminium, exceeding the recreation trigger value on one occasion;
- below the livestock and irrigation trigger values and above the recreation trigger value for total aluminium;
- below the trigger values for dissolved chromium;
- below the livestock, irrigation and recreational trigger values and above the ecosystem protection trigger value for total chromium;
- below the livestock, irrigation and recreational trigger values for both dissolved and total copper;
- above the ecosystem protection trigger value for total copper and on many occasions for dissolved copper;
- below the trigger values for dissolved iron, except for on one occasion, and above the trigger values for total iron;
- below the livestock, irrigation and recreational trigger values and exceeds the ecosystem trigger value on many occasions for dissolved zinc;
- below the trigger values for total zinc; and
- below the ANZECC trigger values for calcium, magnesium, sulphate and for both dissolved and total arsenic, barium, beryllium, cadmium, cobalt, lead, mercury, nickel, selenium, vanadium and manganese.

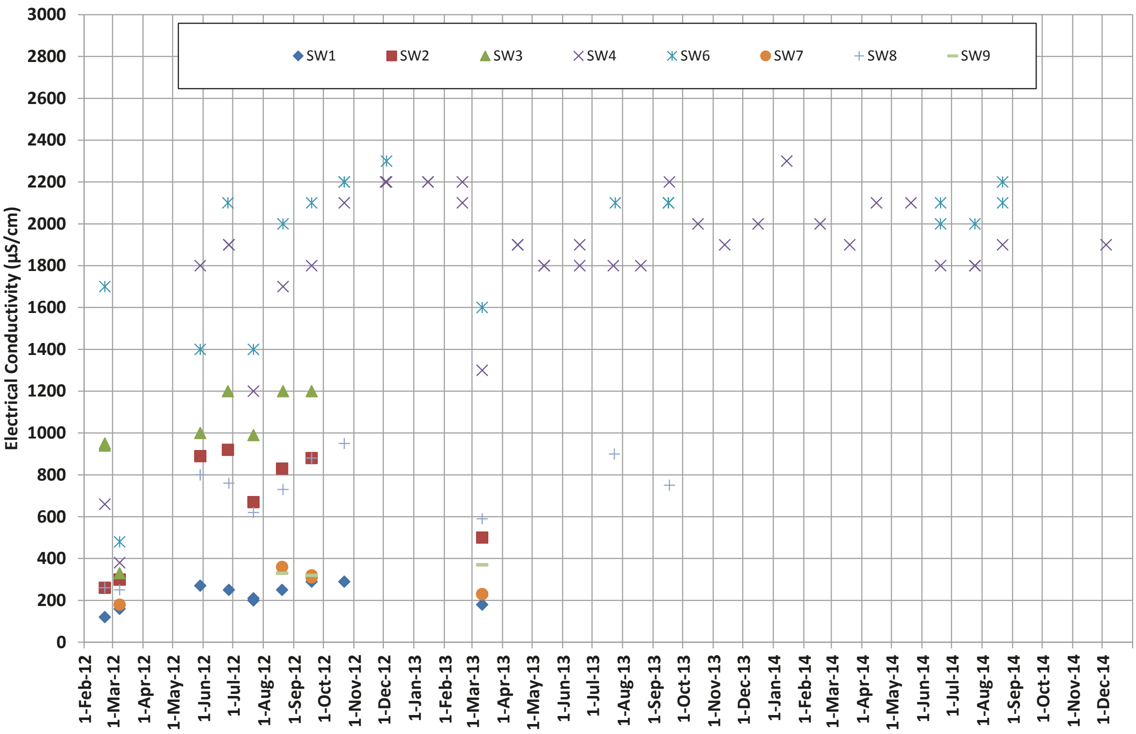


Figure 3.30 - Baseline water quality results - salinity

Table 3.8 – Surface water quality monitoring baseline data (Feb 2012 – Dec 2014)

Water Quality Parameter		Sampling Site							
		Bylong River					Lee Creek		Dry Creek
		SW1	SW2	SW4	SW6	SW8	SW7	SW9	SW3
pH (lab)	20th %ile	7.1	7.2	7.6	8.1	7.6	6.9	7.4	8
	Median	7.3	7.8	7.9	8.3	7.9	7.4	7.5	8.2
	80th %ile	7.5	8.1	8.1	8.3	8.1	7.8	7.6	8.4
	N	10	9	38	19	12	6	4	8
pH (field)	20th %ile	7.8	8.1	7.6	7.5	7.7	7.4	7.9	8.1
	Median	8	8.4	7.7	7.9	7.9	7.8	8.2	8.5
	80th %ile	8.4	8.5	8.1	8.2	8.2	8.1	8.4	8.6
	N	7	6	10	10	7	4	2	5
Electrical Conductivity (µs/cm) – (lab)	20th %ile	176	300	1,800	1,660	596	230	326	944
	Median	230	670	1,900	2,100	755	270	330	995
	80th %ile	274	884	2,100	2,140	864	320	346	1,200
	N	10	9	38	19	12	6	4	8
Electrical Conductivity (µs/cm) – (field)	20th %ile	193	476	1,197	1,328	355	240	330	905
	Median	278	760	1,715	1,794	709	276	343	968
	80th %ile	292	885	1,924	2,089	824	301	368	1,150
	N	9	8	12	10	9	4	3	7
Turbidity (NTU) – (lab)	20th %ile	2.7	2.1	2.4	4.1	2.1	1.8	3	2.3
	Median	3.7	3.5	3.6	14	2.6	2.8	4.4	12.7
	80th %ile	8.5	10.4	7.9	18	4.8	5.1	13.2	81
	N	10	9	38	19	12	6	4	8

Water Quality Parameter			Sampling Site							
			Bylong River					Lee Creek		Dry Creek
			SW1	SW2	SW4	SW6	SW8	SW7	SW9	SW3
Turbidity (NTU) – (field)		20th %ile	4.3	3.4	1	11.8	2.2	6.5	20.2	4.3
		Median	5.5	4.8	3.8	17.5	5	7.1	46.4	6.7
		80th %ile	8	6.7	5.6	20.1	5.4	7.7	72.5	9.1
		N	6	5	10	7	6	2	2	4
Dissolved Oxygen (ppm) – (field)		20th %ile	6.3	6.5	4.6	5.8	5.5	5.6	5	7.5
		Median	9	8.8	7.7	8.5	7	6.2	7.7	10.1
		80th %ile	10.8	11.3	8.7	10.8	8.9	6.4	8.1	13.4
		N	8	7	12	9	8	3	3	6
Alkalinity (mg/L)	Hydroxide (OH^-)	20th %ile	5	5	5	5	5	5	5	2.6
		Median	5	5	5	5	5	5	5	5
		80th %ile	5	5	5	5	5	5	5	5
		N	10	9	38	19	12	6	4	8
	Carbonate (CO_3^{2-})	20th %ile	5	5	5	5	5	5	5	2.6
		Median	5	5	5	11	5	5	5	9
		80th %ile	5	10.6	5	24.6	5	84	63	22
		N	10	9	38	19	12	6	4	8
	Bicarbonate (HCO_3^-)	20th %ile	36	81.2	340	326	111.2	5	68	314
		Median	67	210	360	360	240	64.5	110	350
		80th %ile	81.6	224	390	380	258	83	114	404
		N	10	9	38	19	12	6	4	8

Water Quality Parameter			Sampling Site							
			Bylong River					Lee Creek		Dry Creek
			SW1	SW2	SW4	SW6	SW8	SW7	SW9	SW3
Alkalinity (mg/L)	Total Alkalinity	20th %ile	50.8	95.4	340	350	220	68	110	314
		Median	67	210	360	370	240	83.5	115	360
		80th %ile	81.6	234	390	384	258	84	132	420
		N	10	9	38	19	12	6	4	8
Anions (mg/L)	Chloride (Cl)	20th %ile	22.4	38.2	264	298	59.2	19	21	50.2
		Median	31	78	295	360	80.5	22.5	21	115
		80th %ile	34	114	336	390	100	26	21.4	130
		N	10	9	38	19	12	6	4	8
	Ammonia (NH_3^-) as N	20th %ile	0.005	0.0072	0.005	0.005	0.0084	0.005	0.0306	0.005
		Median	0.007	0.02	0.014	0.011	0.0145	0.01	0.032	0.009
		80th %ile	0.012	0.0264	0.028	0.0294	0.0282	0.015	0.0358	0.0154
		N	10	9	38	19	12	6	4	8
	NO_x (NO_2^- + NO_3^-) as N	20th %ile	0.005	0.026	0.005	0.007	0.005	0.005	0.038	0.005
		Median	0.025	0.04	0.015	0.02	0.02	0.02	0.13	0.01
		80th %ile	0.058	0.14	0.05	0.064	0.038	0.03	0.2	9.036
		N	10	9	38	19	12	6	4	8
	Sulphate (SO_4^{2-})	20th %ile	2.8	8	204	168	6.6	5	13.8	7.4
		Median	3.5	24	240	220	11	12	15	14
		80th %ile	5	47.4	270	248	14.6	18	18.6	22
		N	10	9	38	19	12	6	4	8

Water Quality Parameter			Sampling Site							
			Bylong River					Lee Creek		Dry Creek
			SW1	SW2	SW4	SW6	SW8	SW7	SW9	SW3
Cations - Dissolved (mg/L)	Calcium	20th %ile	5.8	14	100	93.4	29.8	12	22.6	21.4
		Median	8.9	34	120	100	38	15	23	31
		80th %ile	12	49.4	126	110	42	17	25	34.2
		N	10	9	38	19	12	6	4	8
	Potassium	20th %ile	2.6	5.2	6.2	6.5	4.8	3.1	4.6	4.2
		Median	3	6.3	7.2	7.5	5.5	3.1	4.8	6.4
		80th %ile	3.2	6.6	7.8	9.7	6.5	3.2	5.9	7
		N	10	9	38	19	12	6	4	8
	Sodium	20th %ile	15.6	27	170	190	53.4	15	21.4	150
		Median	21.5	60	200	220	71.5	20.5	23.5	170
		80th %ile	26.4	79.4	220	270	94.4	25	24	180
		N	10	9	38	19	12	6	4	8
	Magnesium	20th %ile	6.9	11.6	80.8	79	23.6	11	14	20
		Median	9.1	24	93.5	98	29.5	11.5	14	33.5
		80th %ile	12	37.2	99.6	110	32.8	13	16	39.8
		N	10	9	38	19	12	6	4	8
Metals - Dissolved (mg/L)	Aluminium	20th %ile	0.003	0.0046	0.001	0.0016	0.0022	0.003	0.0074	0.0064
		Median	0.0085	0.005	0.0045	0.003	0.005	0.007	0.009	0.009
		80th %ile	0.05	0.0322	0.009	0.005	0.0092	0.007	0.0098	0.0426
		N	10	9	38	19	12	6	4	8

Water Quality Parameter			Sampling Site							
			Bylong River					Lee Creek		Dry Creek
			SW1	SW2	SW4	SW6	SW8	SW7	SW9	SW3
Metals - Dissolved (mg/L)	Arsenic	20th %ile	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		Median	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		80th %ile	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		N	10	9	38	19	12	6	4	8
	Barium	20th %ile	0.0128	0.0246	0.0808	0.097	0.025	0.027	0.0384	0.0634
		Median	0.0155	0.035	0.09	0.1	0.0335	0.038	0.0445	0.0645
		80th %ile	0.0214	0.053	0.0968	0.11	0.0386	0.045	0.0502	0.0732
		N	10	9	38	19	12	6	4	8
	Beryllium	20th %ile	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
		Median	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
		80th %ile	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
		N	10	9	38	19	12	6	4	8
	Cadmium	20th %ile	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
		Median	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
		80th %ile	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
		N	10	9	38	19	12	6	4	8
	Chromium	20th %ile	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		Median	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		80th %ile	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		N	10	9	38	19	12	6	4	8

Water Quality Parameter			Sampling Site							
			Bylong River					Lee Creek		Dry Creek
			SW1	SW2	SW4	SW6	SW8	SW7	SW9	SW3
Metals – Dissolved (mg/L)	Cobalt	20th %ile	0.001	0.001	0.001	0.001	0.001	0.001	0.0016	0.001
		Median	0.001	0.001	0.001	0.001	0.001	0.001	0.002	0.001
		80th %ile	0.001	0.001	0.001	0.001	0.001	0.001	0.0024	0.0016
		N	10	9	38	19	12	6	4	8
	Copper	20th %ile	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		Median	0.001	0.002	0.001	0.001	0.001	0.001	0.001	0.0015
		80th %ile	0.0022	0.003	0.002	0.0014	0.0028	0.002	0.0014	0.0026
		N	10	9	38	19	12	6	4	8
	Iron (Fe^{2+})	20th %ile	0.061	0.025	0.019	0.01	0.028	0.057	0.282	0.014
		Median	0.088	0.085	0.058	0.01	0.039	0.111	0.29	0.02
		80th %ile	0.21	0.186	0.13	0.017	0.062	0.24	0.294	0.03
		N	10	9	38	19	12	6	4	8
	Lead	20th %ile	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		Median	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		80th %ile	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		N	10	9	38	19	12	6	4	8
	Manganese	20th %ile	0.056	0.005	0.11	0.005	0.011	0.05	0.376	0.005
		Median	0.09	0.04	0.135	0.017	0.049	0.082	0.43	0.005
		80th %ile	0.112	0.086	0.366	0.025	0.118	0.12	0.48	0.005
		N	10	9	38	19	12	6	4	8

Water Quality Parameter			Bylong River SW1	Bylong River SW2	Bylong River SW4	Bylong River SW6	Bylong River SW8	Lee Creek SW7	Lee Creek SW9	Dry Creek SW3
Metals - Dissolved (mg/L)	Mercury	20th %ile	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
		Median	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
		80th %ile	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
		N	10	9	38	19	12	6	4	8
	Nickel	20th %ile	0.002	0.002	0.001	0.001	0.002	0.002	0.0036	0.0014
		Median	0.002	0.003	0.002	0.002	0.0025	0.002	0.004	0.002
		80th %ile	0.003	0.0044	0.002	0.002	0.003	0.003	0.0056	0.002
		N	10	9	38	19	12	6	4	8
	Selenium	20th %ile	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		Median	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		80th %ile	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
		N	10	9	38	19	12	6	4	8
	Vanadium	20th %ile	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001
		Median	0.001	0.001	0.001	0.002	0.001	0.001	0.001	0.001
		80th %ile	0.001	0.001	0.001	0.003	0.001	0.002	0.0014	0.001
		N	10	9	38	19	12	6	4	8
	Zinc	20th %ile	0.0046	0.007	0.002	0.0016	0.008	0.003	0.0038	0.0056
		Median	0.0085	0.011	0.005	0.004	0.012	0.006	0.006	0.0115
		80th %ile	0.014	0.0182	0.009	0.0098	0.0166	0.01	0.011	0.0156
		N	10	9	38	19	12	6	4	8

Water Quality Parameter			Sampling Site							
			Bylong River					Lee Creek		Dry Creek
			SW1	SW2	SW4	SW6	SW8	SW7	SW9	SW3
Metals - Total (mg/L)	Aluminium	20th %ile	1.5	0.494	1.3	0.5	0.53	1.3	-	2.8
		Median	1.5	0.515	1.3	0.5	0.53	1.3	-	2.8
		80th %ile	1.5	0.536	1.3	0.5	0.53	1.3	-	2.8
		N	1	2	1	1	1	1	0	1
	Arsenic	20th %ile	0.001	0.001	0.001	0.001	0.001	0.001	-	0.001
		Median	0.001	0.001	0.001	0.001	0.001	0.001	-	0.001
		80th %ile	0.001	0.001	0.001	0.001	0.001	0.001	-	0.001
		N	1	2	1	1	1	1	0	1
	Barium	20th %ile	0.021	0.028	0.044	0.041	0.023	0.034	-	0.064
		Median	0.021	0.028	0.044	0.041	0.023	0.034	-	0.064
		80th %ile	0.021	0.028	0.044	0.041	0.023	0.034	-	0.064
		N	1	2	1	1	1	1	0	1
	Beryllium	20th %ile	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	-	0.0002
		Median	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	-	0.0002
		80th %ile	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	-	0.0002
		N	1	2	1	1	1	1	0	1
	Cadmium	20th %ile	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	-	0.0001
		Median	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	-	0.0001
		80th %ile	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	-	0.0001
		N	1	2	1	1	1	1	0	1

<table>
<tr><th colspan="3" rowspan="3">Water Quality Parameter</th><th colspan="8">Sampling Site</th></tr>
<tr><th colspan="5">Bylong River</th><th colspan="2">Lee Creek</th><th>Dry Creek</th></tr>
<tr><th>SW1</th><th>SW2</th><th>SW4</th><th>SW6</th><th>SW8</th><th>SW7</th><th>SW9</th><th>SW3</th></tr>
<tr><td rowspan="20">Metals - Total (mg/L)</td><td rowspan="4">Chromium</td><td>20th %ile</td><td>0.004</td><td>0.002</td><td>0.003</td><td>0.002</td><td>0.002</td><td>0.003</td><td>-</td><td>0.004</td></tr>
<tr><td>Median</td><td>0.004</td><td>0.002</td><td>0.003</td><td>0.002</td><td>0.002</td><td>0.003</td><td>-</td><td>0.004</td></tr>
<tr><td>80th %ile</td><td>0.004</td><td>0.002</td><td>0.003</td><td>0.002</td><td>0.002</td><td>0.003</td><td>-</td><td>0.004</td></tr>
<tr><td>N</td><td>1</td><td>2</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td rowspan="4">Cobalt</td><td>20th %ile</td><td>0.001</td><td>0.001</td><td>0.001</td><td>0.001</td><td>0.001</td><td>0.001</td><td>-</td><td>0.001</td></tr>
<tr><td>Median</td><td>0.001</td><td>0.001</td><td>0.001</td><td>0.001</td><td>0.001</td><td>0.001</td><td>-</td><td>0.001</td></tr>
<tr><td>80th %ile</td><td>0.001</td><td>0.001</td><td>0.001</td><td>0.001</td><td>0.001</td><td>0.001</td><td>-</td><td>0.001</td></tr>
<tr><td>N</td><td>1</td><td>2</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td rowspan="4">Copper</td><td>20th %ile</td><td>0.001</td><td>0.001</td><td>0.002</td><td>0.001</td><td>0.001</td><td>0.001</td><td>-</td><td>0.003</td></tr>
<tr><td>Median</td><td>0.001</td><td>0.001</td><td>0.002</td><td>0.001</td><td>0.001</td><td>0.001</td><td>-</td><td>0.003</td></tr>
<tr><td>80th %ile</td><td>0.001</td><td>0.001</td><td>0.002</td><td>0.001</td><td>0.001</td><td>0.001</td><td>-</td><td>0.003</td></tr>
<tr><td>N</td><td>1</td><td>2</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td rowspan="4">Iron (Fe^{2+})</td><td>20th %ile</td><td>1.6</td><td>0.756</td><td>2</td><td>0.62</td><td>0.66</td><td>2</td><td>-</td><td>2.7</td></tr>
<tr><td>Median</td><td>1.6</td><td>0.765</td><td>2</td><td>0.62</td><td>0.66</td><td>2</td><td>-</td><td>2.7</td></tr>
<tr><td>80th %ile</td><td>1.6</td><td>0.774</td><td>2</td><td>0.62</td><td>0.66</td><td>2</td><td>-</td><td>2.7</td></tr>
<tr><td>N</td><td>1</td><td>2</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td rowspan="4">Lead</td><td>20th %ile</td><td>0.001</td><td>0.001</td><td>0.001</td><td>0.001</td><td>0.001</td><td>0.001</td><td>-</td><td>0.001</td></tr>
<tr><td>Median</td><td>0.001</td><td>0.001</td><td>0.001</td><td>0.001</td><td>0.001</td><td>0.001</td><td>-</td><td>0.001</td></tr>
<tr><td>80th %ile</td><td>0.001</td><td>0.001</td><td>0.001</td><td>0.001</td><td>0.001</td><td>0.001</td><td>-</td><td>0.001</td></tr>
<tr><td>N</td><td>1</td><td>2</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td></tr>
</table>

Water Quality Parameter			Sampling Site							
			Bylong River					Lee Creek		Dry Creek
			SW1	SW2	SW4	SW6	SW8	SW7	SW9	SW3
Metals - Total (mg/L)	Manganese	20th %ile	0.047	0.049	0.094	0.022	0.018	0.048	-	0.023
		Median	0.047	0.05	0.094	0.022	0.018	0.048	-	0.023
		80th %ile	0.047	0.051	0.094	0.022	0.018	0.048	-	0.023
		N	1	2	1	1	1	1	0	1
	Mercury	20th %ile	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	-	0.0001
		Median	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	-	0.0001
		80th %ile	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001	-	0.0001
		N	1	2	1	1	1	1	0	1
	Nickel	20th %ile	0.006	0.005	0.006	0.004	0.004	0.006	-	0.008
		Median	0.006	0.005	0.006	0.004	0.004	0.006	-	0.008
		80th %ile	0.006	0.005	0.006	0.004	0.004	0.006	-	0.008
		N	1	2	1	1	1	1	0	1
	Selenium	20th %ile	0.001	0.001	0.001	0.001	0.001	0.001	-	0.001
		Median	0.001	0.001	0.001	0.001	0.001	0.001	-	0.001
		80th %ile	0.001	0.001	0.001	0.001	0.001	0.001	-	0.001
		N	1	2	1	1	1	1	0	1
	Vanadium	20th %ile	0.003	0.002	0.004	0.002	0.002	0.003	-	0.005
		Median	0.003	0.002	0.004	0.002	0.002	0.003	-	0.005
		80th %ile	0.003	0.002	0.004	0.002	0.002	0.003	-	0.005
		N	1	2	1	1	1	1	0	1

<table>
<tr><th colspan="3" rowspan="3">Water Quality Parameter</th><th colspan="8">Sampling Site</th></tr>
<tr><th colspan="5">Bylong River</th><th colspan="2">Lee Creek</th><th>Dry Creek</th></tr>
<tr><th>SW1</th><th>SW2</th><th>SW4</th><th>SW6</th><th>SW8</th><th>SW7</th><th>SW9</th><th>SW3</th></tr>
<tr><td rowspan="4">Metals - Total (mg/L)</td><td rowspan="4">Zinc</td><td>20th %ile</td><td>0.005</td><td>0.002</td><td>0.006</td><td>0.002</td><td>0.001</td><td>0.003</td><td>-</td><td>0.004</td></tr>
<tr><td>Median</td><td>0.005</td><td>0.002</td><td>0.006</td><td>0.002</td><td>0.001</td><td>0.003</td><td>-</td><td>0.004</td></tr>
<tr><td>80th %ile</td><td>0.005</td><td>0.002</td><td>0.006</td><td>0.002</td><td>0.001</td><td>0.003</td><td>-</td><td>0.004</td></tr>
<tr><td>N</td><td>1</td><td>2</td><td>1</td><td>1</td><td>1</td><td>1</td><td>0</td><td>1</td></tr>
<tr><td colspan="2" rowspan="4">Total Phosphorus</td><td>20th %ile</td><td>0.05</td><td>0.05</td><td>0.05</td><td>0.05</td><td>0.05</td><td>0.05</td><td>0.1</td><td>0.05</td></tr>
<tr><td>Median</td><td>0.05</td><td>0.09</td><td>0.05</td><td>0.05</td><td>0.06</td><td>0.05</td><td>0.1</td><td>0.05</td></tr>
<tr><td>80th %ile</td><td>0.05</td><td>0.1</td><td>0.09</td><td>0.05</td><td>0.098</td><td>0.05</td><td>0.1</td><td>0.074</td></tr>
<tr><td>N</td><td>10</td><td>9</td><td>38</td><td>19</td><td>12</td><td>6</td><td>4</td><td>8</td></tr>
</table>

4 Proposed Water Management Strategy and Infrastructure

4.1 TYPES OF WATER GENERATED ON SITE

Land disturbance associated with mining has the potential to adversely affect the quality of surface runoff in downstream receiving waters through increased sediment loads. In addition, runoff from active mining areas (including coal stockpiles, etc.) may have increased concentrations of salts and other pollutants when compared to natural runoff. The proposed strategy for the management of surface water at the Project is based on the separation of water from different sources based on anticipated water quality.

The surface water generated within the Project Boundary is categorised into four types, based on water quality:

- 'mine affected' – water that has generally come in contact with coal such as captured groundwater inflows and surface runoff from the open cut mining area or the ROM coal stockpile. This water may contain high concentrations of salts and other pollutants;
- 'dirty' – surface runoff water from areas that are disturbed by mining operations (including out-of-pit overburden and haul roads). This runoff does not come into contact with coal or other carbonaceous material and may contain high sediment loads, but does not contain contaminated material or high salt concentrations. This runoff must be managed to ensure adequate sediment removal prior to release to receiving watercourses;
- 'clean' – surface runoff from areas unaffected by mining operations. Clean water includes runoff from undisturbed areas and any fully rehabilitated areas; and
- 'contaminated' – surface water from areas potentially containing chemicals of various types used in the mining operations. There are restrictions on the use and release of this water. Contaminated water areas include sumps, service bays and fuel storage areas. Rainfall and resulting runoff from these areas is also potentially contaminated and therefore must be managed to avoid discharge of potentially contaminated water into the natural watercourses. This type of surface water runoff is typically treated prior to being reused in the water management system or pumped out by licensed waste contractors.

4.2 WATER MANAGEMENT STRATEGY OVERVIEW

The proposed water management strategy for the Project is based on diverting clean water around mining disturbance areas and retaining other types of water on site for recycling and reuse.

Surface water runoff from undisturbed areas will be diverted, wherever possible, around areas disturbed by mining and released from the site, minimising the capture of clean surface runoff. Seepage, groundwater and surface runoff inflows to the open cut mining areas will be collected in onsite storages and used preferentially to satisfy mine site water demands. Surface runoff from overburden emplacement areas is likely to have high concentrations of suspended sediment and will be captured in sediment dams to improve water quality prior to reuse in the mine water system, potentially released from the site if the water quality is suitable, or overflows when rainfall exceeds the design capacity of the sediment dams. Further details of the mine site water management strategy are provided in Section 5.

4.3 PROPOSED WATER MANAGEMENT INFRASTRUCTURE

Figure 4.1 to Figure 4.4 show indicative locations of the key features of the mine, including infrastructure related to the management of water on the Project site for four different phases of mining (Years 3, 5, 7 and 9). The main components of water-related infrastructure include:

- sediment dams to collect and treat runoff from overburden emplacement areas;
- dirty water drains to divert sediment-laden runoff from overburden emplacement areas to sediment dams;
- clean water drains to divert runoff from undisturbed catchments around areas disturbed by mining; and
- a mine-affected water system to store water pumped out of the open cut mining areas and to collect runoff from the CHPP and coal stockpile area.

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

4.4 KEY MINE WATER MANAGEMENT OBJECTIVES

The general principles to manage surface water for the Project are as follows:

- maximise the diversion of clean water flows around the mining operations;
- minimise the volume of raw water required from external sources by maximising the recycling of mine affected water;
- achieve and maintain regulatory compliance;
- avoid the discharge of mine-affected water from the site;
- ensure safe and efficient dewatering of the underground mining operations;
- manage sediment affected water (not mine affected) within an Erosion and Sediment Control Plan; and
- seek to protect the environmental values of receiving waters.

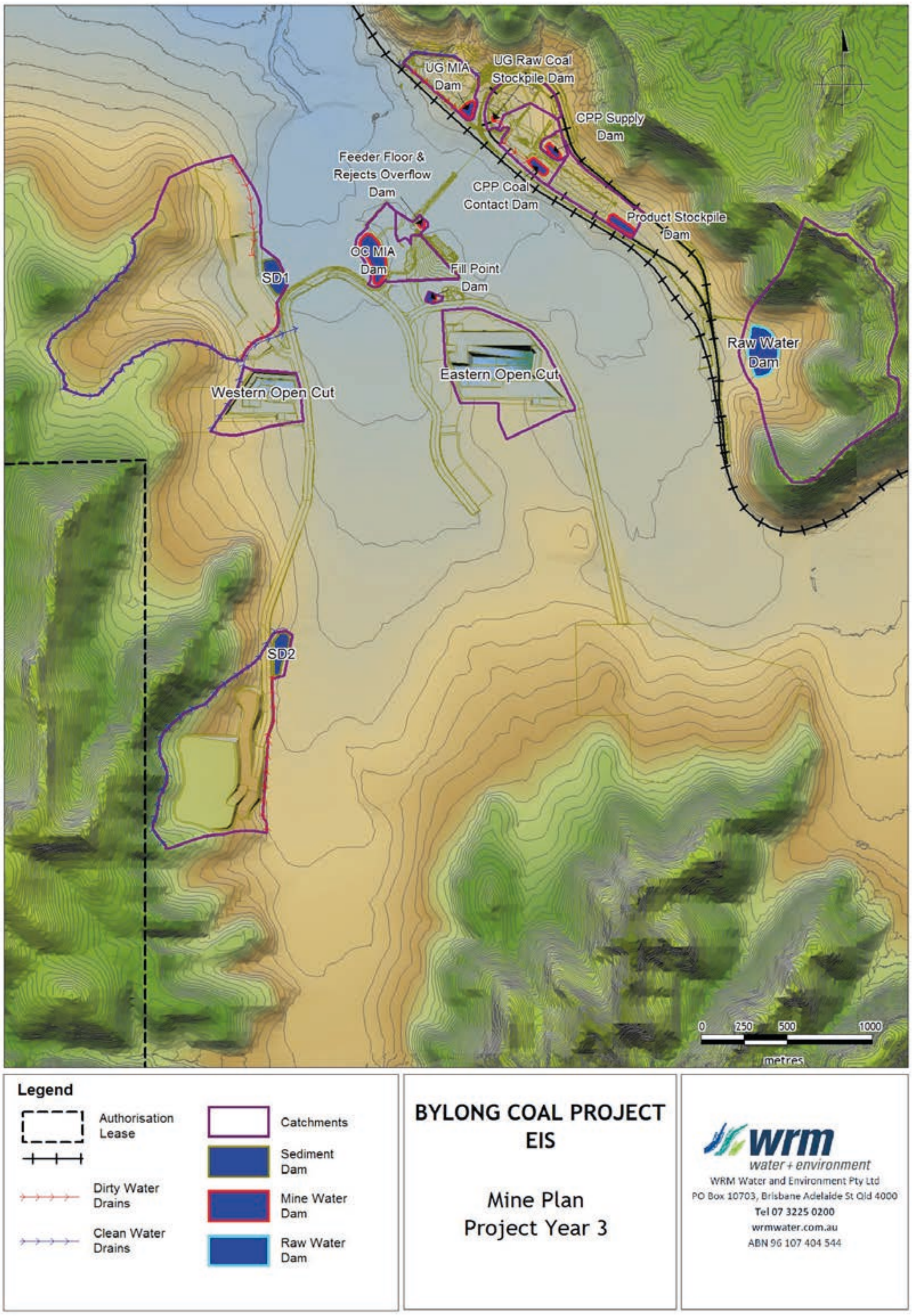


Figure 4.1 - Project Year 3 mine plan

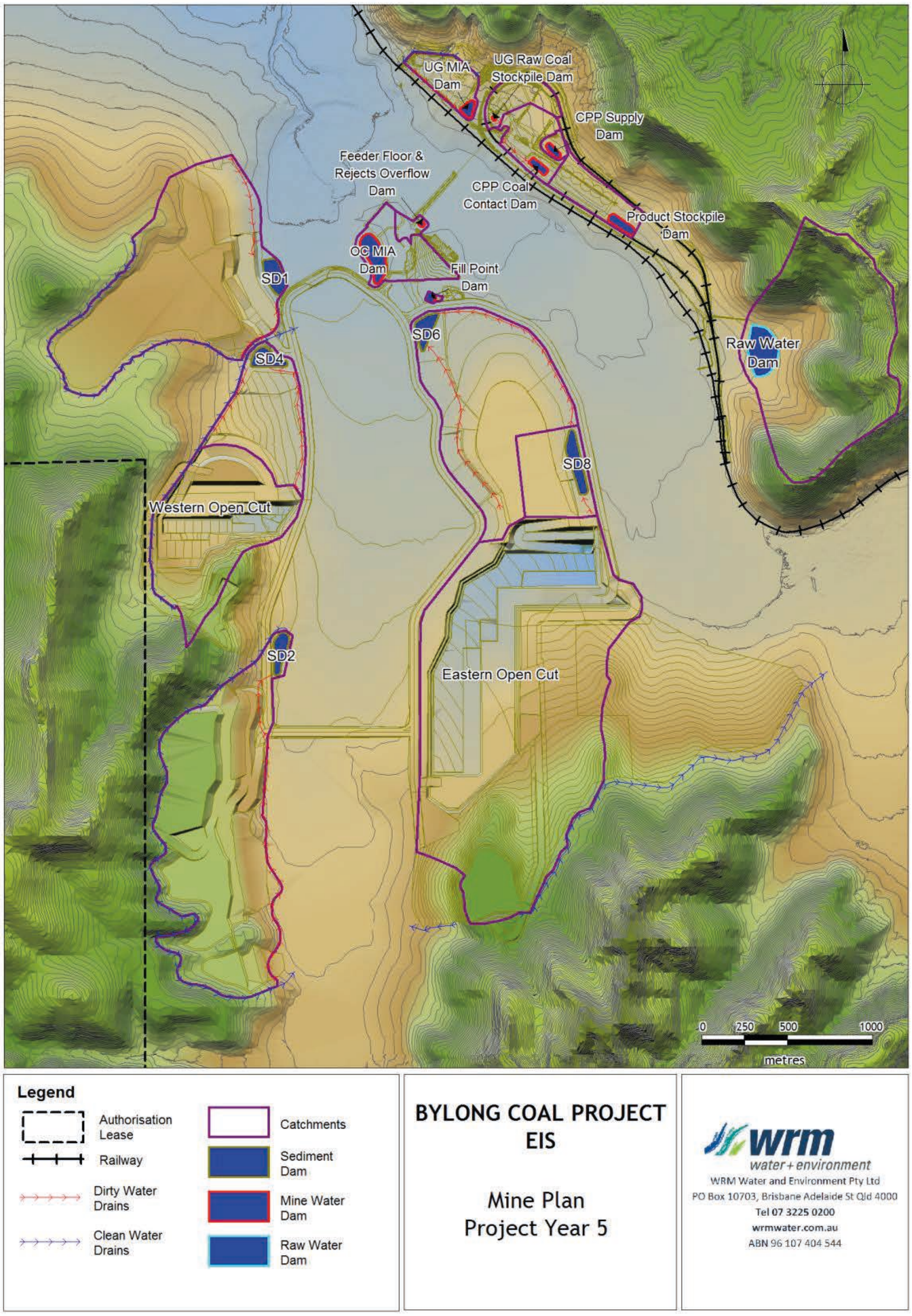
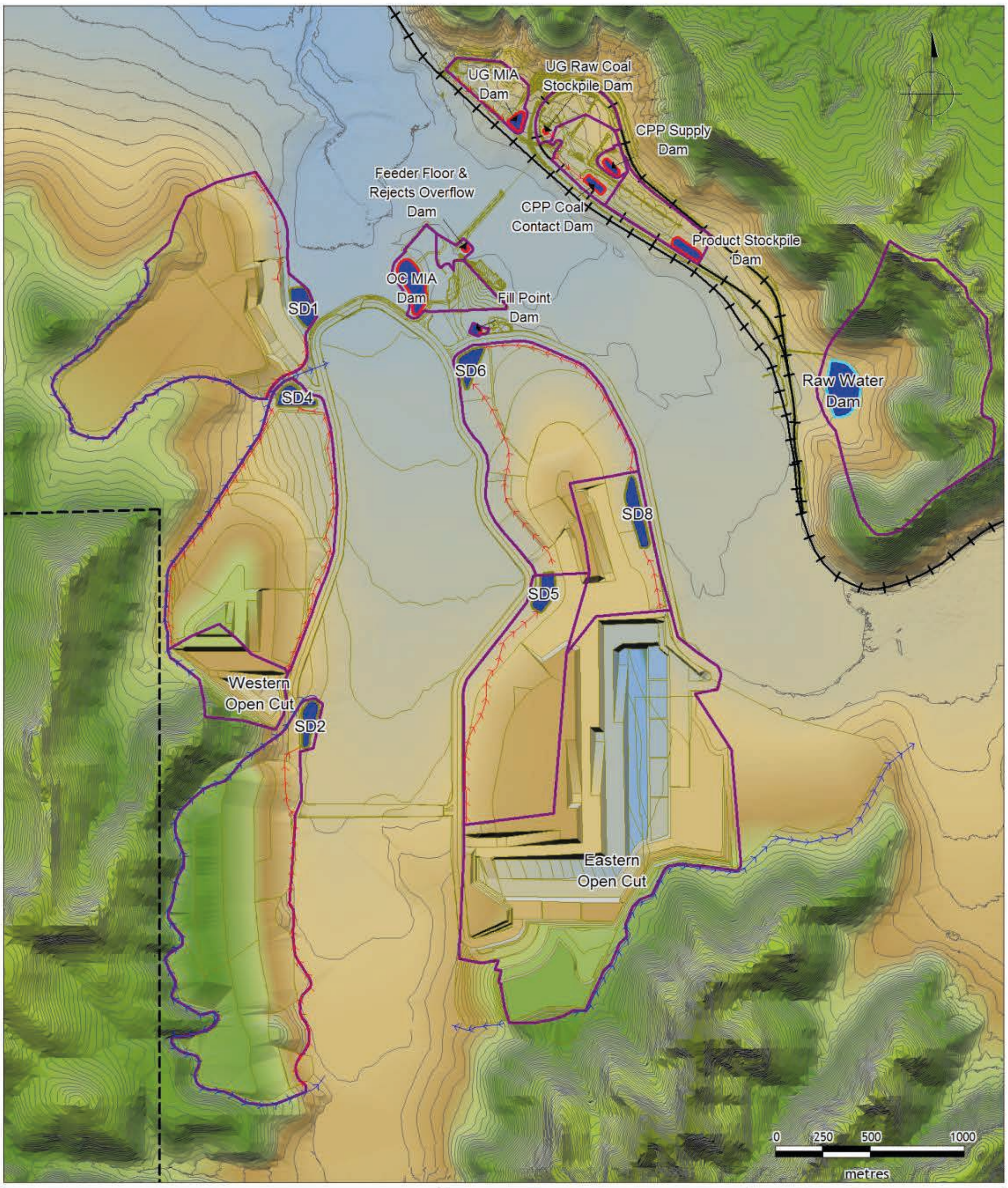


Figure 4.2 - Project Year 5 mine plan



Legend

- Authorisation Lease
- Railway
- Dirty Water Drains
- Clean Water Drains
- Catchments
- Sediment Dam
- Mine Water Dam
- Raw Water Dam

BYLONG COAL PROJECT EIS

Mine Plan
Project Year 7

wrm
water+environment
WRM Water and Environment Pty Ltd
PO Box 10703, Brisbane Adelaide St Qld 4000
Tel 07 3225 0200
wrmwater.com.au
ABN 96 107 404 544

Figure 4.3 - Project Year 7 mine plan

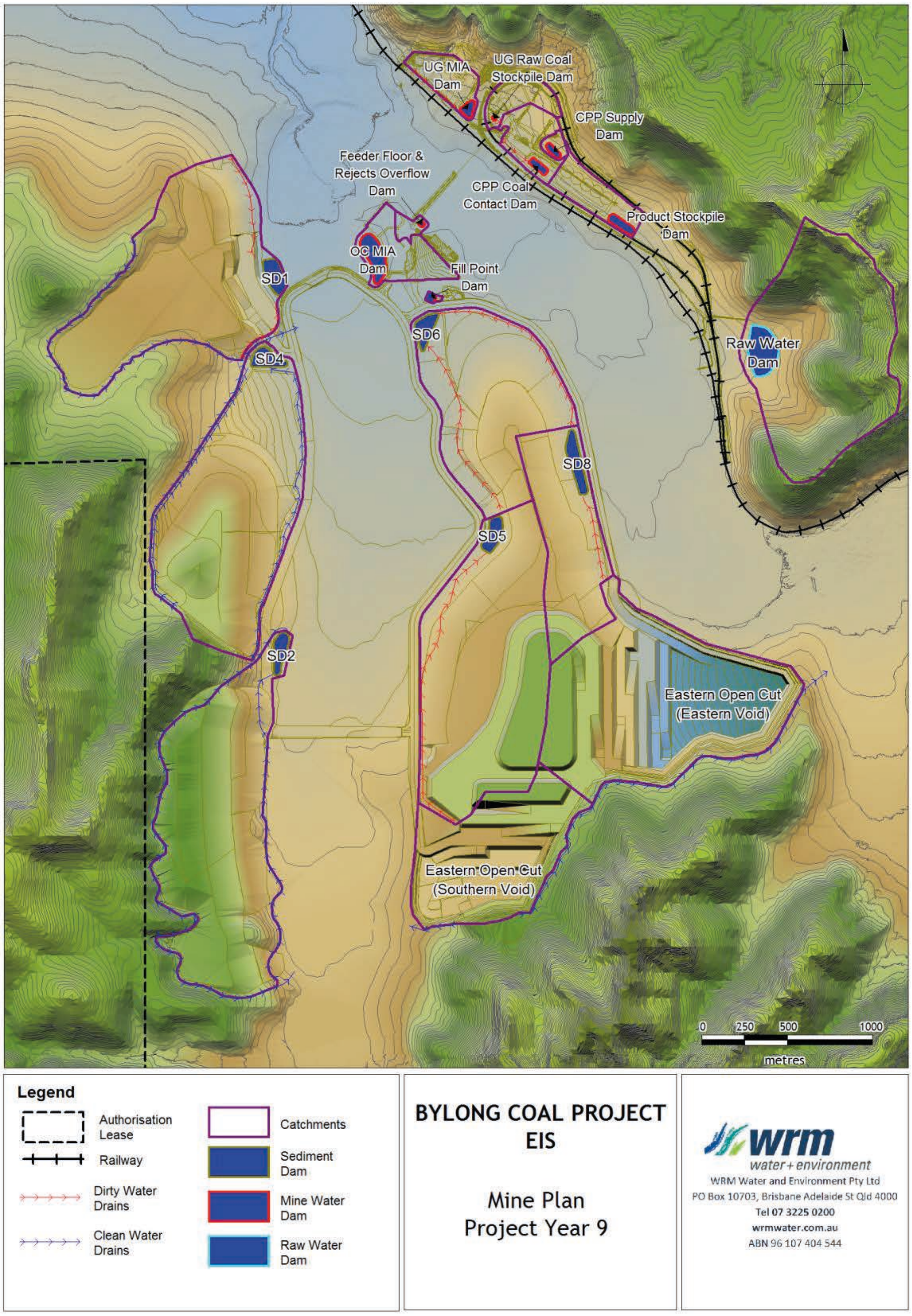


Figure 4.4 - Project Year 9 mine plan

5 Mine Water Balance Model Configuration

5.1 OVERVIEW

A computer-based operational simulation model (OPSIM) was used to assess the dynamics of the mine water balance under conditions of varying rainfall and catchment conditions throughout the development of the Project. The OPSIM model dynamically simulates the operation of the water management system and keeps complete account of all site water volumes and representative water quality on a daily time step.

The model has been configured to simulate the operations of all major components of the water management system. The simulated inflows and outflows included in the model are given in Table 5.1.

Table 5.1 – Simulated inflows and outflows to the mine water management system

Inflows	Outflows
Direct rainfall on water surface of storages	Evaporation from water surface of storages
Catchment runoff	CHPP demand
Groundwater inflows to open cut pit/underground operations	Dust suppression demand
Raw (bore) water supply	Underground water supply
	Mine infrastructure area demand
	Off-site spills from storages

5.2 CONCEPTUAL WATER MANAGEMENT SYSTEM CONFIGURATION AND SCHEMATIC

A conceptual water management system layout for the Project has been developed based on the water management principles described in Section 4, and is presented in Figure 4.1 to Figure 4.4. Note that the Year 9 configuration as shown in Figure 4.4 represents conditions in the final years of open cut mining and has been assumed to represent conditions post-open cut mining. However all overburden emplacement areas draining to sediment dams are assumed to be fully rehabilitated and runoff from these areas is assumed to be suitable for release to the downstream environment.

The Eastern Void within the Eastern open cut mining area and its associated catchment will remain at the completion of open cut mining for the emplacement of coarse and fine rejects materials by the underground operations from the CHPP.

The water management system includes indicative locations of proposed water management infrastructure, including clean and dirty water drains. Proposed water storages include:

- a raw water dam;
- mine water dams; and
- sediment dams.

The proposed period of operation for each water storage is presented in Figure 5.1. A schematised plan for the modelled Project's water management system configuration is shown in Figure 5.2 and operating rules are provided in Table 5.2.

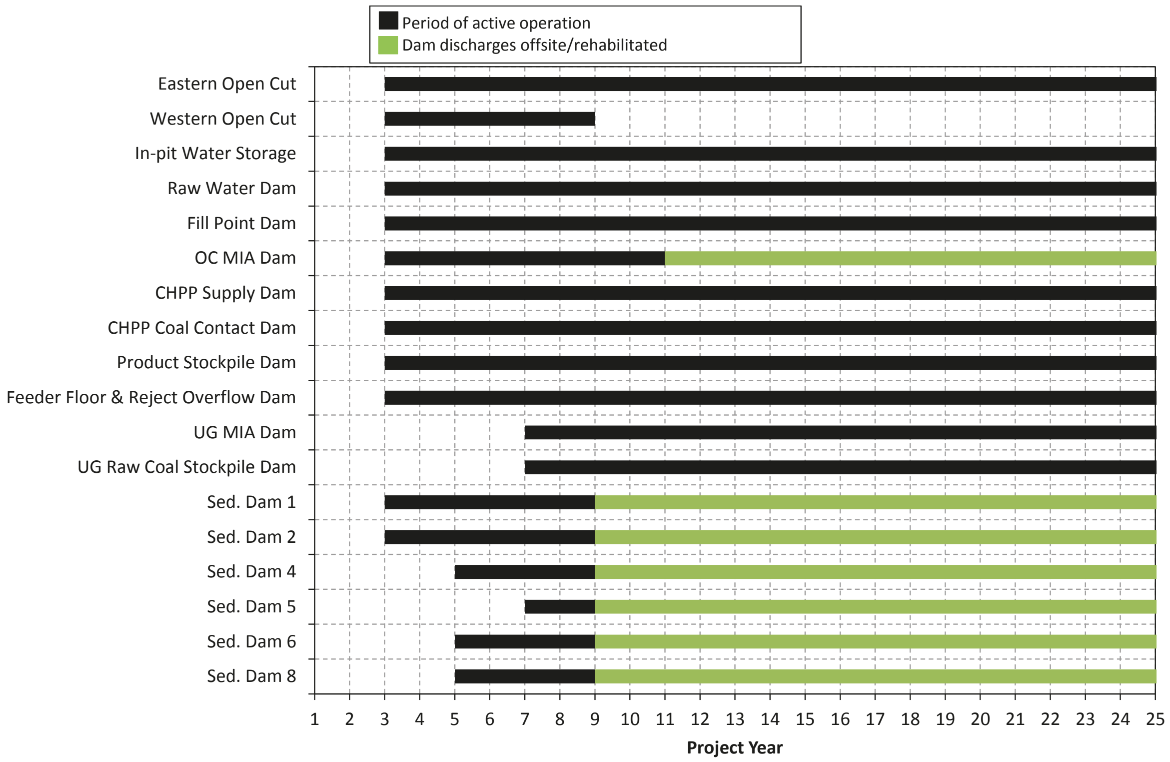


Figure 5.1 -Project storages periods of operation

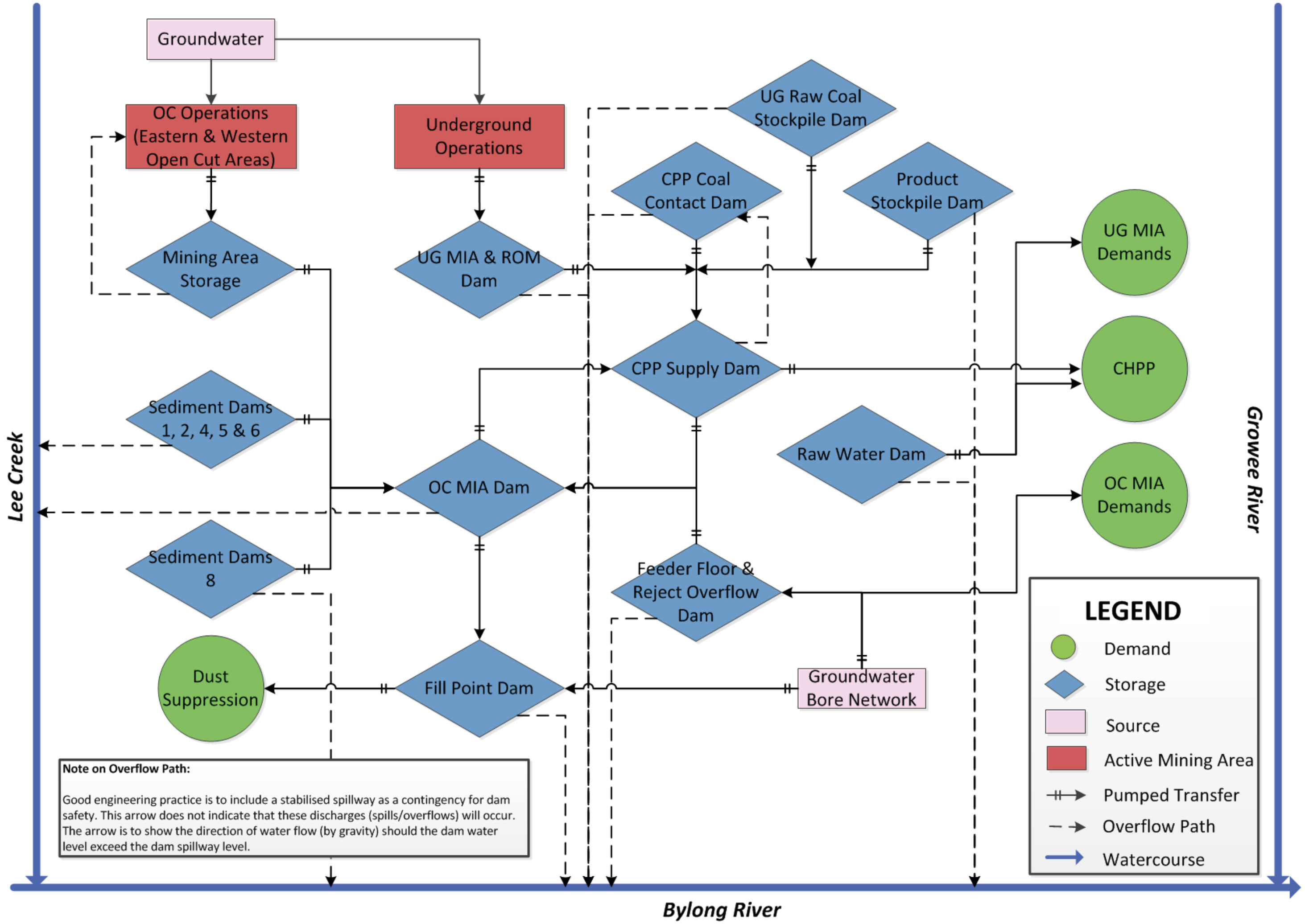


Figure 5.2 - Water management system schematic

Table 5.2 – Project water management system operating rules

Item	Name	Operating Rules
1	**External water supply**	
1.1	Groundwater bores network	• Primary supply to OC Mine Industrial Area • Secondary supply to Fill Point Dam • Supplies to Feeder Floor & Reject Overflow Dam to maintain operating levels
2	**Water demands**	
2.1	CHPP	• Receives supply from CHPP Supply Dam (100 L/s) • Secondary supply from Raw Water Dam (100 L/s) and Groundwater Bore Network (via Feeder Floor & Reject Overflow Dam) (100 L/s)
2.2	Haul road dust suppression	• Receives primary supply from Fill Point Dam (140 L/s) • Secondary supply from Groundwater Bore Network
2.3	Underground mine area infrastructure	• Supply from Raw Water Dam
2.3	Open cut mine area infrastructure	• Supply from Groundwater Bore Network
3	**Active mining areas**	
3.1	Open cut mining areas (Eastern & Western open cut mining areas)	• Continuous dewatering to Mine Water Storage within Mining Areas (200 L/s total) • Receives groundwater inflows
3.2	Underground mine	• Continuous dewatering to UG MIA Dam (200 L/s total) • Receives groundwater inflows
4	**Water Storages**	
4.1	Water Storage within Mining Areas	• Primary mine water storage for the Project. • Dedicated section of Eastern Mining Area void which is used to store excess mine water • Supplies water to OC MIA Dam to meet demands (200 L/s) • Receives dewatering from mining areas (open cut and underground)
4.2	Raw Water Dam	• Receives runoff from local catchment • Supplementary water source for CHPP (100 L/s) • Supplementary water source for haul road dust suppression, CHPP demands and mine infrastructure demands including underground operations • Overflows to Bylong River

Item	Name	Operating Rules
4.3	CHPP Supply Dam	• Receives runoff from a small local catchment • Supplies water to CHPP, haul road dust suppression and mine infrastructure demands including underground operations • Transfers back to the OC MIA Dam to prevent uncontrolled discharges • Receives pumped transfers from the following storages: ○ OC MIA Dam (100 L/s) ○ UG MIA Dam (100 L/s) ○ Product Stockpile Dam (100 L/s) ○ UG Raw Coal Stockpile Dam (100 L/s) ○ CHPP Coal Contact Dam (100 L/s) • Overflows to CHPP Coal Contact Dam
4.4	OC MIA Dam	• Receives runoff from open cut mine infrastructure areas • Receives transfers from the following storages: ○ CHPP Supply Dam (100 L/s) ○ Water Storage within Mining Areas (200 L/s) • Transfers back to In-pit Water Storage when high alarm level is reached (80%), to prevent uncontrolled spills • Supplies water to the CHPP Supply Dam to maintain operating levels • Receives pumped transfers from sediment dams as required • Overflows to Lee Creek
4.5	UG MIA Dam	• Receives runoff from the underground mine infrastructure areas • Transfers back to CHPP Supply Dam, to prevent uncontrolled spills • Overflows to Bylong River
4.6	Raw Coal Dam	• Receives runoff from the ROM stockpile pad • Transfers back to CPP Supply Dam, to prevent uncontrolled spills • Overflows to Bylong River
4.7	CHPP Coal Contact Dam	• Receives runoff from CHPP infrastructure area • Transfers to CHPP Supply Dam to prevent uncontrolled spills • Overflows to the Bylong River

Item	Name	Operating Rules
4.8	Product Stockpile Dam	• Receives runoff from product stockpile area • Transfers back to CHPP Supply Dam to prevent uncontrolled spills • Overflows to Bylong River
4.9	Sediment Dams 1, 2, 4, 5 & 6	• Dewatered to OC MIA Dam following rainfall events • Overflows to Lee Creek
4.9	Sediment Dams 1, 2, 4, 5 & 6	• Dewatered to OC MIA Dam following rainfall events • Overflows to Bylong Creek
5	**Receiving Waters**	
5.1	Bylong River	• Receives storage overflows from UG MIA Dam, UG Raw Coal Contact Dam, Product Stockpile Dam, Fill Point Dam and Sediment Dam 8
5.2	Lee Creek	• Receives storage overflows from OC MIA Dam and Sediment Dams 1, 2, 4, 5 & 6
6	**General**	
6.1	Climate	• All storages and pits receive direct rainfall, local catchment runoff and lose water through evaporation

5.3 SIMULATION METHODOLOGY

5.3.1 Modelled staging of mine plans

Mine plans for the Project have been provided for a number of representative years. The operational rules and physical layout for each representative year of mine progression are applied to a range of years as shown in Table 5.3. Open cut mining will be undertaken from approximately end of Year 2 to Year 10 of the 25 year mine life, with underground mining undertaken from approximately Year 7 to Year 25.

Construction activities are proposed during Year 1 and Year 2 and these two years have not been included in the water balance modelling assessment.

Table 5.3 – Application of representative mine stage to full mine life

Project Modelling Phase	Applied Range of Mine Life
PY3	Year 3 – Year 4
PY5	Year 5 – Year 6
PY7	Year 7 – Year 8
PY9	Year 9 – Year 10
Post-open cut mining	Year 11 – Year 25

5.3.2 Simulation methodology

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

The static water balance results are based on a long-term simulation (125 Years) with the model configuration fixed to a particular phase of mine development. These results provide an indication of the relative magnitude of inflows and outflows at that particular phase of mining.

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

The forecast water balance model has been run on a daily timestep for a 23 year period, corresponding to the period of proposed mining operation for the Project. The model was run for multiple climate sequences, each referred to as a "realisation". Each realisation is based on a 23 year sequence extracted from the historical rainfall data. The first of 102 realisations is based on rainfall data from 1889 to 1911. The second is based on data from 1890 to 1912, and so on. This approach provides the widest possible range of climate scenarios covering the full range of climatic conditions represented in the historical rainfall record.

The model configuration changes over the 23 year Project life, reflecting changes in the water management system over time. The different stages of the mine life are linked in the model to reflect variations over time such as catchments, ROM coal production and groundwater inflows. Four different representative stages of mine life were modelled (Years 3, 5, 7 and 9). Although the catchment areas will continuously change as the Project progresses, the adopted approach of modelling discrete stages will provide a reasonable representation of conditions over the 23 year period.

The changes in the physical layout and site catchment areas are shown in the mine stage plans provided in Figure 4.1 to Figure 4.4. The operational rules at each modelled stage are summarised in Table 5.2.

5.4 WATER DEMANDS

A summary of the water demands for the Project is provided below.

5.4.1 Coal Handling & Preparation Plant

The annual average water usage for the CHPP will vary over the mine life, as shown in Table 5.4 and Figure 5.3. CHPP water demand is assumed to be a net loss from the mine water balance.

Table 5.4 – Adopted CHPP water demands

Project Year	CHPP Water Usage (ML/a)	Representative Mine Phase	Average CHPP Water Usage (ML/a)
PY3	284	PY3	249
PY4	214		
PY5	264	PY5	266
PY6	269		
PY7	307	PY7	269
PY8	230		
PY9	377	PY9	395
PY10	414		
PY11	404	Post Open Cut	366
PY12	432		
PY13	424		
PY14	321		
PY15	344		
PY16	286		
PY17	266		
PY18	427		
PY19	360		
PY20	367		
PY21	359		
PY22	373		
PY23	384		
PY24	332		
PY25	406		

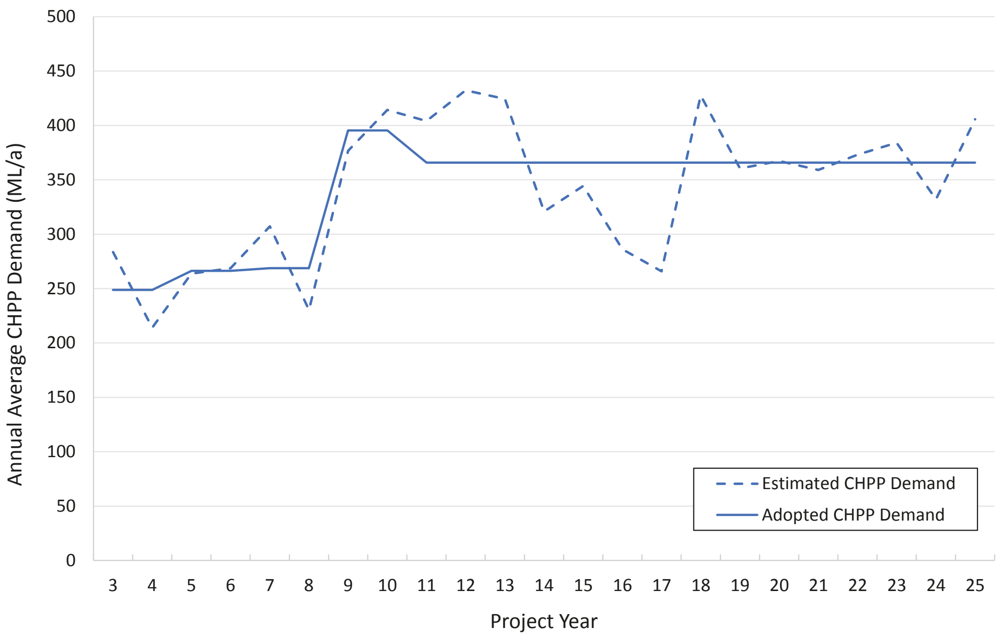


Figure 5.3 - Adopted average CHPP demands

5.4.2 Haul road dust suppression

The estimated daily average dust suppression demand for the open cut operations is predicted to be 2.85 ML/d (1,041 ML/yr). This includes dust suppression on haul roads, dumps, stockpiles and mine facility and hardstand areas (PB, 2014).

The dust suppression demand will reduce once open cut operations cease. The adopted daily average dust-suppression demand during underground operations is 1.37 ML/d (500 ML/yr).

5.4.3 Underground Operations

The total daily underground operations demand for the Project has been estimated at 500 ML/a at full underground production. This demand only applies from PY9 onwards, however a demand of 50 ML/a has been applied during the ramp-up phase (PY7 – PY8)

5.4.4 Mine Infrastructure and Workforce Accommodation Facility

Estimates of open cut mine infrastructure area demand (administration buildings, bathhouse and workshops) vary as follows:

- construction and ramp-up – 5.2 ML/a (PY3)
- steady state operations – 6.5 ML/a (PY5 –PY7)
- open cut wind-down – 1.6 ML/a (PY9)

Estimates of underground mine infrastructure area demands vary as follows:

- construction and ramp-up – 5.2 ML/a (PY9)
- steady state operations – 6.5 ML/a (Post-open cut)

WAF demand has been estimated at 60 kL/day or 21.9 ML/a, applied up until PY 6.

5.4.5 Demand Summary

A summary of the Project demands is presented in Table 5.5.

Table 5.5 – Site water demand summary

Project Modelling Phase	Dust Suppression (ML/a)	CHPP Net Demand (ML/a)	Underground Operations (ML/a)	MIA Demand (OC & UG) (ML/a)	MIA & WAF (ML/a)	Total Site Demand (ML/a)
PY3	1,041	249	-	5.2	21.9	**1,317**
PY5	1,041	266	-	6.5	21.9	**1,335**
PY7	1,041	269	50	11.7	-	**1,372**
PY9	1,041	395	500	6.8	-	**1,943**
Post-open cut	500	366	500	6.5	-	**1,373**

5.5 WATER SOURCES

5.5.1 Open cut and underground mining area groundwater inflows

Groundwater inflows to the open cut and underground mining areas over the life of the Project were adopted based on estimates provided by AGE (2015). The estimates for the open cut pits have been corrected for evaporation from pit walls by AGE.

The adopted groundwater inflow rates for water balance modelling are the average for each representative phase, as shown in Table 5.6, Table 5.7, Table 5.8 and Figure 5.4.

Table 5.6 – Adopted groundwater inflows – Eastern OC Area

Project Year	Total groundwater intercepted (ML/a)	Representative mine phase (ML/a)	Avg. groundwater intercepted for each representative mine phase (ML/a)
PY3	69.4	PY3	94.8
PY4	120.2		
PY5	94.7	PY5	136.5
PY6	178.2		
PY7	200.4	PY7	216.3
PY8	232.3		
PY9	276.0	PY9	245.2
PY10	214.4		
PY11	52.8	PY 11+	47.2
PY12	41.6		
PY13	34.0		
PY14	28.1		
PY15	23.4		
PY16	19.3		
PY17	15.7		
PY18	12.4		
PY19	9.7		
PY20	7.3		
PY21	5.3		
PY22	3.6		
PY23	2.3		
PY24	1.4		
PY25	0.8		

Table 5.7 – Adopted groundwater inflows – Western OC Area

Project Year	Total groundwater intercepted (ML/a)	Representative mine phase (ML/a)	Avg. groundwater intercepted for each representative mine phase (ML/a)
PY3	0.0	PY3	33.0
PY4	65.9		
PY5	39.8	PY5	28.6
PY6	17.4		
PY7	2.1	PY7	1.1
PY8	0.1		
PY9	0.0	PY9	-
PY10	0.0		

Table 5.8 – Adopted groundwater inflows – underground

Project Year	Total groundwater intercepted (ML/a)	Representative mine phase (ML/a)	Avg. groundwater intercepted for each representative mine phase (ML/a)
PY3	0.0	PY3	1.3
PY4	2.6		
PY5	7.2	PY5	8.6
PY6	10.0		
PY7	12.7	PY7	13.3
PY8	13.9		
PY9	1,130	PY9	1,148
PY10	1,167		
PY11	1,140	Post open-cut mining	1,125
PY12	1,077		
PY13	983		
PY14	927		
PY15	970		
PY16	845		
PY17	682		
PY18	1,465		
PY19	1,345		
PY20	1,358		
PY21	1,204		
PY22	1,109		
PY23	1,437		
PY24	932		
PY25	1,404		

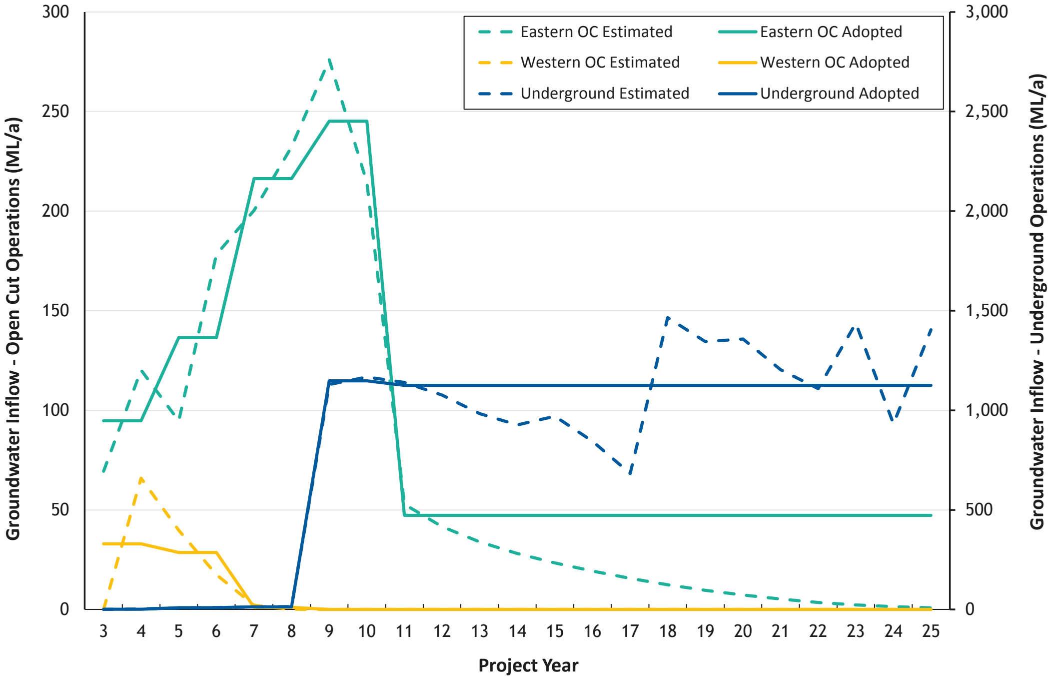


Figure 5.4 - Adopted groundwater inflows

5.5.2 Groundwater Bores

KEPCO has licences to extract approximately 2,535 units from the Bylong River water source as managed under the HUAWSP. This water will be used to meet site water demands in excess of what is captured and stored on site.

5.6 SIMULATION OF RAINFALL RUNOFF

5.6.1 Catchment Yield Parameters

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

The AWBM uses a group of connected conceptual storages (three surface water storages and one groundwater storage) to represent a catchment. Water in the conceptual storages is replenished by rainfall and is reduced by evaporation. Simulated surface runoff occurs when the storages fill and overflow. The model uses daily rainfalls and estimates of catchment evapotranspiration to calculate daily values of runoff using a daily water balance of soil moisture. The model has a baseflow component which simulates the recharge and discharge of a shallow subsurface store. Runoff depth calculated by the AWBM model is converted into runoff volume by multiplying the contributing catchment area.

The model parameters define the storage depths (C1, C2 and C3), the proportion of the catchment draining to each of the storages (A1, A2 and A3), and the rate of flux between them (Kb, Ks and BFI) (Boughton & Chiew, 2003). Catchments across the site have been characterised into the following land use types:

- natural/undisturbed;
- roads/hardstand;

- spoil;
- mining areas;
- rehabilitated spoil; and
- stockpile.

The AWBM model parameters are shown in Table 5.9. The natural/undisturbed catchment parameters were calibrated to recorded rainfall and runoff data for Moolarben Creek (WRM, 2013). Using the adopted model parameters with Bylong rainfall, the calculated average volumetric runoff coefficient was 4%. This is within the range of the observed volumetric runoff coefficients for the adjoining Wollar Creek and Widden Brook catchments (2% and 10% respectively – see Section 3.6).

Model parameters for mining area, hardstand and stockpile catchments were adopted based on previous experience with OPSIM modelling on these types of catchments. Model parameters for spoil catchments were adopted from a previous study of runoff from disturbed mine catchments in the Hunter Valley region (ACARP, 2001).

Natural/undisturbed catchment AWBM parameters were adopted for rehabilitated spoil catchments. Table 5.9 also shows the long term volumetric runoff coefficient for each of the parameter sets.

Table 5.9 – Adopted AWBM parameters for various catchment types

Parameter	Natural/ Undisturbed	Roads/ Hardstand	Spoil	Mining Areas	Rehab Spoil	Stockpile
A1	0.2	0.1	0.1	0.1	0.2	0.1
A2	0.2	0.9	0.3	0.9	0.2	0.9
C1	45	4	15	4	45	4
C2	95	16	50	16	95	16
C3	150	-	110	-	150	-
BFI	0.55	0	0.2	0	0.55	0
kb	0.7	0	0	0	0.7	0
Ks	0	0	0	0	0	0
Long-term C_v*	4%	32%	8%	32%	4%	32%

* Volumetric runoff co-efficient

5.6.2 Catchment Areas

Catchment areas for each of the site storages and mining areas have been estimated from the available topographic information and mine plans, as shown in Figure 4.1 to Figure 4.4. The catchment for the eastern mining area at Year 9 is assumed to remain at the completion of open cut mining while the remaining mining void is used for the disposal of coarse and fine reject materials from the underground operations. A summary of catchment areas for the current mine configuration is provided in Table 5.10.

Table 5.10 – Storage catchment areas

Project Modelling Phase	Storage	Contributing Catchment (ha)				
		Active Spoil	Mine Pit/ Hardstand/Roads	Natural/ Undisturbed	Rehabilitated Spoil	TOTAL
PY3	CHPP Coal Contact Dam	-	10.3	-	-	10.3
	CHPP Supply Dam	-	1.7	-	-	1.7
	Feeder Floor Dam	-	2.1	-	-	2.1
	Fill Point Dam	-	0.4	-	-	0.4
	OC MIA Dam	-	14.3	-	-	14.3
	Eastern OC Area	-	23.1	13.1	-	36.2
	Western OC Area	-	11.7	2.5	-	14.2
	Product Stockpile Dam	-	10.8	-	-	10.8
	RWD	-	4.1	92.5	-	96.6
	SD1	23.8	1.9	100.5	-	100.5
	SD2	28.1	4.9	23.2	-	56.2
	UG MIA Dam	-	9.3	-	-	9.3
	UG Stockpile Dam	-	7.6	-	-	7.6
PY5	CHPP Coal Contact Dam	-	10.3	-	-	10.3
	CHPP Supply Dam	-	1.7	-	-	1.7
	Feeder Floor Dam	-	2.1	-	-	2.1
	Fill Point Dam	-	0.4	-	-	0.4
	OC MIA Dam	-	14.3	-	-	14.3
	Eastern OC Area	-	145.3	71.8	-	217.2
	Western OC Area	10.4	34.3	11.3	-	56.0
	Product Stockpile Dam	-	10.8	-	-	10.8
	RWD	-	4.1	92.5	-	96.6
	SD1	79.9	1.9	18.7	-	100.5
	SD2	82.2	5.0	24.1	-	111.3
	SD4	26.5	3.8	-	-	30.4
	SD6	66.7	6.8	-	-	73.5
	SD8	17.7	2.5	-	-	20.2
	UG MIA Dam	-	9.3	-	-	9.3
	UG Stockpile Dam	-	7.6	-	-	7.6

Project Modelling Phase	Storage	Contributing Catchment (ha)				
		Active Spoil	Mine Pit/ Hardstand/Roads	Natural/ Undisturbed	Rehabilitated Spoil	TOTAL
PY7	CHPP Coal Contact Dam	-	10.3	-	-	10.3
	CHPP Supply Dam	-	1.7	-	-	1.7
	Feeder Floor Dam	-	2.1	-	-	2.1
	Fill Point Dam	-	0.4	-	-	0.4
	OC MIA Dam	-	14.3	-	-	14.3
	Eastern OC Area	-	181.9	2.2	-	184.1
	Western OC Area	1.8	16.6	1.8	-	20.3
	Product Stockpile Dam	-	10.8	-	-	10.8
	RWD	-	4.1	92.5	-	96.6
	SD1	60.8	1.9	18.9	18.9	100.5
	SD2	84.1	5.0	13.9	8.6	111.6
	SD4	43.8	3.9	-	36.5	84.2
	SD5	55.5	2.0	-	-	57.6
	SD6	66.2	6.8	-	-	73.1
	SD8	26.4	2.7	-	-	29.1
	UG MIA Dam	-	9.3	-	-	9.3
	UG Stockpile Dam	-	7.6	-	-	7.6
PY9	CHPP Coal Contact Dam	-	10.3	-	-	10.3
	CHPP Supply Dam	-	1.7	-	-	1.7
	Feeder Floor Dam	-	2.1	-	-	2.1
	Fill Point Dam	-	0.4	-	-	0.4
	OC MIA Dam	-	14.3	-	-	14.3
	Eastern OC Area (East Void)	33.2	138.2	2.8	0.7	174.9
	Western OC Area (South Void)	33.2	138.2	2.8	-	174.2
	Product Stockpile Dam	-	10.8	-	-	10.8
	RWD	-	4.1	92.5	-	96.6
	SD1	60.8	1.9	18.9	18.9	100.5
	SD2	-	1.5	13.7	96.1	111.3
	SD4	0.6	1.9	1.2	100.1	103.7
	SD5	43.2	2.5	-	64.7	110.4
	SD6	17.8	6.8	-	47.2	71.7

Project Modelling Phase	Storage	Contributing Catchment (ha)				
		Active Spoil	Mine Pit/ Hardstand/Roads	Natural/ Undisturbed	Rehabilitated Spoil	TOTAL
	SD8	5.0	3.1	-	36.7	44.8
	UG MIA Dam	-	9.3	-	-	9.3
	UG Stockpile Dam	-	7.6	-	-	7.6
Post open cut	CHPP Coal Contact Dam	-	10.3	-	-	10.3
	CHPP Supply Dam	-	1.7	-	-	1.7
	Feeder Floor Dam	-	2.1	-	-	2.1
	Fill Point Dam	-	0.4	-	-	0.4
	OC MIA Dam	-	14.3	-	-	14.3
	Eastern OC Area (East Void)	14.2	91.7	1.2	0.7	107.8
	Western OC Area (South Void)	34.8	8.5	0.4	-	43.7
	Product Stockpile Dam	-	10.8	-	-	10.8
	RWD	-	4.1	92.5	-	96.6
	SD1	60.8	1.9	18.9	18.9	100.5
	SD2	-	1.5	13.7	96.1	111.3
	SD4	0.6	1.9	1.2	100.1	103.7
	SD5	65.7	2.5	-	64.7	132.9
	SD6	17.8	6.8	-	47.2	71.7
	SD8	5.0	3.1	-	36.7	44.8
	UG MIA Dam	-	9.3	-	-	9.3
	UG Stockpile Dam	-	7.6	-	-	7.6

5.7 SALINITY PARAMETERS

The Project OPSIM model has been configured to use salinity as an indicator of water quality. This has been achieved by assigning representative total dissolved solids (TDS) levels to runoff from catchments and other sources of water.

The salinity concentrations for runoff from spoil, stockpiles and mining pit catchments was determined based on information provided in the EIS Geochemical Impact Assessment (RGS, 2015).

Salinity of natural catchment runoff was based on the median of the recorded EC data at the Bylong River and Lee Creek receiving water monitoring sites. It has been assumed that runoff salinity from rehabilitated catchments will be similar to the natural catchments.

Salinity of the mining area groundwater and bore water inflows was based on the groundwater sampling data (DP, 2014).

The adopted salinity concentrations applied to the model are given in Table 5.11.

Table 5.11 – Adopted salinity concentrations

Water Source / Land use	EC (µs/cm)	Comment
Natural/undisturbed/rehab	700	Based on median EC data at SW2 & SW8 (see Table 3.8)
Roads/hardstand	1,200	Adopt same as spoil
Spoil	1,200	Combined surface runoff (80% @ 500 µS/cm) & baseflow (20% @ 4000 µS/cm). Based on RGS Geochem. Report (S4.1.1 Graph 2, approx. 80th %ile, S5.3.2 p.41)
Mining pit	500	Based on RGS Geochem. Report (S4.1.2 Graph 8, approx. 80th %ile)
Stockpile	500	Based on RGS Geochem. Report (S4.1.2 Graph 8, approx. 80th %ile)
Pit groundwater inflows	1,200	Based on median sample data from DP Report, Table 8
Raw (bore) water	1,200	Based on median sample data from DP Report, Table 8

Notes: a/ Bylong Coal Project – Geochemical Impact Assessment, RGS, January 2015.
b/ Addendum Report of Hydrogeological Investigations and Monitoring – January to May 2014 Proposed Coal Mine, Bylong, Douglas Partners, June 2014.

5.8 MINE WATER STORAGE CAPACITIES

The following storage capacities were adopted for the water balance modelling:

- Raw Water Dam - 300 ML
- CHPP Supply Dam - 22.2 ML
- CHPP Coal Contact Dam - 23.3 ML
- OC MIA Dam - 106.1 ML
- UG MIA Dam - 15.7 ML
- UG Raw Coal Stockpile Dam - 3.4 ML
- Product Stockpile Dam - 18.0 ML
- Feeder Floor & Reject Overflow Dam - 6.0 ML
- Fill Point Dam - 2.0 ML

Capacities of the mining areas have been estimated from the contour information supplied with the mine plans, and are as follows:

- Eastern OC Area:
  - PY3 - 1,981 ML
  - PY5 - 7,093 ML
  - PY7 - 8,810 ML
  - PY9 - 2,890 ML (South Void) & 18,719 ML (East Void)
  - Post Open Cut - 497 ML (South Void) & 18,831 ML (East Void)
- Western OC Area:
  - PY3 - 538 ML
  - PY5 - 1,586 ML
  - PY7 - 432 ML
  - PY9 - backfilled
  - Post Open Cut - backfilled

Sediment dam sizes have been based on the proposed design standards for sediment control dams (see Section 5.9). Storage surface areas have been estimated based on an assessment of required dam volumes and likely dam footprint areas.

5.9 SEDIMENT DAMS

5.9.1 Sizing

Conceptual sediment dam locations have been proposed based on the current mine plans and are shown in in Figure 4.1 to Figure 4.4. There are a total of 6 sediment dams conceptually proposed over the life of the Project.

The sediment dams will be sized in accordance with current recommended design standards in the following guidelines:

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

The sediment dam volumes will be based on the following design standards and methodology:

- “Type F” sediment basins consistent with SD 6-4 (page 6-19, Landcom 2004);
- total sediment basin volume = settling zone volume + sediment storage volume. The sediment storage volume is the portion of the basin storage volume that progressively fills with sediment until the basin is de-silted. The settling zone is the minimum required free storage capacity that must be restored within 5 days after a runoff event;
- sediment basin settling zone volume based on 90^{th} percentile 5-day duration rainfall at Scone (35.9 mm) with an adopted volumetric event runoff coefficient for disturbed catchments of 0.64; and
- solids storage volume = 50% of settling zone volume.

The adopted design standard does not provide 100% containment for runoff from disturbed areas. Hence, it is possible that overflows will occur from sediment dams if rainfall exceeds the design standard.

Table 5.12 provides the adopted sediment dam volumes and the associated pump requirements to restore the settling zone capacity within 5 days. Note that current design guidelines (DECC, 2008) allow for the adoption of larger dam sizes to allow for dewatering over a longer period to reduce the required pumping rate.

Table 5.12 – Sediment dam sizing

Sediment Dam	Maximum Catchment Area (ha)	Total Volume Required (ML)	5-day Pump Requirement (L/s)
SD1	100.5	34.6	80
SD 2	111.3	38.4	89
SD 4	103.7	35.7	83
SD 5	132.9	45.8	106
SD 6	73.5	25.3	59
SD 8	44.8	15.4	36

5.9.2 Sediment Dam Collection System – Operating Rules

The operating rules for the sediment dam collection system are based on the recommendations in the guidelines Managing Urban Stormwater Soils and Construction Guideline: Mines and Quarries (DECC 2008). The operating rules are as follows:

- runoff from disturbed areas will be captured in a sediment dam and pumped to OC MIA Dam;
- pump capacities will be sized to empty sediment dams in 5 days;
- runoff from rehabilitated areas established for more than two years will be directed to a sediment dam and released off-site; and
- sediment dams will overflow when rainfall exceeds the design criteria (90th percentile 5-day rainfall).

In practice, water may be released from sediment dams if it meets water quality criteria and water is not required for use in the water management system.

5.10 PUMP CAPACITIES

The following pump capacities have been adopted for the water balance model:

- sediment dams to OC MIA Dam – (refer to Section 5.9.1); and
- for all other pumped transfers, a pump rate of 100 L/s been adopted.

5.11 LIMITATIONS OF THE WATER BALANCE MODEL

The water balance model developed for the Project is based on the best information currently available and is expected to provide a reasonable representation of the performance of the mine water management system. The model will be updated and validated in the future when more suitable site specific data becomes available. The performance of the actual system may differ from the model predictions for a variety of reasons, including different climatic sequences and hydrologic behaviour of catchments, as well as variations in operating procedures due to potential equipment failure or operation system error.

6 Water Management System Assessment

6.1 OVERVIEW

The potential implications of the site water balance include:

- potential to run out of water for the production of coal;
- potential for uncontrolled spills from the mine water dams; and
- potential to impact on production as a result of water inundation to the mining areas.

An assessment of the Project's mine water management system has been undertaken using the water balance model, using the following key performance indicators:

- mine water inventory – the risk of accumulation (or reduction) of the overall mine water inventory at the Project, and the associated water volumes;
- external raw water requirements – the risk of requiring imported external water to supplement on-site mine water supplies;
- uncontrolled spillway discharges – the risk of uncontrolled discharges from the site storages to receiving waters; and
- overall site water balance.

A schematic layout of the water balance model is presented in Figure 5.2. Operational guidelines and controls applied to the model are described in Section 5.2.

It is important to note that investigation outcomes are dependent on the accuracy of input assumptions. There is inherent uncertainty with respect to some key site characteristics (e.g. catchment yield/rainfall runoff, mining area groundwater inflows) which cannot be accurately determined prior to the commencement of operations. The use of a large number of climate sequences reflecting the full range of historical climatic conditions provides an indication of the system performance under very wet, very dry and average climatic conditions.

6.2 INTERPRETATION OF RESULTS

The modelling methodology of a forecast simulation is described in Section 5.3. In interpreting the results of the water balance assessment, it should be noted that the results provide a statistical analysis of the water management system's performance over the 23 years of mine life, based on 102 realisations with different climatic sequences.

The 50th percentile probability represents the median results, the 10th percentile represents 10% exceedance (i.e. wet conditions) and the 90th percentile results represent 90% exceedance (i.e. dry conditions). There is an 80% chance that the result will fall within the 10th and 90th percentiles and a 98% chance the result will fall between the 1st and 99th percentiles. Importantly, note that a percentile trace shows the percentile chance of a particular value on each day, and does not represent continuous results from a single model realisation e.g. the 50th percentile trace does not represent the model time series for median climatic conditions.

A single realisation can also be selected from the 102 modelled realisations in order to show the water management system's actual performance (not a statistical representation) for a particular climate sequence.

6.3 WATER BALANCE MODEL RESULTS

6.3.1 Overall Water Balance

Water balance results for one of the 102 modelled realisations is presented in Table 6.1, averaged over each phase of modelled mine life (phases are defined in Section 5.3.1). The water balance results provided are those for the single realisation with median inflows (including direct rainfall, catchment runoff and groundwater) over the life of the Project. The results for this single realisation show inflows, outflows and overall water balance for each of the mine phases for a representative climate sequence. It should be recognised that the following items are subject to climatic variability:

- rainfall runoff;
- evaporation;
- bore water requirements; and
- site releases/spills.

The results for a single realisation with median inflows show that over the life of the Project:

- bore water supply is required in all phases, with the greatest amount required in PY3;
- the largest demand from the water management system is due to dust suppression;
- total mine water demand (including CHPP make-up, dust suppression, accommodation camp, OC/UG MIA usage, underground operations) supplied from the water management system ranges between approximately 1,317 ML/yr and 1,942 ML/yr, with the highest demand in PY 9+;
- no overflows from the mine water system occurred for this simulation; and
- the combined spill volume from the sediment dams is highest in PY 7 (266 ML/a), and ranges between 0 ML/yr and 160 ML/yr for the remaining phases.

Note that the results presented in Table 6.1 are for a single realisation and will include wet and dry periods distributed throughout the mine life. Rainfall yield for each phase is affected by the variation in climatic conditions within the adopted climate sequence. For example, the high runoff yield indicated for PY 7 likely reflects a wet period during this part of the selected realisation.

Table 6.1 – Average annual water balance – Realisation 72 (1960 to 1982)					
	PY 3	**PY 5**	**PY 7**	**PY 9**	**PY11+**
Water Inputs (ML/a)					
Rainfall/runoff yield	220	737	961	563	729
Groundwater inflows	129	174	231	1,393	1,172
Raw (bore) water intake	931	472	548	21	0
GROSS WATER INPUTS	**1,280**	**1,383**	**1,740**	**1,958**	**1,901**
Water Outputs (ML/a)					
Evaporation from storages	47	51	72	107	312
Dam overflows (offsite)					
Mine water system	0	0	0	0	0
Sedimentation system	0	0	56	0	152
Total	0	0	56	0	152
CHPP demand (loss)	249	266	269	395	366
Dust suppression	1,041	1,041	1,041	1,041	500
WAF	22	22	0	0	0
OC MIA Dam usage	5	7	7	1	0
UG MIA Dam usage	0	0	5	5	7
Underground operations Usage	0	0	50	500	500
GROSS WATER OUTPUTS	**1,364**	**1,387**	**1,500**	**2,049**	**1,837**
Water Balance (ML/a)					
Change in storage volumes	-84	-4	240	-91	64

6.3.2 Borefield Water Supply Requirements

Substantial volumes of water are required on the mine site to meet operational water demands. In addition to the water captured within the water management system from surface runoff and groundwater inflows, water will also need to be sourced from a borefield to be constructed within the Bylong River alluvium.

A key objective of the mine site water management system is to maximise the reuse of on-site surface water runoff and groundwater inflows. Recycling mine water will minimise the volume of water from external sources (groundwater bores) that is required to satisfy site demands. However, the volume of water captured on site is highly variable dependent upon climatic conditions. Hence, the required makeup water volume from the groundwater bores is likely to vary significantly from year to year.

Figure 6.1 shows the total annual modelled demand for water from groundwater bores over the Project period. The results indicate that the annual bore water requirements are generally highest during the period of open cut only operations (PY3 to PY6). The bore water requirements significantly reduce once underground operations commence due to the increase in groundwater inflows to the mine workings and reduction in site water demands. A summary of bore water requirements for different periods of operation is shown in Table 6.2.

Table 6.2 - Summary of bore water requirements

Operational period	Bore Water Supply 1% chance of requiring	 10% chance of requiring	 50% chance of requiring
Open cut only operations (PY3 to PY6)	985 to 1170 ML/a	940 to 1,140 ML/a	560 to 990 ML/a
Combined mining operations (PY7 to PY10)	380 to 1,005 ML/a	195 to 895 ML/a	0 to 500 ML/a
Underground only operations (PY11 to PY25)	55 to 150 ML/a	0 to 60 ML/a	0 ML/a

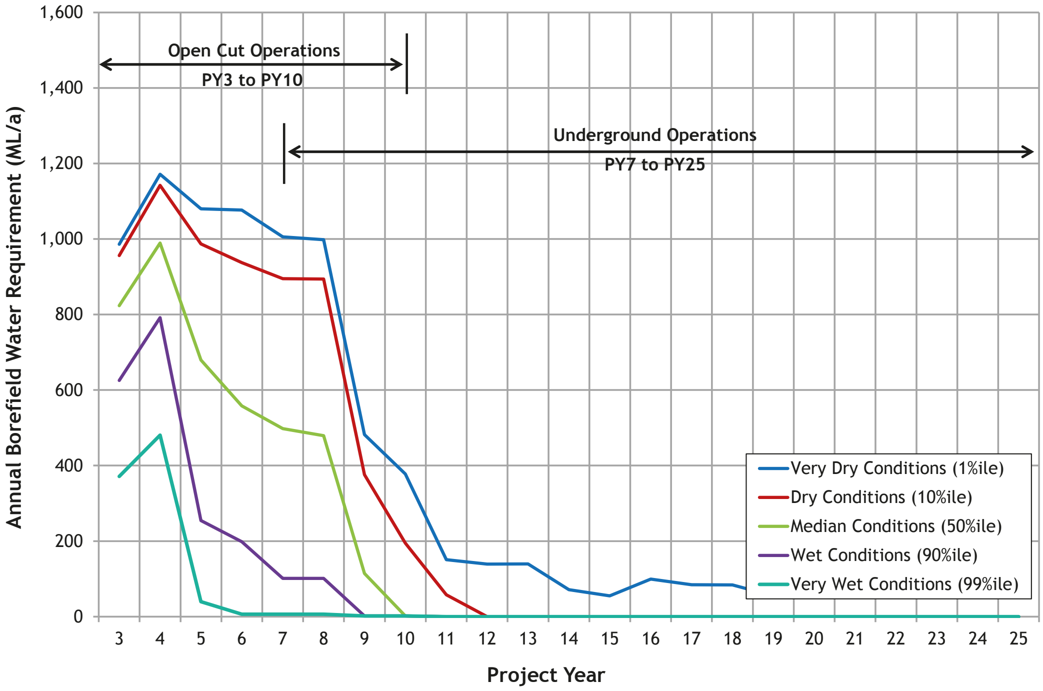


Figure 6.1 - Annual borefield water requirements

6.3.3 Mining Pit Inundation Characteristics

As described in Section 5.2, the water management system is configured to pump excess water to the mining areas when the capacity of the water management system is exceeded. The stored water is available for re-use as required.

Figure 6.2 shows the percentile plots of stored inventory in the combined mining pits over the Project life. The results indicate the following:

- prior to the commencement of underground mining, there is a low risk of significant volumes of water accumulating in the open cut mining areas. Once underground operations commence, groundwater inflows increase significantly. This results in the potential for water accumulating within the mining voids if wet climatic conditions occur.
- during open cut only operations (PY3 to PY6), there is a:
  - 1% chance of storing up to 1,000 ML in the open cut mining areas;
  - 10% chance of storing up to 380 ML in the open cut mining areas; and
  - 50% chance that the mining area will not be required to store significant volumes of water.
- during combined and underground only operations (PY7 to PY25), there is a:
  - 1% chance of storing up to 3,560 ML in the Eastern open cut mining area;
  - 10% chance of storing up to 2,000 ML in the Eastern open cut mining area; and
  - 50% chance of storing up to 1,330 ML in the Eastern open cut mining area.

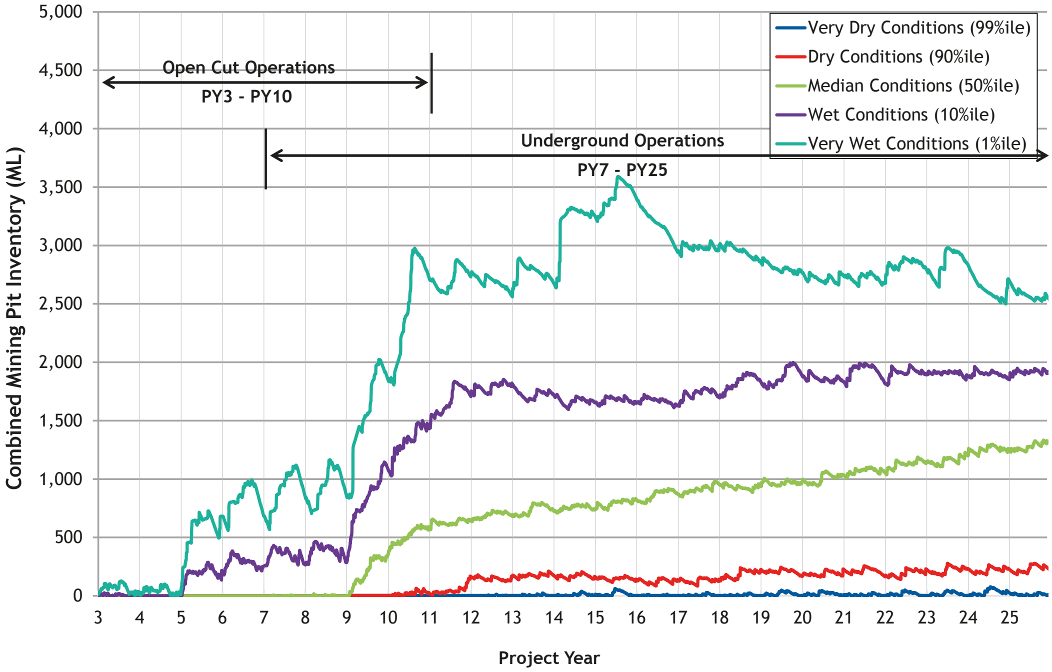


Figure 6.2 - Combined open cut mining area stored inventory

The model results show that during open cut only operations, the accumulation of water with the open cut mining operations is manageable. However once underground operations commence, the additional groundwater inflows and reduction in site water demands increase the risk of water accumulation. This water will need to be managed within the water management system, most likely within one or both of the Eastern Open Cut voids.

Once open cut operations cease around PY 10, the capacity of the Eastern Void will be around 18,800 ML, providing ample capacity to store any excess water if climatic conditions are very wet. If wet conditions occur over this period, the Eastern Open Cut mining area will be used to store rejects and to store excess water. The total bulk volume of rejects during underground operations is estimated to be around 11,700 ML. This would indicate approximately 7,000 ML of remaining capacity available within the Eastern Void to store excess mine water captured through surface runoff and groundwater inflows.

Depending on climatic conditions over the Project life, there may be water contained within the Eastern Void at the completion of mining. The proposed management strategy for contained water at the end of mine life is to return this water to the underground mine workings. The impacts of returning this water underground are assessed in the groundwater impact assessment report for the Project.

6.3.4 Uncontrolled Offsite Releases

The results of the site water balance modelling show that the site water management system can be operated to ensure with at least 99% probability that no uncontrolled release of saline water over the Project life.

As explained in Section 5.9.1 the only uncontrolled offsite releases will be from sediment dams during periods of rainfall above the relevant design criteria.

6.4 SALT BALANCE

To assess the impact of the Project on the receiving water salt balance, the OPSIM model was run as a forecast simulation. Figure 6.3 shows a schematic of the salt inputs and outputs from the Project.

Salt inputs to the Project include salts in the groundwater inflows, catchment runoff, direct rainfall, and bore water. Salt outputs from the Project include salts which are lost through the CHPP in the rejects and product coal, site demands (including dust suppression, MIA usage and underground operations) and offsite discharges from the sediment water system (there are no predicted offsite discharges from the mine water system). The CHPP is a net user of water, as during the washing and sizing process the moisture content of the rejects material is increased. This process traps water (and salt) in the rejects material. The material is then disposed of in dedicated zones within the open cut mining areas.

Table 6.3 shows the average annual salt balance for the Project, for each phase. The results indicate the following:

- the largest contributor to the Project salt load varies between phases. In PY 3 and PY 5, the bore water inflows contribute the most. In later phases when underground mining operations commence, the largest contributor is groundwater inflows; and
- net loss from dust suppression contributes the greatest salt loss for all phases, with CHPP demand the next largest contributor.

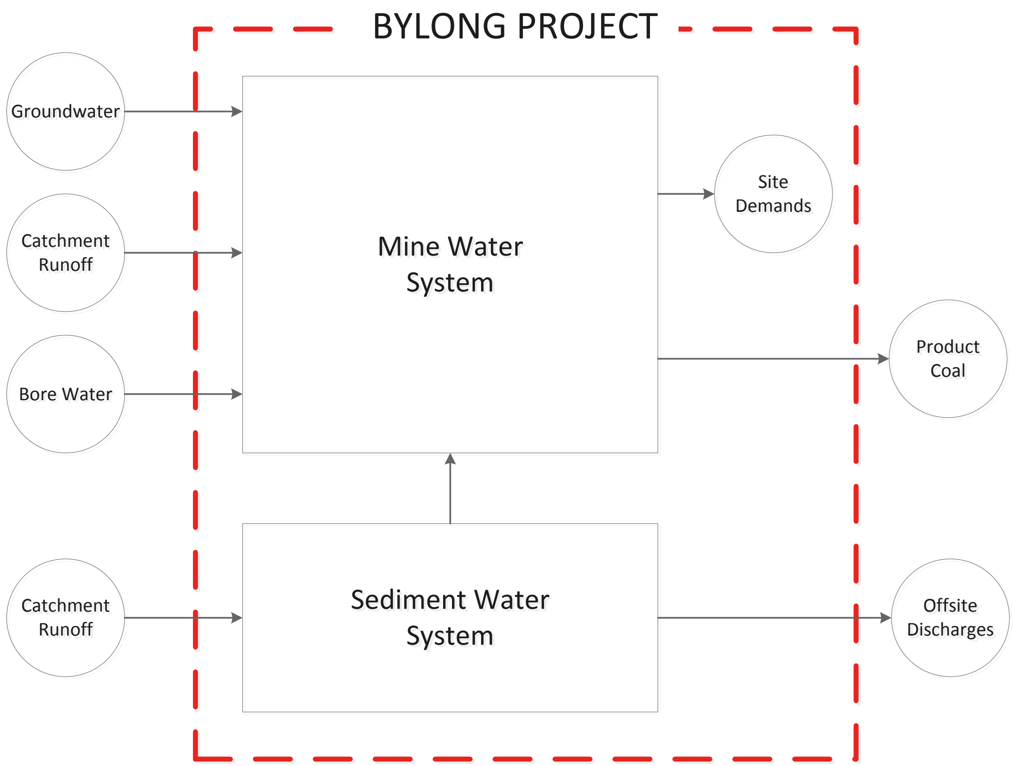


Figure 6.3 -Project - surface water salt load schematic

Table 6.3 – Project Average Annual Salt Balance

	PY 3	PY 5	PY 7	PY 9	PY11+
Salt Inputs (tonnes/year)					
Rainfall/runoff yield	188	522	566	662	363
Groundwater inflows	104	140	186	1,122	944
Raw (bore) water intake	705	486	408	83	3
GROSS SALT INPUTS	**997**	**1,148**	**1,160**	**1,867**	**1,310**
Salt Outputs (tonnes/year)					
Evaporation from storages	-	-	-	-	-
Dam overflows (offsite)					
Mine water system	-	-	-	-	-
Sedimentation system	4	24	33	24	118
Total	4	24	33	24	118
CHPP demand (loss)	155	211	215	320	305
Dust suppression	812	847	849	836	423
WAF	14	17	-	-	-
OC MIA Dam usage	4	5	5	1	-
UG MIA Dam usage	-	-	4	4	6
Underground Operations Usage	-	-	40	403	419
GROSS SALT OUTPUTS	**989**	**1,104**	**1,146**	**1,588**	**1,271**
Salt Retained on Site (tonnes)					
Change in storage salt load	8	44	14	279	39

6.5 ADAPTIVE MANAGEMENT OF MINE WATER BALANCE

The model results presented above represent the application of the adopted mine water management system rules over the mine life, regardless of climatic conditions. In reality, there are numerous options for adaptive management of the mine water system to respond to climatic conditions and the current site water inventory in a way that will reduce the risks of impacts to surface water resources.

7 Assessment of Bylong River Flood Behaviour

7.1 OVERVIEW

The flood behaviour of the Bylong River in the vicinity of the Project was simulated using a runoff-routing hydrologic model (XP-RAFTS) to estimate flow rates and a two-dimensional hydraulic model (TUFLOW) to simulate flood levels and flow velocities.

Design flood hydrographs were simulated for the 2, 50 and 100 year ARI design events. Details of the methodology and results of the hydrologic and hydraulic modelling are provided in the following sections.

7.2 HYDROLOGIC MODELLING

7.2.1 Model Configuration

The Bylong River catchment XP-RAFTS model was divided into 31 sub-catchments. Figure 7.1 shows the model configuration including all sub-catchment nodes and links. The sub-catchment areas and slopes are shown in Table 7.1. The XP-RAFTS model was run for storm durations from 1 to 72-hours for the three design events.

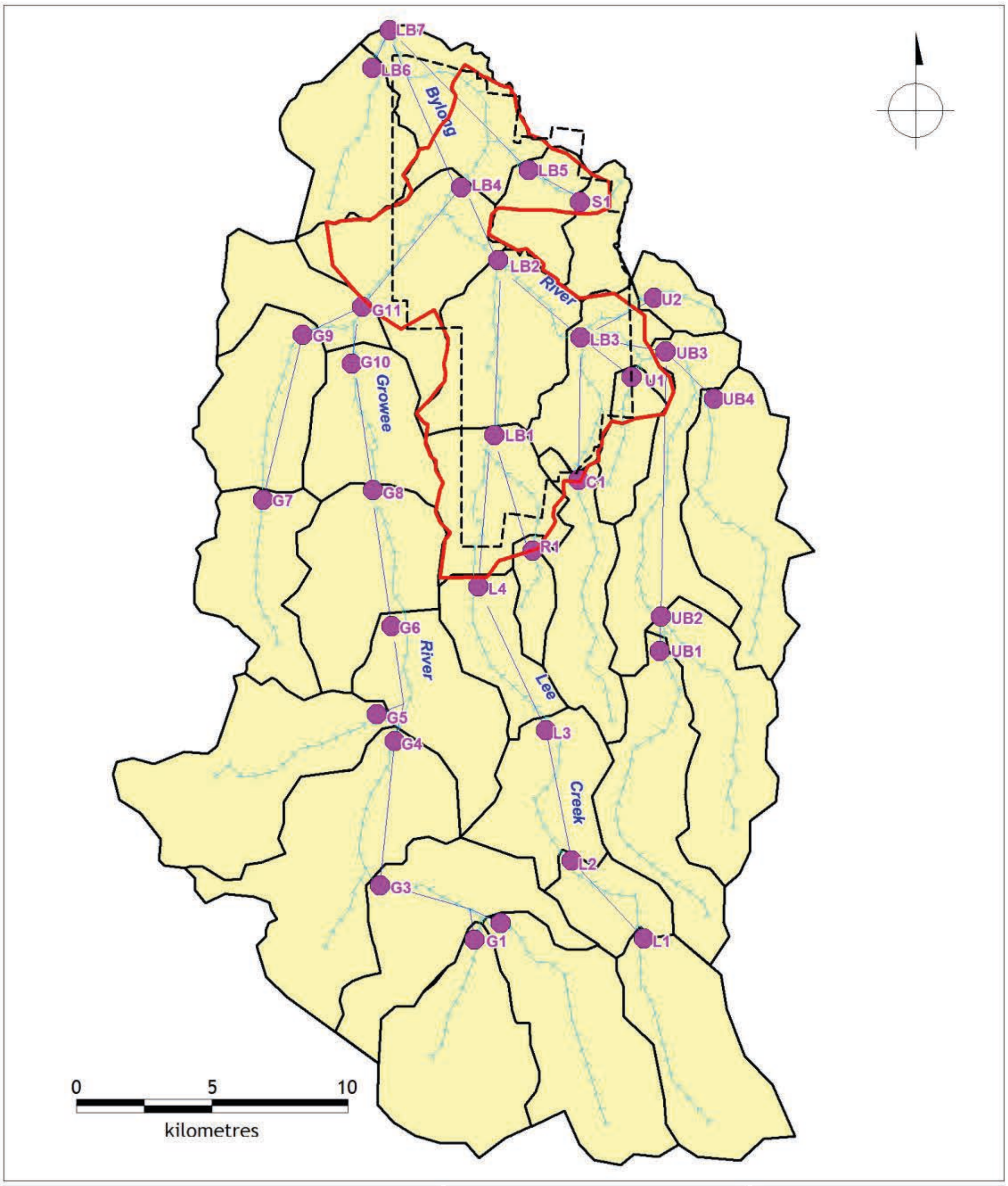
The following is of note with respect to the XP-RAFTS model:

- Catchment areas were determined using a 1:250,000 topographic map with 50 m contours;
- A percentage impervious of 0% was adopted for all sub-catchments;
- A PERN 'n' value of 0.12 was adopted for all sub-catchments;
- A global storage coefficient "Bx" value of 1 was adopted; and
- An initial loss of 30 mm and a continuing loss of 2.5 mm per hour were adopted.

7.2.2 Hydrologic Model Verification

Very limited historical flow data was available for the Bylong River. Data from the stream gauge at Bylong No.2 (BoM Station No. 210062), which is located on the Bylong River about 8 km upstream of its confluence with the Goulburn River, has a relatively short period of record and contained significant periods of missing data (see Section 3.6). For this reason, peak flow rates at this station were not available. In the absence of suitable historical data for calibration, the model was verified using a combined approach:

- Peak discharges for individual sub catchments were compared against discharges calculated using the Rational Method; and
- Modelled daily flows for the January 1974 flood event were compared against recorded data at the Bylong No. 2 gauge. The 1974 flood event was the largest flood event recorded at the Bylong No. 2 stream gauge for which data is available.



LEGEND

- Nodes
- Links
- Subcatchment Boundary
- Drainage Path
- TUFLOW Modelling Area
- Project Boundary

BYLONG COAL EIS

Bylong River
Catchment Area
XP-RAFTS
Model Configuration

wrm
water + environment
WRM Water and Environment Pty Ltd
PO Box 10703, Brisbane Adelaide St Qld 4000
Tel 07 3225 0200
wrmwater.com.au
ABN 96 107 404 544

Figure 7.1- Bylong River XP-RAFTS model configuration

Table 7.1- Adopted XP-RAFTS sub-catchment parameters

Sub-catchment ID	Catchment Area (km^2)	Catchment Slope (%)
C1	20.1	4.0
G1	32.5	6.9
G10	21.1	5.6
G11	15.2	4.6
G2	35.2	4.6
G3	29.6	3.3
G4	45.6	3.6
G5	37.8	5.0
G6	23.2	6.8
G7	22.6	4.3
G8	28.7	6.0
G9	23.3	5.7
L1	29.1	5.1
L2	10.9	8.3
L3	21.2	7.8
L4	14.0	6.7
LB1	20.6	5.7
LB2	26.1	5.8
LB3	17.6	7.3
LB4	29.1	3.0
LB5	11.1	5.2
LB6	22.5	4.8
LB7	22.5	3.3
R1	5.2	8.3
S1	8.6	4.1
U1	9.1	5.2
U2	6.2	4.0
UB1	28.1	3.0
UB2	27.0	3.6
UB3	26.8	4.2
UB4	31.6	3.5
Total Catchment Area (km^2)	**702**	-

Peak discharges from several sub-catchments in the Bylong River catchment were calculated using the Rational Method in accordance with the eastern NSW Rational Method from Australian Rainfall and Runoff (IEAust, 1998). A C_{10} runoff coefficient of 0.18 and the frequency factors given in Table 7.2 were adopted. The C_{10} runoff coefficient represents a relationship between the 1 hour rainfall intensity for the 10 year ARI design event and the fraction impervious determined for the catchment. A C_{10} runoff coefficient indicates a ground covering of medium density bush with good grass cover and medium to high soil permeability.

Table 7.2 – Adopted Rational Method Frequency Factors – Bylong River

Parameter	Altitude <500m	Altitude >500m
FF2	0.54	0.64
FF50	1.71	1.52
FF100	2.14	1.78

Table 7.3 to Table 7.6 compare the 2, 50 and 100 year ARI design event peak discharges calculated by the Rational Method with the XP-RAFTS model output for sub-catchments G1, LB6, G5 and C, respectively (see Figure 7.1 for sub-catchment locations). The XP-RAFTS model discharges are in reasonable agreement with the Rational Method flows. The XP-RAFTS model discharges were adopted for this assessment.

Table 7.3 - Comparison of Rational Method and XP-RAFTS Model Peak Discharges, Catchment G1

	Peak Design Discharge (m^3/s)		
Design Storm Event	XP-RAFTS	Rational Method	% Diff
2 year ARI	14	11	27%
50 year ARI	82	69	19%
100 year ARI	105	97	8%

Table 7.4 - Comparison of Rational Method and XP-RAFTS Model Peak Discharges, Catchment LB6

	Peak Design Discharge (m^3/s)		
Design Storm Event	XP-RAFTS	Rational Method	% Diff
2 year ARI	10	8	21%
50 year ARI	57	52	10%
100 year ARI	72	73	-1%

Table 7.5 - Comparison of Rational Method and XP-RAFTS Model Peak Discharges, Catchment G5

	Peak Design Discharge (m^3/s)		
Design Storm Event	XP-RAFTS	Rational Method	% Diff
2 year ARI	15	12	22%
50 year ARI	87	77	13%
100 year ARI	112	108	3%

Table 7.6 - Comparison of Rational Method and XP-RAFTS Model Peak Discharges, Catchment C1

	Peak Design Discharge (m^3/s)		
Design Storm Event	XP-RAFTS	Rational Method	% Diff
2 year ARI	8	9	-3%
50 year ARI	48	41	19%
100 year ARI	61	53	14%

Figure 7.2 shows a comparison of cumulative daily runoff from the XP-RAFTS model with recorded runoff at the Bylong No. 2 gauge. Due to the use of daily rainfall data, the model results are approximate only. However, these results show that the XP-RAFTS model provides general agreement with the recorded data for the 1974 event.

Due to the configuration of the Bylong River, with a wide overbank floodplain, it is likely that flood levels and velocities will not be very sensitive to flow rate. A higher flow would spread out across the floodplain resulting in a relatively small increase in flood level and velocity. Hence, the adopted model parameters are considered suitable for impact assessment.

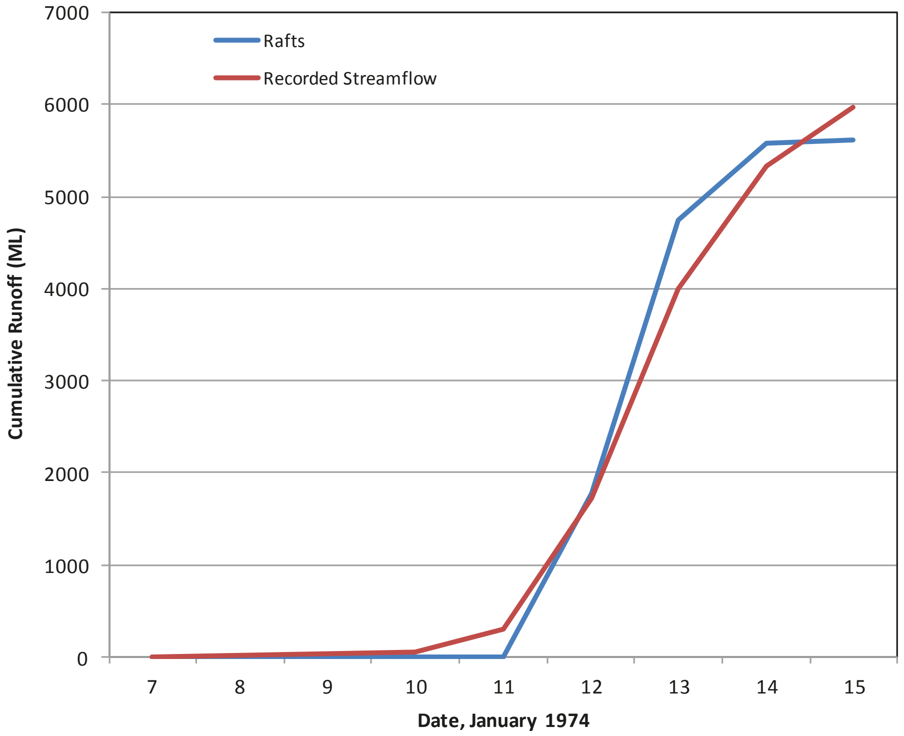


Figure 7.2 - Comparison of January 1974 Recorded and Modelled Cumulative Daily Flow, Bylong No.2 Stream Gauge

7.2.3 Estimation of Design Discharges

Rainfall patterns and intensities for the 2, 50 and 100 year ARI design events were determined using standard procedures in Australian Rainfall and Runoff (IEAust, 1998). The Bylong River XP-RAFTS model was run for storm durations from 1 to 72 hours to estimate design discharges. Table 7.7 shows the estimated design discharges and critical storm durations at several of the hydraulic (TUFLOW) model inflow boundary locations.

Table 7.7 - Estimated Design Discharges at TUFLOW Inflow Boundaries, Bylong River catchment

Location	Design Peak Discharges (m^3/s)		
	2 year ARI	50 year ARI	100 year ARI
U2 (Local Inflow)	3.6	19.8	24.5
UB3 (Bylong River)	38.5	224.4	286.5
U1 (Local inflow)	5.6	29.5	36.2
C1 (Cousins Creek)	8.4	48.3	61.5
L4 (Lee Creek)	41.8	202.1	250.0
G11 (Growee River)	127.1	668.6	837.5
S1 (Dry Creek)	4.7	26.0	32.2
Critical Storm Duration	**48 Hrs**	**12 Hrs**	**12 Hrs**

7.3 HYDRAULIC MODELLING

7.3.1 Overview

The TUFLOW hydrodynamic modelling software (WBM, 2010) was used to simulate the existing flow behaviour of the waterways and floodplains in the vicinity of the Project. TUFLOW represents hydraulic conditions on a fixed grid by solving the full two-dimensional depth averaged momentum and continuity equations for free surface flow. The model automatically calculates breakout points and flow directions.

The TUFLOW model was used to estimate design flood levels, depths, velocities and extents for the 2, 50 and 100 year ARI design events for existing conditions and developed conditions. Design flood hydrographs predicted by the XP-RAFTS model were used as inflows into the TUFLOW models

7.3.2 Model Extent and Configuration

Figure 7.3 shows the extent of the TUFLOW model developed for the Bylong River. The Bylong River, the Growee River, their tributaries and the surrounding floodplain were modelled using a two dimensional domain with a 5 m grid size and a 1 second time step.

7.3.3 Topography

A digital terrain model (DTM) of the Bylong River floodplain, with a grid size of 1.0 m, was developed using LIDAR data. The LIDAR data was acquired from a fixed wing aircraft on the 8th March and 9th of April, 2011. The area covered by both flights is approximately 320 square kilometres. The LIDAR data has a horizontal and vertical accuracy of +/- 0.2 m.

7.3.4 Adopted Manning's 'n' values

The TUFLOW model uses Manning's 'n' values to represent hydraulic resistance (notionally channel or floodplain roughness). Discrete regions of continuous vegetation types and land uses were mapped, and an appropriate roughness value assigned to each region. Vegetation and land use mapping was undertaken using aerial photography. The Manning's 'n' values applied to the hydraulic model are based on typical published values (for example, Chow, 1957) and are as follows:

- Thick grass/Floodplain: 'n' = 0.045
- Dry Creek Beds: 'n' = 0.03
- Vegetated Overbanks and Forested Areas: 'n' = 0.08
- Buildings: 'n' = 0.10

7.3.5 Inflow boundaries

Figure 7.3 shows the location of inflow boundaries used in the Bylong River catchment TUFLOW model. Model inflows were extracted from the XP-RAFTS hydrological model. Catchment hydrographs were applied to the 2D model domain as a local or total catchment hydrograph for the appropriate sub catchment or inflow boundary.

7.3.6 Downstream boundary conditions

The downstream boundary of the Bylong River TUFLOW model is located approximately 1.1 km south of the Goulburn River confluence. A normal depth tailwater slope of 0.0006 m/m was adopted. This slope is representative of the very flat bed gradients found in this section of the modelled area.

7.3.7 Waterway Structures

The Upper Bylong Road crossing of Bylong River was incorporated into the existing conditions TUFLOW model as a layered flow constriction. There are numerous low-level waterway structures located within the Bylong River catchment modelling area. These crossings are overtopped by floodwater during minor flooding events and will have minimal impact on flood flows and hence were not included in the existing conditions model configuration.

7.3.8 Developed Model Configuration

In order to assess the impacts of the Project on the flow behaviour of the various watercourses, the existing conditions TUFLOW model was amended to include proposed mine infrastructure. The mine plan for PY5 was selected as it has the largest encroachment upon the existing waterway corridors of the developed open cut mine plans. The configuration of the developed TUFLOW model is shown in Figure 7.4 and includes the following:

- An embankment for the proposed haul roads and access road crossing;
- Culverts through the haul roads and access road embankment (14 x 3.0 metre diameter circular pipes);
- Overland conveyor (OLC) embankment; and
- Various embankments protecting mine infrastructure, water supplies and sediment dams.

The Upper Bylong Road realignment will cross the Bylong River as a low level causeway that will be drowned out during flood events and have no impact on flood levels.

The adopted hydrology, Manning's 'n' values and tailwater conditions for the post-developed model were identical to those included in the existing conditions model.

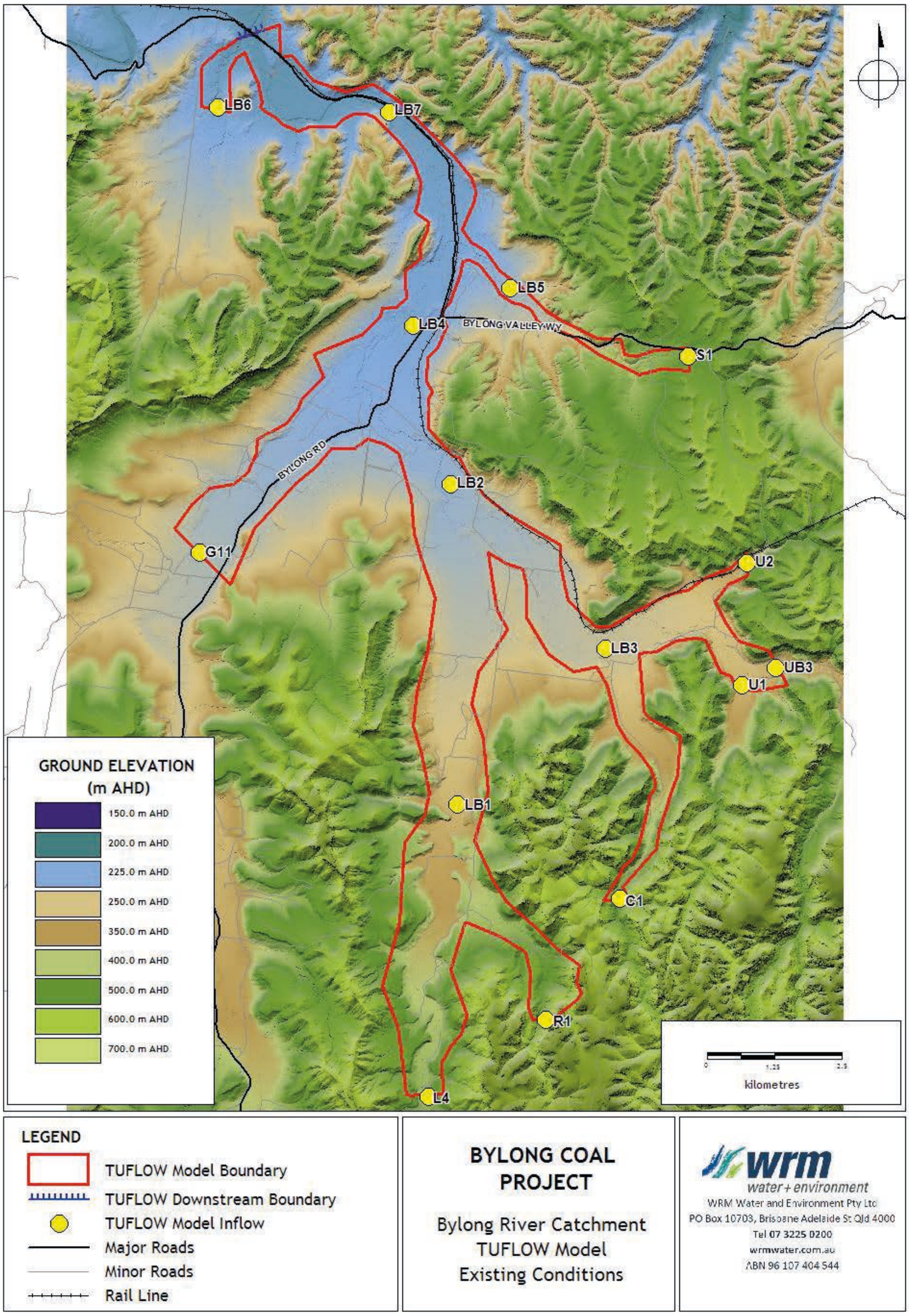


Figure 7.3 - Existing TUFLOW model extent, Bylong River catchment

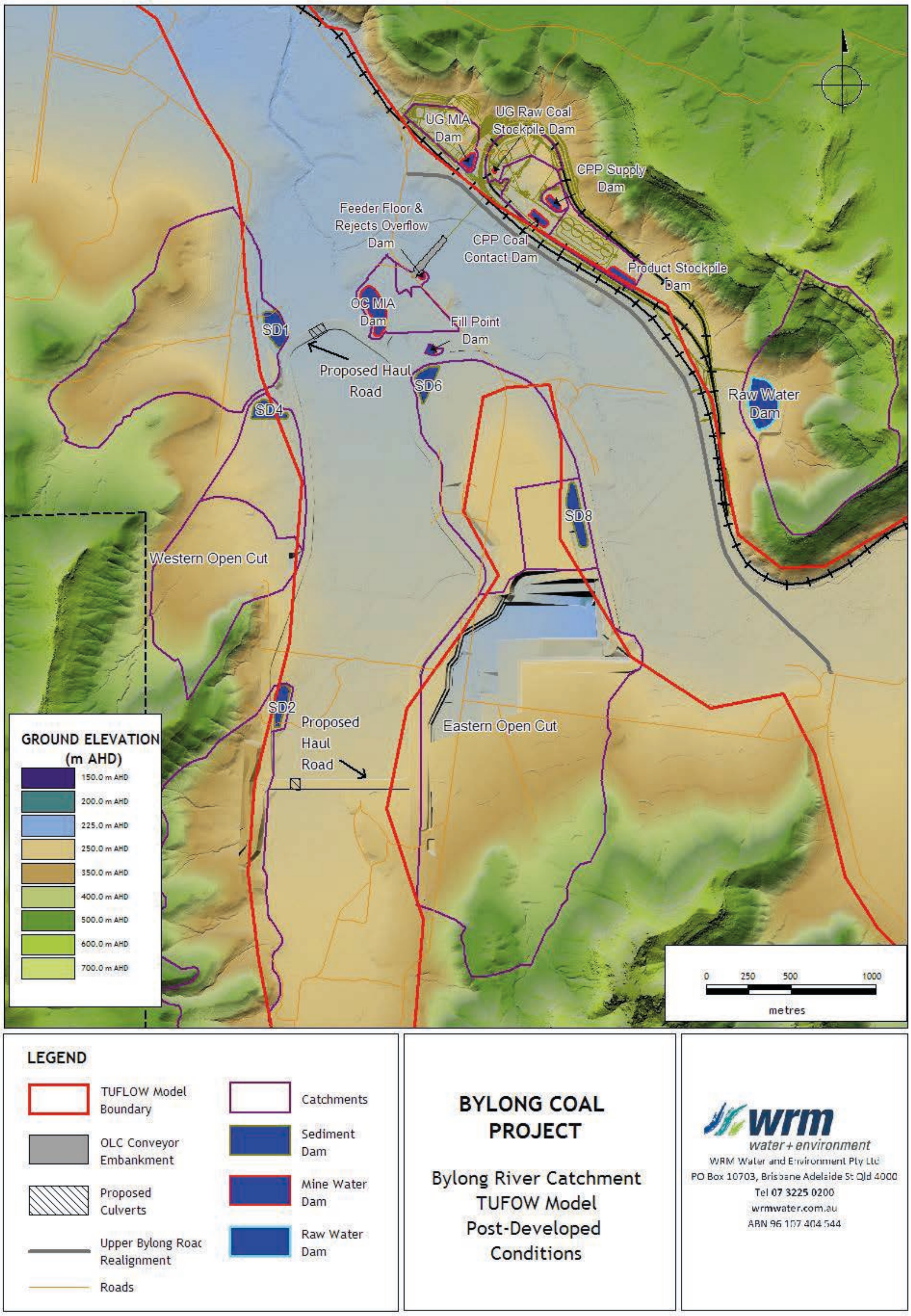


Figure 7.4 – Project Year 5 TUFLOW model extent, Bylong River catchment

7.4 HYDRAULIC MODELLING RESULTS

7.4.1 Overview

The Bylong River catchment TUFLOW model was run for the 2, 50 and 100 year ARI design events for existing and developed conditions. Plans showing the maximum flood extents, depths and velocities for the 2, 50 and 100 year ARI design events for existing conditions are presented in Attachment 1. Plans showing the maximum flood extents, depths and velocities for the 2, 50 and 100 year ARI design events for Project Year 5 developed conditions are presented in Attachment 2. Plans showing the change in water level and velocity under developed conditions are also presented in Attachment 2.

7.4.2 Existing Conditions

Plans showing the existing maximum flood extent, depth and velocity for the 100 year ARI design event under existing conditions are presented in Figure 7.5 and Figure 7.6. Due to the floodplain topography, the extent of inundation is very similar for large flood events such as the 50 and 100 year ARI design event.

The Bylong River, Growee River and Lee Creek floodplains are typically wide with small, incised main channels. The model results indicate that the highest depths are confined to the main channels with shallower depths at the fringes of the floodplain. The Bylong River is somewhat constricted in the downstream section of the model and depths greater than 3.0 metres occur at this location during the 100 year ARI design event. Similarly, the highest velocities are generally confined to the main channels with lower velocities in the adjacent floodplains.

The model results show that all of Lee Creek, Growee River and most of the Bylong River overflows for the 2 year ARI event. The Bylong River flows are confined to the main channel for this event for a small section of channel downstream of the Lee Creek confluence.

7.4.3 Developed Conditions

Plans showing the existing maximum flood extent, depth and velocity for the 100 year ARI design event under PY5 developed conditions are presented in Figure 7.7 and Figure 7.8. Plans showing the change in water level and velocity for the 100 year ARI design event for PY5 developed conditions are presented in Figure 7.9 and Figure 7.10. The concept design for the proposed structures impacting the floodplain is based on maintaining existing flow paths for regular flood events which will minimise impacts on stream geomorphology.

7.4.4 Analysis of Impacts

The inclusion of the proposed mine infrastructure causes an isolated change in water levels in the vicinity of the haul roads and overland conveyor embankment for all modelled design events. The increase in flood depth ranges from 1.0 m to 2.5 m immediately upstream during the 100 year ARI design event. Impacts on water levels from the haul roads and overland conveyor embankment propagate approximately 0.5 km upstream of these structures during the 100 year ARI design event. However, all flood impacts are confined to land owned by the Proponent.

The impact on existing water levels is smaller for the 2 year and 50 year ARI design events. There is an increase in water level of between 1.0 m and 2.0 m and between 0.5 m and 1.0 m upstream of the structures in the 50 year and 2 year ARI design events, respectively.

The presence of the haul roads and overland conveyor embankment results in an isolated change in velocity for all modelled design events. There is a decrease in velocity of between 0.2 m/s and 1.0 m/s upstream and isolated increases of between 1.0 m/s and 2.0 m/s immediately downstream of the structures during the 100 year ARI design event due to concentration of flow at the culvert outlets.

The impact on existing velocity is not as severe during the 2 year and 50 year ARI design events. The modelling results indicate that rock protection would be required downstream of the haul road culverts crossing Lee Creek and immediately adjacent to the overland conveyor embankment to prevent erosion during flood events. The extent of required local erosion mitigation measures will be determined by additional flood modelling to be undertaken as part of detailed infrastructure design.

Haul road crossings will be removed and rehabilitated at the completion of operations, ensuring that long-term floodplain conditions will be similar to existing.

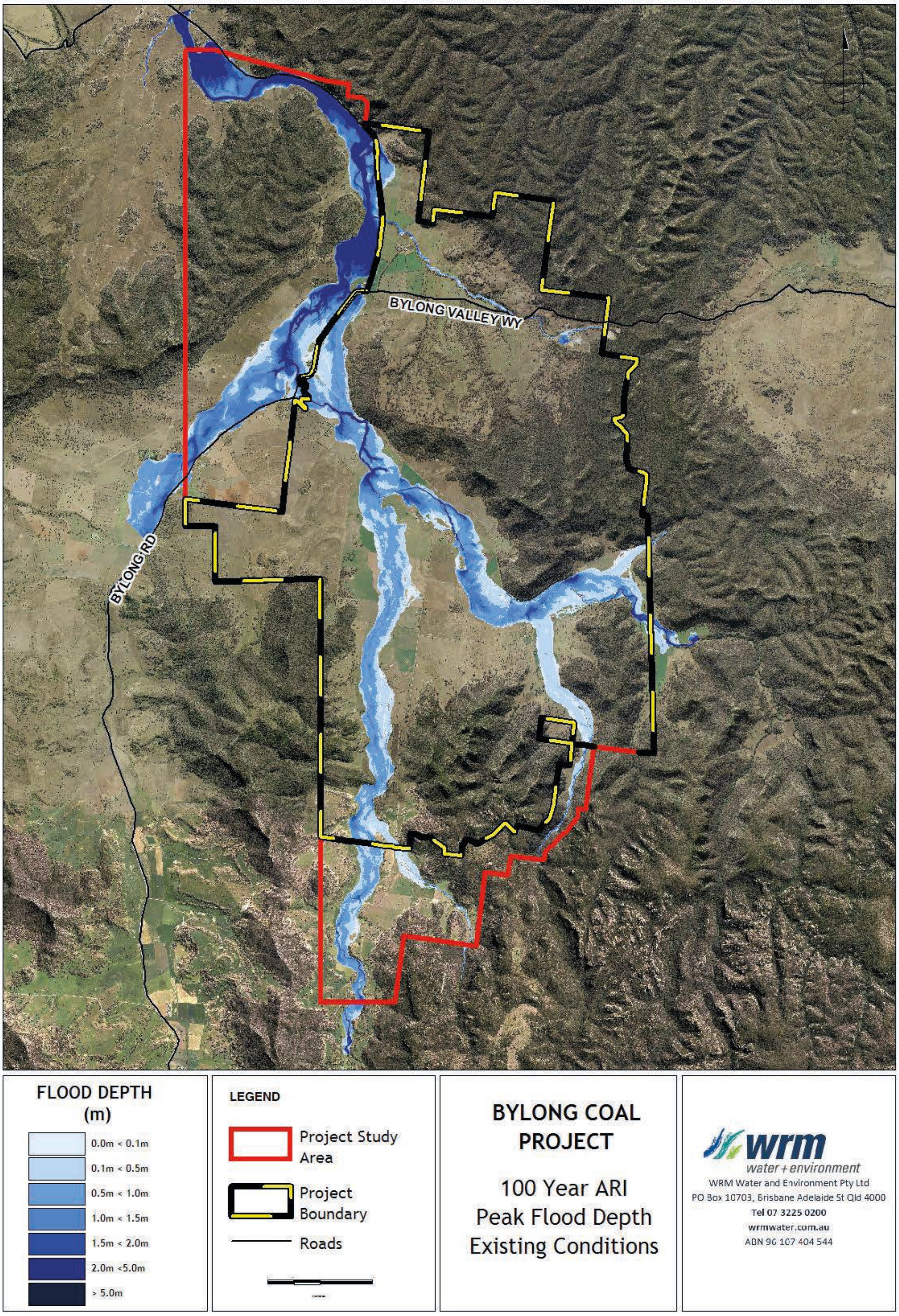


Figure 7.5 – 100 year ARI Existing Flood Depth, Bylong River Catchment

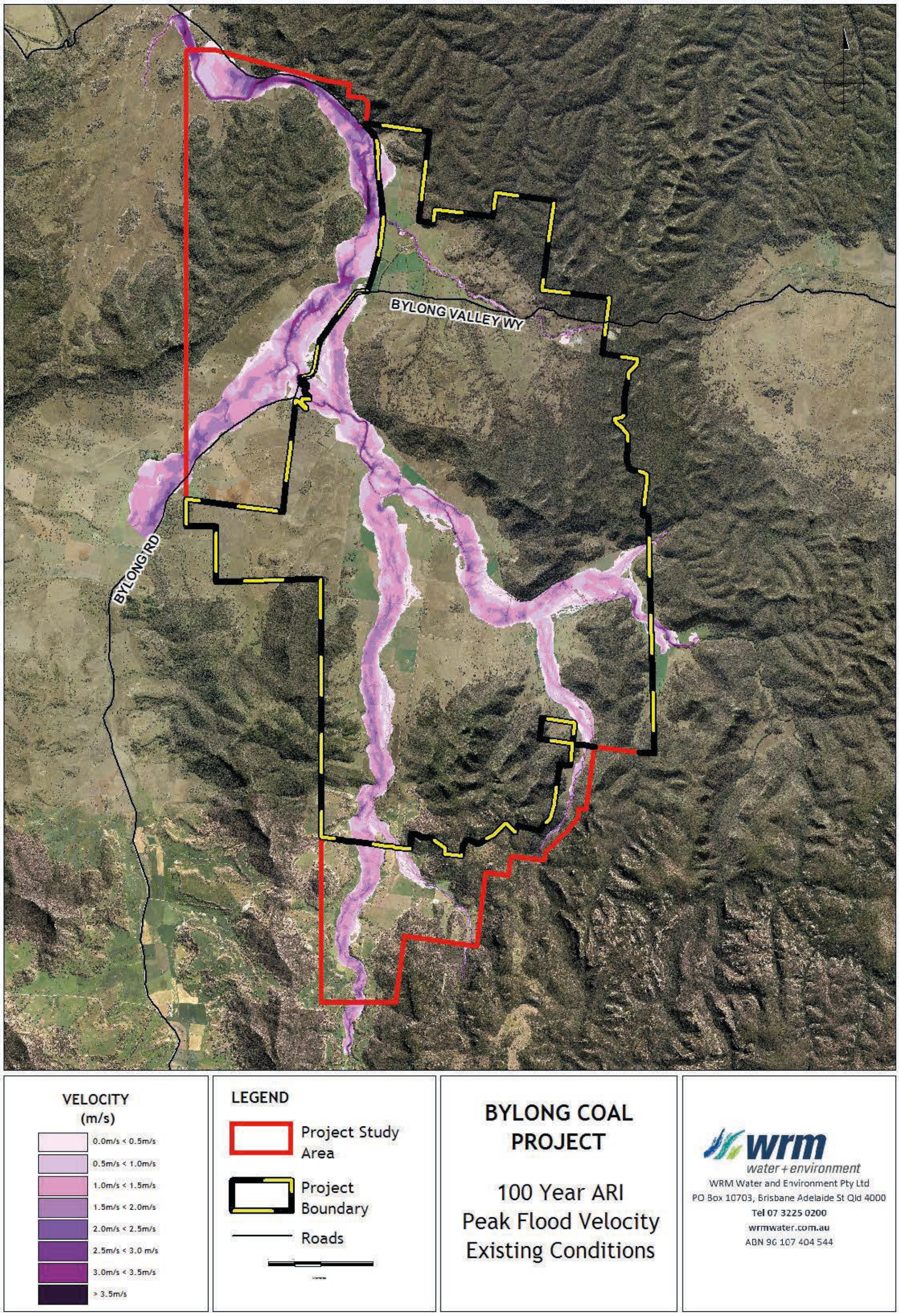


Figure 7.6 - 100 year ARI Existing Flood Velocity, Bylong River Catchment

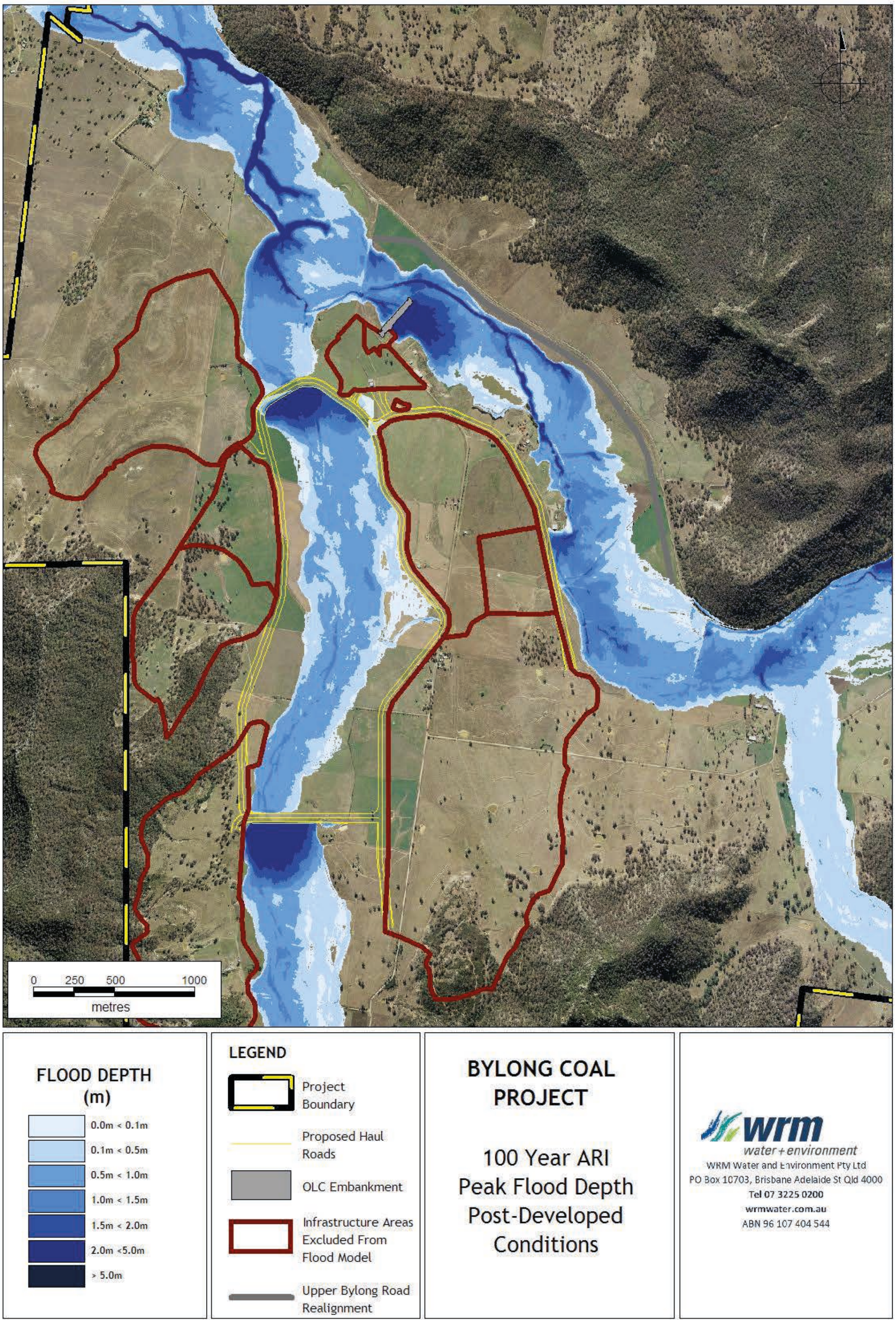


Figure 7.7 - 100 year ARI PY5 Developed Flood Depth, Bylong River Catchment

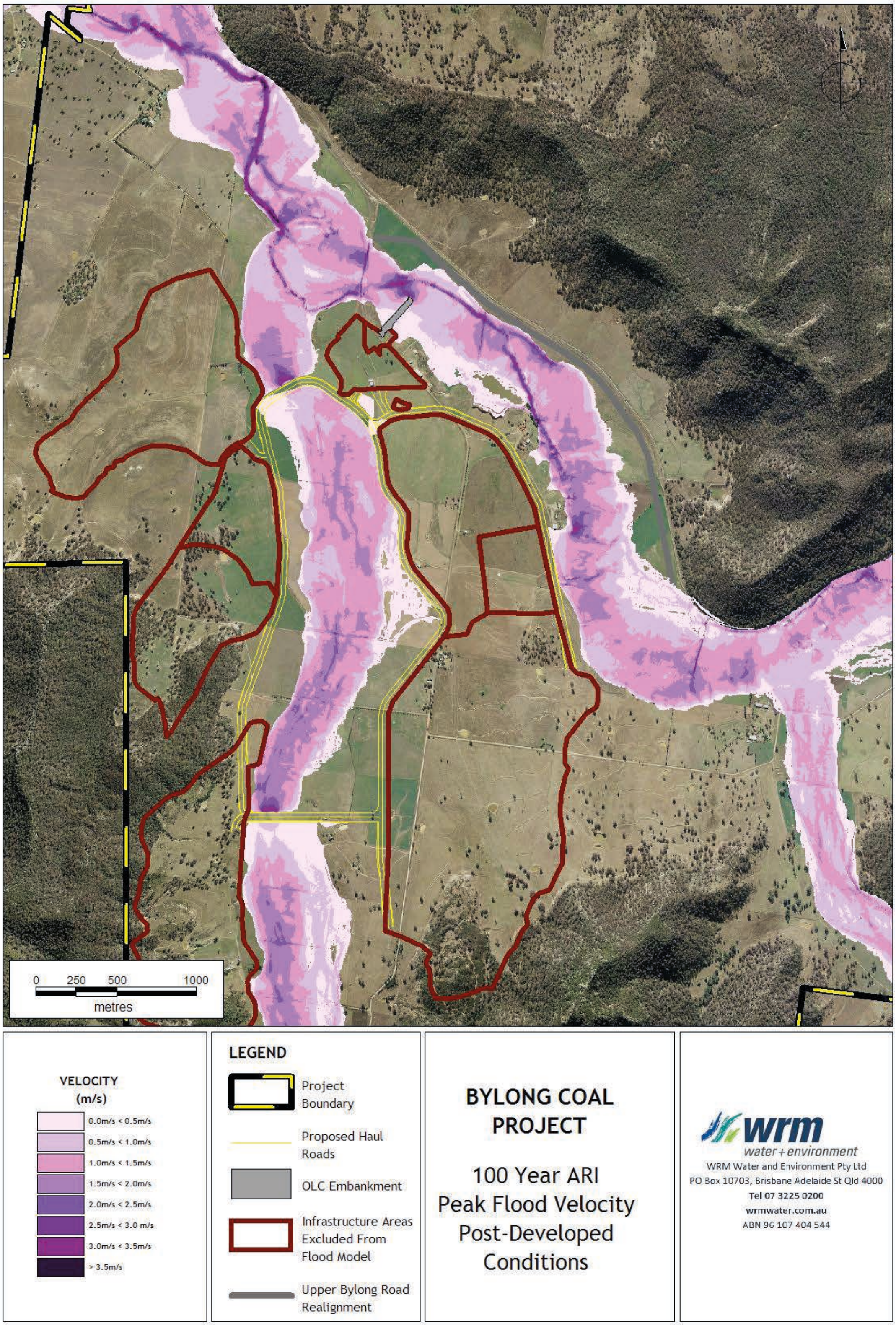


Figure 7.8 – 100 year ARI PY5 Developed Flood Velocity, Bylong River Catchment

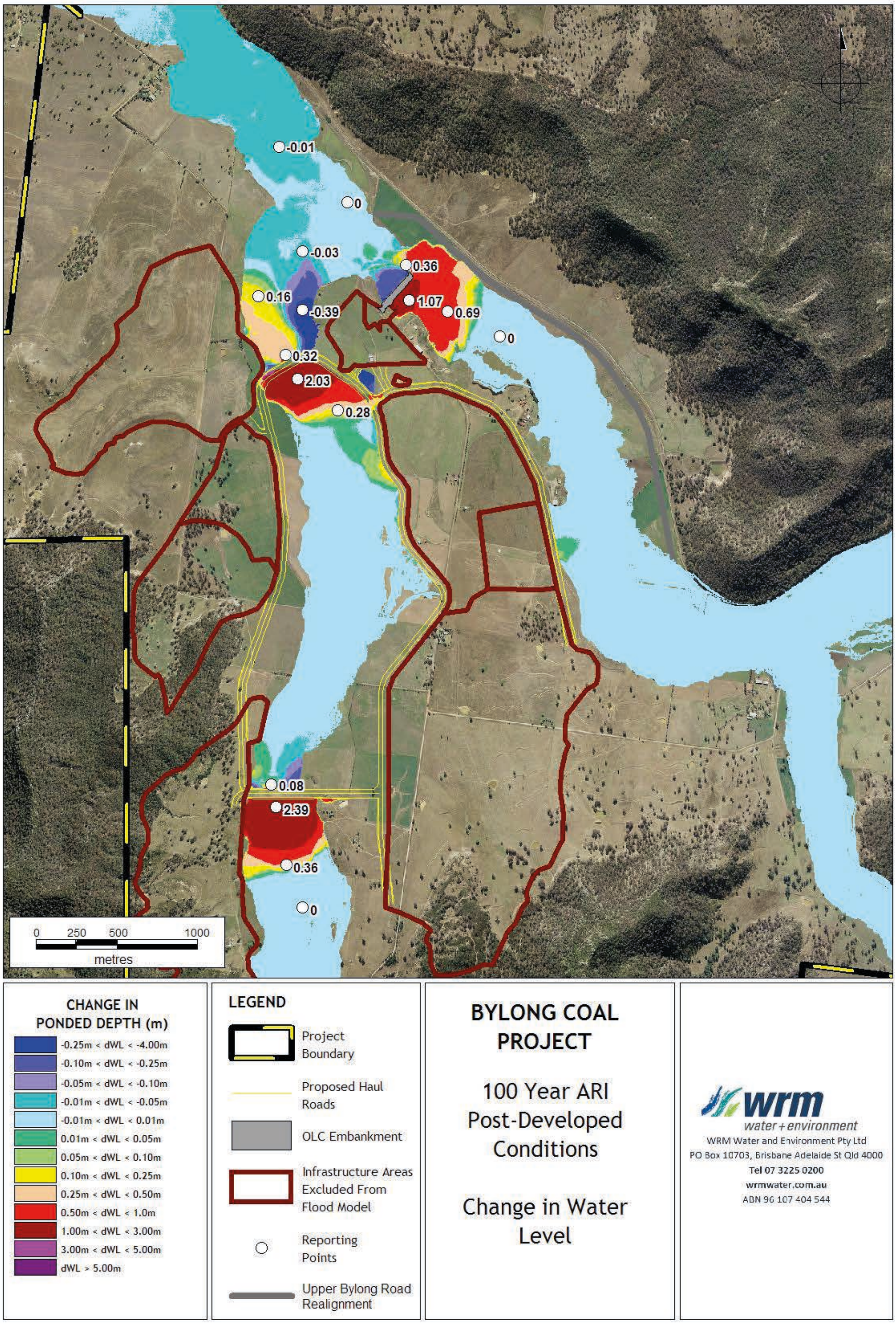


Figure 7.9 – 100 year ARI PY5 Developed Change in Water Level, Bylong River Catchment

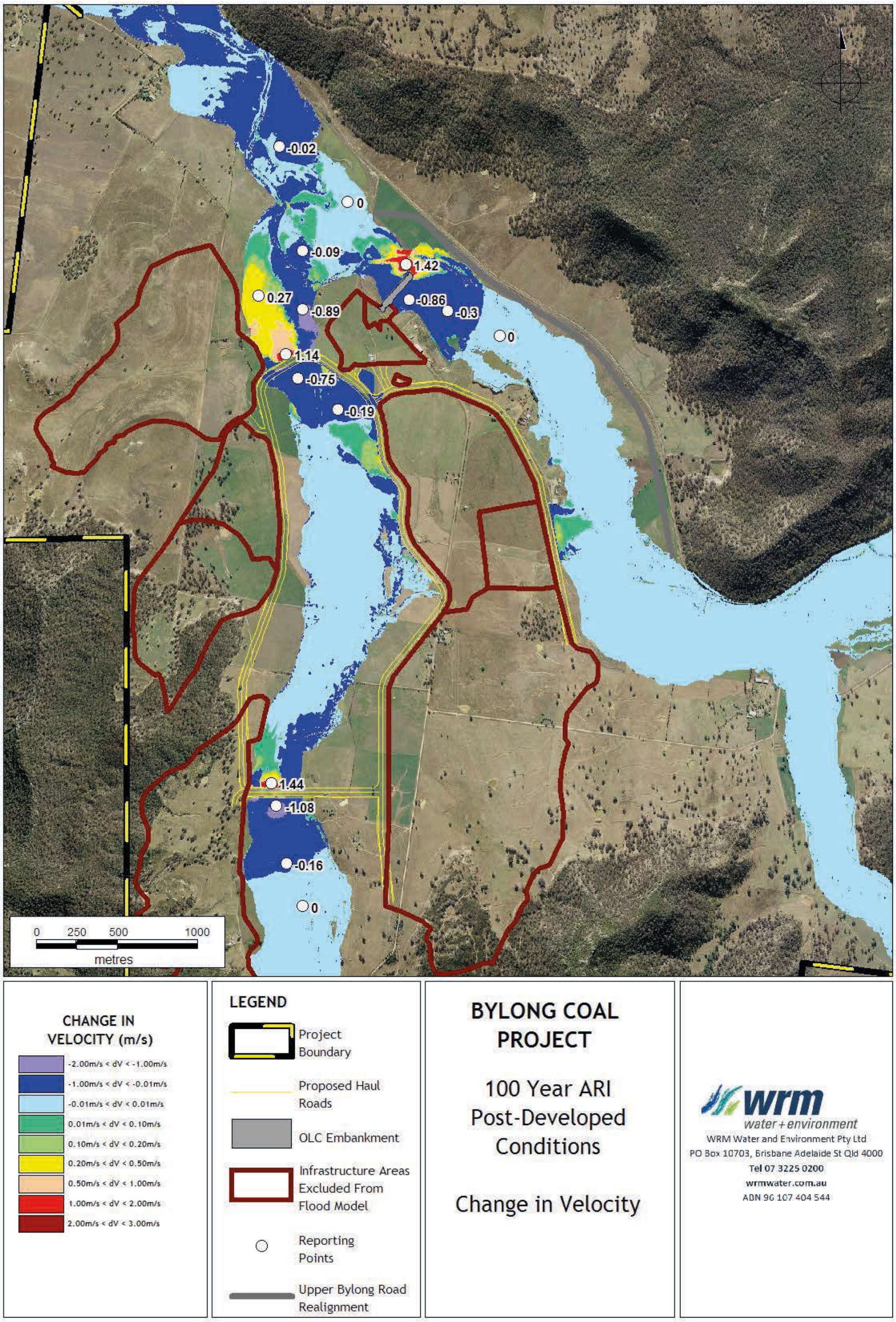


Figure 7.10 – 100 year ARI PY5 Developed Change in Velocity, Bylong River Catchment

8 Assessment of Dry Creek Flood Behaviour

8.1 OVERVIEW

To assess the potential impacts of mine subsidence in the Dry Creek catchment, detailed hydrologic and hydraulic models were developed for the Dry Creek catchment. The modelling for the Dry Creek catchment adopted a similar methodology to the modelling of the Bylong River. Details of the methodology and results of the modelling are provided in the following sections.

8.2 HYDROLOGIC MODELLING

8.2.1 Model Configuration

The Dry Creek catchment covers an area of 19.49 km^2 and was divided into 46 subcatchments for the XP-RAFTS model, using the CatchmentSIM software package (CatchmentSIM, 2005). Figure 8.1 shows the configuration of subcatchment nodes and routing links. The subcatchment areas and slopes are shown in Table 8.1. The XP-RAFTS model was run storm durations from 1 to 72 hours, for the 2, 50 and 100 year ARI design events.

Key points with regard to the adopted XP-RAFTS model parameters are:

- Routing link lengths and catchment slopes were determined from supplied LiDAR data using CatchmentSIM;
- A percentage impervious of 0% was adopted for all subcatchments;
- PERN 'n' values for each subcatchments were adopted based on proportional land use, with 0.10 adopted for open space and 0.16 adopted for dense bush;
- A channel routing 'X' of 0.25 was adopted for all routing links;
- A global 'Bx' factor of 1.3 was adopted; and
- An initial loss of 40 mm and a continuing loss of 2.5 mm per hour were adopted for the XP-RAFTS model.

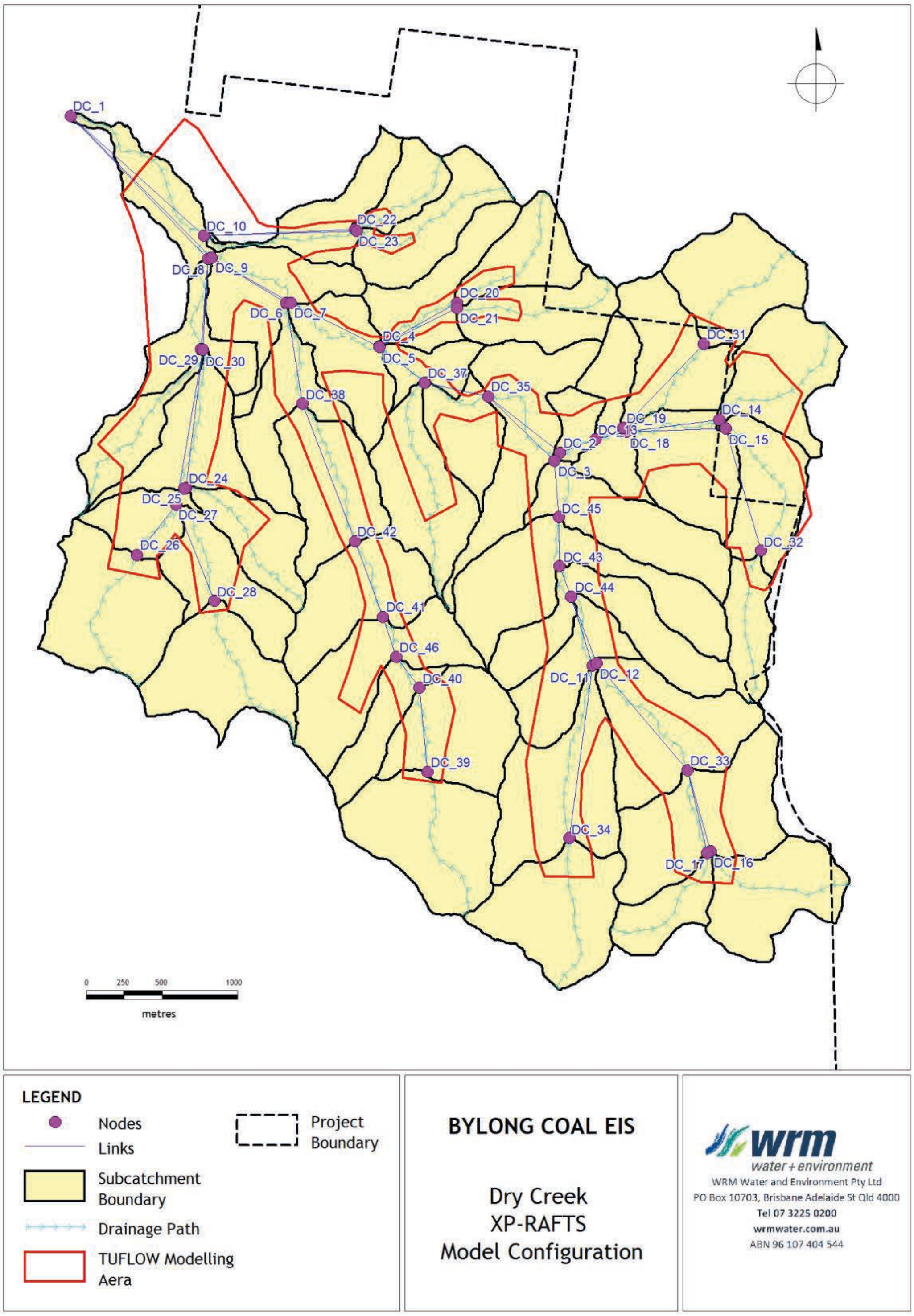


Figure 8.1 - Dry Creek XP-RAFTS model configuration

Table 8.1 - Dry Creek XP-RAFTS subcatchment parameters

Subcatchment ID	Subcatchment Area (ha)	Subcatchment Slope (%)
DC_1	28.43	1.7
DC_2	11.92	5.3
DC_3	50.1	4.3
DC_4	37.74	8.0
DC_5	17.04	4.6
DC_6	39.36	3.4
DC_7	39.76	3.4
DC_8	25.96	2.5
DC_9	46.76	2.7
DC_10	31.64	3.8
DC_11	67.95	4.7
DC_12	64.52	4.1
DC_13	31.27	5.6
DC_14	46.58	5.0
DC_15	39.87	4.2
DC_16	49.36	7.0
DC_17	22.5	7.3
DC_18	44.73	3.1
DC_19	46.68	4.4
DC_20	30.74	6.5
DC_21	37.81	6.3
DC_22	18.74	9.7
DC_23	39.67	7.4
DC_24	31.16	6.0
DC_25	22.38	7.1
DC_26	65.67	7.7
DC_27	38.09	4.8
DC_28	53.39	6.6
DC_29	24.98	5.1
DC_30	43.2	3.3
DC_31	51.61	5.6
DC_32	23.42	6.1
DC_33	69.62	5.9
DC_34	60.06	6.4
DC_35	59.94	4.7
DC_36	27.44	5.9
DC_37	49.83	5.9
DC_38	50.04	3.9
DC_39	66.84	8.1
DC_40	52.52	6.1
DC_41	56.36	6.5
DC_42	50.37	4.8
DC_43	52.96	3.6
DC_44	34.06	3.0
DC_45	73.12	4.8

8.2.2 Hydrologic Model Verification

There are no streamflow gauging stations in the Dry Creek catchment. Hence, the hydrologic model was verified by comparing model-predicted design discharges to the Rational Method. Design rainfall data for events up to the 100 year ARI design event was obtained from the BoM AR&R87 IFD tool (BoM, 2014). Rational Method estimates of peak discharge were calculated in accordance with the Eastern NSW Rational Method from Australian Rainfall and Runoff (IEAust, 1998). A C_{10} value of 0.20 and the frequency factors given in Table 8.2 were adopted.

Table 8.2 - Adopted Rational Method Frequency Factors - Dry Creek

Parameter	Adopted Value
FF_2	0.54
FF_{50}	1.71
FF_{100}	2.14

Table 8.3 shows a comparison of estimated peak design discharges for the 2, 50 and 100 year ARI design events with Rational Method estimates at the catchment outlet (Node DC_1). It also shows peak discharge estimates from corresponding node LB5 in the regional Bylong River XP-RAFTS model. The results show that the Dry Creek XP-RAFTS model reproduces both the Rational Method and Bylong River XP-RAFTS model discharges reasonably well for the 50 and 100 year ARI design events. The XP-RAFTS flows are slightly higher than those calculated using the Rational Method for the 2 year ARI design event. The XP-RAFTS model discharges were adopted for this assessment.

Table 8.3 - Comparison of Rational Method and XP-RAFTS peak discharges

	XP-RAFTS (DC_1)	Rational Method		XP-RAFTS (LB5)	
	Discharge (m^3/s)	Discharge (m^3/s)	Difference (%)	Discharge (m^3/s)	Difference (%)
2 year ARI	13.5	8.58	57%	11.1	22%
50 year ARI	58.9	52.1	13%	60.0	-2%
100 year ARI	74.4	74.1	0%	74.5	0%

8.2.3 Estimation of Design Discharges

Rainfall patterns and intensities for design events up to the 100 year ARI event were determined using standard procedures in Australian Rainfall and Runoff (IEAust, 1998). The Dry Creek XP-RAFTS model was run for storm durations from 1 to 72-hours to estimate the 2, 50 and 100 year ARI design discharges. Table 8.4 shows the estimated design discharges and critical storm durations at several of the hydraulic (TUFLOW) model inflow boundary locations.

Table 8.4 - Peak discharge and critical duration at selected locations, Dry Creek XP-RAFTS model

Location	Design Peak Discharges (m^3/s)		
	2 year ARI	50 year ARI	100 year ARI
DC_1	13.3	58.9	74.4
DC_26	0.63	2.78	3.50
DC_31	0.30	1.52	1.87
DC_33	0.92	4.29	5.23
DC_34	0.37	1.80	2.22
DC_46	1.00	4.48	5.51
Critical Duration	**30 Hrs**	**9 Hrs**	**9 Hrs**

8.3 HYDRAULIC MODELLING

8.3.1 Overview

A TUFLOW model was developed to estimate design flood levels, depths, velocities and extents in the Dry Creek catchment area for the 2, 50 and 100 year ARI design events for existing conditions and post-subsidence conditions. The Dry Creek TUFLOW model, which was simulated using the TUFLOW GPU Solver, used a variable time step determined by the modelling software package.

Design flood hydrographs predicted by the XP-RAFTS models were used as inflows into the TUFLOW model.

8.3.2 Model Extent and Configuration

Figure 8.2 shows the extent of the TUFLOW model developed for the Dry Creek catchment. The TUFLOW model was developed using a 2 m grid due to the complexity of the watercourses located within the Dry Creek catchment.

8.3.3 Topography

A DTM of Dry Creek floodplain, with a grid size of 1.0 m, was developed using LIDAR data. The LIDAR data was acquired from a fixed wing aircraft on the 8th March and 9th of April, 2011. The area covered by both flights is approximately 320 square kilometres. The LIDAR data has a horizontal and vertical accuracy of +/- 0.2 m.

8.3.4 Adopted Manning's 'n' values

The TUFLOW model uses Manning's 'n' values to represent hydraulic resistance (notionally channel or floodplain roughness). Discrete regions of continuous vegetation types and land uses were mapped, and an appropriate roughness value assigned to each region based on published values such as those in Chow (1957). Vegetation and land use mapping was undertaken using aerial photography. The adopted Manning's 'n' values were:

- Thick grass/Floodplain: 'n' = 0.045
- Dry Creek Beds: 'n' = 0.03
- Vegetated Overbanks and Forested Areas: 'n' = 0.08
- Buildings: 'n' = 0.10

8.3.5 Inflow boundaries

Figure 8.2 shows the location of inflow boundaries used in the Dry Creek catchment TUFLOW model. Model inflows were extracted from the XP-RAFTS hydrological model. Catchment hydrographs were applied to the 2D model domain as a local or total catchment hydrograph for the appropriate sub catchment or inflow boundary.

8.3.6 Downstream boundary conditions

A HT (water level) Boundary was used as the downstream boundary in the Dry Creek TUFLOW model which was located approximately 0.9 km upstream of the confluence of the Bylong River and Dry Creek.

8.3.7 Waterway Structures

Dry Creek and its tributaries traverse underneath Bylong Valley Way at several locations. These crossings would be overtopped during minor flooding events and therefore were not explicitly represented in the Dry Creek TUFLOW model.

8.3.8 Post-Subsidence Model Configuration

The ground levels within the existing case hydraulic model were amended to include the proposed post-subsidence ground elevations predicted following the mining of the last longwall panel (LW206). This data was supplied to WRM by MSEC (EIS Subsidence Impact Assessment) as a fine grid which was subtracted from the existing DTM to reflect the post-subsidence conditions. The depth of the predicted subsidence is up to 3.2 m. The configuration of the post-subsidence TUFLOW model and the depths of subsidence panels are shown in Figure 8.3.

The adopted hydrology, Manning's 'n' values and tailwater conditions for the post-subsidence model was identical to those included in the existing conditions model.

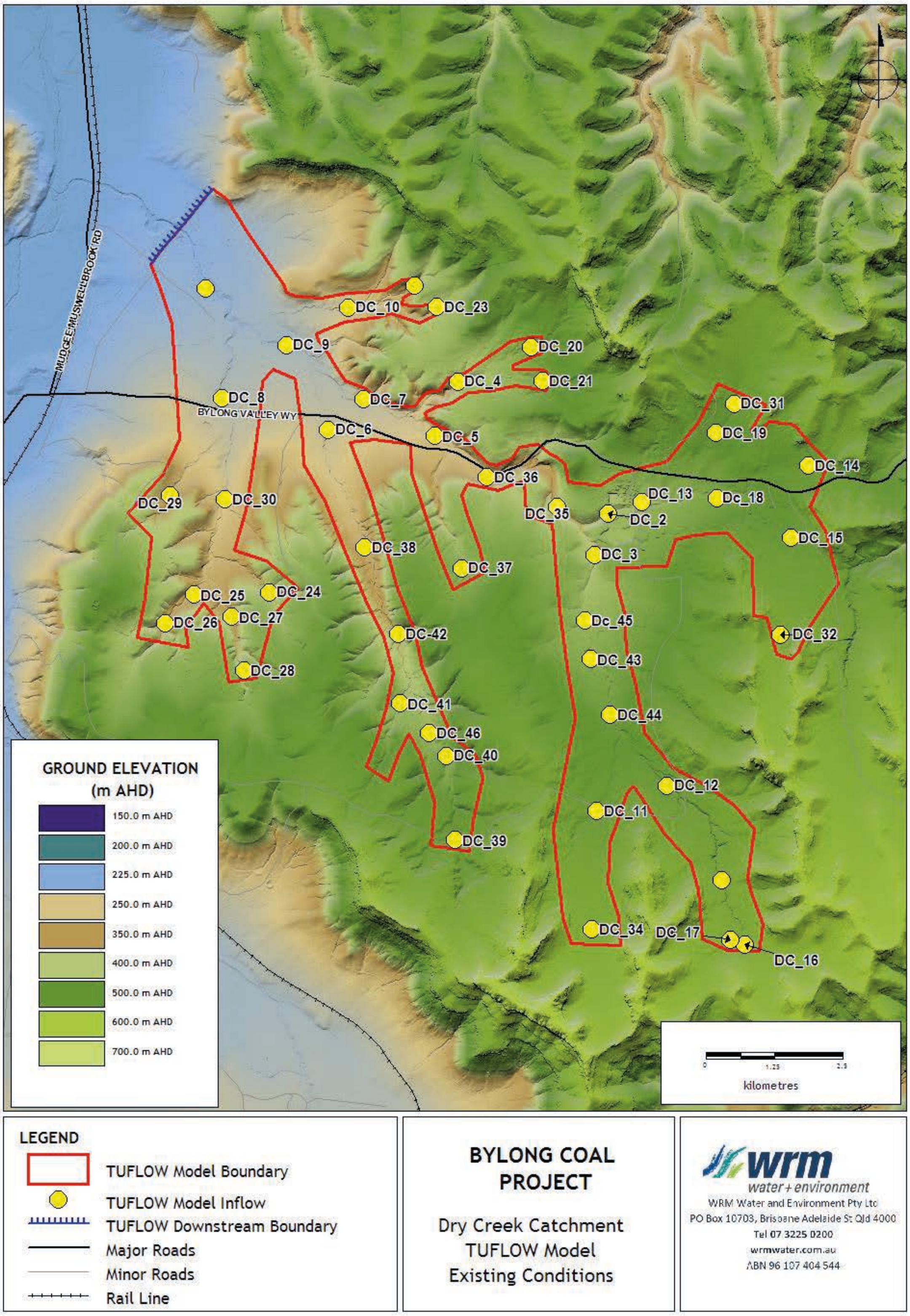


Figure 8.2 - Existing TUFLOW model configuration, Dry Creek Catchment

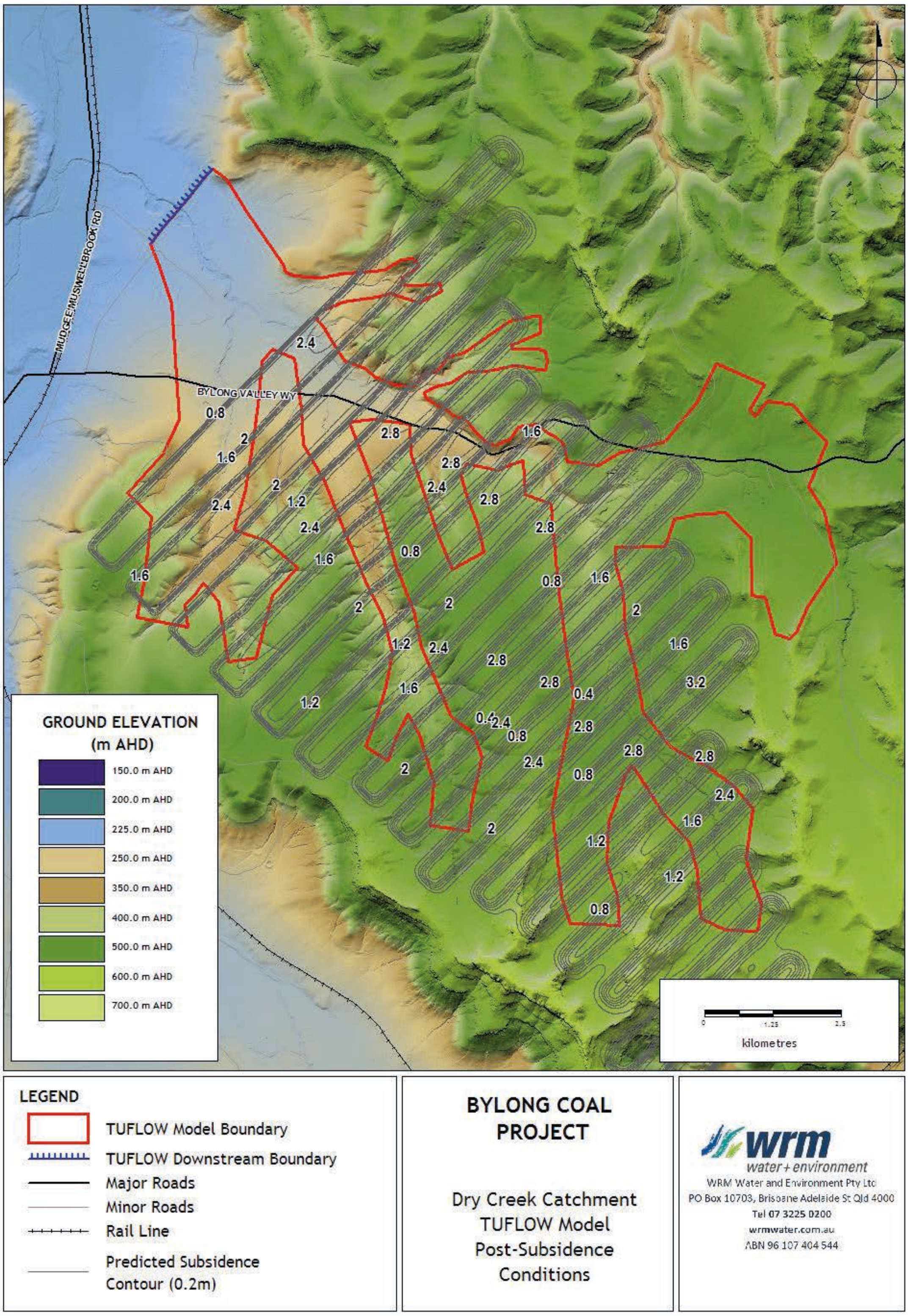


Figure 8.3 – Post Subsidence TUFLOW model configuration, Dry Creek Catchment

8.4 HYDRAULIC MODELLING RESULTS

8.4.1 Overview

The Dry Creek catchment TUFLOW model was run for the 2, 50 and 100 year ARI design events for existing and post-subsidence conditions. Plans showing the maximum flood extents, depths and velocities for the 2, 50 and 100 year ARI design events are presented in Attachment 3. Plans showing the maximum flood extents, depths and velocities for the 2, 50 and 100 year ARI design events are presented in Attachment 4. Plans showing the change in water level and velocity under post-subsidence conditions are also presented in Attachment 4.

8.4.2 Existing Conditions

The Dry Creek catchment contains contain small, incised channels in the upper reaches with wider floodplain areas in the lower section of the catchment. The model results indicate that the highest depths are confined to the Dry Creek and tributary channels with shallower depth at the fringes of the floodplain. Flow depth within the Dry Creek channel is typically between 1.0 m and 2.0 m during the 100 year ARI design event with isolated areas slightly greater than 3.0 m. Similarly, the highest velocities are generally confined to the Dry Creek channels.

Plans showing the existing maximum flood extent, depth and velocity for the 100 year ARI design event under existing conditions are presented in Figure 8.4 and Figure 8.5.

8.4.3 Post-Subsidence Conditions

Plans showing the existing maximum flood extent, depth and velocity for the 100 year ARI design event under post-subsidence conditions are presented in Figure 8.6 and Figure 8.7. Plans showing the change in water level and velocity for the 100 year ARI design event under post-developed conditions are also presented in Figure 8.8 and Figure 8.9.

8.4.4 Analysis of Impacts

The mine subsidence causes a general reduction in flood level along Dry Creek. Changes in water level typically reflect the change in ground elevations caused by the subsidence with a maximum reduction in water level of 3.0 m occurring along the main channel of Dry Creek during the 100 year ARI design event, commensurate with the reduction in ground level. This difference is replicated in the 2 year and 50 year ARI design events. The predicted subsidence also results in isolated increases in water level where the channel capacity has reduced.

The predicted subsidence also results in a change in stream velocity in all design events with some isolated increases located between subsidence panels (across the chain pillars). Velocity is typically reduced in the base of the subsidence panels.

Flows are typically contained within the channels of Dry Creek and its tributaries under post-subsidence conditions in a similar manner to existing conditions. The exception is a breakout of flow located along the western edge of the western-most subsidence panel (LW206) in the vicinity of Bylong Valley Way during the 50 year and 100 year ARI design events. The subsidence has resulted in flow within a tributary channel breaking out to flow in north-easterly direction along the edge of the subsidence panel and across Bylong Valley Way before flowing to the north towards Dry Creek. The depths and velocities of the flow in this breakout are less than 0.25 m and 0.75 m/s, respectively, for the 50 year and 100 year design events.

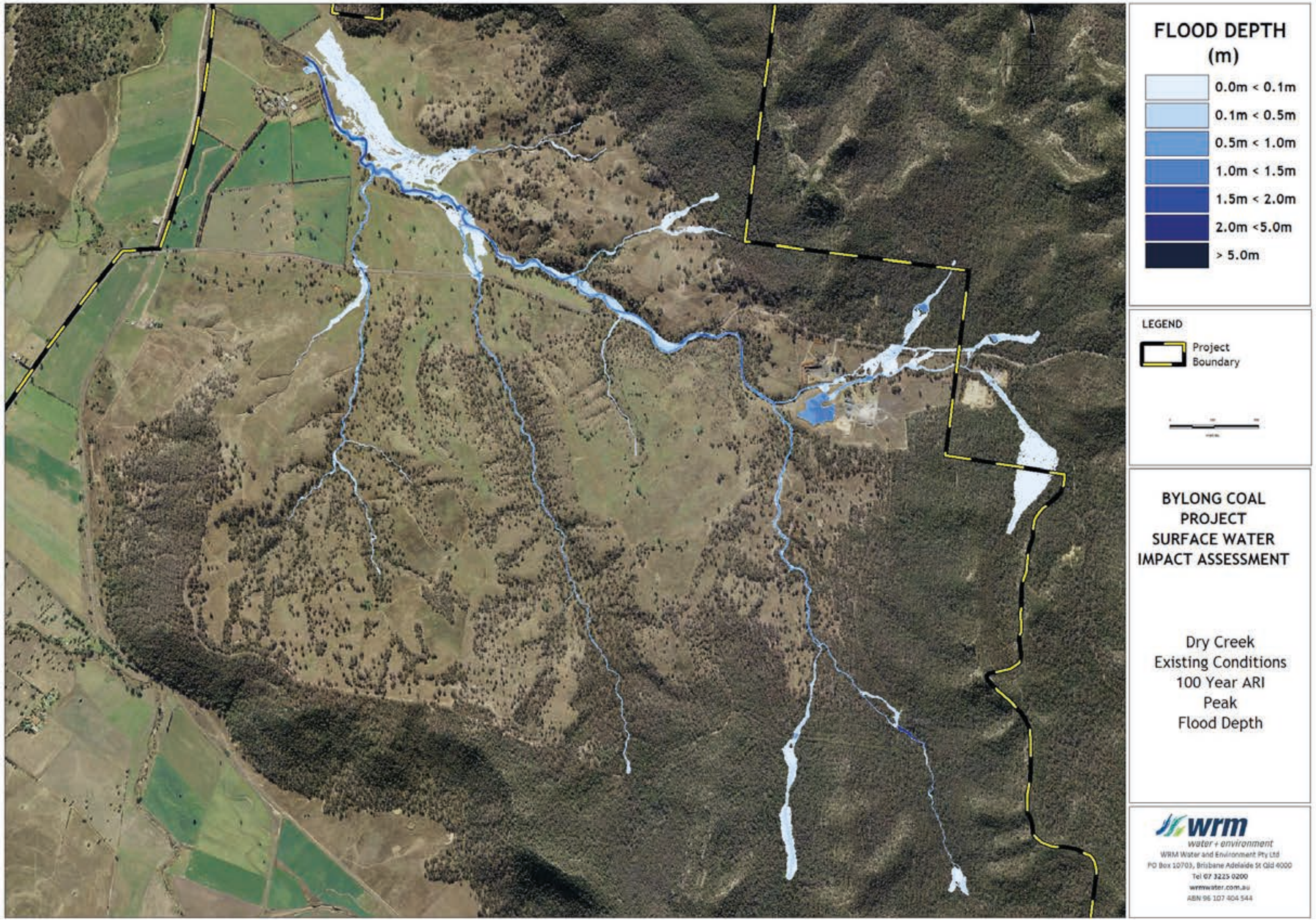


Figure 8.4 - 100 Year ARI Existing Flood Depth, Dry Creek Catchment

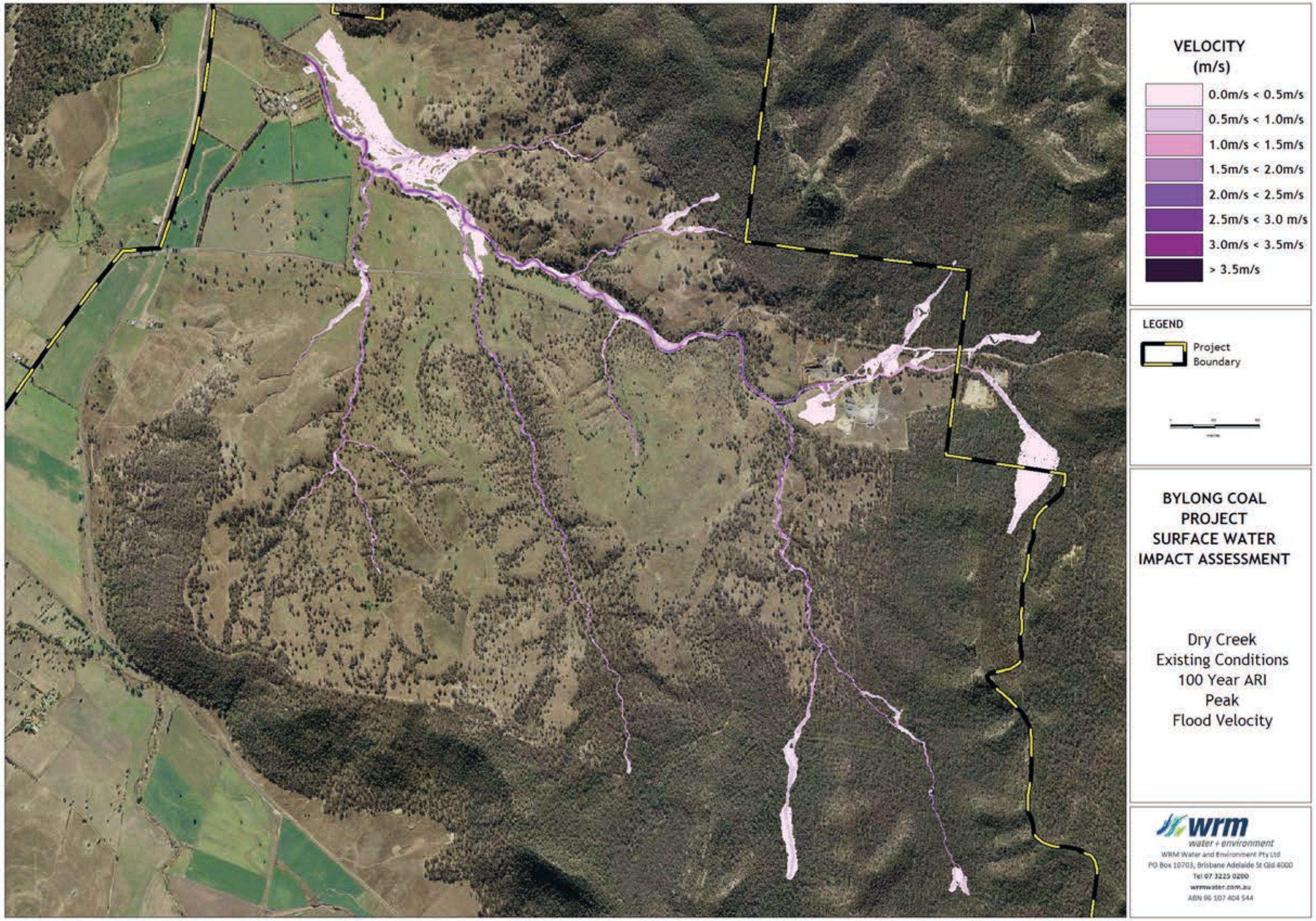


Figure 8.5 - 100 Year ARI Existing Flood Velocity, Dry Creek Catchment

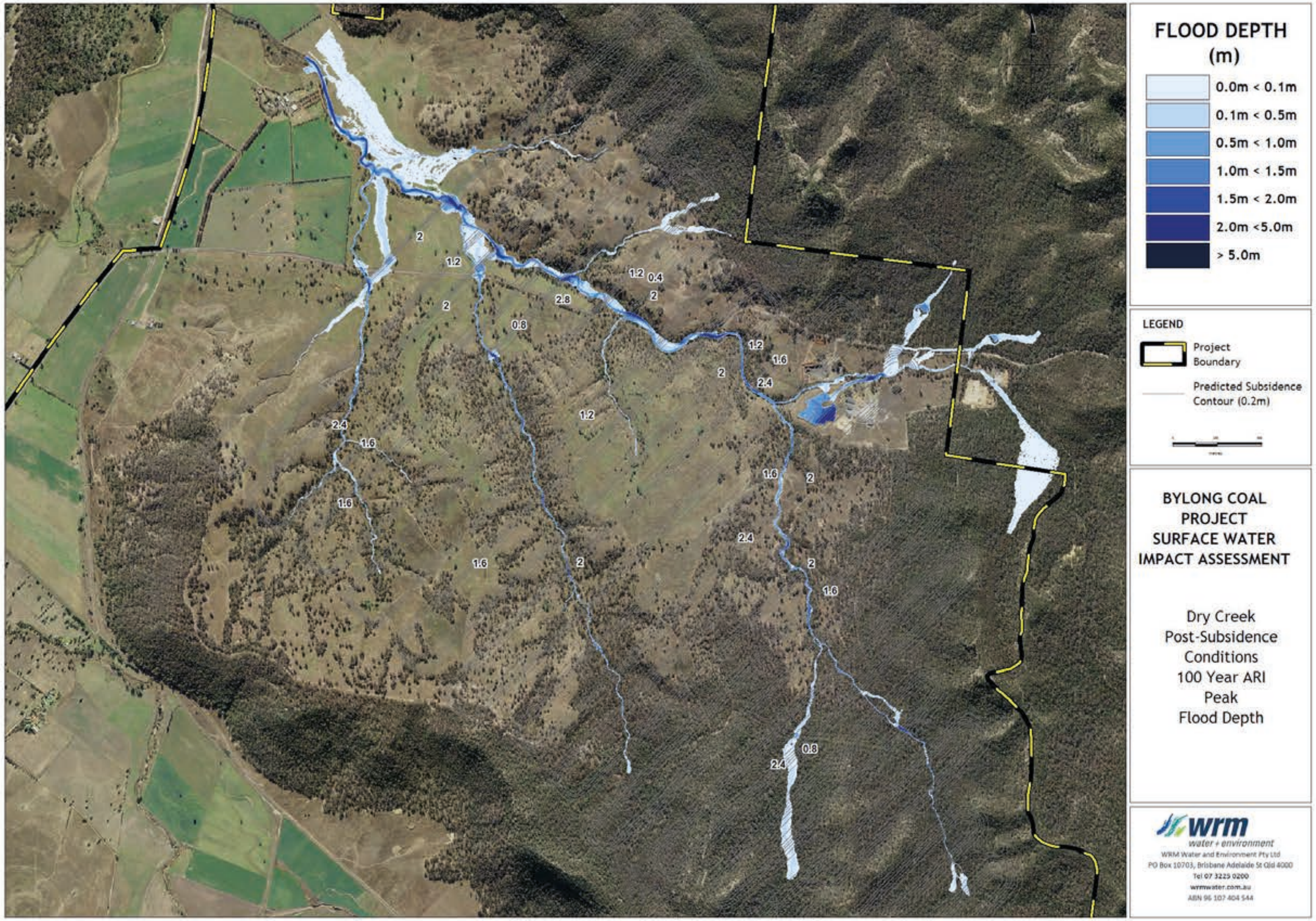


Figure 8.6 - 100 Year ARI Post-Subsidence Flood Depth, Dry Creek Catchment

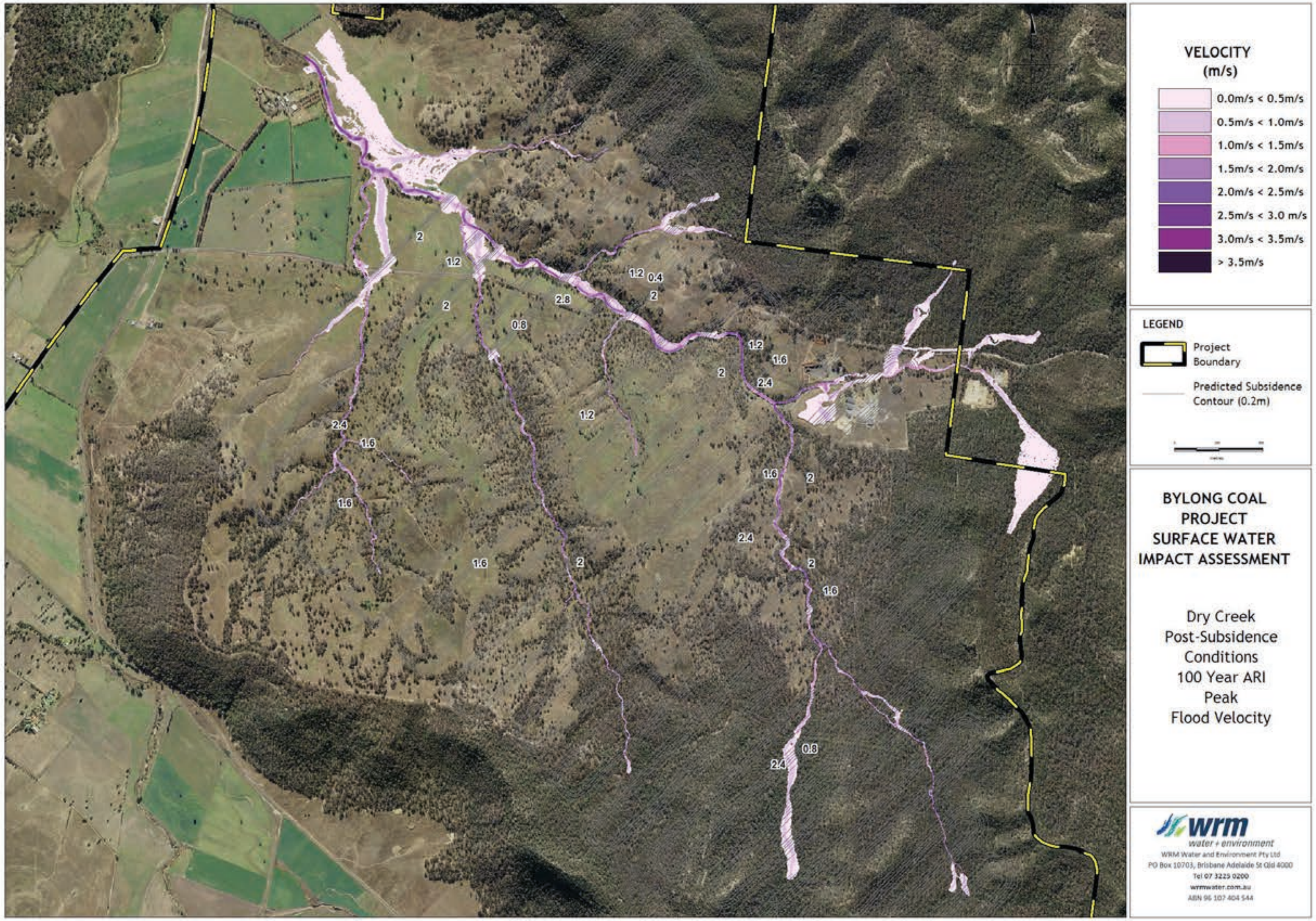


Figure 8.7 - 100 Year ARI Post-Subsidence Velocity, Dry Creek Catchment

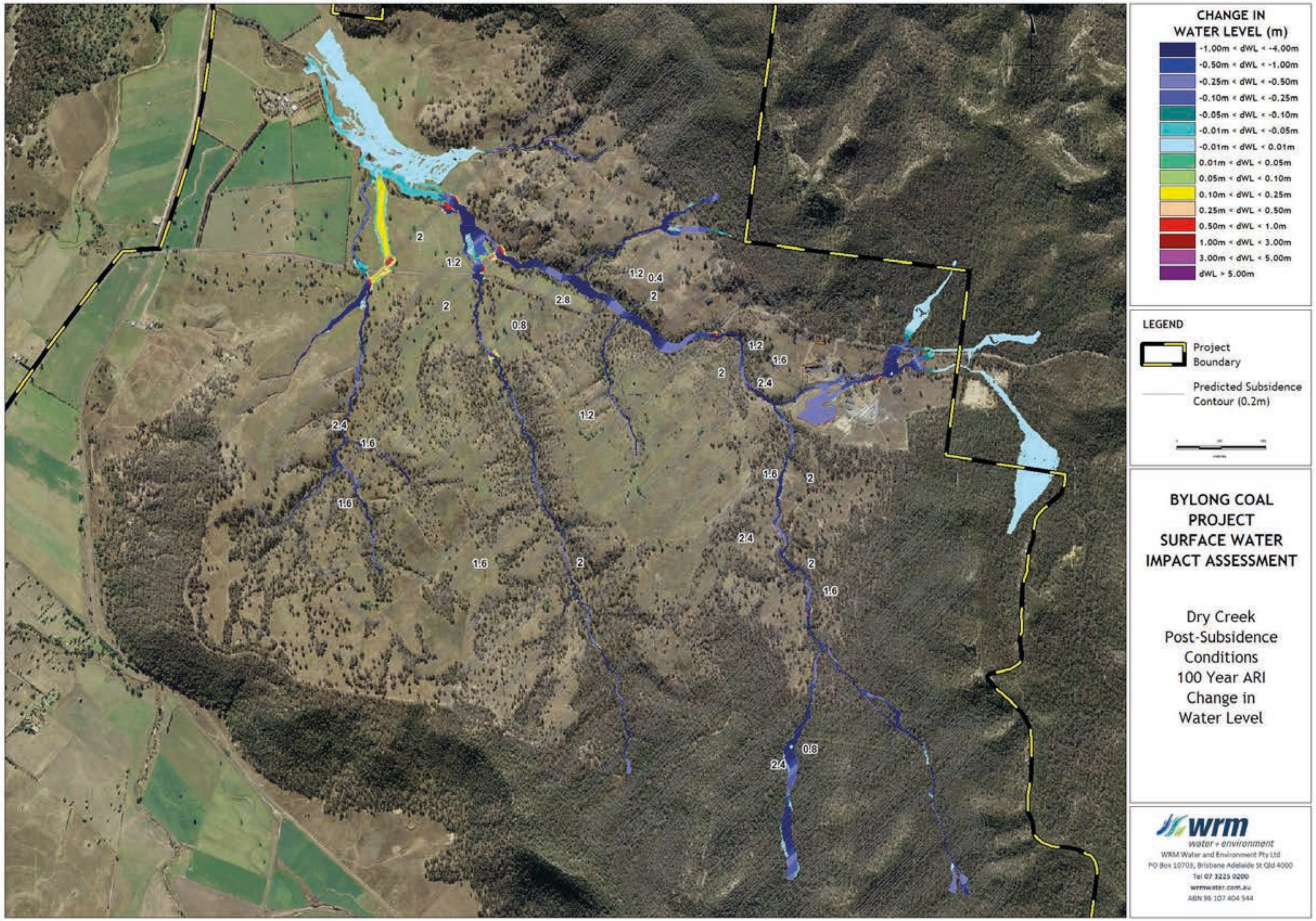


Figure 8.8 - 100 Year ARI Change in Water Level, Dry Creek Catchment

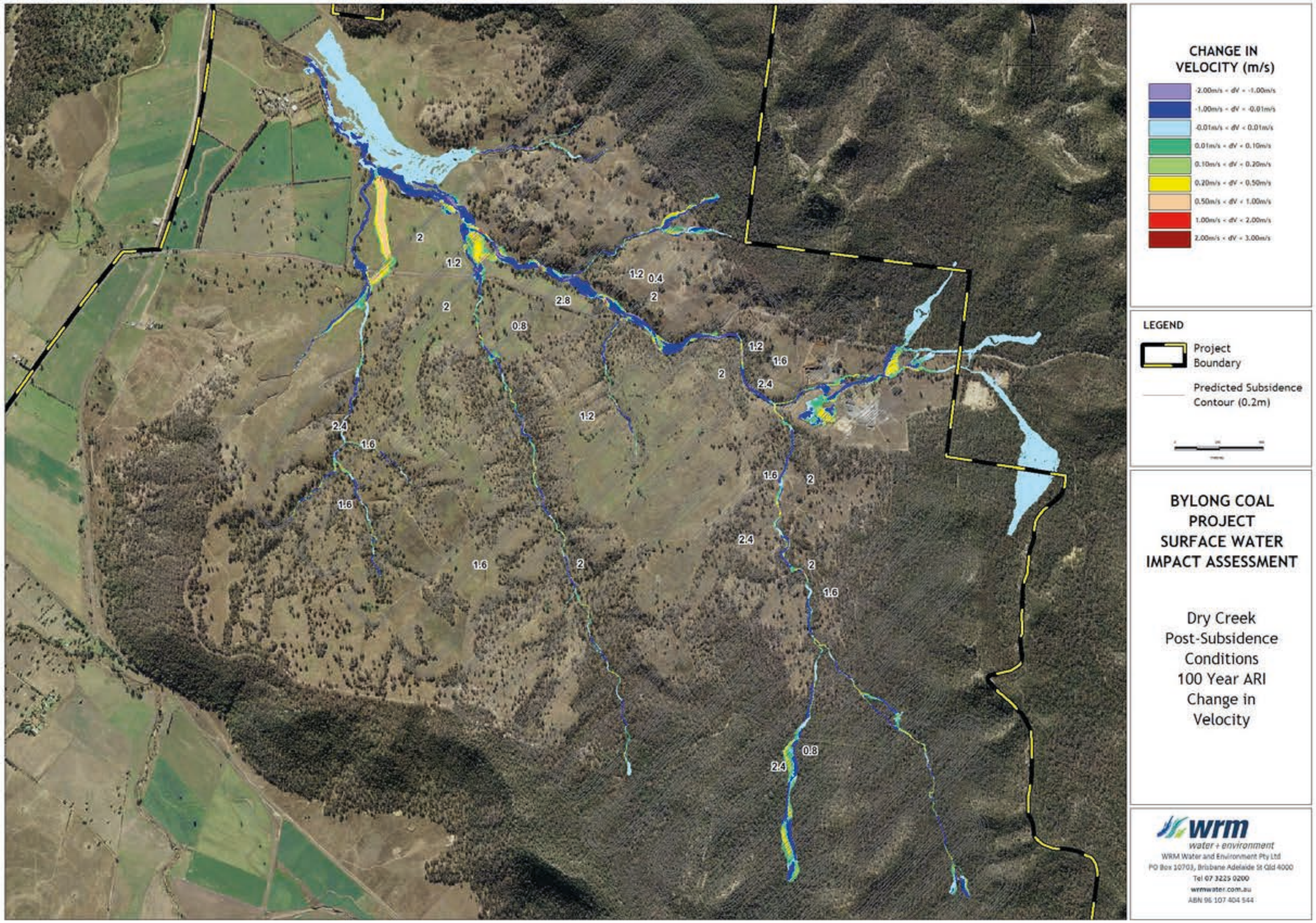


Figure 8.9 - 100 Year ARI Change in Velocity, Dry Creek Catchment

9 Impact Assessment

9.1 POTENTIAL IMPACTS

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

- impacts on regional water availability due to the need to extract bore water to meet the operational water requirements of mining operations;
- adverse impacts on the quality of surface runoff draining from the disturbance areas to the various receiving waters surrounding the Project, during both construction and operation of the Project;
- loss of catchment area draining to local drainage paths due to capture of runoff within onsite storages and the open cut pit;
- potential impacts on flood levels and flood velocities in the Bylong River and its tributaries, including Dry Creek.

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

The assessment of surface water impacts has been undertaken based on commonly applied methodologies for the simulation of hydrologic and hydraulic processes using currently available data. The adopted approach is considered suitable for quantifying impacts to a level of accuracy consistent with current industry practice. Certain aspects of the project, such as changes to landforms due to construction of overburden emplacements or mine subsidence, will create impacts that are irreversible, although this does not mean that any such impacts are necessarily detrimental to the environmental values of receiving waters.

9.2 REGIONAL WATER AVAILABILITY

9.2.1 Bylong River Water Source

Water taken from the Bylong River Water Source by the Project is required to be licensed by way of a water access licence under the Hunter River Unregulated and Alluvial Water Sharing Plan. Schedule 5 of the *Water Management (General) Regulation 2011* provides a number of exemptions for requiring a water access licence for taking water from a water source.

9.2.2 Harvestable Rights

Under the WM Act, landholders in most rural areas are permitted to collect a proportion of the rainfall runoff on their property and store it in one or more dams up to a certain size. This is known as a 'harvestable right'. A dam can capture up to 10 percent of the average regional rainfall runoff for their landholding without requiring a licence.

Based on the Project’s total landholding within the Study Area of 5,467 ha and a harvestable rights multiplier value of 0.065 ML/ha for the relevant area, the total harvestable right for the Project is 355 ML.

The Project’s landholding includes 63 existing farm dams (see Figure 9.1) with a combined total surface area of 5.9 ha. Based on an average depth of 1.5 m, the total capacity of existing farm dams is estimated at 89 ML. Subtracting the capacity of existing farm dams (89 ML) from the harvestable right (355 ML) leaves an available harvestable rights volume of 266 ML.

9.2.3 Excluded Works

The water management system for the Project has been designed to minimise the capture of clean runoff wherever possible. Schedule 5, clause 12 of the *Water Management (General) Regulation 2011* provides that a water access licence is not required for water take that is caused by an "excluded work" as outlined in Schedule 1. Schedule 1, clause 3 of the *Water Management (General) Regulation 2011* provides that dams solely for the capture, containment and recirculation of mine affected water consistent with best management practice to prevent the contamination of a water source are "excluded works".

On this basis, water captured in the site water management structures with the exception of rainfall runoff from undisturbed natural catchments, is not subject to licencing requirements.

9.2.4 Natural Catchments

The capture of runoff from undisturbed natural catchment draining to the any of the site water management dams may require a Water Access Licence. Figure 9.2 shows the undisturbed catchment areas draining to the site water management dams. For the Bylong River Water Source, the maximum undisturbed catchment that is proposed to be captured by the Project is approximately 123 ha.

The estimated maximum annual runoff capture from the undisturbed area of 123 ha is 149 ML. This volume has been estimated using a runoff depth of 121 mm, based on the maximum annual rainfall at Kerrabee (Murrumbo) (BoM Station No. 62046) of 1,208 mm and a volumetric runoff coefficient of 0.10 (10%) which is the runoff coefficient used for harvestable rights calculations (10% of runoff = 0.065 ML/ha = 6.5 mm runoff. 100% of runoff = 65 mm. 65mm/657 mm average annual rainfall = 10%).

The available harvestable rights volume of 266 ML (excluding existing farm dams) significantly exceeds the estimated maximum runoff capture volume from undisturbed areas of 149 ML. Hence, the capture of runoff within the mine water management system does not require licensing.

9.2.5 Mine Site Water Requirements

A significant proportion of mine site water requirements will be sourced from water collected on the site, including rainfall runoff and groundwater inflows to the open cut mining area which will be stored in the Mining Areas Water Storage for re-use.

The results of the water balance modelling (see Section 6) show that the existing water licence allocation from the bores of 2,535 units (currently equivalent to 2,535 ML/year) significantly exceeds the requirement for external water supply to satisfy all site demands for all years of operation, even in the driest climatic sequence experienced over the past 125 years. Further water allocations under the HUAWSP may also be secured by KEPCO into the future through a new water licence application under Part 5 of the Water Act.

The impact of the groundwater extraction and interception on regional water availability is given in the EIS Groundwater Impact Assessment for the Project completed by AGE (2015). As all makeup water supplies for the Project would be obtained from the alluvial borefield under existing Water Access Licences held by KEPCO , there is not anticipated to be any adverse impact on other licensed groundwater users within the water source who will still have access to their entitlement (subject to climatic conditions and the operation of the water supply scheme).

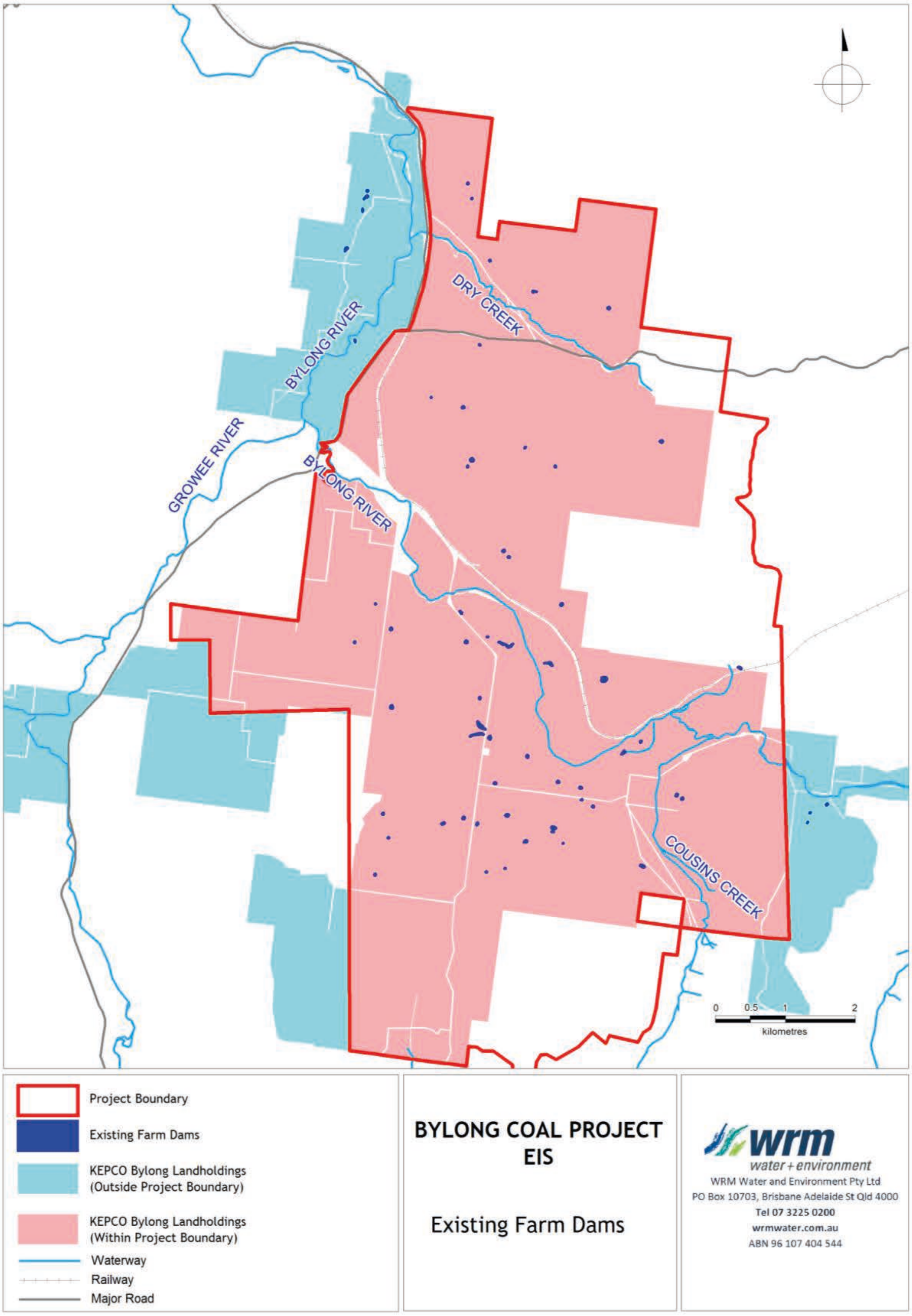


Figure 9.1 – Existing farm dams on KEPCO property

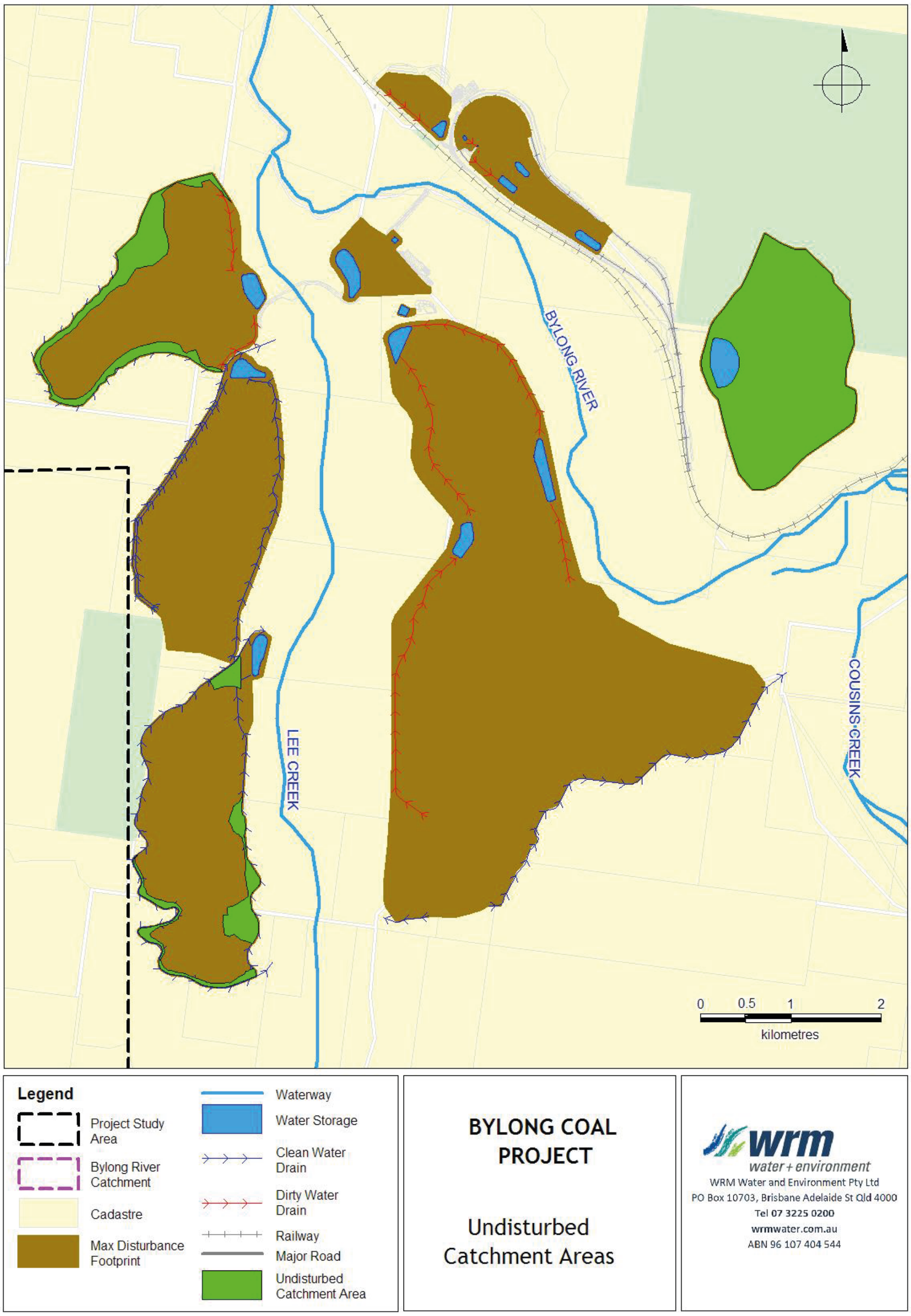


Figure 9.2 – Natural catchment areas draining to the mine water management system

9.3 WATER QUALITY IMPACTS

9.3.1 Construction Phase Impacts

Key activities during the construction phase will include land clearing and earthworks associated with construction of the rail loop, CHPP and mine infrastructure areas, as well as road upgrades and construction of water management structures. The potential impacts during the construction phase of the Project primarily relate to the potential for release of sediment in surface runoff due to land disturbance from construction activities.

The management of surface runoff during the construction phase of the Project will be in accordance with a Construction Water Management Plan (CWMP). The CWMP will identify the erosion and sediment control measures to be implemented on the site, taking into account the staging of construction works. All management measures will be designed in accordance with relevant standards and best practice guidelines, including *'Managing Urban Stormwater: Soils and Construction, Volume 1'* (Landcom, 2004). The CWMP will also identify requirements for storage of fuels and other potential contaminants to minimise the risk of release of other pollutants.

Water use during the construction phase (estimated at approximately 5.2 ML/a – see Section 5.4.4) will be very small compared to the operational water requirements. All water required for construction will be obtained from appropriately licensed groundwater bores.

9.3.2 Operational Phase Impacts

The results of the water balance modelling indicate that under the current model assumptions and configuration, there are no uncontrolled spills of mine-affected water from the Product Stockpile Dam, Fill Point Dam, CHPP Coal Contact Dam, Feeder Floor and Reject Overflow Dam, OC MIA Dam, UG MIA Dam or the open cut pits. Therefore the mine water management system is sufficient to protect the environmental values of the receiving waters.

Some overflow of water from sediment dams may occur during wet periods that exceed the design standard of the sediment control system (see Section 5.9.1). Available geochemical information indicates that the runoff draining to most of the sediment dams should have salinity consistent with receiving waterways. Overflows would only occur during significant rainfall events which will also generate runoff from surrounding undisturbed catchments. Hence, it is unlikely that sediment dam overflows will have a measurable impact on receiving water quality.

9.3.3 Surface water salt load impacts on receiving catchments

The surface water salt load on the receiving environment in Bylong River is potentially impacted in two ways:

- A reduction in catchment area results in an effective reduction in salt load to the receiving environment; and
- An increase in salt load from sediment dam overflows.

The net impact on the Bylong River at a location immediately downstream of the Bylong River/Lee Creek confluence has been assessed. Table 9.1 provides a summary of the salt balance for the pre-mine catchments and each phase of the mine life.

The model results show that the total average salt load released offsite in surface runoff is reduced by the Project, when compared with the pre-mine case. The average annual salt load released to Bylong River is reduced by around 5.6% to 8.4%, depending on the mine phase. Note that this represents a likely upper limit of the salt load impact since the quality of surface runoff from rehabilitated areas is likely to improve over time.

Under normal operation, runoff from OEAs collected in sediment dams is pumped back for use in the mine water management system. Sediment dams would only spill following extended periods of significant rainfall that exceed the design criteria. Under these conditions, it is likely that the quality of water collected in sediment dams would be improved by fresh surface runoff inflows.

Table 9.1 – Long Term Average Surface Water Salt Balance

	Pre-mine	PY 3	PY 5	PY 7	PY 9	PY11+
	Average Annual Salt Balance (tonnes/year)					
Bylong River Salt Load						
Catchment Runoff	3,947	3,610	3,553	3,546	3,539	3,539
Dam Overflows	-	5	142	178	119	128
Total	**3,947**	**3,615**	**3,695**	**3,724**	**3,658**	**3,668**

9.3.4 Post-Mining Impacts

Once the post-mining landform is established and rehabilitated, it is expected that long-term water quality from surface runoff should be similar to pre-mining conditions. However, there is the potential for seepage through the backfilled overburden and coarse and fine reject materials to have some impact on the salinity of water in the alluvial aquifer in the vicinity of the Project.

An assessment of the potential impact on the salinity of post-mining alluvial groundwater (AGE, 2015) indicates that salinity may rise from about 699 to 783 mg/L. This could potentially result in an increase in baseflow salinity in the Bylong River by a similar amount. The results of the groundwater modelling completed by AGE indicate an average annual baseflow volume of the order of 500 ML. Hence, the change in baseflow salinity could potentially increase the baseflow salt load from about 350 tonnes per year to 392 tonnes per year. Assuming no change in the salinity of surface runoff compared to pre-mining (see Table 9.1), the total salt load (surface runoff plus baseflow) could increase from 4,297 to 4,339 tonnes per year, an increase of just under 1%.

When considered in the context of variability of background salinity (see Figure 3.30), a change in average salt load of less than 1% would be virtually undetectable. Such a change would be unlikely to affect stream health as indicated by the River Condition Index (see Section 3.4) which considers stream geomorphology, riparian vegetation, hydrology and biodiversity. Ongoing monitoring will be undertaken to confirm the magnitude of any impact on baseflow quality. The results of background water quality monitoring to date show that vegetated areas of the catchment have lower salinity runoff. Hence, any observable impact could be mitigated through catchment revegetation, which could be applied to the immediate vicinity of the Project, as well as the extensive biodiversity offset areas (> 30 km^2) to be acquired under the Project. Further information on the water quality of vegetated catchment areas will be gathered over the Project life to inform revegetation strategies.

9.4 LOSS OF CATCHMENT

9.4.1 During Active Mining Operations

During active mining operations, the mine water management system will capture runoff from areas that would have previously flowed to the receiving waters of Bylong River, Lee Creek and Growee River. The mine stage plans are shown in Figure 4.1 to Figure 4.4 for Years 3, 5, 7 and 9 respectively. A breakdown of the catchment areas reporting to the mine site storages are provided in Table 5.10.

Figure 9.3 shows the maximum catchment area captured within the mine water management system during active mining operations assuming that no water overflows or is released from sediment dams following treatment. The maximum captured catchment areas represent:

- less than 1.3% of the Bylong River catchment to a point downstream of the Project Boundary (this includes Lee Creek and Growee River catchments);
- approximately 5.8% of the Lee Creek catchment to the confluence with the Bylong River; and
- less than 0.1% of the Growee River catchment to the confluence with the Bylong River.

These reductions in catchment area indicate that the likely reduction in surface flow would represent a small proportion of total catchment runoff. The loss of flow in the Goulburn River catchment, which has an area of more than 3,300 km^2, would be immeasurably small.

Table 9.2 – Catchment area captured within the mine water management system

Catchment	Total Catchment Area (km^2)	Mine Captured Catchment Area (km^2)				
		Year 3	Year 5	Year 7	Year 10	Year 11+
Bylong River (to d/s of Project Boundary)	702	3.6	7.6	8.1	8.7	8.7
Lee Creek	120	2.2	6.0	6.7	6.9	6.9
Growee River	344	0.1	0.1	0.1	0.1	0.1

9.4.2 Final Landform

The final landform at the completion of the Project will consist generally of the following:

- rehabilitated OEAs which are shaped into the surrounding natural landform.
- rehabilitated open cut mining areas and associated OEAs to blend into the surrounding natural topography, including no final void.
- Removal and rehabilitation of all infrastructure related disturbed areas including haul roads and MIAs.

At the completion of mining, surface runoff from rehabilitated OEAs will be released from the site. No final void is proposed to remain at the completion of the Project. As such, there is not anticipated to be any significant changes in catchment areas between pre- and post-mining, and therefore no measurable impact on the receiving water volumes.

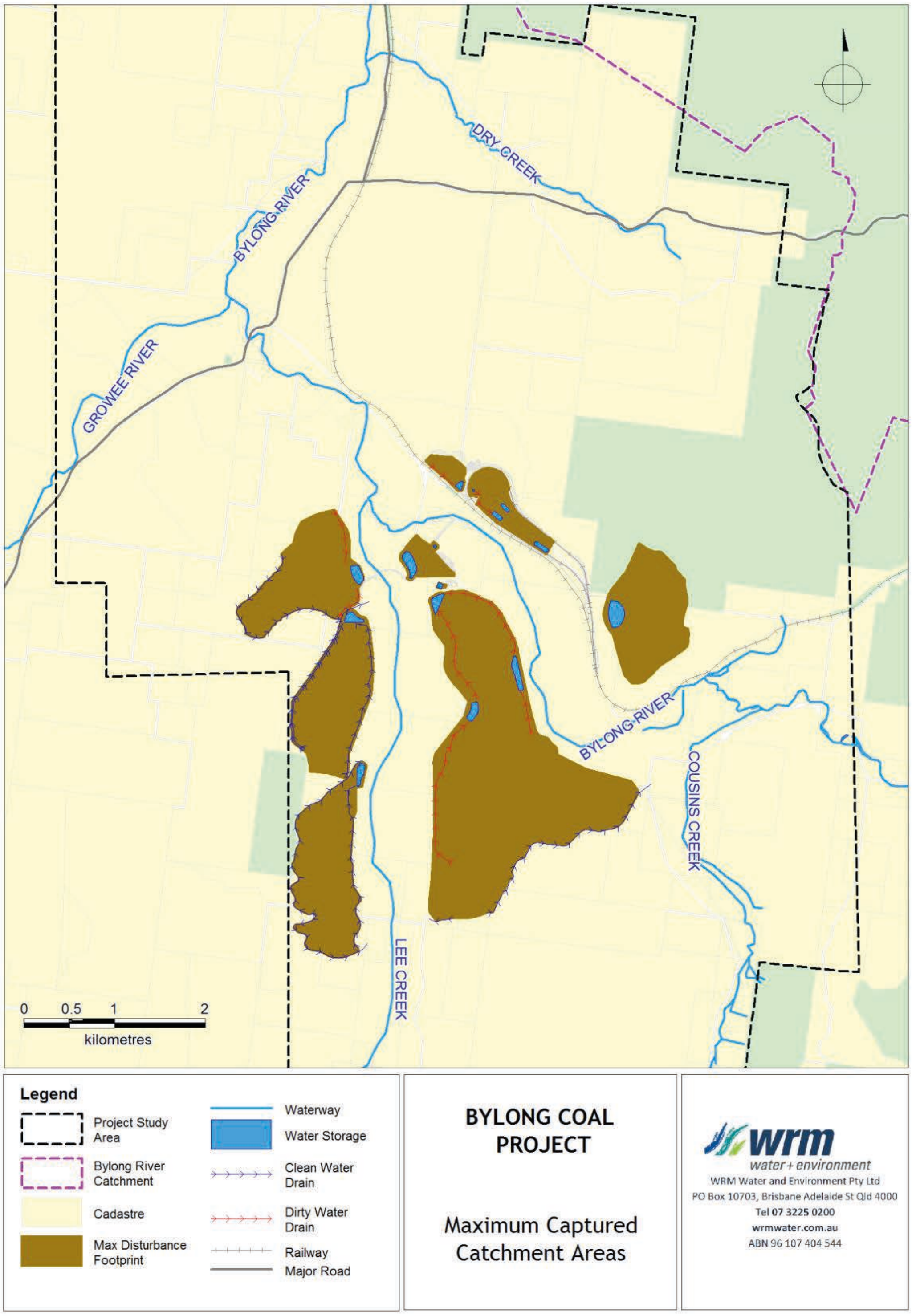


Figure 9.3 - Maximum captured catchment area during operations

9.5 FLOW IMPACT ASSESSMENT

9.5.1 Bylong River

The mine plan has been designed to minimise the impacts on the Bylong River, Lee Creek and associated floodplains. Most mine infrastructure is located outside of the 100 year ARI flood extent which significantly reduces flood impacts. Details of the flood modelling studies undertaken to quantify flood impacts on the Bylong River and Lee Creek are provided in Section 7.

The key elements of the Project which impact flood behaviour are the proposed road crossings of Lee Creek and the overland conveyor embankment crossing of the Bylong River. Each of these structures results in local increases in upstream flood level and downstream velocity due to constriction of flood flows. Flood level increases extend approximately 500 m upstream. Details of flood level and velocity impacts are presented in Section 7. As for any waterway crossing structure, appropriate erosion control measures, such as rock protection, will be required to mitigate local velocity impacts.

Following the initial feasibility design for the Project, detailed modelling was undertaken of the flood impacts of the proposed conveyor embankment that extends a significant distance across the Bylong River floodplain. An initial assessment indicated that the as-designed embankment had a significant impact on river flow velocities. For this reason, a number of alternative embankment lengths were investigated to determine an embankment configuration that produced acceptable velocity impacts. The range of embankment configurations investigated is shown in Figure 9.7.

Figure 9.5 shows the longitudinal velocity profiles of average main channel velocity for the different embankment configurations for the 100 year ARI flood event. The conveyor embankment as designed produces a main channel average flood velocity of up to 2.1 m/s, which is higher than all existing velocities along the reach of interest. The model results show that reducing the embankment length by 95 m compared to the as-designed structure brings the peak main channel average velocity back to approximately 1.6 m/s which is consistent with the range of existing velocities along the reach of the Bylong River of interest. Hence, this reduced embankment length was adopted as the preferred design configuration and used for the flood impact assessment in Section 7.

The flood modelling results show that local velocities around the end of the embankment are higher than elsewhere along the Bylong River and will require suitable erosion protection to minimise the risk of erosion damage to the embankment during a major flood event. Further refinement of the conveyor embankment configuration will be undertaken during detailed design, including the potential to achieve similar or reduced velocity impacts by providing waterway area through the embankment structure, away from the main channel of the Bylong River towards the lowest point on the floodplain.

Figure 9.4 – Alternative conveyor embankment lengths investigated

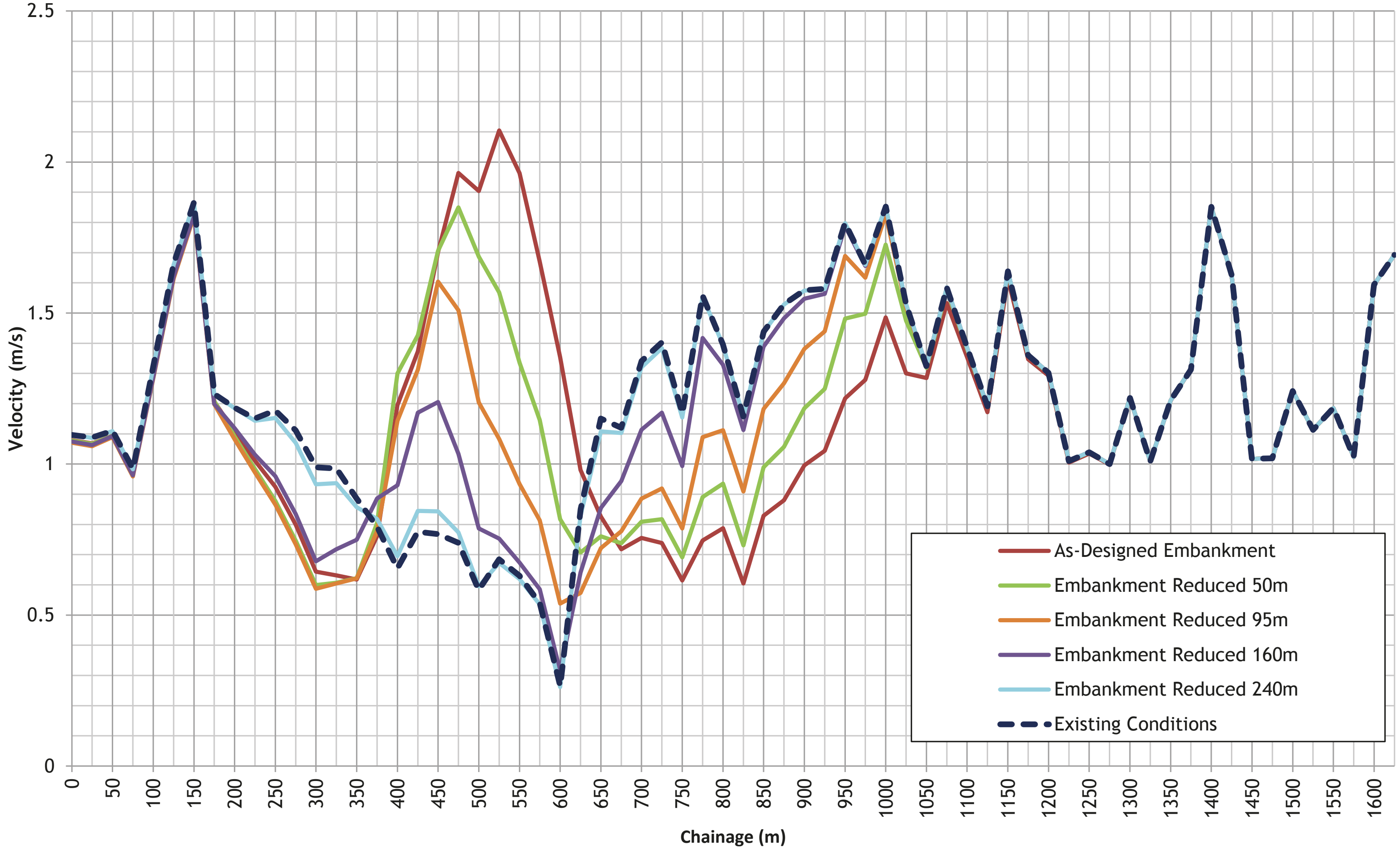


Figure 9.5 - Longitudinal profile of Bylong River main channel 100 year velocities for different conveyor embankment lengths

9.5.2 Dry Creek Catchment

The effects of subsidence beneath the Dry Creek catchment will affect flow behaviour along Dry Creek and its tributaries. Details of the flood modelling studies undertaken to quantify flood impacts on Dry Creek are provided in Section 8.

The impacts on Dry Creek drainage characteristics may be summarised as:

- potential for reduced flow due to infiltration through subsidence-induced cracking and additional water captured in ponds created by subsidence;
- increased flow depth and reduced flow velocity upstream of longwall chain pillars;
- reduced flow depth and increased flow velocity downstream of longwall chain pillars; and
- a potential flow breakout along the lower reaches of a Dry Creek tributary.

The potential for infiltration through subsidence-induced cracks is considered in the EIS Subsidence Impact Assessment for the Project (MSEC, 2015) and the EIS Groundwater Impact Assessment (AGE, 2015). The subsidence report indicates that fracturing, buckling and dilation are likely to occur in the uppermost bedrock beneath the soil beds of the drainage lines, which may result in additional infiltration of surface water flows. The rate of inflow to groundwater via cracks is estimated in the groundwater assessment to be up to about 0.15 ML/d (AGE, 2015). However, such losses are expected to occur only after moderate-sized events when sufficient water flow depth occurs to saturate the alluvium and fracture network overlying the active longwall panel. Based on the rainfall runoff model for natural catchment areas adopted for the site water balance (see Section 5.6) runoff in excess of 1 mm over the catchment occurred on 377 days of the 125 year simulation period. This indicates a total loss of runoff volume of about 57 ML (377 days x 0.15 ML/d) over the entire simulation period, compared to a total simulated runoff volume of over 66,000 ML. Hence, the loss of surface water to groundwater (less than 0.1% of runoff) via cracking is considered to be negligible.

An assessment of potential additional surface ponding within the catchment was undertaken using a direct rainfall model across the subsidence area. Due to the steep topography of the existing catchment, the model results showed minimal impacts, with increased ponding essentially confined to waterway channels immediately upstream of longwall chain pillars. The total area of additional ponding across the entire catchment is approximately 2.3 hectares, indicating a potential total ponded volume of the order of 10 ML. Subtracting this volume from runoff events over the 125 year simulation period indicates a potential capture volume of the order of 4,200 ML over the simulation period, representing about 6% of the total runoff volume. This potential capture volume in ponded areas could have benefits for the maintenance of riparian vegetation along Dry Creek. However, if necessary, the volume of water captured in ponded areas could be mitigated by drainage works to limit the net impact on runoff volume in the Dry Creek catchment to a few percent.

Figure 9.6 is a longitudinal section showing a comparison of the existing and post-subsidence Dry Creek bed levels and 100 year ARI flood levels. An analysis of the impacts on the 2 year and 100 year ARI design event velocity, stream power and bed shear stress was undertaken using the HEC-RAS one-dimensional hydraulic model. Comparisons of the velocity, stream power and bed shear stress between existing and post-subsidence conditions are shown in Figure 9.7 to Figure 9.12 respectively. The results from this analysis indicate a number of locations where increases in velocity, stream power and bed shear stress are potentially significant, most notably at chainages 1,800 and 3,850 (see Figure 9.13) where these indicators of erosion potential increase beyond the range of observed values for existing conditions. The increase in velocity at chainages 1,800 and 3,850 is approximately 1.3 m/s and 0.8 m/s, respectively, during the 100 year ARI design event. These increases are generally located across the chain pillars.

It is possible that some scour of the channel bed may occur as flows across the chain pillars and some sedimentation will occur in the subsidence zones until an equilibrium level is reached. It is recommended that a Restoration Plan for Dry Creek is prepared in consultation with the Hunter Local Land Services and other relevant agencies to mitigate the impact of any potential scour following subsidence effects.

At the potential breakout location on the Dry Creek tributary (see Figure 9.13), the modelling shows that the flows are confined to the main channel for the 2 year ARI event but floodwater breaks out and drains along the longwall panel, eventually crossing Bylong Valley Way. It is recommended that minor drainage works are undertaken within the tributary and along the longwall panel to reduce the frequency of overflows. Given that this occurs following construction of the last longwall panel, detailed design of these works will be undertaken at a later date and in consultation with the Hunter Local Land Services prior to the mining of this longwall panel.

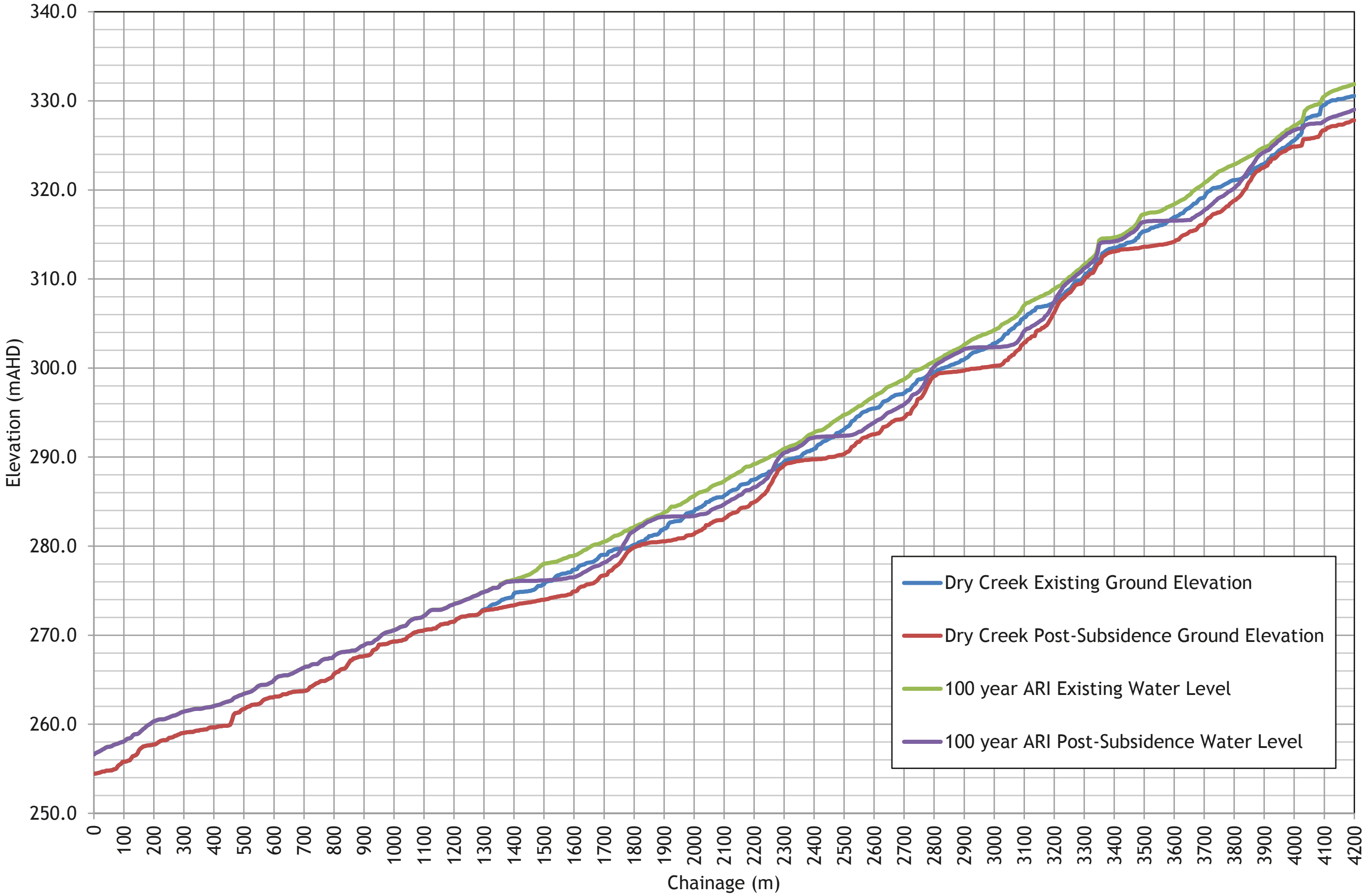


Figure 9.6 – Comparison of Dry Creek bed level and 100 year ARI design event peak water level, existing and post subsidence

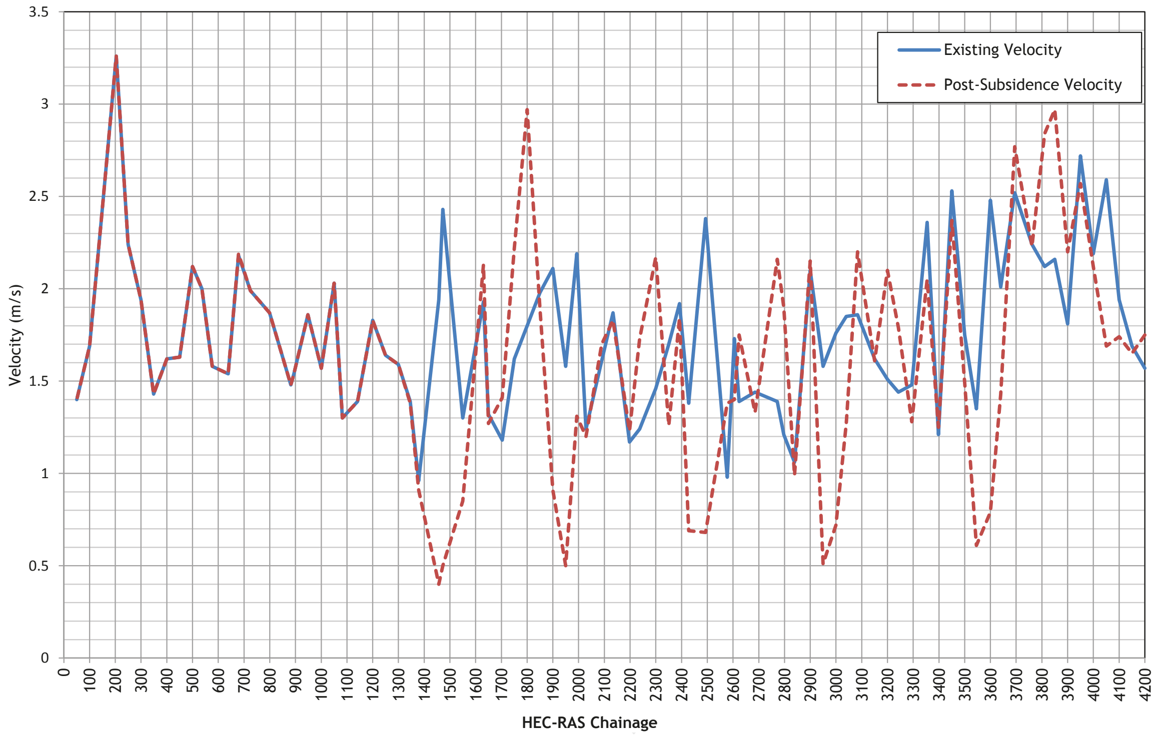


Figure 9.7 - Comparison of velocity, 100 year ARI design event

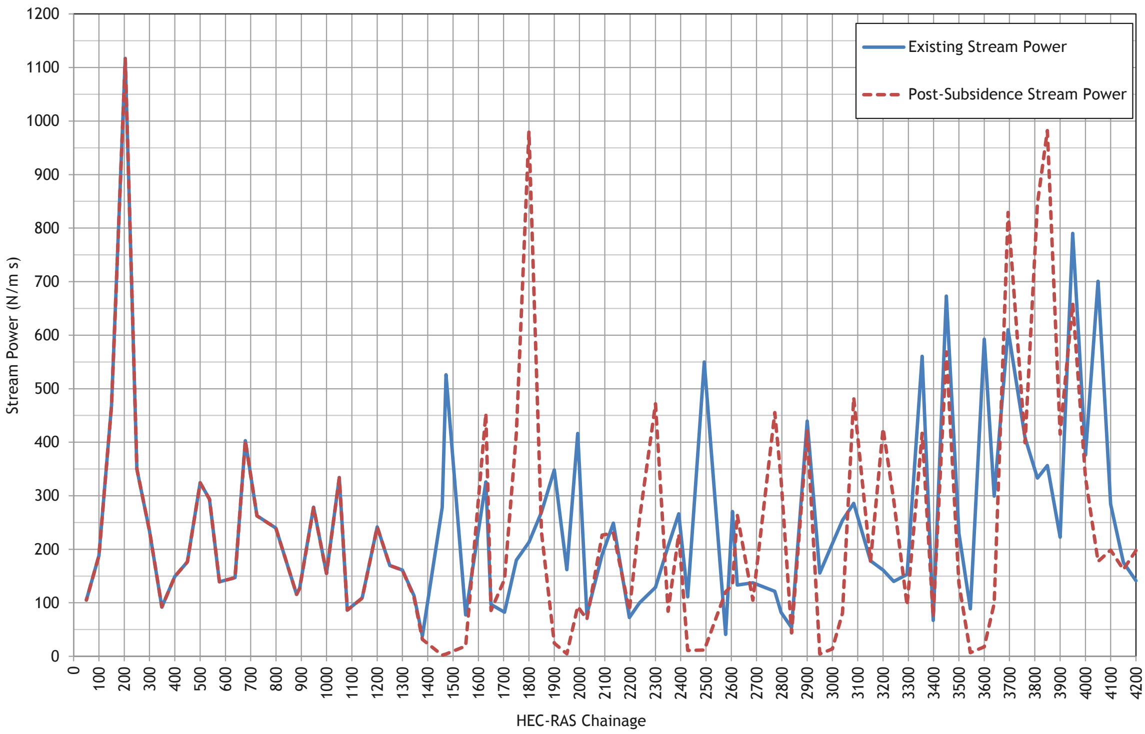


Figure 9.8 - Comparison of stream power, 100 year ARI design event

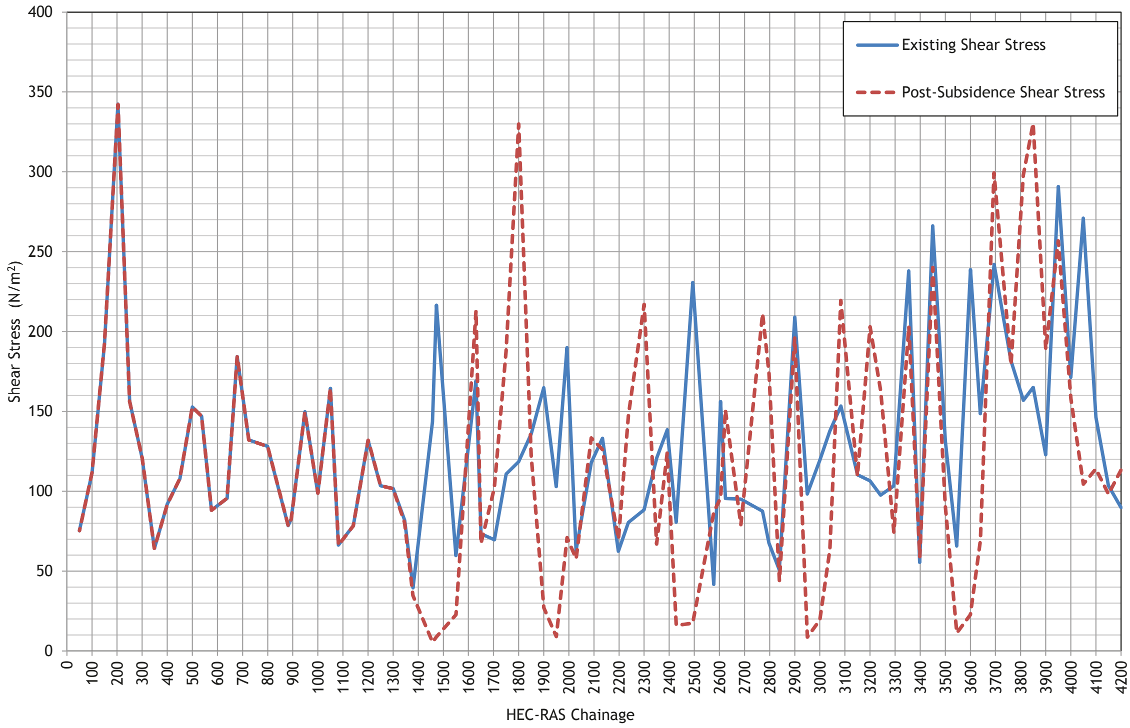


Figure 9.9 - Comparison of bed shear stress, 100 year ARI design event

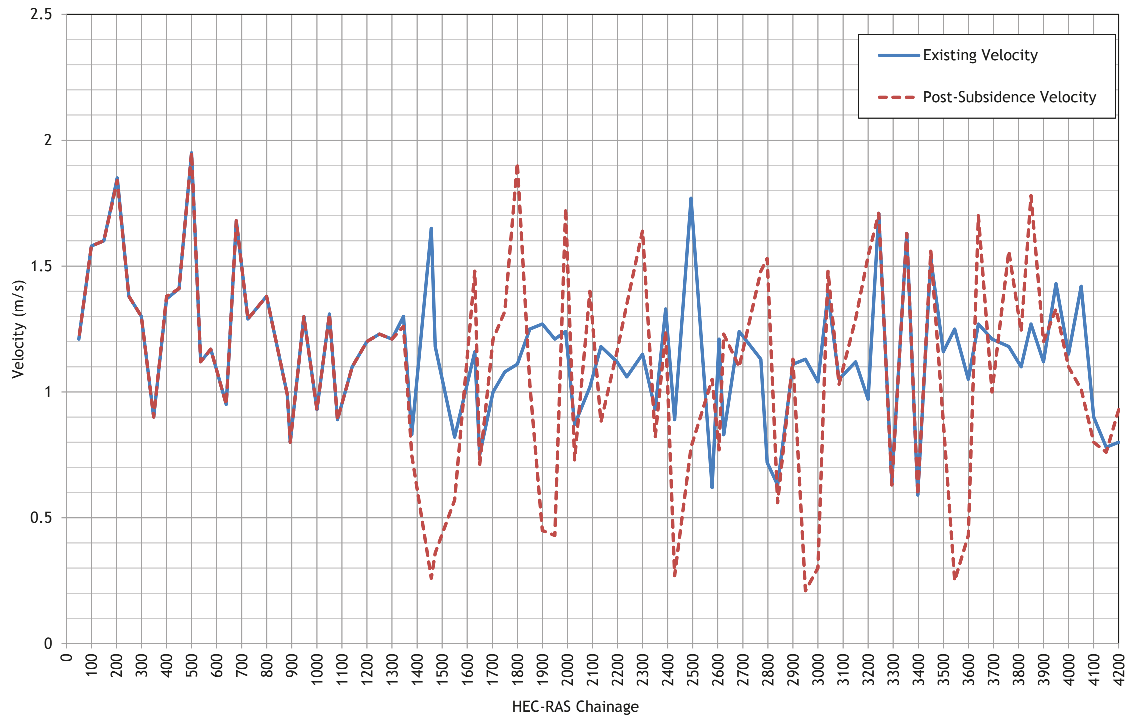


Figure 9.10 - Comparison of velocity, 2 year ARI design event

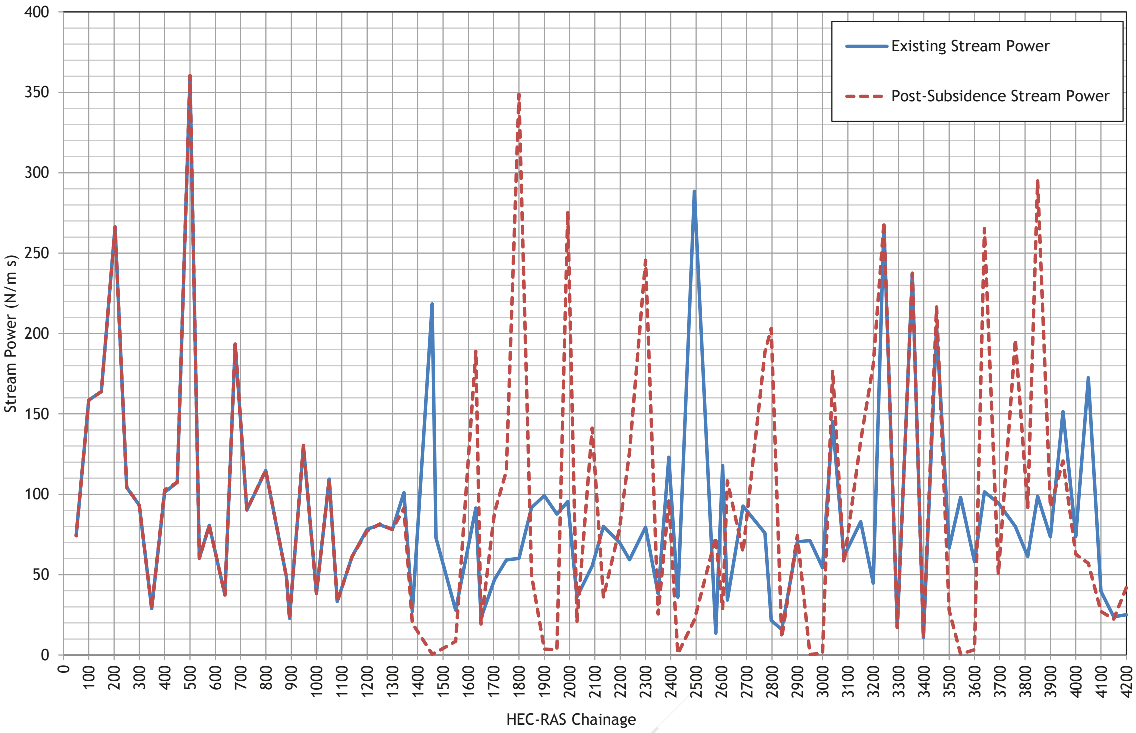


Figure 9.11 - Comparison of stream power, 2 year ARI design event

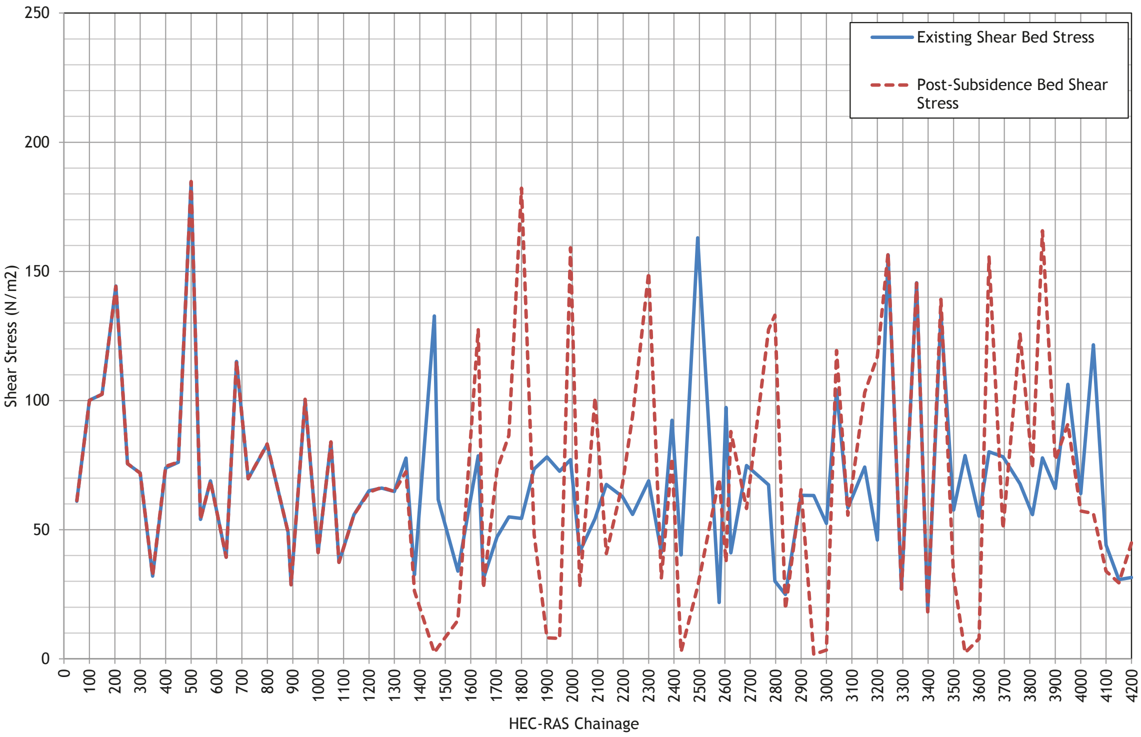


Figure 9.12 - Comparison of bed shear stress, 2 year ARI design event

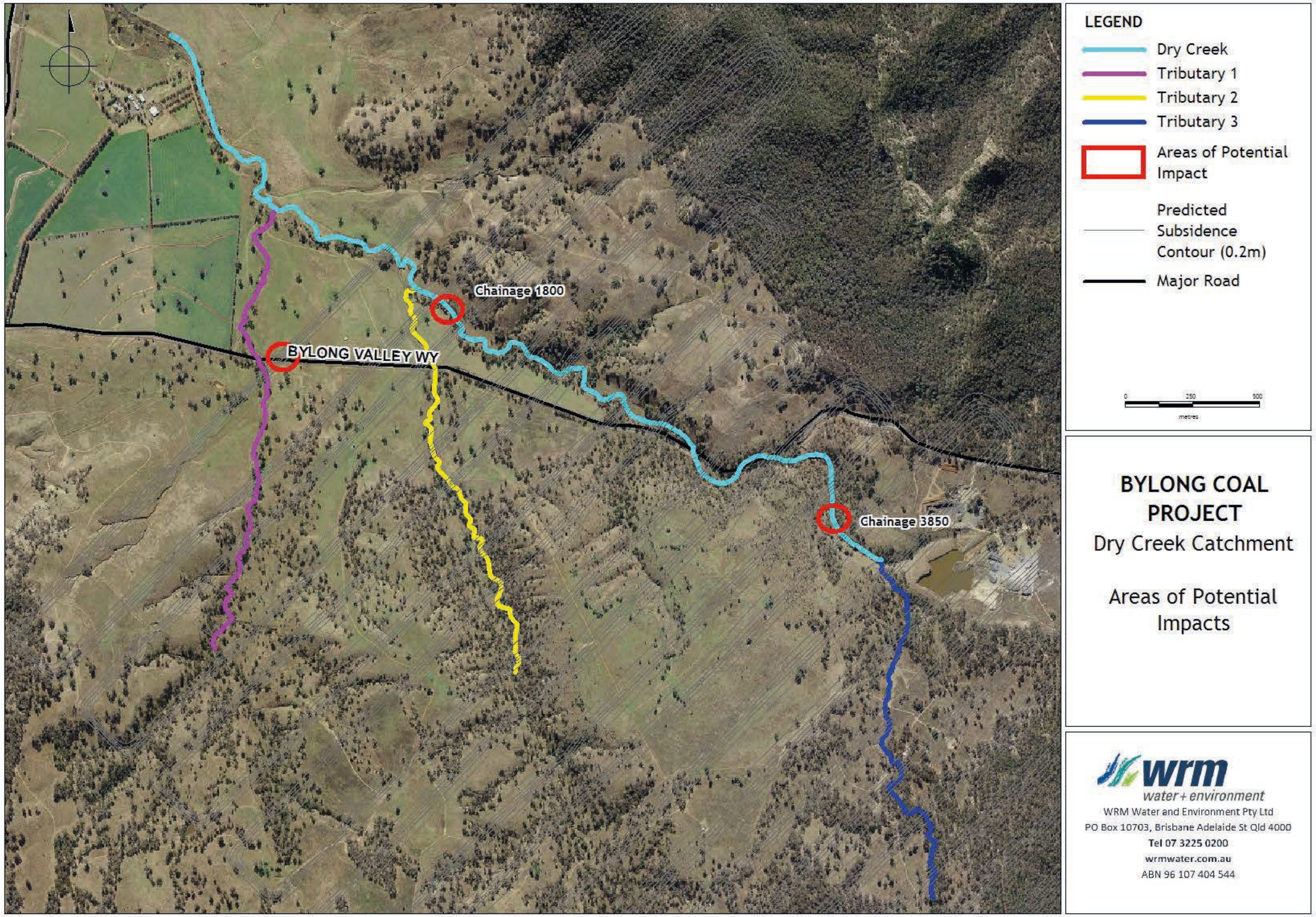


Figure 9.13 - Key potential impact areas under post-subsidence conditions

10 Cumulative Surface Water Impacts

10.1 OVERVIEW

An assessment has been undertaken of the potential cumulative impacts of the Project with projects proposed, under development or already in operation in the vicinity of the Project.

Cumulative impacts may be relevant at a local or regional level:

- Localised cumulative impacts 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 additive effect on the receiving environment.
- Regional cumulative impacts include the Project's contribution to impacts that are caused by mining operations throughout the 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.

10.2 RELEVANT PROJECTS

Projects which are currently operating in the upper Goulburn River catchment and have been considered in the cumulative impact assessment are listed in Table 10.1. Projects currently under assessment or recently determined are listed in Table 10.2.

The relevant projects are located in the Goulburn River catchment, upstream of the Bylong River confluence. The locations of these projects are shown in Figure 1.2.

Numerous other mining projects, some of which are shown in Figure 1.2, are located downstream in the Hunter River Valley.

Table 10.1 – Existing projects considered in the cumulative impact assessment

Project Proponent	Description	Operational Status	Relationship to the Project Mining Lease	
			Timing	Location
Wilpinjong Mine - Peabody Energy	Open cut coal mine with a yield of 12.7 Mtpa.	Operating	May have overlapping operational phases with the construction and operations of the Project.	25 km to the northwest of the Project Boundary. Located within Goulburn River catchment.
Moolarben Mine (Stage 1) - Yancoal Australia	Open cut and underground coal mine.	Open cut operating, underground not yet operating	May have overlapping operational phases with the construction and operations of the Project.	35 km to the northwest of the Project Boundary. Located within Goulburn River catchment.
Ulan Mine - Glencore	Underground coal mine with an open cut reserve.	Operating	May have overlapping operational phases with the construction and operations of the Project.	40 km to the northwest of the Project Boundary. Located within Goulburn River catchment.

Table 10.2 – New or developing projects considered in the cumulative impact assessment

Project Proponent	Description	Operational Status	Relationship to the Project Mining Lease	
			Timing	Location
Moolarben Mine - (Stage 2) Yancoal	Proposed expansion to both the open cut and underground operations. Combined yield of 17 Mtpa.	Approved	May have overlapping operational phases with the construction and operations of the Project.	35 km to the northwest of the Project Boundary. Located within Goulburn River catchment.
Ulan Mine - Glencore	Proposed expansion to the underground mine and recommence open cut mining. Combined yield of 20 Mtpa.	Operating	May have overlapping operational phases with the construction and operations of the Project.	40 km to the northwest of the Project Boundary. Located within Goulburn River catchment.
Wilpinjong Coal Mine	Proposed extension of mine footprint to gain access to additional ROM coal reserves and an extension to the approved life of the mine.	Operating	May have overlapping operational phases with the construction and operations of the Project.	25 km to the northwest of the Project Boundary. Located within Goulburn River catchment.

10.3 CUMULATIVE IMPACTS – SURFACE WATER RESOURCES

10.3.1 Surface Water Flows

As detailed in Section 9.4, the Project will result in a small loss of catchment to the receiving waters, depending on the stage of the Project. The surface runoff volume lost from the catchment will be in proportion to the loss of catchment area. The Project will capture less than 1.3% of the catchment area of the Bylong River to the downstream boundary of the Project.

In the context of the Goulburn River, the catchment captured by the Project represents less than 0.3% of the Goulburn River catchment downstream of the Bylong River confluence (3,340 km^2).

The Wilpinjong, Moolarben and Ulan mines also capture runoff from the Goulburn River catchment. However, the total captured area of all these projects combined would represent of the order of 1.5% of the Goulburn River catchment to the Bylong River confluence. In addition, these mines have discharge licences which return captured surface water, as well as groundwater collected in underground workings, to the Goulburn River catchment. Site discharges reduce the impact on surface water volumes. The discharge volumes reported in Annual Reviews/AEMRs for 2013 from the three projects were as follows:

- Ulan Mine: 3,974 ML discharged (EPL 394, Limit of 10,950 ML/yr)
- Wilpinjong Mine: 75 ML discharged (EPL 12455, Limit of 5 ML/d)
- Moolarben Mine: Zero discharge (EPL 12932, Limit of 10 ML/d) (Moolarben reported runoff capture of 411 ML for 2012/2013).

Based on the relatively small captured catchment area and the discharge of captured water from the three existing mine sites, the cumulative net impact on surface flow volumes would be too small to measure.

The discharge of water from the three existing mines would potentially have an impact on the flow-duration behaviour of the Goulburn River because runoff that occurs during a rainfall event is collected and discharged over an extended period. Similarly, intercepted groundwater from the existing mines may be discharged as a continuous flow. However, any such impacts are a consequence of existing approved operations. The Project does not propose to discharge mine water to the receiving watercourses and hence will not contribute to any localised or regional impacts, beyond the small loss of catchment area.

10.3.2 Water Quality

Cumulative impacts of potential mine water discharges further downstream in the regulated section of the Hunter River are managed through the Hunter River Salinity Trading Scheme (HRSTS). However, the HRSTS does not apply to the upper Goulburn River where the Project is located. Impacts of any discharges from existing operations in the upper Goulburn River catchment are regulated through Environmental Protection Licences for each operation.

The mine water management system for the Project has been designed for no-discharge, with passive releases of water from the sediment dam system occurring only after rainfall that exceeds the design standard. The on-site containment and recycling of water with potentially elevated levels of contaminants will ensure that the Project does not contribute to localised or regional cumulative impacts.

10.3.3 External Water Requirements

Water requirements for the Project will be supplied from captured runoff, groundwater inflows and recycled water on the site. Any shortfall in water availability from these sources will be obtained from licensed bores.

Licensed water volumes are determined through a Water Sharing Plan, developed under the WM Act. The Water Sharing Plan establishes rules for sharing water between the environmental needs of the river or aquifer and water users and hence considers cumulative impacts at the catchment scale. By complying with licence restrictions on water consumption, the Project will not create unexpected cumulative impacts on water availability.

11 Mitigation and Management Measures

11.1 OVERVIEW

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

- siting of the majority of Project infrastructure outside the Bylong River 100 year ARI flood extent;
- a mine site water management system to control the flow and storage of water of different qualities across the site;
- an erosion and sediment control plan to reduce sediment loads from disturbed area runoff;
- a surface water monitoring program to continually assess environmental impacts and ensure that the site water management system is meeting its objectives of minimal impact on receiving waters; and
- a waterway rehabilitation and management program to manage the potential impacts on watercourses, including subsidence in the Dry Creek catchment.

An overview of each of these management measures is provided in the following sections. The proposed mitigation and management measures will be documented in management plans for the approved Project which will include performance criteria, monitoring, reporting, corrective action, contingencies and responsibility for all management measures.

For State Significant Developments, the key determining authority for the various management plans and monitoring programs is the Department of Planning and Environment. Water-related matters will be addressed in consultation with NOW. Other relevant agencies include: OEH, Local Land Services, EPA and the local council (MWRC). All mitigation measures and monitoring programs will be prepared in consultation with the relevant government agencies.

11.2 AVOIDANCE OF IMPACTS

A key mitigation measure for the Project has been the siting of most infrastructure outside the Bylong River 100 year ARI flood extent. Apart from local impacts at waterway crossings, the adopted design approach has avoided any alterations to the Bylong River and Lee Creek main channel course and riparian vegetation.

11.3 MINE WATER MANAGEMENT SYSTEM

The mine water management system has been designed to minimise the risk of uncontrolled releases from water storages on the site. To achieve this objective, operation of the mine water management system will be based on the following principles:

- diversion of clean surface water runoff away from areas disturbed by mining activities;
- operation of the mine water management system to ensure no uncontrolled releases of mine water from the site;
- collection of potentially sediment-affected runoff in sediment dams for treatment prior to release from site or reuse in the mine water management system;

- transfer of groundwater and seepage inflows to the open cut pits to the mine water system for reuse as a water supply;
- collection of contaminated water from industrial areas for treatment in an oil and grease separator prior to recycling in the mine water management system; and
- minimisation of fresh water usage by recycling water from the mine water system before taking additional water from external sources.

Further information on proposed water management infrastructure and the operation of the mine water management system is provided in Section 6 and will be documented in detail in the Site Water Management Plan

The results of a water balance simulation of the mine water management system (see Section 6) indicate that the system can be operated with no releases of mine water from site water management system. The water balance simulation also shows that mining can continue during extended wet periods as accumulation of water in the open cut mining areas is manageable. Sufficient water licences have been obtained to meet the potential shortfall in water during dry conditions.

The Site Water Management Plan will detail reporting and action procedures to monitor compliance with objectives and a process for implementing corrective actions if required.

11.4 SEDIMENT AND EROSION CONTROL PLAN

A Sediment and Erosion Control Plan will be developed as part of detailed design for the Project. The design of sediment control measures will be based on the principle of ensuring that runoff from disturbed areas is separated from clean area runoff and collected in sediment dams for treatment.

Sizing of the proposed sediment basins will be undertaken in accordance with the guideline Managing Urban Stormwater, Soils and Construction, Mine and Quarries (DECC, 2008) which provides guidance on sediment basin sizing, design and operation. Sizing of sediment dams using the Department of Environment and Climate Change guideline is based on capturing the 5-day, 90th percentile runoff volume. That is, it is targeted towards treating the smaller, more frequent events which comprise the bulk of the annual sediment loads. However, it also provides sediment trapping benefits during larger, less frequent storms through removal of coarse sediments passing through the basin.

Locations of proposed major sediment dams to collect and treat runoff from overburden emplacement areas are shown in Figure 4.1 to Figure 4.4. Additional minor sediment traps may also be required at other locations across the site.

11.5 SURFACE WATER MONITORING PROGRAM

Monitoring of surface water both within and external to the mine site will form a key component of the surface water management system. Monitoring of upstream, onsite and downstream water quality will assist in demonstrating that the site water management system is effective in meeting its objective of minimal impact on receiving water quality and will allow for early detection of any impacts and appropriate corrective action.

The surface water monitoring program will:

- assess compliance with the EPL for the Project;
- characterise on-site and receiving water quality;
- identify impacts of the Project, if any, on receiving water quality;
- provide information on the performance of the water management system; and
- facilitate adaptive management of water resources on the site.

The Proponent has an existing surface water quality monitoring program as detailed in Section 3.7. The proposed program will be based on:

- continuation of the existing receiving water monitoring locations;
- addition of new monitoring locations on the Bylong River downstream of the Lee Creek confluence and Dry Creek upstream of the Bylong River confluence;
- monitoring of water quality in site water storages; and
- monitoring of water levels in key storages and transfer volumes from the Open Cut and Underground Mining Area and between storages to provide a basis for validating the water balance modelling to reflect operating experience.

Figure 11.1 shows proposed stream monitoring locations. Details of the proposed monitoring locations, including sample collection frequency and key water quality parameters to be monitored, are shown in Table 11.1 and Table 11.2.

Where more than 25 mm of rainfall is recorded in 24 hours, an inspection of the site water management system, in particular, sediment control infrastructure will be undertaken. The post-event inspection will include field-based assessment of water quality for any sediment dam overflows. Daily rainfall and dam volumes will also be recorded at the sites to assist in identifying significant rainfall events.

Table 11.1 – Surface water monitoring locations

Location		Co-ordinates		Parameters [a]	Frequency
		Easting	Northing		
Bylong River	SW1	234,825	6,405,904	Full suite	Monthly or rainfall >25mm/d
	SW2	228,686	6,409,898		
	SW4	229,930	6,412,631		
	SW6	226,317	6,416,901		
	SW8	231,187	6,407,758		
	SW10	230,019	6,408,155		
Lee Creek	SW7	229,979	6,398,577	Full suite	Monthly or rainfall >25mm/d
	SW9	229,979	6,400,329		
Growee Creek	SW5	226,819	6,409,062	Full suite	Monthly or rainfall >25mm/d
Dry Creek	SW3	232,948	6,411,101	Full suite	Monthly or rainfall >25mm/d
	SW11	230,513	6,412,922		
Raw Water Dam CHPP Supply Dam CHPP Coal Contact Dam				Field parameters	Monthly until baseline established, then quarterly
OC MIA Dam UG MIA Dam UG Raw Coal Stockpile Dam Product Stockpile Dam Feeder Floor & Reject Overflow Dam Fill Point Dam				Full suite	Quarterly until baseline established, then annually
Raw Water Dam CHPP Supply Dam OC MIA Dam UG MIA Dam				Water level	Weekly
Open cut pit				Pumped volume	Weekly

[a] See Table 11.2

Table 11.2 – Water quality monitoring parameters

Parameter Suite	Parameters		Unit of Measurement
Full Suite	pH		-
	EC		µS/cm
	Turbidity		NTU
	Alkalinity		mg/L
	Chloride		mg/L
	Ammonia as N		mg/L
	NO_x (NO_2^- + NO_3^-)		mg/L
	Sulphate		mg/L
	Calcium		mg/L
	Potassium		mg/L
	Sodium		mg/L
	Magnesium		mg/L
	Total Dissolved Solids		mg/L
	Total Suspended Solids		mg/L
	Total Phosphorus		mg/L
	Total Metals	Al, As, Ba, Be, Cd, Cr, Co, Cu, Fe, Pb, Mn, Hg, Ni, Se, Va, Zn	mg/L
	Dissolved Metals	Al, As, Ba, Be, Cd, Cr, Co, Cu, Fe, Pb, Mn, Hg, Ni, Se, Va, Zn	mg/L
Field parameters	pH		-
	EC		µS/cm
	Turbidity		NTU

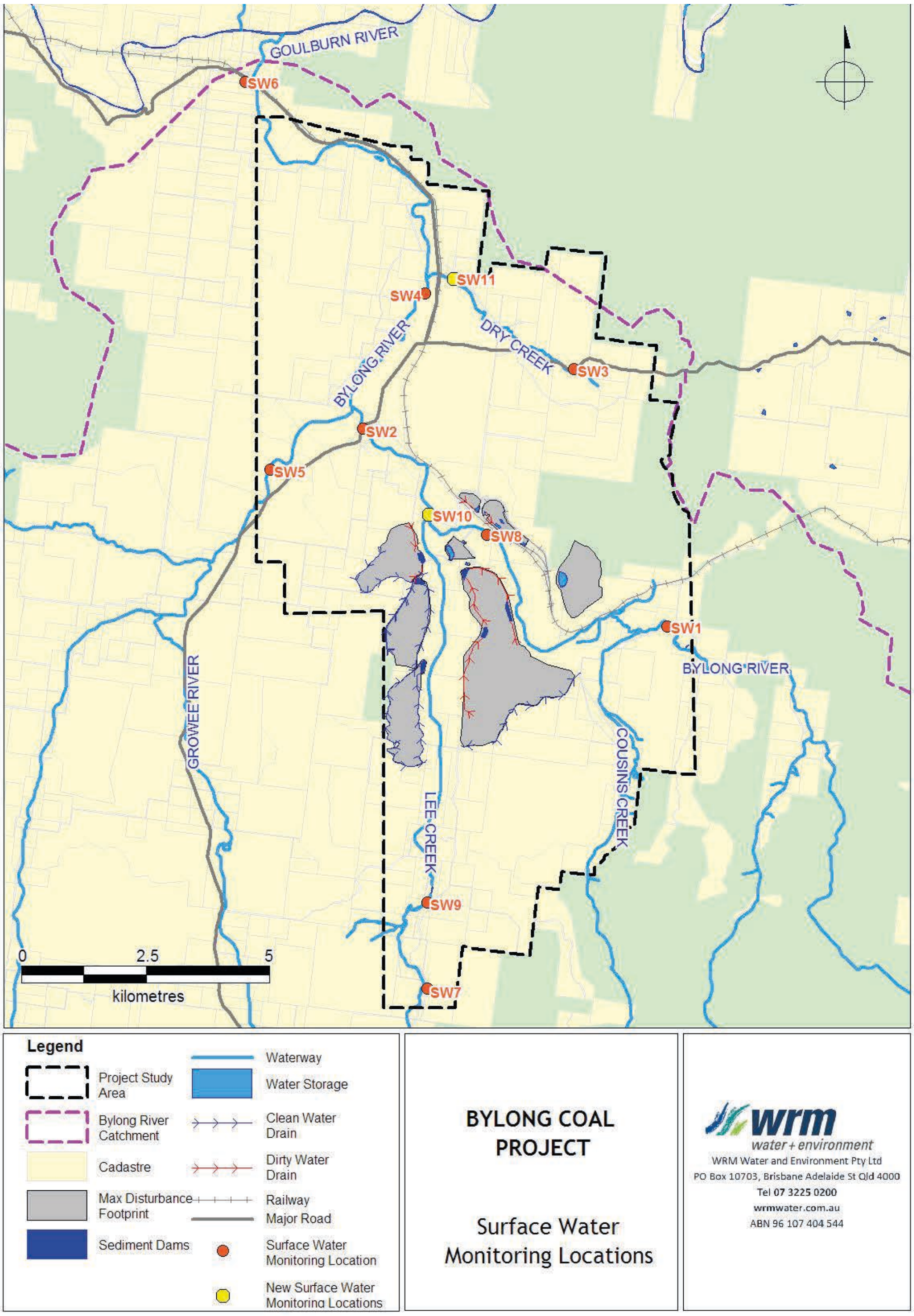


Figure 11.1 – Proposed water monitoring locations

11.6 WATERWAY REHABILITATION AND MANAGEMENT PROGRAM

11.6.1 Bylong River Catchment

Potential impacts on the Bylong River may occur due to increased flow velocity caused by constriction of the floodplain at proposed road crossings and the conveyor embankment. The waterway management program will include inspection of these locations following any significant river flow event to assess impacts, if any, on bed and bank stability and riparian vegetation.

The appropriate corrective action will be determined based on the nature and scale of any observed impacts, but may potentially include repair and revegetation of any locations of scour.

11.6.2 Dry Creek Catchment

The riparian vegetation in the Dry Creek catchment is in relatively poor condition due to historical land clearing (see Section 3.3). As presented in Section 9.5.2, subsidence associated with underground mining will increase the risk of geomorphic impacts through increased water ponding at some locations along the waterway channel and increased bed gradient and flow velocities at other locations.

Every section of Dry Creek that will be undermined will experience subsidence associated with the progression of longwall panels. The majority of subsidence will occur when the longwall directly underlying that a creek section is extracted. A smaller amount of subsidence may be experienced when the subsequent longwall panel are mined.

The management strategy for Dry Creek and its tributaries will be based on monitoring of changes in surface levels and erosion. Regular visual inspections and comparative ground level survey will be undertaken to assess changes in the condition of the streams during mining, with a particular focus on the identified areas of higher risk (see Figure 9.13).

Targeted management actions will be developed to respond to the observed impacts, ensuring that any intervention minimises surface disturbance. Potential mitigation measures would include:

- Sealing of any observable bed cracking along watercourses by filling and compaction with suitable material followed by revegetation;
- Draining of any new ponded areas caused by subsidence to minimise additional water capture if required;
- Implementation of in-stream bed controls, such as rock rip-rap or large woody debris, in locations where increased bed gradients result in observable change in geomorphic characteristics.

A key component of management action will be revegetation of the riparian corridor, with a focus on rehabilitation of the stream to a condition equivalent to or better than existing using soft engineering techniques where possible. This will be undertaken in consultation with the Hunter Local Land Services. Mitigation works within the Dry Creek tributary will also be undertaken to reduce the potential for breakouts of flow from the current flow path .

11.7 RESIDUAL IMPACTS

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

- a small reduction in the volume of surface runoff to the Bylong River during open cut mining operations due to capture of runoff in the mine water management system (see Section 9.4.1); and

- potential changes to the longitudinal profile of Dry Creek and its tributaries caused by subsidence. The impacts of subsidence would be monitored and managed to maintain or improve stability of the creek channel.

12 Summary of Findings

The potential surface water impacts of the Project relate to possible changes in water quality and quantity in the Bylong River and Dry Creek catchments. Impacts on the Bylong River may be caused by land disturbance, construction of mine infrastructure, storage of mine-affected water and taking water from surface and underground sources for use in mine operations. The impacts in the Dry Creek catchment relate primarily to potential changes in drainage patterns and flow behaviour caused by subsidence.

A key mitigation measure for the Project has been the siting of most infrastructure outside the Bylong River 100 year ARI flood extent. Apart from local impacts at waterway crossings, the adopted design approach has avoided any alterations to the river main channel course and riparian vegetation. In addition, filling of the open cut mining voids at the completion of the Project will ensure no long-term reduction in surface runoff to the Bylong River catchment.

The diversion of runoff from undisturbed catchment areas will minimise the volume of clean water captured within the mine water management system. Surface runoff from disturbed areas that is captured on the site, as well as groundwater inflows to the open cut and underground mining areas, will be recycled to satisfy mine site demands and minimise the requirement for makeup water supplies.

Further mitigation and management measures for the Project include:

- a mine site water management system to control the flow and storage of water of different qualities across the site;
- an Sediment and Erosion Control Plan to reduce sediment loads from disturbed area runoff;
- a surface water monitoring program to continually assess environmental impacts and ensure that the site water management system is meeting its objectives of minimal impact on receiving waters; and
- a waterway rehabilitation and management program to manage the potential impacts on watercourses, including subsidence in the Dry Creek catchment.

The water requirements of the Project have been investigated using a detailed site water balance model. The model results may be summarised as follows:

- The annual groundwater bore water requirements are highest during the period of open cut only operations (PY 3 to PY 8). The bore water requirements significantly reduce once underground operations commence due to the increase in groundwater inflows to the mine workings.
- There is a 10% chance that the volume of bore water supply required in any year from PY 3 to PY 8 will be of the order of 1,100ML/a. During underground operations (PY 9 to PY 25), the 10% chance volume reduces to around 680ML/a.
- KEPCO's existing Water Allocation Licence of 2,535 units (currently equivalent to 2,535 ML/year) has at least a 99% chance of meeting all site demands for all years of operation.
- Prior to the commencement of underground operations, there is a low risk of significant volumes of the accumulating in the open cut pit. Once underground operations commence, groundwater inflows increase significantly which increases the risk of water accumulating with the water management system. However, the water balance model results indicate that site water inventory can be managed without the need for discharges of mine affected water from the site.

- Once open cut operations cease (around PY 10), the Eastern Void will be able to provide approximately 18,800ML of capacity. After allowing for the total bulk volume of rejects (11,700ML), there is approximately 7,000ML of capacity available within Eastern Void to store excess mine water.
- The only offsite releases will be from the sediment dam system (in accordance with their specified design criteria).

The riparian vegetation in the Dry Creek catchment is in relatively poor condition due to historical land clearing. Subsidence associated with underground mining will increase the risk of geomorphic impacts through increased water ponding at some locations along the waterway channel and increased bed gradient and flow velocities at others.

The management strategy for Dry Creek and its tributaries will be based on monitoring of changes in surface levels and erosion. Regular visual inspections and comparative ground level survey will be undertaken to assess changes in the condition of the streams during mining, with a particular focus on the identified areas of higher risk. Targeted management actions will be developed to respond to the observed impacts, ensuring that any intervention minimises surface disturbance. A key component of management action will be revegetation of the riparian corridor, with a focus on rehabilitation of the stream to a condition equivalent to or better than existing using soft engineering techniques where possible.

The combination of the mine design, which aims to avoid surface water impacts and the proposed mitigation and management measures, will ensure that the Project can be constructed and operated with a minimal impact on surface water resources.

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