BOGGABRI - TARRAWONGA - MAULES CREEK COMPLEX

WATER MANAGEMENT STRATEGY

MAY 2019

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1. INTRODUCTION

1.1 BACKGROUND AND PURPOSE

The purpose of the cumulative Boggabri-Tarrawonga-Maules Creek Complex (BTM Complex)[1] Water Management Strategy is to document the approach that will be taken by mines within the BTM Complex to monitor and collectively manage the cumulative surface water and groundwater impacts of their operations. The Water Management Strategy details the relevant water resources, the potential cumulative impacts on those water resources, and the cumulative water management protocols within the BTM Complex.

The BTM Complex is an existing mining precinct located within and around the Leard State Forest, approximately 15 kilometres (km) north-east of Boggabri in the Narrabri Local Government Area (LGA) (Figure 1.1). The BTM Complex includes the Tarrawonga Coal Mine (TCM) in the south, the Boggabri Coal Mine (BCM) to the north and the Maules Creek Coal Mine (MCCM) to the north-west. The extent of the relevant tenements for each of the mines that comprise the BTM Complex are presented in Figure 1.1.

BCM is managed by Boggabri Coal Operations Pty Limited (BCOPL), a wholly owned subsidiary of Idemitsu Australia Resources Pty Limited (IAR).

MCCM is managed by Maules Creek Coal Pty Ltd, a wholly owned subsidiary of Whitehaven Coal Mining Limited (Whitehaven).

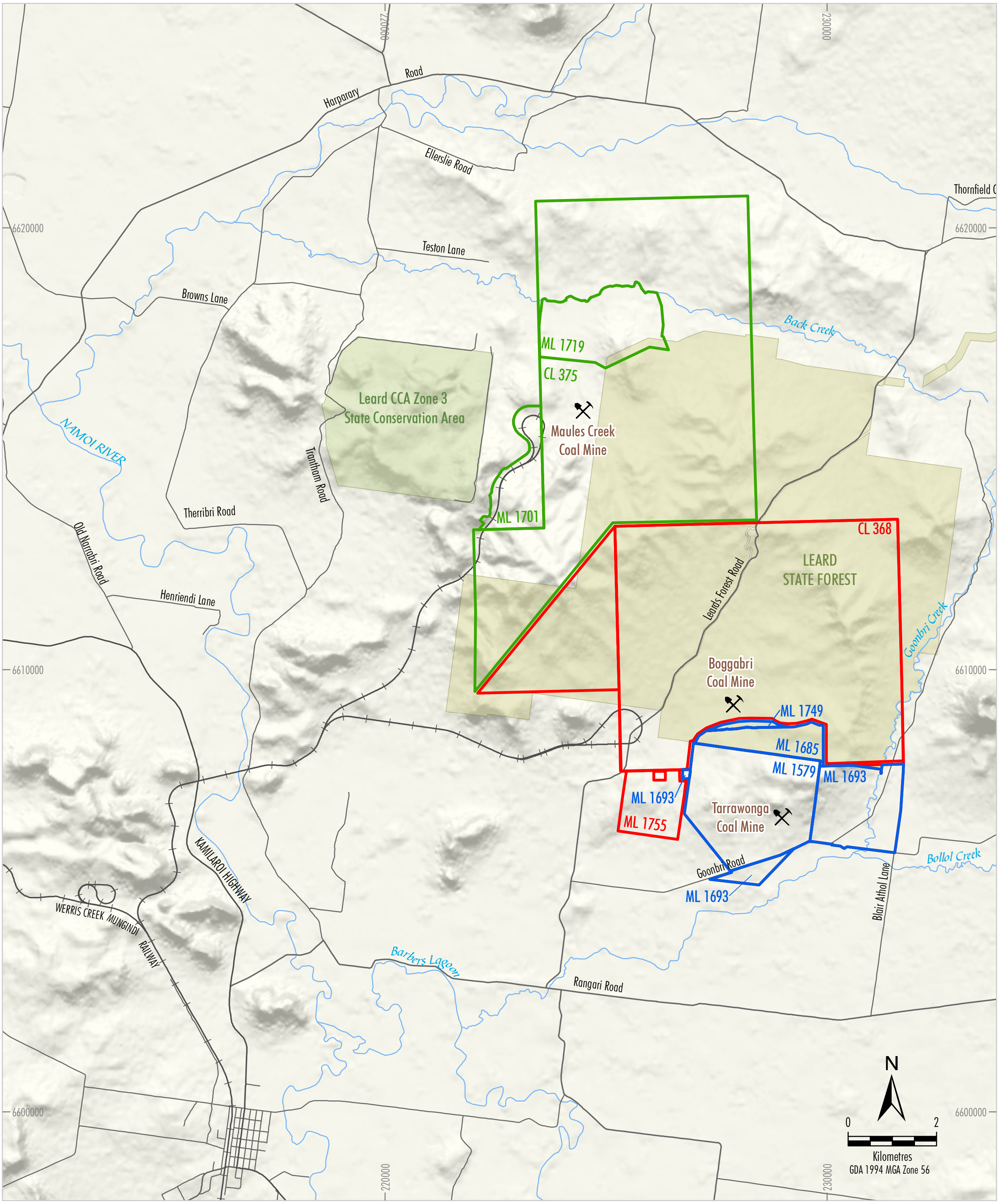
TCM is managed by Tarrawonga Coal Pty Ltd, a wholly owned subsidiary of Whitehaven.

A summary of the ownership details for each mine within the BTM Complex is provided below in Table 1.1.

Table 1.1
Management and ownership of BTM Complex Mines

Mine	Management	Ownership	Share
Boggabri Coal Mine	Boggabri Coal Operations Pty Limited	Idemitsu Australia Resources Pty Ltd	80%
		Chugoku Electric Power Australia Resources Pty Ltd	10%
		NS Boggabri Pty Ltd	10%
Maules Creek Coal Mine	Maules Creek Coal Pty Ltd	Aston Coal 2 Pty Limited (owned 100% by Whitehaven Coal Limited)	75%
		Itochu Coal Resources Australia Maules Creek Pty Ltd (ICRA MC)	15%
		J-Power Australia (J-Power) Pty Ltd	10%
Tarrawonga Coal Mine	Tarrawonga Coal Pty Ltd	Whitehaven Coal Mining Limited	100%

[1] In previous environmental assessments and approval documents this group of mines has been referred to as the Leard Forest Mining Precinct. For the purposes of the Water Management Strategy and all other relevant cumulative impact management documents, all references to the 'Leard Forest Mining Precinct' have been replaced with the term 'BTM Complex'.



LEGEND

Mining Tenement Boundary - Boggabri Coal Mine

Mining Tenement Boundary - Tarrawonga Coal Mine

Mining Tenement Boundary - Maules Creek Coal Mine

NSW National Parks and Wildlife Services (NPWS) Estate

State Forest

Railway

Source: Whitehaven Coal Limited (2016); NSW Department of Land and Property Information (2016); NSW Department of Industry (2016); Office of Environment and Heritage NSW (2016)

BTM WATER MANAGEMENT STRATEGY

Regional Location

Figure 1.1

Development applications for the continued operation of the BCM (Project Approval 09_0182) and the development of the MCCM (Project Approval 10_0138) were determined by the NSW Planning Assessment Commission (PAC) in July and October 2012 respectively, under delegation by the NSW Minister for Planning and Infrastructure. Subsequent to this, the Department of the Environment and Energy (DoEE) (formerly the Commonwealth Department of Environment [DoE]), granted conditional approval for both the BCM (EPBC 2009/5256) and the MCCM (EPBC 2010/5566) on 11 February 2013. These projects were granted approval subject to stringent conditions related to the management of cumulative impacts.

The TCM application for continuation of mining was approved on 22 January 2013, with similar cumulative impact management conditions to those detailed in the BCM and MCCM approvals.

Approval conditions require the preparation of a suite of environmental strategies developed in partnership by all three mines of the BTM Complex. This Water Management Strategy has been developed to satisfy each mine's project approval conditions. Approval conditions relevant to the management of cumulative water impacts within the BTM Complex are detailed in Table 1.2.

Table 1.2
Approval requirements for a Water Management Strategy

BCM PA 09_0182	MCCM PA 10_0138	TCM PA 11_0047	Details	Section
Sch. 3 Cond. 38 (d)	Sch. 3 Cond. 40 (d)	Sch. 3 Cond. 39 (c)(iv)	*The Proponent shall prepare and implement a Water Management Plan for the project… this plan must include:* *"… a Leard Forest Mining Precinct Water Management Strategy that has been prepared in consultation with other mines within the Precinct to:*	
			▪ *minimise the cumulative water quality impacts of the mines;*	Section 1.1
			▪ *review opportunities for water sharing/water transfers between mines;*	Sections 1.1, 3 and 4.3
			▪ *co-ordinate water quality monitoring programs as far as practicable;*	Sections 1.1 and 6.2
			▪ *undertake joint investigations/studies in relation to complaints/exceedances of trigger levels where cumulative impacts are considered likely; and*	Sections 1.1 and 8
			▪ *co-ordinate modelling programs for validation, re-calibration and re-running of the groundwater and surface water models using approved mine operation plans.* *Note: The Leard Forest Mining Precinct Water Management Strategy can be developed in stages and will need to be subject to ongoing review dependent upon the determination of and commencement of other mining projects in the area."*	Section 4

1.2 SCOPE

This document is the overarching strategy for cumulative surface water and groundwater management at the BTM Complex.

Individual mines manage their ongoing operations and associated surface water and groundwater management in accordance with their site-specific Water Management Plans (WMPs). Statutory requirements relating to water quality are considered in each site-specific WMP. Table 1.3 outlines the status of the site-specific WMPs for the BTM Complex at the time of writing this document.

Table 1.3
Status of Site-Specific Water Management Plans

Mine	Site-specific WMP Status
BCM	Last published May 2017. Available on the Idemitsu website (https://www.idemitsu.com.au/mining/operations/boggabri-coal/approvals-plans-reports/)
MCCM	Last published March 2019. Available on the Whitehaven website (http://www.whitehavencoal.com.au/sustainability/environmental-management/maules-creek-mine/)
TCM	No approved WMP. A draft WMP was submitted to DoI -Water (then DPI – Water) in August 2018 for review and TCPL is currently addressing comments from DoI – Water at the time of writing this document.

DoI - Water – NSW Department of Industry – Water.

DPI - Water – NSW Department of Primary Industries – Water.

1.3 SUMMARY OF PREVIOUS STUDIES

Previous environmental studies carried out for individual BTM Complex projects have been used in preparation of this document. A summary of these studies is presented in Table 1.4. These studies are publically available on the respective company websites and on the Major Projects database.

Given the location of the BTM Complex within the Namoi Catchment, reference is also made to findings of the Namoi Catchment Water Study (Schlumberger, 2012), commissioned by the NSW Government in August 2010. The study involved a strategic assessment of the likelihood of potential impacts from coal and gas development in the Namoi Catchment on the quantity and quality of surface and groundwater resources.

Table 1.4
Summary of Previous Water Impact Assessment Studies

Surface Water	Groundwater
Boggabri Coal Mine	
Parsons Brinckerhoff, *Continuation of Boggabri Coal Mine Project – Surface Water Assessment*, prepared for Hansen Bailey as part of the Environmental Assessment, October 2010*	Australasian Groundwater & Environmental Consultants Pty Ltd (AGE), *Continuation of Boggabri Coal Mine Groundwater Assessment*, prepared for Boggabri Coal Pty Ltd, October 2010
WRM, *Continuation of Boggabri Coal Mine- Namoi River Flood Impact Assessment*, prepared for Hansen Bailey, December 2009	Parsons Brinckerhoff, Boggabri Coal Mine - *Project Approval Modification Environmental Assessment (MOD 5)*, November 2015
Tarrawonga Coal Mine	
Gilbert and Associates Pty Ltd, *Tarrawonga Coal Project-Surface Water Assessment*, prepared for Whitehaven Coal Pty Ltd, March 2010	Heritage Computing Pty Ltd, *A Hydrogeological Assessment in Support of the Tarrawonga Coal Project Environmental Assessment,* prepared for Tarrawonga Coal Pty Ltd, January 2012*
Gilbert and Associates Pty Ltd, *Tarrawonga Coal Project-Surface Water Assessment*, prepared for Whitehaven Coal Pty Ltd, November 2011	GeoTerra Pty Ltd, *Surface Water and Groundwater 2006/2009 Monitoring Tri-annual Review,* prepared for Tarrawonga Coal Pty Ltd, November 2009
GeoTerra Pty Ltd, *Surface Water and Groundwater 2006/2009 Monitoring Tri-annual Review*, prepared for Tarrawonga Coal Pty Ltd, November 2009	
Maules Creek Coal Mine	
WRM, *Surface Water Impact Assessment for Maules Creek Coal Project*, prepared for Aston Resources, 9 February 2011	Australasian Groundwater & Environmental Consultants Pty Ltd (AGE), *Maules Creek Coal Project Groundwater Impact Assessment,* prepared for Aston Resources Ltd, June 2011*

Table 1.4 (Continued)
Summary of Previous Water Impact Assessment Studies

Surface Water	Groundwater
NSW Planning Assessment Commission, *Review Report- Maules Creek Coal Project,* March 2012	Heritage Computing Pty Ltd, *Peer Review of the Maules Creek Coal Project Groundwater Impact Assessment,* prepared for Aston Resources Ltd, February 2011
NSW Planning and Environment, *Director General's Environmental Assessment Report- Major Project Assessment Maules Creek Coal Project,* August 2012	NSW Planning Assessment Commission, *Review Report- Maules Creek Coal Project*, March 2012
	NSW Planning and Environment, *Director General's Environmental Assessment Report- Major Project Assessment Maules Creek Coal Project*, August 2012
	AGE Pty Ltd, *Installation of Monitoring Bore Network & Updating Groundwater Model*, 2014
BTM Complex	
	AGE, *Boggabri; Tarrawonga Maules Creek Complex Numerical Model Update*, August 2018*

* Study details the potentially cumulative impacts of the BTM Complex.

1.4 AGENCY CONSULTATION

The Water Management Strategy draws upon the site-specific WMPs and site water balance reports for the three mines. These documents have undergone extensive review by DP&E on numerous occasions and subsequent approval.

The site-specific mine WMPs which form the basis of the Water Management Strategy have been prepared in consultation with representatives from the NSW Office of Environment and Heritage (OEH), DoI – Water and North West Local Land Services (NWLLS) (formerly Namoi Catchment Management Authority).

The draft version of the Water Management Strategy has been reviewed by DP&E and comments have been addressed. A draft version of this BTM Complex Water Management Strategy has also been provided to DoI – Water, and a final draft version will also be provided to DoI – Water.

1.5 DOCUMENT STRUCTURE

The structure of this report is as follows:

Section 1 Provides an introduction to the Water Management Strategy, including the background and scope of the Water Management Strategy. A list of previous studies is also included.

Section 2 Provides an overview of the BTM Complex mines (BCM, TCM, MCCM).

Section 3 Briefly outlines the existing surface water and groundwater resources of the area and the administrative context of their management.

Section 4 Summarises the existing site-specific surface water and groundwater models for each mine, and cumulative modelling for the BTM Complex.

Section 5 Describes potential cumulative impacts and issues associated with the BTM Complex.

Section 6 Describes surface water and groundwater monitoring networks relevant to the BTM Complex.

Section 7	Describes surface water and groundwater impact mitigation and response to triggers.
Section 8	Describes how the Water Management Strategy will be implemented and the complaint management strategy.
Section 9	Outlines the requirements for reviewing and revising the Water Management Strategy.
Section 10	Lists the references used in this document.

2. THE BTM COMPLEX

The BTM Complex is located in the Narrabri LGA in the Northwest Slopes and Plains of New South Wales. The BTM Complex is located within and adjoining the Leard State Forest, north-east of Boggabri and south of Maules Creek. The major regional centres of Narrabri and Gunnedah are located approximately 50 km north-west and 40 km south-east of the BTM Complex, respectively.

2.1 BOGGABRI COAL MINE

BCM is an existing open cut mine that consists of an open cut pit, overburden dump, infrastructure area including coal processing facilities, water management structures, and a rail spur.

BCM obtained NSW State Government approval on the 18 July 2012, and Commonwealth Government approval on 11 February 2013. These approvals (as modified) allow operations at BCM to extend for a further 21 years at a rate of 8.6 million tonnes per annum (Mtpa) of run-of-mine (ROM) coal. The project approval for BCM provides for operation of existing ancillary equipment; construction and operation of a new coal handling and preparation plant (CHPP); 17 km rail spur line; bridges over the Namoi River and Kamilaroi Highway; a rail load-out facility located at the mine; upgrade of the overburden and coal extraction haulage fleet (with an option for a drag-line); upgrade of electricity transmission lines; and establishment of a water supply borefield and other ancillary infrastructure.

2.2 TARRAWONGA COAL MINE

TCM is an existing open cut coal mine located immediately south of BCM. TCM initially had approval to extract 2 Mtpa of ROM coal until 2017. TCPL submitted an application in July 2011 under Part 3A of the Environment Planning and Assessment Act 1979 (EP&A Act) for an extension of open cut mining operations to 3 Mtpa of ROM coal for a further 17 years. This application was approved by the NSW State Government on 22 January 2013.

TCM have modified Project Approval 11_0047 on a number of occasions since then, with the most recent being in November 2018. Project Approval 11_0047 allow operations at TCM until 2030 at a rate of 3 Mtpa of ROM coal.

2.3 MAULES CREEK COAL MINE

A Project Application for the MCCM was submitted to the NSW Department of Planning (now Department of Planning and Environment) in August 2010 under Part 3A of the EP&A Act. Project approval was granted by the Planning Assessment Commission under delegation of the Minister for Planning and Infrastructure on 23 October 2012. The project approval allows for the construction and operation of an open cut coal mine, with the recovery of up to 13 million tonnes per annum (Mtpa) of ROM coal for a period of 21 years. Key features of the project include transportation of coal by rail to Newcastle, and development of site infrastructure including a CHPP and associated facilities, a train loading facility and rail spur and loop, a mine access road, communications and power reticulation, explosives storage, and a water pipeline from the Namoi River.

Construction of the MCCM commenced in December 2013. Extraction of first coal commenced in the fourth quarter of 2014.

3. WATER RESOURCES AND ADMINISTRATIVE CONTEXT

3.1 SURFACE WATER

3.1.1 Catchments and streams

The slopes and upland areas of the BTM Complex are drained by a series of ephemeral streams rising in the Willowtree Range. The local drainage catchments associated with the area are, from the north, Maules Creek, Back Creek, 'Nagero Creek', Goonbri Creek and Bollol Creek, as shown in Figure 3.1.

BCM is contained within the catchment of an unnamed ephemeral waterway, locally known as 'Nagero Creek'. Nagero Creek drains west towards the Namoi River.

MCCM is largely within the Back Creek catchment with small tributaries flowing north into Back Creek which itself then flows west to meet Maules Creek before flowing into the Namoi River.

TCM is within the catchments of Nagero, Goonbri and Bollol Creeks. These creeks and their unnamed tributaries drain in a westerly and south-westerly direction towards the Namoi River.

Further detail regarding each site-specific mine's surface water systems is provided in the BCM, MCCM and TCM surface water assessments (available on each respective company website).

3.1.2 Relevant surface water sharing plans

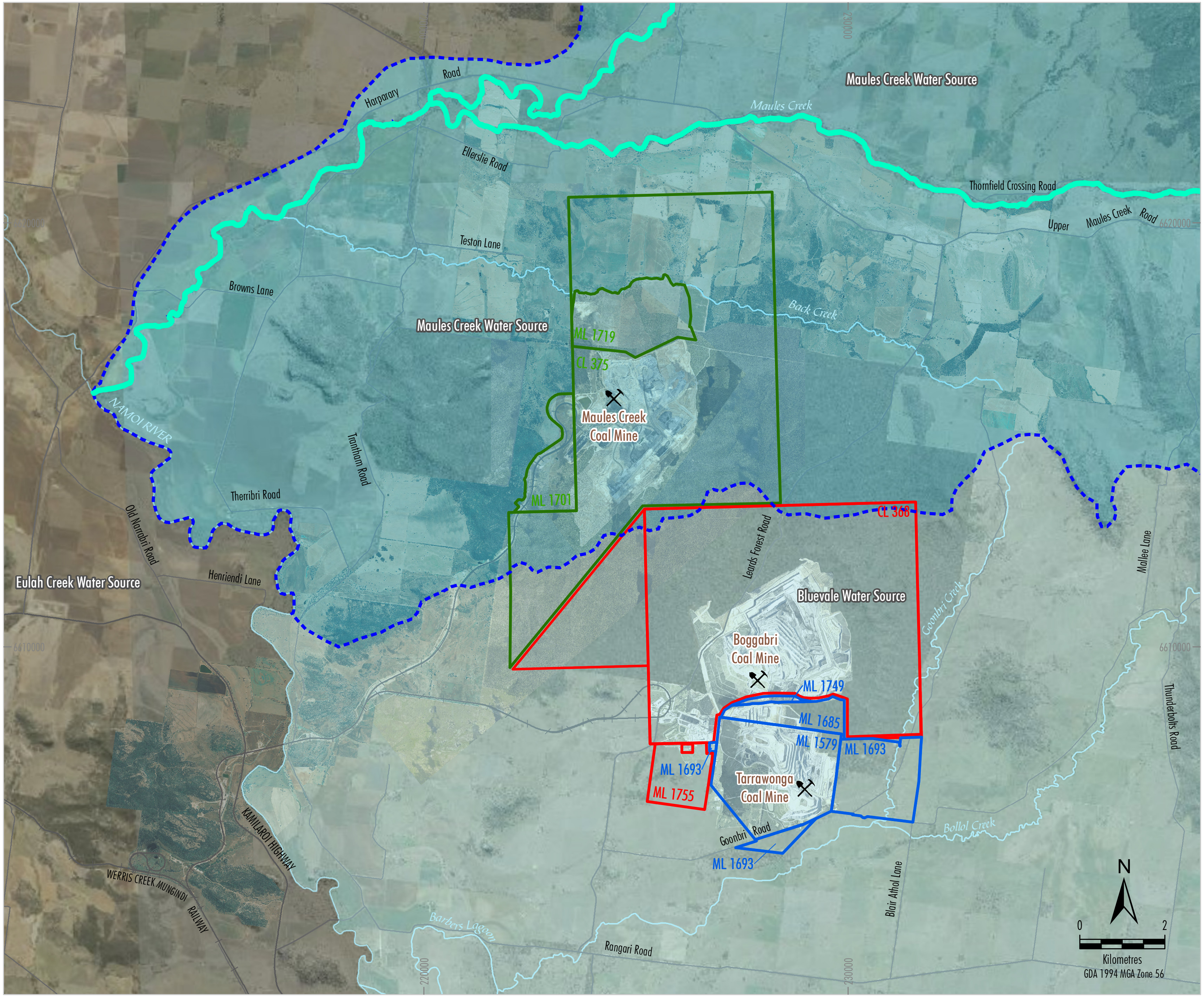
The BTM Complex lies within the Maules Creek Water Source, administered under the Water Sharing Plan (WSP) for the Namoi Unregulated and Alluvial Water Sources. The Maules Creek Water Source is divided into two management zones, the Maules and Horsearm Creeks Management Zone, and the Maules Creek Tributaries Management Zone (Figure 3.1). These local unregulated creeks flow into the Namoi River, which is administered under the WSP for the Upper and Lower Namoi Regulated River Water Sources. Water access licences (WALs) for both these water sources are fully allocated. Each mine site is responsible for holding or obtaining sufficient WALs prior to accessing surface water. WALs currently held by each mine site are listed in Section 3.3.

3.2 GROUNDWATER

3.2.1 Regional geology and hydrogeology

The BTM Complex is located in an area geologically characterised by the Permian Maules Creek Formation, with minor Quaternary alluvium to the south-east and Permian Boggabri Volcanics to the south-west (DMR, 1998). Minor alluvium is also associated with local creeks. Beyond the mining leases, extensive Quaternary alluvium deposits overlie the Boggabri Volcanic deposits to the west and south-west, and the Maules Creek Formation to the south. Coal is extracted from the seams of the Maules Creek Formation. Further south the alluvium directly overlies the Boggabri Volcanics (Figure 3.2).

The thickness of the highly productive Quaternary alluvial deposits along the Namoi River ranges from approximately 30 m to 120 m, decreasing from the thicker palaeochannel in the south-west to a thin cover in the east. The regional groundwater flow direction within this alluvium is generally to the north-northwest. Groundwater in the alluvium associated with Bollol Creek flows south-west towards the Namoi River.



LEGEND

- Mining Tenement Boundary - Boggabri Coal Mine
- Mining Tenement Boundary - Tarrawonga Coal Mine
- Mining Tenement Boundary - Maules Creek Coal Mine
- Maules Creek Tributaries Management Zone
- Maules and Horsearm Creeks Management Zone
- Bluevale Water Source
- Maules Creek Water Source
- Eulah Creek Water Source

Source: *Department of Industry (2019); DPI - Gunnedah Coalfield South (2013)*

WHITEHAVEN COAL

IDEMITSU BOGGABRI COAL

BTM WATER MANAGEMENT STRATEGY

Surface Water Features

Figure 3.1

WHC-13-15 BTM_207A

The Maules Creek alluvial aquifers are located north of BTM and are divided into two distinct zones by a constriction in the flood plain created by the outcropping Permian basement. Upstream of the constriction the Maules Creek alluvium is some 90 square kilometres (km^2) in area and drained by three ephemeral creeks; Horesarm Creek, Middle Creek and Maules Creek (i.e. Upper Namoi Zone 11, Maules Creek Groundwater Source). Downstream of the constriction area, Horsearm Creek and Middle Creek discharge into Maules Creek and a zone of permanent water holes known as Elfin Crossing are present. The Maules Creek alluvial plain widens significantly in this area and Maules Creek eventually discharges into the Namoi River about 11 km west of the MCCM mining lease (AGE, 2011).

Bore yields in the alluvial aquifers are highly variable and dependent on the nature and thickness of the sediment intersected when drilling. The bores in the alluvial aquifers show a very wide range in yields, from less than 1 L/s up to a maximum of 175 L/s (AGE, 2018).

The major groundwater aquifers within the Maules Creek Formation are the coal seams, in particular the Merriown Seam. The Maules Creek Formation aquifers are 'confined' to 'semi-confined', bounded below by fresh volcanic bedrock and above by low permeability sandstones and conglomerates. Leakage from the Permian strata is restricted, both between coal seam layers and from the overlying and underlying sandstone, shale, conglomerate and siltstone. Groundwater flow direction in the Maules Creek Formation is to the south-west (Parsons Brinckerhoff, 2012a), consistent with the topographic gradient. The groundwater flow within the coal seams of the Maules Creek Formation is controlled primarily by lateral flow within the seams.

Residual volcanic soils associated with the Boggabri Volcanics (weathered profile) to the south-west of the mine lease areas are generally thick enough to retain groundwater volumes of consequence, however their permeability is low. The weathered rock aquifer is generally 40 m to 50 m thick and provides a hydraulic connection between the coal seam aquifers and the alluvium associated with ephemeral creeks ('Nagero Creek' and Bollol Creek) and the Namoi River.

Further details regarding the hydrogeology of the BTM Complex area are provided in the site-specific groundwater assessments and in the *Boggabri, Tarrawonga, Maules Creek Complex Numerical Model Update* (AGE, 2018).

3.2.2 Relevant groundwater sharing plans

The three BTM Complex mines target coal seams in the Maules Creek Formation within the Gunnedah-Oxley Basin MDB Groundwater Source defined in the WSP for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2011. The surrounding alluvial sediments lie within the following groundwater sources, defined in the WSP for the Upper and Lower Namoi Groundwater Sources 2003 (Figure 3.3):

- Upper Namoi Zone 4, Namoi Valley (Keepit Dam to Gin's Leap) Groundwater Source.
- Upper Namoi Zone 5, Namoi Valley (Gin's Leap to Narrabri) Groundwater Source.
- Upper Namoi Zone 11, Maules Creek Groundwater Source.

The BTM Complex mines are required to obtain access licences for any volumetric groundwater impacts on these water sources. These may be direct impacts such as drainage of the alluvial or porous rock groundwater sources via bores and/or pumps from mine workings, or indirect impacts resulting from drainage, or reduction in inflows to the alluvial groundwater sources. The Upper and Lower Namoi alluvial groundwater sources are fully allocated. As such, licences to account for volumetric impacts would need to be obtained from existing holders. Water entitlements currently held across the BTM Complex are detailed in each mine's respective surface water and groundwater management plans and are provided in Section 3.3.

3.3 WATER ACCESS LICENCES

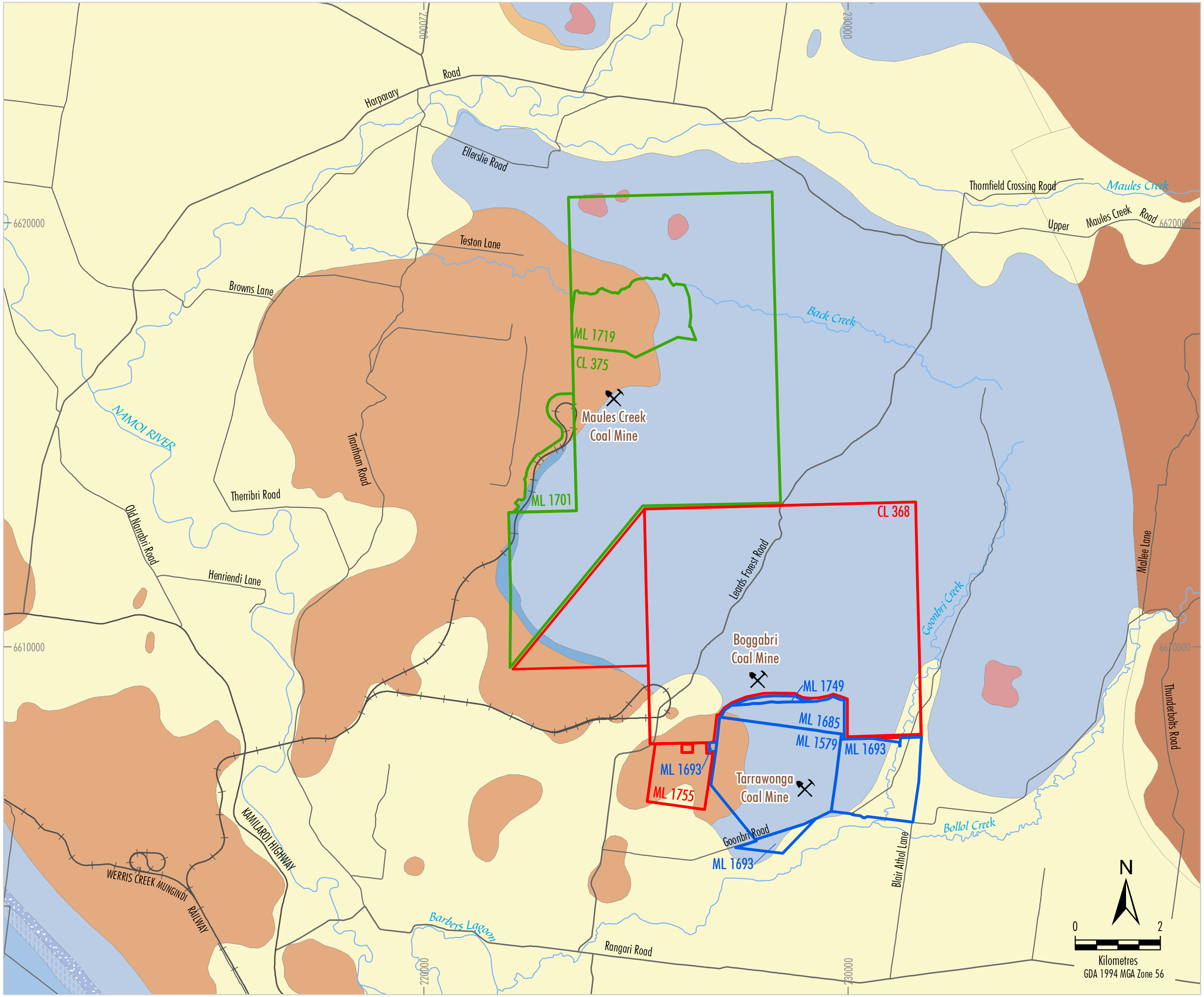
Table 3.1 summarises the surface water and groundwater WALs currently held (at the time of writing) by each mine site. Mine-specific WMPs contain the predicted annual take per mine.

Table 3.1
Water Access Licences for the BTM Complex

Water Source	Predicted Water Take*#	Licence No.	Total Entitlement (units)^	Type
Maules Creek Coal Mine				
Lower Namoi Regulated River Water Source	As required	WAL13050	3,000.00	Surface water extraction
Maules Creek Water Source (Maules Creek Tributaries Management Zone)	N/A	WAL41585	30.00	Surface water extraction
Upper Namoi Zone 4, Namoi Valley (Keepit Dam to Gin's Leap) Groundwater Source	60	WAL27385	38.00	Indirect Aquifer Interception
		WAL12645	35.00	Indirect Aquifer Interception
Upper Namoi Zone 5, Namoi Valley (Gin's Leap to Narrabri) Groundwater Source	0	WAL12811	135.00	Indirect Aquifer Interception
Upper Namoi Zone 11, Maules Creek Groundwater Source	4	WAL12479	78.00	Indirect Aquifer Interception
	-	WAL27383	0.00	Indirect Aquifer Interception
	-	WAL12491	77.00	Indirect Aquifer Interception
	-	WAL12480	215.00	Indirect Aquifer Interception
Gunnedah - Oxley Basin MDB Groundwater Source (Gunnedah - Oxley Basin MDB [Other] Management Zone)	108	WAL36641	800.00	Aquifer interception
Gunnedah - Oxley Basin MDB Groundwater Source (Gunnedah - Oxley Basin MDB [Other] Management Zone)	-	WAL29588	0.00 (subject to conditions)	N/A
Gunnedah - Oxley Basin MDB Groundwater Source (Gunnedah - Oxley Basin MDB [Other] Management Zone)	306	WAL29467	306.00	Aquifer interception
Boggabri Coal Mine				
Lower Namoi Regulated River Water Source	As required	WAL2571	51.00	Surface water extraction
	As required	WAL2572	5.60	Surface water extraction
	As required	WAL2595	243.00	Surface water extraction
	As required	WAL2596	26.50	Surface water extraction
Upper Namoi Regulated River Water Source	-	WAL37067	128.00	Surface water extraction
Upper Namoi Zone 4, Namoi Valley (Keepit Dam to Gin's Leap) Groundwater Source	-	WAL12691	457.00	Aquifer Extraction
	-	WAL12767	3.00	Aquifer Extraction
	-	WAL15037	172.00	Aquifer Extraction
	-	WAL24103	275.00	Aquifer Extraction
	-	WAL36547	37.00	Aquifer Extraction
	66	WAL37519	84.00	Aquifer Extraction
Upper Namoi Zone 11, Maules Creek Groundwater Source	4	WAL42234	20.00	Indirect Aquifer Interception
Gunnedah - Oxley Basin MDB Groundwater Source (Gunnedah - Oxley Basin MDB [Other] Management Zone)	-	WAL29473	142.00	Aquifer Extraction
	459	WAL29562	700.00	Aquifer Interception
Tarrawonga Coal Mine				
	145	WAL31084	250.00	Aquifer Interception

Gunnedah - Oxley Basin MDB Groundwater Source (Gunnedah - Oxley Basin MDB [Other] Management Zone)	-	WAL29548	50.00	Aquifer Interception
Upper Namoi Zone 4, Namoi Valley (Keepit Dam to Gin's Leap) Groundwater Source	21	WAL36548	36.00	Indirect Aquifer Interception
Upper Namoi Zone 11, Maules Creek Groundwater Source	1	WAL12480	215.00	Indirect Aquifer Interception

* Value provided via predictive water modelling of the BTM Groundwater Model to be revised periodically. Please refer to section 5.2.
# Predicted modelled water take maximum value to 2020 as per Table 8.10 of BTM Complex Numerical Model Update until a future model review identifies revised predicted values.
^ Licenced entitlement does not include accounting for any licenced carryover permitted under applicable Water Sharing Plan conditions.



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BTM WATER MANAGEMENT STRATEGY

Regional Geology

Figure 3.2

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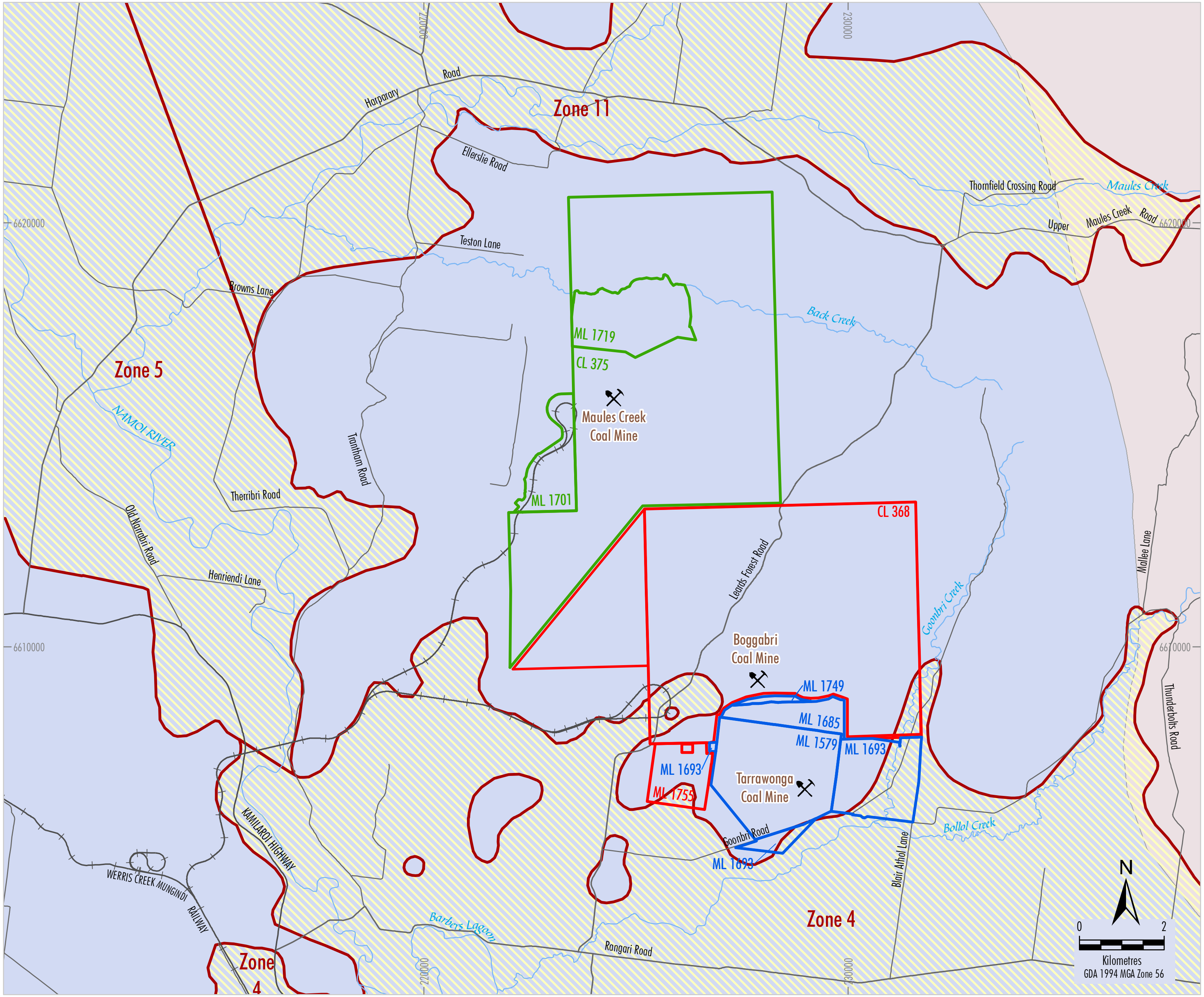

LEGEND

Mining Tenement Boundary - Boggabri Coal Mine

Mining Tenement Boundary - Tarrawonga Coal Mine

Mining Tenement Boundary - Maules Creek Coal Mine

Water Sharing Plan for the Upper and Lower Namoi Groundwater Sources 2003

Alluvial Groundwater Source

Water Sharing Plan for the NSW Murray Darling Basin Porous Rock Groundwater Sources 2011

Gunnedah-Oxley Basin MDB Groundwater Source

Water Sharing Plan for the NSW Murray Darling Basin Fractured Rock Groundwater Sources 2011

New England Fold Belt MDB Groundwater Source

Source: Department of Industry (2019); DPI - Gunnedah Coalfield South (2013)

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BTM WATER MANAGEMENT STRATEGY

Relevant Groundwater Sources

Figure 3.3

WHC-13-15 BTM_206A

4. MODELLING

Site-specific surface water and groundwater assessments have previously been prepared for Environmental Assessments and Environmental Impact Statements for the MCCM, TCM and BCM (Table 1.3). The surface water and groundwater models developed to support these assessments are described in Sections 4.1.1 and 4.2.1.

In addition to site-specific assessment, cumulative consideration and modelling of surface water and groundwater has been conducted for the BTM Complex in support of this WMS, which is described in Sections 4.1.2 and 4.2.2.

The overall goal of cumulative consideration/modelling is to demonstrate the conceptual understanding of the cumulative behaviour of surface and groundwater resources in the BTM Complex area, and as such:

1. to estimate quantitatively the cumulative impacts from the BTM Complex on groundwater and surface water resources to inform appropriate management responses (e.g. licence acquisition, compensatory measures for affected landholders, structural measures, additional monitoring, etc.);
2. to estimate the contribution to impacts by individual mines in order to determine appropriate responsibilities for management responses; and
3. to verify the predicted impacts over the course of mining operations through evaluation of design hydraulic behaviour, mine inflows and groundwater drawdown magnitude/extent, with this information feeding back into the above management responses.

4.1 SURFACE WATER

4.1.1 Site-Specific Modelling

Hydrologic and hydraulic models have been developed for BCM (Parsons Brinckerhoff, 2010). The purpose of the modelling was to assess the potential impact of BCM on peak flows in the 'Nagero Creek' catchment, and for the preliminary sizing of diversion drains. The hydrologic and 1D hydraulic models were developed using XPSWMM (version 10.6) software. These models do not include hydraulic structures (such as culverts), but do include sediment basins from the northern spoil dump at the existing TCM.

The Boggabri XPSWMM model provided results for the 5, 20 and 100 year Average Recurrence Interval (ARI) design storm events, for Years 1, 5, 10 and 21 of BCM. The modelling suggests that peak flow rates at the catchment outlet (where 'Nagero Creek' meets the Namoi River floodplain, approximately 1 km downstream of BCM) will reduce over the life of the mine, as a result of water being captured and reused on site (Parsons Brinckerhoff, 2010).

Additionally, a flood study was prepared by WRM (2011) for BCM, using TUFLOW software. The intent of the model was to assess the impact of the proposed rail bridge, haul road upgrade and Therribri Road overpass on the Namoi River floodplain. The model boundary was restricted to the infrastructure area of the Namoi River, and predicted a negligible to minor impact to flood levels, extent and velocities.

Hydrologic and hydraulic modelling has also been carried out for the TCM by Gilbert & Associates (2011). The purpose of the modelling was to design the realignment of Goonbri Creek around the eastern edge of the proposed extended open cut pit. Hydrological modelling was carried out using RORB software, to predict peak design flows for the 2, 20 and 100 ARIs and the Probable Maximum Flood (PMF). 1D hydraulic modelling was carried out using HEC-RAS software to assess the viability of the channel design.

Gilbert & Associates (2011) recommend further hydraulic modelling be carried out using additional survey data, to model the hydraulic characteristics of Goonbri Creek down to Bollol Creek, and downstream to Barbers Lagoon and the Slush Holes. The results of the recommended additional modelling could then be used to provide a more accurate baseline characterisation of existing conditions in Goonbri Creek and Bollol Creek in the final design of the realigned section of Goonbri Creek. Recommendations of the report (among others) include the placement of flow gauging stations on Goonbri Creek to verify and calibrate the completed models, and to assist in performance evaluation during and post construction.

The results of the hydraulic modelling indicate that peak flow velocities in the channel and overbank areas are indicators of stability in the Goonbri Creek realignment.

Hydrological analysis for MCCM was carried out using the Rational Method (WRM, 2011). The method was used to estimate the 100 year ARI design flood discharges in Back Creek along the reach adjacent to the proposed northern overburden area. The estimated flows were then input into a HEC-RAS model to determine the extent of flooding along Back Creek and to quantify potential impacts of TCM on flood levels and behaviour. The results of the modelling indicate that the proposed limit of disturbance is outside of the 100 year ARI flood extent, and therefore no adverse impact to flood levels or behaviour from TCM is expected for flood events up to the 100 year ARI.

4.1.2 Cumulative Considerations

To achieve the cumulative objectives, it is proposed that a detailed review of site-specific surface water models be undertaken to determine if and how cumulative flow behaviour has been incorporated, in terms of flow distribution, timing, depth and velocities throughout the BTM Complex area and downstream. The models should be assessed for their capabilities and limitations with respect to prediction of cumulative surface water impacts as a result of the BTM Complex.

4.2 GROUNDWATER

4.2.1 Site-Specific Modelling

The three existing regional groundwater models are already standardised on common software, namely MODFLOW-SURFACT Version 4 that is distributed commercially by HydroGeoLogic, Inc. (Virginia, USA). This software is able to simulate variably saturated flow and can handle desaturation and re-saturation of multiple aquifers without the “dry cell” problems of Standard-MODFLOW. This is pertinent to the dewatering of water-bearing formations adjacent to open cut mines and to reliable prediction of water level recovery post-mining.

However, there are differences in the user interfaces to each model. The TCM model (Heritage Computing, 2012b) uses the Groundwater Vistas Version 6 graphic user interface (GUI), while the BCM and MCCM models (AGE, 2010 and 2011) rely on proprietary FORTRAN code with some assistance from the PMW in GUI.

More fundamentally, the models differ in the number of model layers and in the way in which target coal seams have been aggregated, reflecting different mining objectives and variable seam geometry for each site.

Each of the BCM, TCM and MCCM models undergo regular maintenance and recalibration as additional data on groundwater responses to progressive mining improves the understanding of the groundwater systems.

4.2.2 Cumulative Modelling

Heritage Computing (2012)

Groundwater modelling of cumulative groundwater impacts was undertaken by Heritage Computing (2012a) as part of the development of the Water Management Strategy. This is in addition to two regional models developed incrementally by AGE for BCM and MCCM, and a separate regional model for TCM developed by Heritage Computing.

The Heritage Computing (2012) groundwater model utilised the geological layers developed during the data sharing process established between the BCM, TCM and MCCM.

The potential cumulative surface water and groundwater impacts and issues are discussed in Section 5.1.

Australasian Groundwater and Environmental Consultants (2018)

Australasian Groundwater and Environmental Consultants Pty Ltd (AGE) prepared the report *Boggabri, Tarrawonga, Maules Creek Complex Numerical Model Update* (AGE, 2018) to satisfy the approval conditions for the verification of predicted groundwater impacts against observed datasets every three years. Each of the BTM Complex mines are required to prepare a "*Groundwater Management Plan, which includes… a program to validate the groundwater model for the project, including an independent review of the model every 3 years, and comparison of monitoring results with modelled predictions*".

As part of the report, the numerical model for the BTM complex was reviewed and verified against monitoring data collected since 2013. Prior to further calibration the model was imported into MODFLOW USG to allow the geological units to be me more accurately represented. Further calibration of the model aimed at reproducing the water level trends observed within the BTM complex monitoring bore network. The calibration resulted in increasing the coal seam hydraulic conductivity (AGE, 2018).

The modelling results and outcomes are described in Sections 5.2 and 5.3.

5. POTENTIAL CUMULATIVE IMPACTS AND ISSUES

Regional numerical modelling conducted as part of the Namoi Catchment Water Study (Schlumberger, 2012) concluded that the area encompassing the BTM Complex (defined as Upper Namoi Zone 4, Namoi Valley [Keepit Dram to Gin's Leap] Groundwater Source) is considered to be at moderate risk from coal and gas developments. In addition, Upper Namoi Zone 5 Namoi Valley (Gin's Leap to Narrabri) Groundwater Source and Upper Namoi Zone 11, Maules Creek Groundwater Source have been located in the vicinity of the BTM Complex and are considered to be at moderate and high risk from mining and coal seam gas developments, respectively. Schlumberger (2012) indicated potential impacts within the Namoi Catchment would likely occur as follows:

- Interception of rainfall and run-off; There is a greater potential for open-cut mines to intercept rainfall and run-off. Where possible operators tend to divert existing surface water drainage around the perimeter of the site to minimise drainage into the open cut. Water intercepted is removed from the surface/groundwater systems and stored on-site for use in operations or treated and discharged.
- Lowering of groundwater levels; Mining below the water table can have an impact on groundwater resources. Dewatering of pits can potentially induce local changes in groundwater gradients and flow directions.
- Pit runoff water and pumped groundwater can be contaminated with suspended solids and/or dissolved minerals and metals, and would need to be treated before discharge into the local drainage system.

Sections 5.1 and 5.2 provide an overview of the detailed assessments of the potential surface water and groundwater impacts associated with BTM Complex operations undertaken as part of the Environmental Assessments (EAs) and technical reports prepared in support of development applications for each project. A summary of previous surface water and groundwater studies is provided in Table 1.4.

5.1 SURFACE WATER

5.1.1 Contaminant export

Mine water, containing suspended solids and soluble salts, will be generated from coal stockpiles and the mining void, as well as groundwater inflows to the mining void. In addition, dirty water containing suspended solids will be generated from runoff from disturbed areas within the mine sites, including from infrastructure areas, unshaped spoil dumps and haul roads. For all mines, mine water will be retained onsite for use (if required), and dirty water will report to settlement ponds for on-site use, or be shared with other mines within the BTM Complex, subject to water sharing agreements being reached on terms acceptable to the mines acting reasonably, or discharged from site in line with approval conditions and licences for each of the mines.

The management of dirty water and mine water at each of the mines is detailed in each site-specific WMP. It will remain the responsibility of each mine to implement the mitigation measures detailed in their WMP's to reduce any cumulative impacts on the surrounding environment during operations and post-mining until relinquishment of the relevant leases.

5.1.2 Catchment areas and flows to local creeks and Namoi River

Mining operations will result in modifications to local surface water catchments. The area of undisturbed (or rehabilitated) catchment draining to the local creeks will reduce over the life of each mine, as the area draining to dirty and mine water management systems increases. Areas draining to local catchments will subsequently increase as rehabilitation is established and runoff is of suitable quality.

Peak flow rates at the catchment outlets are likely to reduce over the life of the mines. This reduction may be attributed to dirty water runoff being captured in sediment dams, thus attenuating peak flow rates. An overall reduction in catchment outflow may also be associated with mine water runoff being stored on-site for reuse, rather than being discharged to the creeks.

Surface water will also, where possible, be diverted around disturbed and mining areas and directed into catchment outlets.

Given the very small contribution of these creeks to the Namoi River catchment, the impacts on the Namoi River flows downstream and the Namoi River water users are likely to be minimal. However, local creek environmental flows may be affected.

The extent to which impacts on streamflows persist beyond the life of BTM Complex will depend on the final landform for each mine (i.e. changes in runoff direction due to the final landforms and permanent catchment excision due to final voids). It will remain the responsibility of each mine to ensure rehabilitation and landform design (including final void catchment areas) is undertaken in accordance with the relevant site-specific approvals.

In locations where the landforms interface, consultation will be conducted between the relevant BTM Complex mines to achieve beneficial cumulative landform objectives (e.g. to minimise long term water impacts).

5.1.3 Flooding

Investigations undertaken as part of the EAs for each mine found that peak flow rates at catchment outlets in the BTM Complex area are likely to reduce as mine areas increase, as described in the section above.

Changes to landforms and hydrology from BTM Complex mining and overburden emplacement have the potential to change flood characteristics for flood prone areas.

For BCM, analysis undertaken by WRM Water and Environment Pty Ltd, and summarised in the EA (WRM, 2009) indicated that mine infrastructure would cause no riverbank erosion upstream or downstream of the project, and predicted a minor impact on flood levels, extent and velocities.

Gilbert & Associates (2011) undertook initial hydrologic and hydraulic modelling for the TCM. The assessment identified the TCM to be predominantly on land with an elevation greater than 275 m AHD, which is above any conceivable flood impact. It determined that the proposed flood bund and embankments of the Goonbri Road realignment would have minimal impact on the Goonbri/Bollol Creek floodplain south of Dripping Rock Road. As part of the proposed Goonbri Creek realignment, further hydraulic modelling will be carried out using additional survey data, to model the hydraulic characteristics of Goonbri Creek down to Bollol Creek, and downstream to Barbers Lagoon and the 'Slush Holes'. The results of this additional modelling can then be used to provide a more accurate baseline characterisation of existing conditions in Goonbri Creek and Bollol Creek in the final design of the realigned section of Goonbri Creek.

Hydrologic and hydraulic analysis for MCCM was carried out by WRM (2011) to determine the extent of flooding along Back Creek and to quantify potential impacts of the MCCM on flood levels and behaviour. Results indicated that the proposed limit of disturbance is outside of the 100 year ARI flood extent, and therefore no adverse impact to flood levels or behaviour from the project is expected for flood events up to the 100 year ARI.

5.2 GROUNDWATER

5.2.1 Groundwater flow

Changes to groundwater flows in areas surrounding each mine are anticipated. Schlumberger (2012) highlighted potential for below water table mining in either open-cut or underground mines to have an impact on quantity and quality of groundwater resources. Dewatering of pits and mines can potentially induce local changes in groundwater gradients and flow directions.

Worst case cumulative groundwater impact assessment undertaken by AGE (2010) determined that cumulative groundwater depressurisation impacts could be expected from the TCM, BCM and MCCM projects. The modelling indicated that depressurisation would reduce the net volume of groundwater flowing from the Permian bedrock into the overlying alluvial aquifers by approximately 30%.

5.2.2 Alluvial aquifer impacts

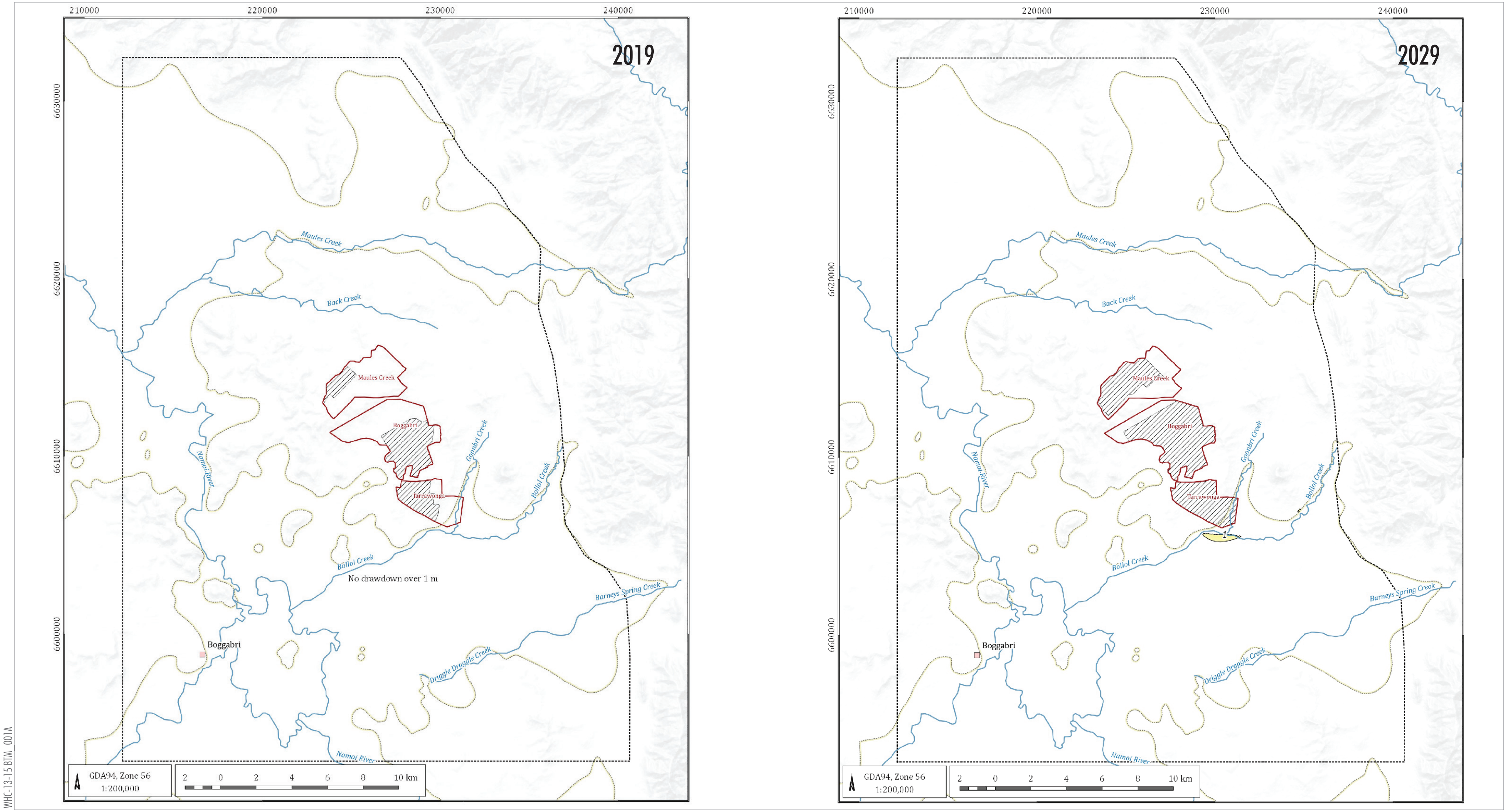
Changes in alluvial groundwater volumes and levels have the potential to occur as a result of mining within the BTM Complex.

The recalibrated model prepared by AGE (2018) predicted limited and localised drawdown within the Narrabri and Gunnedah alluvium, consistent with previous versions of the model. As shown on Figures 5.1 and 5.2, the drawdown is confined to the zones of alluvium that that have infilled valleys immediately adjacent to the active mining areas at Boggabri and Tarrawonga Mine (AGE, 2018).

The drawdown shown in Figures 5.1 and 5.2 represent the cumulative impact on the groundwater regime generated by all three mines operating together. Appendix A contains a series of figures that show how each mine contributes proportionally to the total drawdown and cumulative impact (taken from Appendix D of AGE [2018]. The figures show the proportion of each mine to the cumulative impact is most significant within the active mining area and reduces with distance from the mine. The figures also show that the proportion for each mine changes with time, as mining depth and location progresses.

Modification 5 of the Boggabri Coal Mine involved establishment and operation of a borefield which included two production bores and four contingency production bores. The borefield will contribute to regional cumulative groundwater drawdown associated with the adjacent mining operations. This is estimated to be an additional groundwater drawdown of 1 to 3 m in the alluvium to the east and north-east of the borefield where mine cumulative drawdown is experienced (Parsons Brinckerhoff, 2015).

Insert Figure 5.1



LEGEND

- Populated place
- Major drainage
- Mine maximum open cut outlines
- Mine extent
- Model extent
- Alluvium

Drawdown (m)

- 1
- 2
- 5
- 10
- 20
- 50
- 100
- 200
- 500
- Drawdown contour (m)

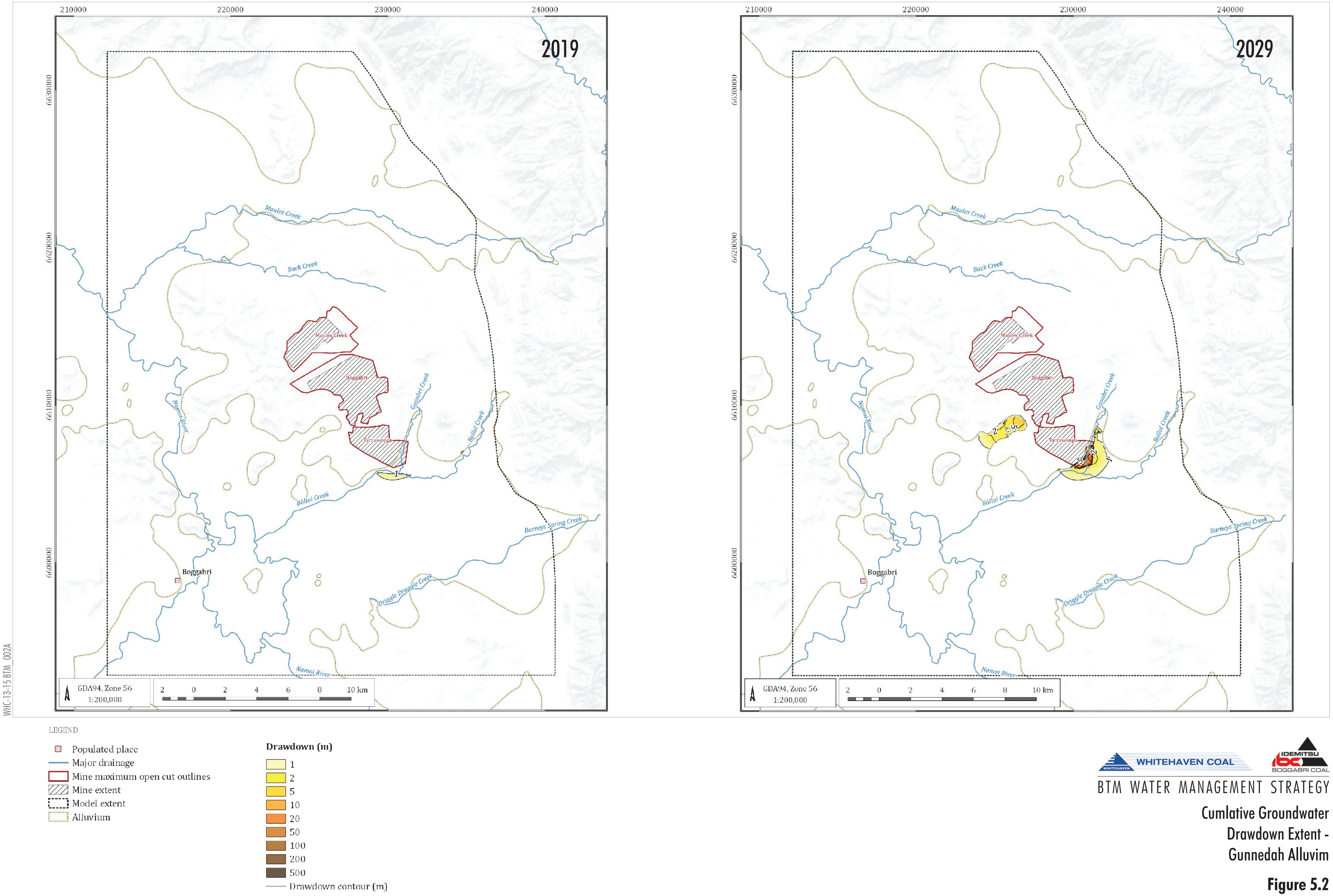
WHITEHAVEN COAL

IDEMITSU BOGGABRI COAL

BTM WATER MANAGEMENT STRATEGY

Cumlative Groundwater Drawdown Extent - Narrabri Alluvim

Figure 5.1



BTM WATER MANAGEMENT STRATEGY

Cumlative Groundwater Drawdown Extent - Gunnedah Alluvim

Figure 5.2

5.2.3 Hard rock aquifer impacts

Impacts to hard rock aquifers are considered to be a potential cumulative issue for the BTM Complex.

Figure 5.3 shows the predicted drawdown extent within the Merriown Seam (refer to AGE [2018] for further details regarding model layers). Compared to previous modelling, the drawdown predicted by the updated model is less extensive to the west and does not extend into the Boggabri Volcanics, but is more extensive towards the east reaching the model boundary. These differences are expected to be a result of:

- changing from MODFLOW SUFACT to MODFLOW USG that allowed pinching out of the coal seams towards the west where they do not exist;
- a simplified approach to representing rainfall recharge (use of the pseudo soil option); and
- the more permeable hydraulic conductivity values determined from the calibration process.

The drawdown shown in Figure 5.3 represents the cumulative impact on the groundwater regime generated by all three mines operating concurrently. Appendix A contains a series of figures that show how each mine contributes proportionally to the total drawdown and cumulative impact.

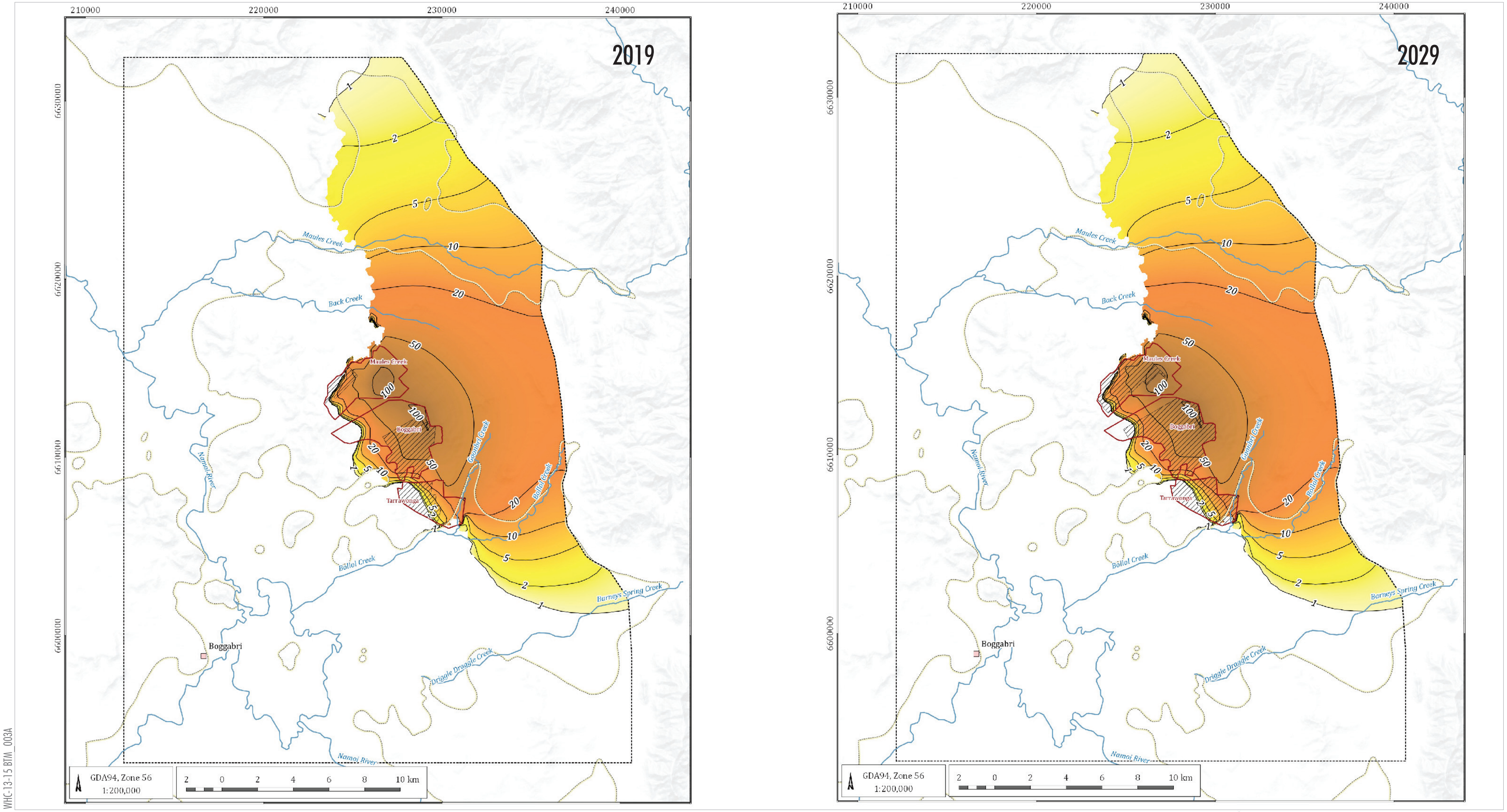
5.2.4 Water quality impacts

The open cuts for each mine in BTM Complex are considered groundwater sinks during operations and post-mining (i.e. final landform) (AGE, 2010; AGE, 2011; Heritage Computing 2012b). The open cuts will draw in groundwater from surrounding aquifers, preventing the release of potentially brackish to saline water back into the surrounding aquifers.

5.3 WATER SUPPLY AND DEMAND

All site WMPs for the BTM Complex mines aim to:

- divert clean water runoff where possible from undisturbed catchment areas around the mine workings into local creeks (‘Nagero Creek’ for BCM, ‘Nagero’, Bollol and Goonbri Creeks for TCM, and Back Creek for MCCM);
- capture dirty water from disturbed areas in sedimentation dams. If the water quality meets licence requirements, and the water is not required for use on-site, it may be discharged into the local catchments or alternatively, if required, shared with other mines within the BTM Complex, subject to water sharing arrangements being agreed between the mines on terms acceptable to the mines acting reasonably;
- use dirty water wherever possible for coal processing and dust suppression;
- use imported water as follows:
  - for BCM, to supplement water from on-site surface water storages and its Zone 4 borefield to meet dust suppression and coal processing demands and as potable water for use in vehicle wash down and construction activities;
  - for TCM, use imported raw water for potable water as well as for other site water deficits and use groundwater from a licensed production bore with an annual entitlement of 50 ML during protracted dry periods; and
  - for MCCM, use imported raw water from an existing high security licence for 3000 ML/yr from the Namoi River for mining operations.



LEGEND

- Populated place
- Major drainage
- Mine maximum open cut outlines
- Mine extent
- Model extent
- Alluvium

Drawdown (m)

- 1
- 2
- 5
- 10
- 20
- 50
- 100
- 200
- 500
- Drawdown contour (m)

Source: AGC (2018)

WHITEHAVEN COAL

IDEMITSU BOGGABRI COAL

BTM WATER MANAGEMENT STRATEGY

Cumlative Groundwater Drawdown Extent - Coal Seams

Figure 5.3

Each mine may experience shortfalls during prolonged dry periods. Further details are contained within each mine’s respective site water balances.

It is proposed that the mines explore opportunities for water sharing and water transfers between mines within the BTM Complex. This may include sharing excess mine water stored on-site as well as purchasing and/or trading of any excess surface water or groundwater (either allocated or produced) between the mines. The infrastructure to be utilised to share the water between the mines will depend on the terms of the agreement reached between the mines (acting reasonably) as to the volume of water to be transferred and the location of the water source and ultimate destination. The water sharing may involve the use of both permanent and temporary water management infrastructure. Water management plans will be updated where required to reflect any new water sharing arrangements and infrastructure.

Where it is not practicable or feasible to share water, additional water may be purchased on the open market, either temporarily or permanently, by the relevant mine to make up any shortfalls. Furthermore, groundwater may also be traded on a temporary or permanent basis within the greater Gunnedah-Oxley Basin Groundwater Source.

AGE (2018) concluded that the three mines cumulatively have sufficient water licenses to account for groundwater intercepted by mining in the areas managed under the Water Sharing Plan for the NSW Murray-Darling Basin Porous Rock Groundwater Sources, and sufficient water licenses to account for water indirectly removed from Zone 4 and 11 of the alluvial aquifers managed under the Water Sharing Plan for the Namoi Unregulated and Alluvial Water Sources.

6. MONITORING

6.1 EXISTING MONITORING NETWORK

6.1.1 Surface water

Surface water monitoring in the BTM Complex area is carried out by BCM, TCM and MCCM in line with their respective WMPs.

Refer to the approved WMP for each mine's existing surface water monitoring program, including locations, frequency and parameters. The approved site-specific WMPs developed and managed in accordance with the relevant site-specific approvals and licences.

Reporting of surface water monitoring can be found in site-specific Annual Reviews.

6.1.2 Groundwater

Groundwater levels and quality

The current groundwater monitoring network within the BTM Complex comprises a combination of monitoring bores and vibrating wire piezometers (VWPs). Monitoring has been carried out for BCM since mid-2006, TCM since June 2006 and MCCM since June 2010 (AGE, 2018). Installation of the groundwater monitoring network is described in more detail in AGE (2018).

Refer to the approved WMPs for each mine's existing groundwater monitoring locations, frequencies and parameters.

Groundwater seepage

Monitoring of groundwater pit seepage is currently carried out for all mines within the BTM Complex.

The seepage monitoring programs for each of the sites is detailed in their approved site WMPs and includes tracking water pumped from the pit, and calculations of groundwater seepage via water balance calculations.

6.2 BTM COMPLEX CUMULATIVE IMPACT MONITORING NETWORK

6.2.1 Surface water

This section details the cumulative surface water monitoring program to be implemented across the BTM Complex. The program focuses on ambient monitoring in order to identify and manage cumulative impacts on surface water quality, flows and third parties. Monitoring locations have been strategically selected to enable the distribution of surface water quality and quantity impacts from each mine to be understood and appropriately managed.

The cumulative surface water monitoring program does not supersede site WMPs currently in place. Rather the program has been developed to work in parallel. The monitoring locations selected for the cumulative monitoring network are part of the existing networks of each mine (Table 6.1 below). The management of data and reporting for the cumulative network is discussed in Section 8. Table 6.1 sets out the surface water quality and flow monitoring locations, parameters, sampling frequencies and reasoning, with locations shown on Figure 6.1.

Table 6.1
Cumulative Surface Water Monitoring Program

Location	Frequency[e]	Parameters	Rationale
Boggabri Coal Mine			
SW2	Event based[d]	Field parameters - EC & pH, TSS, oil and grease, nutrients[b], metals[c]	Monitors ambient conditions on 'Nagero Creek' upstream of BCM
SW1	Event based	Field parameters - EC & pH, TSS, oil and grease, nutrients[b], metals[c]	Monitors conditions on 'Nagero Creek' downstream of BCM, and downstream of TCM (TCM discharges to 'Nagero Creek' and Goonbri Creek)
Tarrawonga Coal Mine			
GC-U	Event based when the creek is flowing and until a baseline is established, then quarterly + event based only when the creek is flowing.	Field parameters[a], TSS, oil and grease, nutrients[b], metals[c]	Monitors ambient conditions on Goonbri Creek upstream of TCM and proposed Goonbri Creek realignment
BC-U	Event based when the creek is flowing and until a baseline is established, then quarterly + event based only when the creek is flowing.	Field parameters[a], TSS, oil and grease, nutrients[b], metals[c]	Monitors conditions of Bollol Creek just upstream of the confluence of Goonbri and Bollol Creeks, upstream of TCM and proposed Goonbri Creek realignment
BC-D	Quarterly + event based only when the creek is flowing.	Field parameters[a], TSS, oil and grease, nutrients[b], metals[c]	Monitors conditions just downstream of the confluence of Goonbri and Bollol Creeks, downstream of TCM and proposed Goonbri Creek realignment
Maules Creek Coal Mine			
SW4	Monthly + event based until a baseline is established, then quarterly (March, June, September, December) + event based	Field parameters[a], TSS, oil and grease, nutrients[b], metals[c]	Monitors ambient conditions on Back Creek upstream of MCCM
SW9	Quarterly (March, June, September, December) + event based	Flow measurement + field parameters[a], TSS, oil and grease, nutrients[b], metals[c]	Monitors conditions on Back Creek downstream of MCCM
SW5	Monthly + event based until a baseline is established, then quarterly (March, June, September, December) + event based	Flow measurement + field parameters[a], TSS, oil and grease, nutrients[b], metals[c]	On the Namoi River, upstream of the BTM Complex
SW8	Monthly + event based until a baseline is established, then quarterly (March, June, September, December) + event based	Flow measurement + field parameters[a], TSS, oil and grease, nutrients[b], metals[c]	On the Namoi River, downstream of confluence with Maules Creek and downstream of the BTM Complex

a: pH, EC, temperature, dissolved oxygen, turbidity, ORP

b: Nutrients: phosphorus (total), phosphorus (reactive), nitrogen (total)

c: Aluminium, arsenic, cadmium, chromium, copper, iron, manganese, nickel and zinc.

d: 'Event based' refers to as soon as practicable after a discharge from authorised discharge point has occurred. Please refer to mine specific WMPs for more detailed descriptions of events including post-event monitoring frequency.

e: Quarterly and monthly monitoring within ephemeral creeks (i.e. Nagero Creek, Bollol Creek and Goonbri Creek) will only be undertaken if the creeks are flowing at the time of the scheduled monitoring.

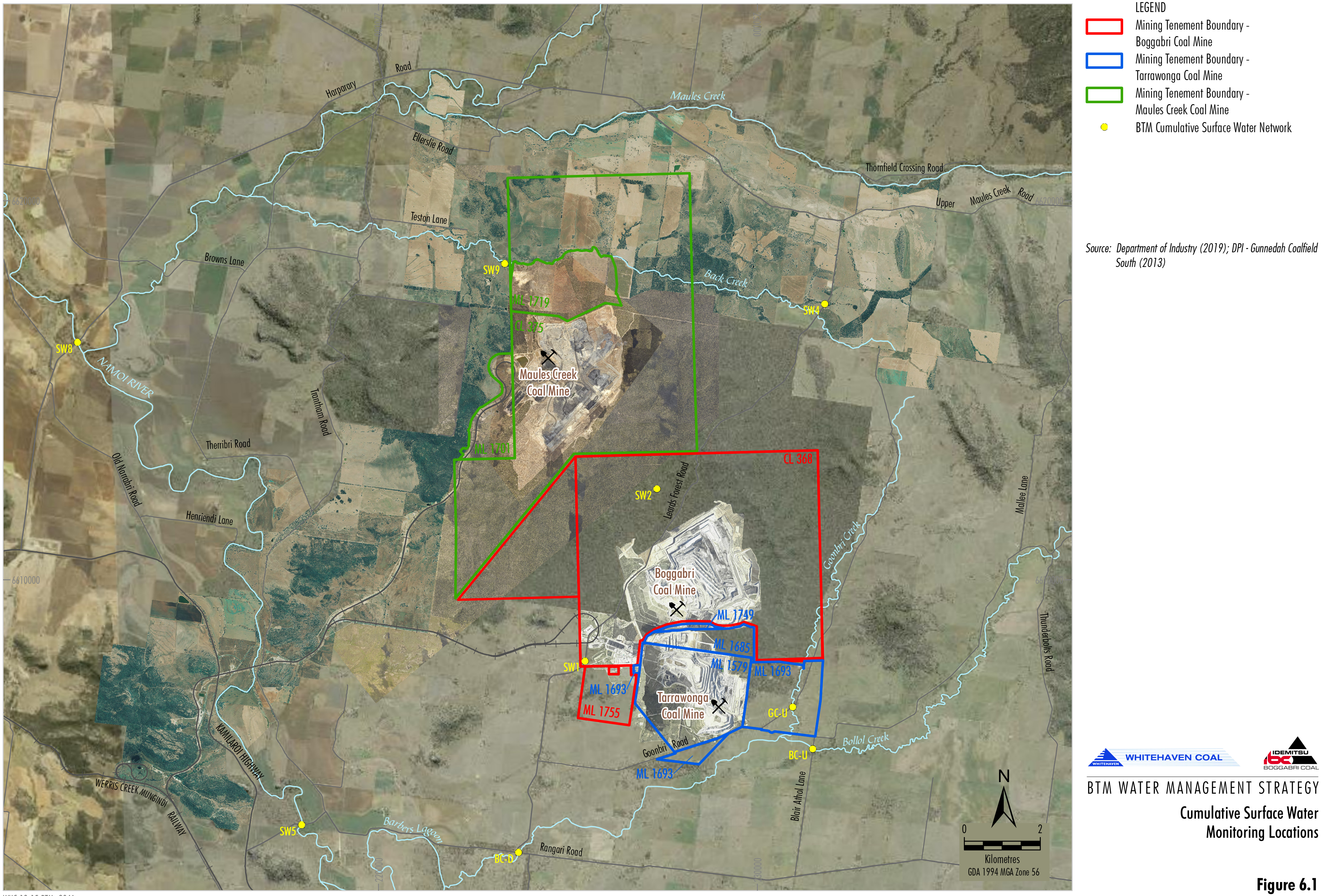


Figure 6.1

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Water quality parameters listed in Table 6.1 have been specified based on a combination of existing Environment Protection Licences (EPL) (12407 for the BCM, 20221 for the MCCM and 12365 for the TCM), Namoi catchment uncontrolled streams Water Quality Objectives (WQOs) (DoI – Water, 2006), monitoring carried out for existing surface water operational plans and recommendations made in previous studies (Parsons Brinckerhoff, 2010; Gilbert & Associates, 2011; WRM, 2011).

Flow monitoring involving the installation of water level logger or similar within the main channel of the creeks has been recommended where feasible at the locations listed in Table 6.1 and are considered to be more appropriate than permanent flow gauging stations for the following reasons:

- flow in each creek is ephemeral;
- SW2 will eventually be rendered obsolete due to the progression of mining; and
- water level recording equipment is easier to deploy, does not require extensive calibration and is easier to maintain than flow gauging station equipment.

6.2.2 Groundwater

Groundwater levels and quality

Recommendations were made by Heritage Computing (2012a) to monitor and manage the cumulative impacts on groundwater conditions as a result of mining within the BTM Complex. Those recommendations have been used to guide the development of the BTM Complex groundwater monitoring program.

The program is based on a network of monitoring bores and VWPs to monitor regional groundwater conditions, in addition to existing monitoring bore networks (Section 6.1.2). During October 2013 to January 2014, the proposed bores were constructed. Some sites selected for groundwater quality monitoring have been aligned with existing bores that monitor alluvial aquifers, with the new bores placed to monitor underlying aquifers at the same location. Some sites were selected for water level monitoring only. A number of bores have automatic dataloggers installed to collect continuous water level data, which can be downloaded during sampling rounds.

Some monitoring bores were combined or substituted for those previously recommended in individual mine EAs, provided the targeted lithology and construction was consistent with the rationale defined by Heritage Computing (2012a). Possible rationalisations are included in Table 6.2.

Table 6.2 sets out the cumulative groundwater monitoring network, along with sampling frequencies, parameters and rationale. MCCM installed all individual bores that make up the cumulative groundwater monitoring network. A consultant engaged by MCCM sample these bores for cumulative data for the BTM Complex. Figure 6.2 shows the cumulative groundwater monitoring network for the BTM Complex. Monitoring locations for the cumulative groundwater monitoring network were selected as per recommendations from Heritage Computing (2012a) and in consultation with regulatory agencies.

Groundwater seepage and use

The current groundwater seepage monitoring program being implemented for each mine (Section 6.1.2) will be used to provide a dataset for periodic water balance modelling across the BTM Complex.

Table 6.2
Cumulative Groundwater Monitoring Locations

Location	Installation type (no. piezometers)	Bore Depth (m)	Screen/Sensor Depth (mgbl)	Sampled lithology	Frequency	Parameters	Rationale
Reg1	VWP in interburden and coal seams (4)	N/A	118.7 134.5 193.5 281.5	Alluvium (existing bore GW967138/2), interburden and coal seams	Continuous water level measurement (datalogger).	Water level	Just outside predicted 1 m water table drawdown (Heritage Computing, 2012a). To assess potential impact on middle reaches of Maules Creek. Adjacent DoI – Water bore GW967138/1/2.
Reg2	VWP in interburden and coal seams (4)	N/A	60 120 200 260	Alluvium (existing bore GW041027) and underburden	Continuous water level measurement (datalogger).	Water level	Just outside predicted 1 m water table drawdown (Heritage Computing, 2012a). To assess potential impact on upper reaches of Maules Creek. Adjacent DoI – Water bore GW041027.
Reg3	Bore (1)	57	50.50 – 56.50	Boggabri Volcanics	Quarterly (March, June, September, December) until baseline established, then half yearly.	Water level + field parameters[a] + major ions + metals[b] + nutrients[c]	Just outside predicted 1 m water table drawdown (Heritage Computing, 2012a). To assess potential impact on lower reaches of Maules Creek. Adjacent DoI – Water bore GW030130.
Reg4	Bore (1)	72.5	65.5 – 71.5	Boggabri Volcanics	Quarterly (March, June, September, December) until baseline established, then half yearly.	Water level + field parameters[a] + major ions + metals[b] + nutrients[c]	Outside predicted drawdown impact zones (Heritage Computing, 2012a). 2 km east of Namoi River.

Table 6.2 (Continued)
Cumulative Groundwater Monitoring Locations

Location	Installation type (no. piezometers)	Bore Depth (m)	Screen/Sensor Depth (mgbl)	Sampled lithology	Frequency	Parameters	Rationale
Reg5	Bore (1)	78.7	72.2 – 78.2	Boggabri Volcanics	Quarterly (March, June, September, December) until baseline established, then half yearly.	Water level + field parameters[a] + major ions + metals[b] + nutrients[c]	Within predicted 1 m water table drawdown zone in alluvium (Heritage Computing, 2012a).
Reg5a	Bore (1)	22	18 – 21	Alluvium	Quarterly (March, June, September, December) until baseline established, then half yearly.	Water level + field parameters[a] + major ions + metals[b] + nutrients[c]	Within predicted 1 m water table drawdown zone in alluvium (Heritage Computing, 2012a).
Reg6	Bore (1)	96	88.0 – 94.0	Boggabri Volcanics	Quarterly (March, June, September, December) until baseline established, then half yearly.	Water level + field parameters[a] + major ions + metals[b] + nutrients[c]	Within predicted 1 m water table drawdown zone in 'Nagero Creek' alluvium (Heritage Computing, 2012a). To assess potential impact on 'Nagero Creek'.
Reg7	VMP in interburden and coal seams (3)	N/A	67.5 148.2 242.5	Maules Creek Formation interburden and coal seams	Continuous water level measurement (datalogger).	Water level	On edge of predicted 1 m water table drawdown in Bollol Creek alluvium (Heritage Computing, 2012a). To assess potential impact on Bollol Creek. Adjacent bore BCS6.
Reg7a	Bore (1)	36	24 – 30	Bollol Creek Alluvium	Quarterly (March, June, September, December) until baseline established, then half yearly.	Water level + field parameters[a] + major ions + metals[b] + nutrients[c]	On edge of predicted 1 m water table drawdown in Bollol Creek alluvium (Heritage Computing, 2012a). To assess potential impact on Bollol Creek. Adjacent bore BCS6.

Table 6.2 (Continued)
Cumulative Groundwater Monitoring Locations

Location	Installation type (no. piezometers)	Bore Depth (m)	Screen/Sensor Depth (mgbl)	Sampled lithology	Frequency	Parameters	Rationale
Reg8	VWP in interburden and coal seams (3)	N/A	91.5 221 274	Maules Creek Formation interburden and coal seams	Continuous water level measurement (datalogger).	Water level	In high drawdown zone east of MCCM and north-east of BCM (Heritage Computing, 2012a). In Maules Creek Formation.
Reg9	VWP in interburden and coal seams (3)	N/A	115.8 175.2 268	Maules Creek Formation interburden and coal seams	Continuous water level measurement (datalogger).	Water level	In moderate drawdown zone to north-east of TCM and east of BCM (Heritage Computing, 2012a). In Maules Creek Formation.
Reg10	VWP in interburden and coal seams (4)	N/A	55 144.2 178 185.5	Shallow Maules Creek Formation (and Back Creek water)	Continuous water level measurement (datalogger).	Water level	In moderate drawdown zone on Back Creek north of MCCM (Heritage Computing, 2012a). To assess potential impact on Back Creek. In Maules Creek Formation.
Reg10a	Bore (1)	10	6.75 – 9.75	Alluvium	Quarterly (March, June, September, December) until baseline established, then half yearly.	Water level + field parameters[a] + major ions + metals[b] + nutrients[c]	In moderate drawdown zone on Back Creek north of MCCM (Heritage Computing, 2012a). In Maules Creek Formation.

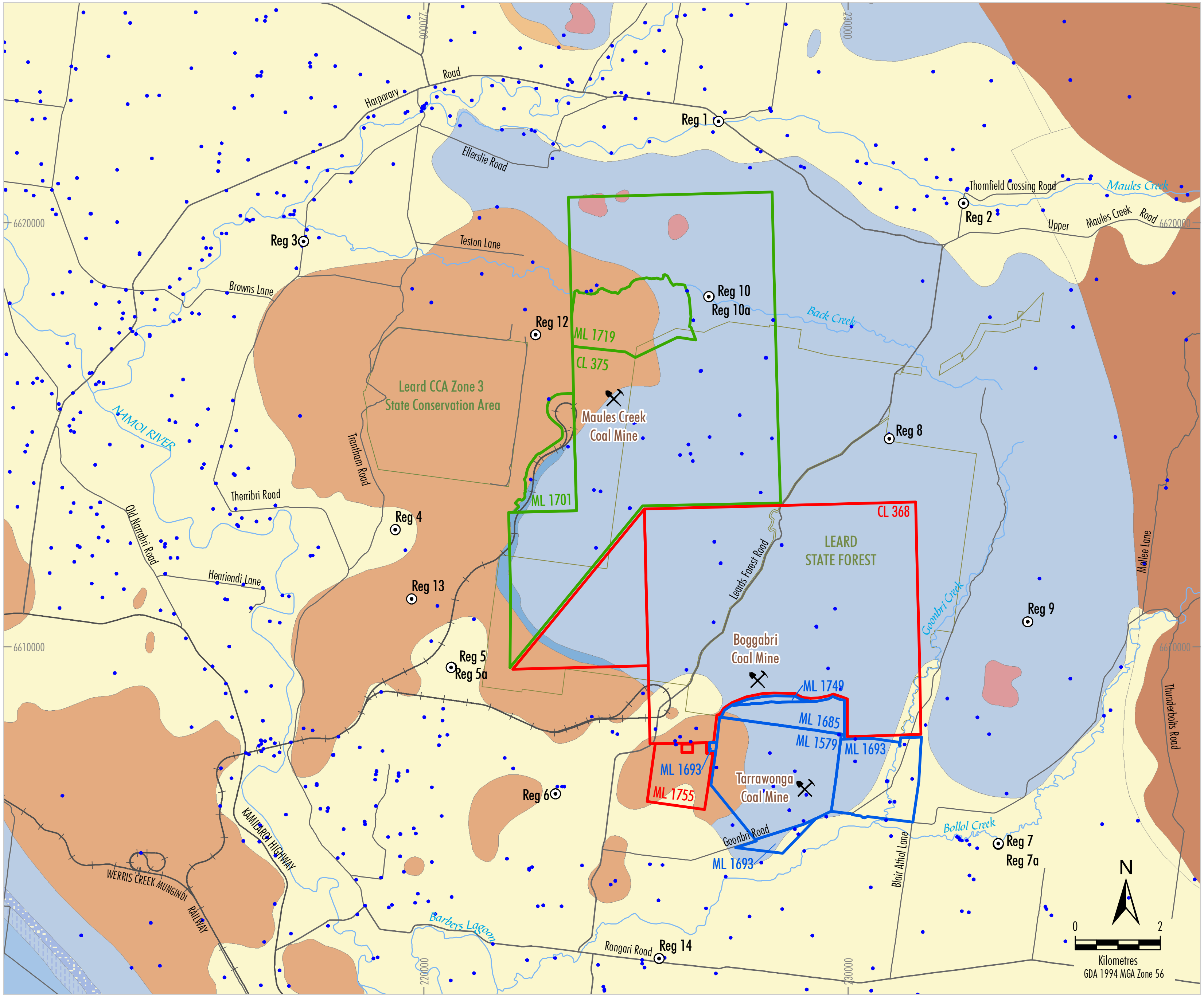
Table 6.2 (Continued)
Cumulative Groundwater Monitoring Locations

Location	Installation type (no. piezometers)	Bore Depth (m)	Screen/Sensor Depth (mgbl)	Sampled lithology	Frequency	Parameters	Rationale
Reg12	Bore (1)	48.3	38.4 – 44.4	Boggabri Volcanics	Quarterly (March, June, September, December) until baseline established, then half yearly.	Water level + field parameters[a] + major ions + metals[b] + nutrients[c]	Within 1 m regolith drawdown zone north-west of MCCM (Heritage Computing, 2012a). In Boggabri Volcanics.
Reg13	Bore (1)	133	128 – 132	Boggabri Volcanics	Quarterly (March, June, September, December) until baseline established, then half yearly.	Water level + field parameters[a] + major ions + metals[b] + nutrients[c]	On edge of 1 m regolith drawdown zone west of BCM (Heritage Computing, 2012a). In Boggabri Volcanics.
Reg14	Bore (1)	102	90 - 96	Alluvium	Quarterly (March, June, September, December) until baseline established, then half yearly.	Water level + field parameters[a] + major ions + metals[b] + nutrients[c]	In Bollol Creek alluvium well outside any predicted drawdown. Adjacent bore DoI – Water GW030472.

a: pH, EC, temperature, dissolved oxygen, turbidity, ORP.

b: Aluminium, arsenic, cadmium, chromium, copper, iron, manganese, nickel and zinc.

c: Nutrients: phosphorus (total), phosphorus (reactive), nitrogen (total).



LEGEND

- Mining Tenement Boundary - Boggabri Coal Mine
- Mining Tenement Boundary - Tarrawonga Coal Mine
- Mining Tenement Boundary - Maules Creek Coal Mine
- NSW National Parks and Wildlife Services (NPWS) Estate
- State Forest
- Railway
- BTM Cumulative Groundwater Network
- Water NSW Registered Bore

Regional Geology Legend (relevant formations)

- Undifferentiated Alluvial Deposits
- Maules Creek Formation
- Plf Leard Formation
- Pbr Boggabri Volcanics

Source: Department of Industry (2019); DPI - Gunnedah Coalfield South (2013)

WHITEHAVEN COAL

IDEMITSU BOGGABRI COAL

BTM WATER MANAGEMENT STRATEGY

Cumulative Groundwater Monitoring Locations for the BTM Complex

Figure 6.2

WHC-13-15 BTM_205B

7. IMPACT MITIGATION

The site-specific WMPs for each of the mines within the BTM Complex contain the following:

- water management and mitigations measures;
- water quality and quantity triggers; and
- event definitions.

Where the monitoring program identifies water quality results above a set trigger level then:

- Each mine in the BTM Complex will be notified as soon as practicable of the monitoring result.
- Monitoring results will be reviewed against previous results to identify a trend or other anomaly.
- An investigation of the potential cause of the impact will be undertaken as well as deliberation between BCM, TCM and MCCM to identify the mine/mines potentially causing the exceedance. The investigator will consider and document:
  - the extent of potential water issue;
  - the receiving environment of the potential water issue; and
  - the timeframe of the potential water issue.
- The mine/mines identified in the previous step as causing the exceedance rectify the issue where possible.
- Report to external agencies will be undertaken, as required by each mine's Project Approval conditions.

8. MANAGEMENT AND IMPLEMENTATION

Each site will maintain the responsibility to comply with the management and monitoring requirements contained in their site management plans, approvals and licences specific to their operation to minimise their impact on water quality and subsequently on the cumulative water quality with the BTM Complex.

The sites will work collectively to coordinate the modelling programs where required.

The Water Management Strategy is one of a number of cumulative environmental management strategies developed in response to mine development approval conditions. As such, the mines will work collectively to:

- Convene BTM Complex meetings quarterly to discuss cumulative monitoring results.
- Communicate changes to any site-specific monitoring locations.
- Provide access to monitoring locations.
- Share data relating to the cumulative monitoring network.
- Respond in a timely manner to requests to enable the Water Management Strategy to be implemented.

Table 8.1 articulates the roles and responsibilities for identifying and managing cumulative impacts where joint mitigation is required.

Table 8.1
Roles and Responsibilities for the BTM Complex

Role	Responsibility	Timing
Roles within the BTM Complex Sites …………………… **Site General Manager or Mine Manager/HSE Manager***	• Each site to comply with the management and monitoring requirements contained in their respective site management plans.	Ongoing
	• Each site to complete surface water and groundwater monitoring required under the BTM Water Strategy.	As required
	• Each mine to maintain responsibility for site-specific licencing requirements.	Ongoing
	• Provide the relevant resources to enable implementation of the BTM Water Management Strategy.	As required
	• BTM Complex sites will ensure the relevant operational personnel are aware of this document.	As required
Site Environmental Representatives (Environmental Superintendent or Environmental Officer*)	• Represent respective operations at regular BTM Complex meetings regarding water management.	As required
	• Regularly convene meetings to discuss cumulative monitoring results.	Quarterly
	• Coordinate updates collectively to the Water Management Strategy.	As required
	• Liaise across BTM sites to address trigger events and review mitigation options.	As required
	• Investigate cumulative complaints with other BTM site representatives.	As required
	• Provide access to monitoring locations.	As required
	• Assist in data and information provision as required by the Water Management Strategy.	Ongoing
	• Share data relating to the BTM Complex cumulative monitoring network.	Ongoing
	• Apply and implement the required monitoring and/or modelling methodologies.	Ongoing and as required
	• Notify sites within the BTM Complex of the monitoring result where the monitoring program identifies water quality results exceed trigger level listed in individual WMPs and identify the mine/mines causing the exceedance.	As required

	• Undertake joint mitigation if required as per any relevant agreed terms.	As required
	• Implement and coordinate reviews of the Water Management Strategy.	Refer to Section 9
	• Implement the site-specific mitigation measures and controls within the applicable site WMP.	Ongoing
Strategy groundwater & surface water monitoring contractors & modelling consultants	• Review and if necessary, update any BTM Complex surface water and groundwater models on an agreed periodic basis.	Refer to Section 9
	• Advise the relevant site of any in-field monitoring related incidents that may have cumulative relevance to the BTM sites.	As required

*or delegate

8.1 COMPLAINT MANAGEMENT

It is recognised that each mine within the BTM Complex has their own complaint handling and incident management protocols, including hotlines, and that these will continue to operate independently. The Water Management Strategy supports the use of the existing mechanisms, with individual mining operations investigating complaints that are raised with them. If the investigating mine considers the complaint to be potentially related to a cumulative impact, it will:

- Advise the other mines of the complaint and potential for cumulative impact as soon as practicable.
- Seek comments from other mines on the complaint/issue.
- Investigate the complaint jointly to determine if the impact was cumulative.
- Develop a response jointly to the complaint.
- Log the complaint on their complaints register where found to be cumulative impact.

9. REVIEW AND REVISION

The BTM Complex WMS has been developed with the input of representatives of BCM, TCM, and MCCM. It is proposed to review, and update if required, the WMS every three years. The review and update of the WMS will be undertaken by BTM, TCM and MCCM collectively. The review would include consideration of new or different monitoring technologies that could be incorporated into the cumulative monitoring program.

Each of the BTM Complex mines are required to prepare a "*Groundwater Management Plan, which includes… a program to validate the groundwater model for the project, including an independent review of the model every 3 years, and comparison of monitoring results with modelled predictions*". Accordingly, the cumulative groundwater model would be reviewed every three years. Any substantial and relevant changes to the model resulting from the review would be considered in the context of the WMS, and the WMS would be updated to reflect the changes if required. It is noted that this version of the WMS includes consideration of the report *Boggabri, Tarrawonga, Maules Creek Complex Numerical Model Update* prepared by AGE (2018).

The supporting site-specific WMPs and monitoring plans will be reviewed, and if necessary revised in accordance with Schedule 5, Condition 5 of each site-specific Project Approval:

> *Within 3 months of the submission of an:*
>
> *(a) annual review under condition 4 above;*
> *(b) incident report under condition 8 below;*
> *(c) audit under condition 10 below; or*
> *(d) any modification to the conditions of this approval,*
>
> *the Proponent shall review, and if necessary, revise, the strategies, plans, and programs required under this approval to the satisfaction of the Secretary.*

The site-specific BCM, TCM and MCCM models undergo regular maintenance and recalibration as additional data on groundwater responses to progressive mining improves the understanding of the groundwater systems.

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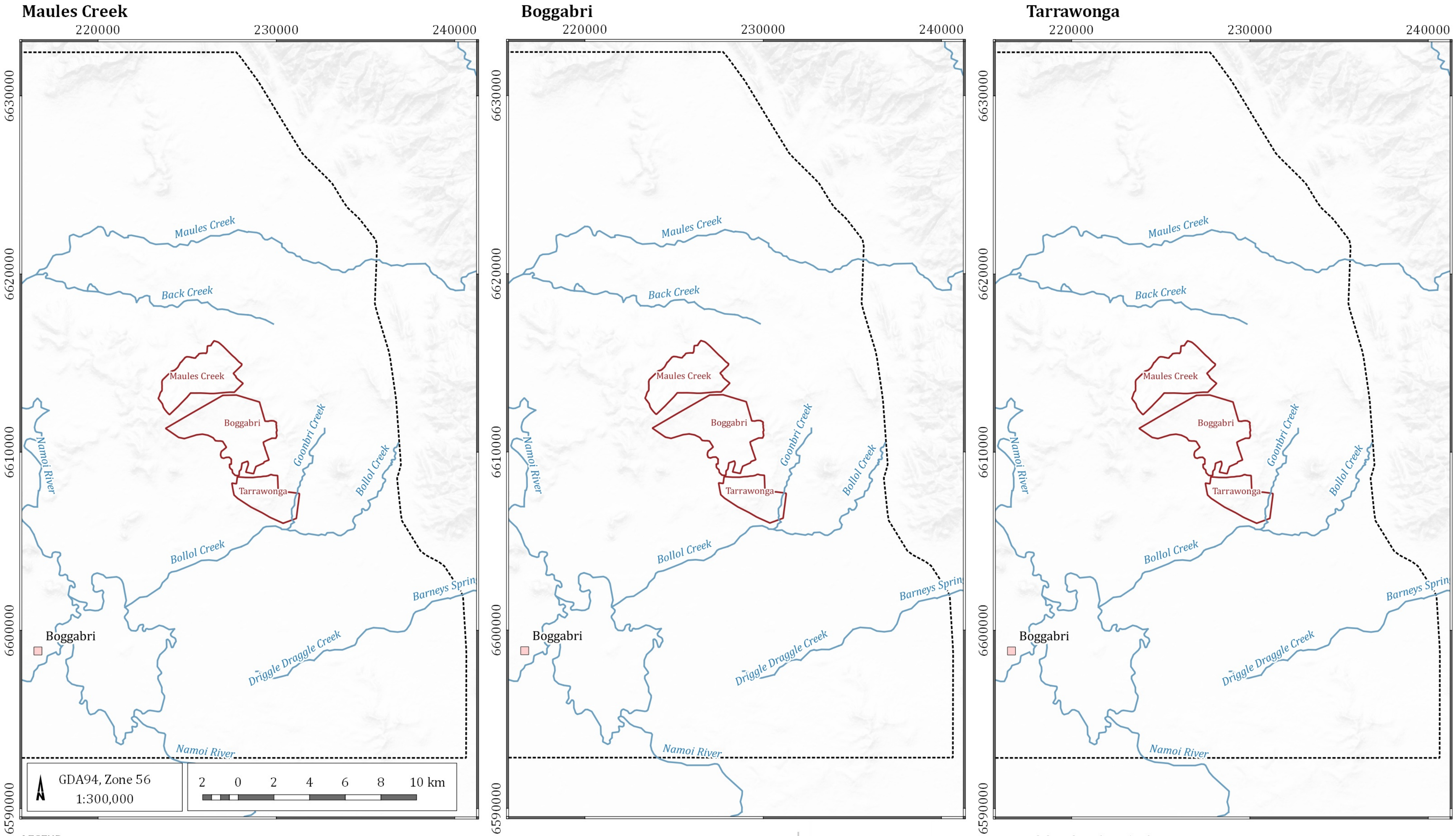
APPENDIX A

SITE-SPECIFIC CONTRIBUTION TO CUMULATIVE GROUNDWATER DRAWDOWN (FROM AGE [2018])



LEGEND

- Populated place
- Major drainage
- Mine maximum open cut outlines
- Model extent

Drawdown contribution percentage

0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

Drawdown contribution percentage contour

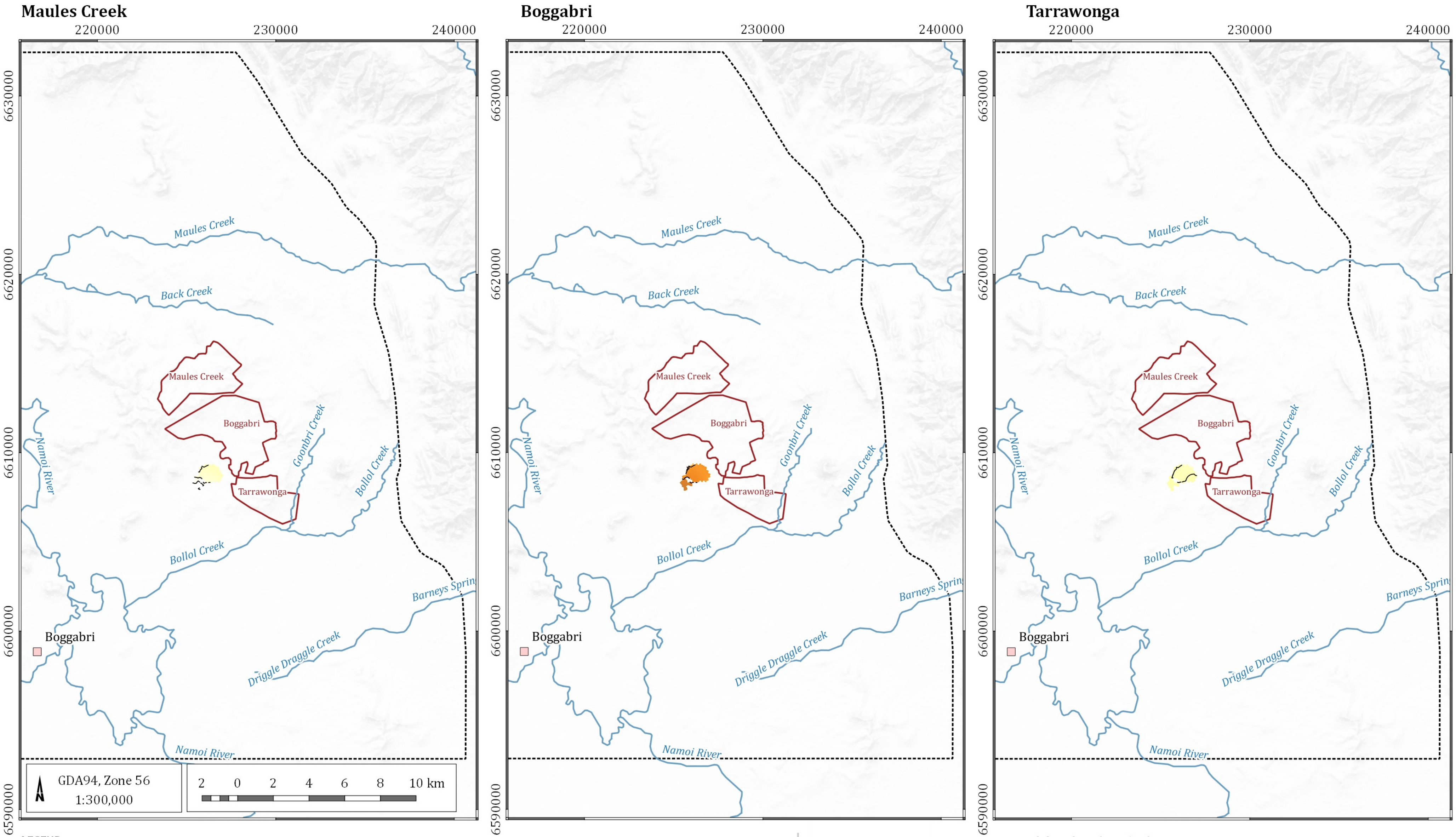
BTM model update (G1850A)

Percentage of simulated drawdown attributed to each mine at end 2019 - Layer 1 - Narrabri alluvium

DATE
29/03/2017

FIGURE No:
D.1

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:/Projects/G1850A.BTM_Model/3_GIS/Workspaces/001_Deliverable1/D.01-06_G1850A_Percentage of simulated drawdown attributed to each mine.qgs



LEGEND

- Populated place
- Major drainage
- Mine maximum open cut outlines
- Model extent

Drawdown contribution percentage

0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

Drawdown contribution percentage contour

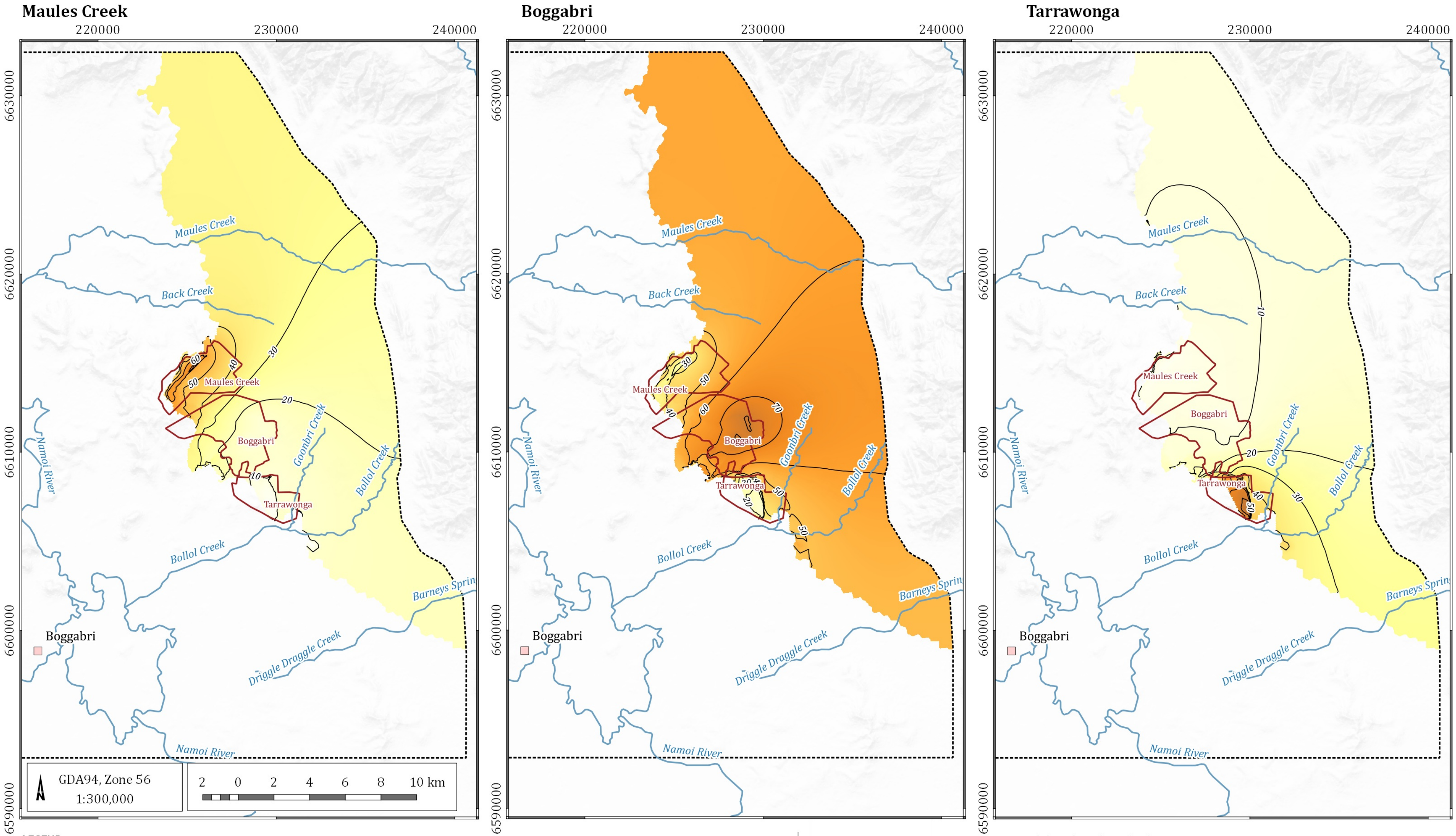
BTM model update (G1850A)

Percentage of simulated drawdown attributed to each mine at end 2019 - Layer 2 - Gunnedah alluvium

DATE
29/03/2017

FIGURE No:
D.2

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:/Projects/G1850A.BTM_Model/3_GIS/Workspaces/001_Deliverable1/D.01-06_G1850A_Percentage of simulated drawdown attributed to each mine.qgs



LEGEND

- Populated place
- Major drainage
- Mine maximum open cut outlines
- Model extent

Drawdown contribution percentage

0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

Drawdown contribution percentage contour

BTM model update (G1850A)

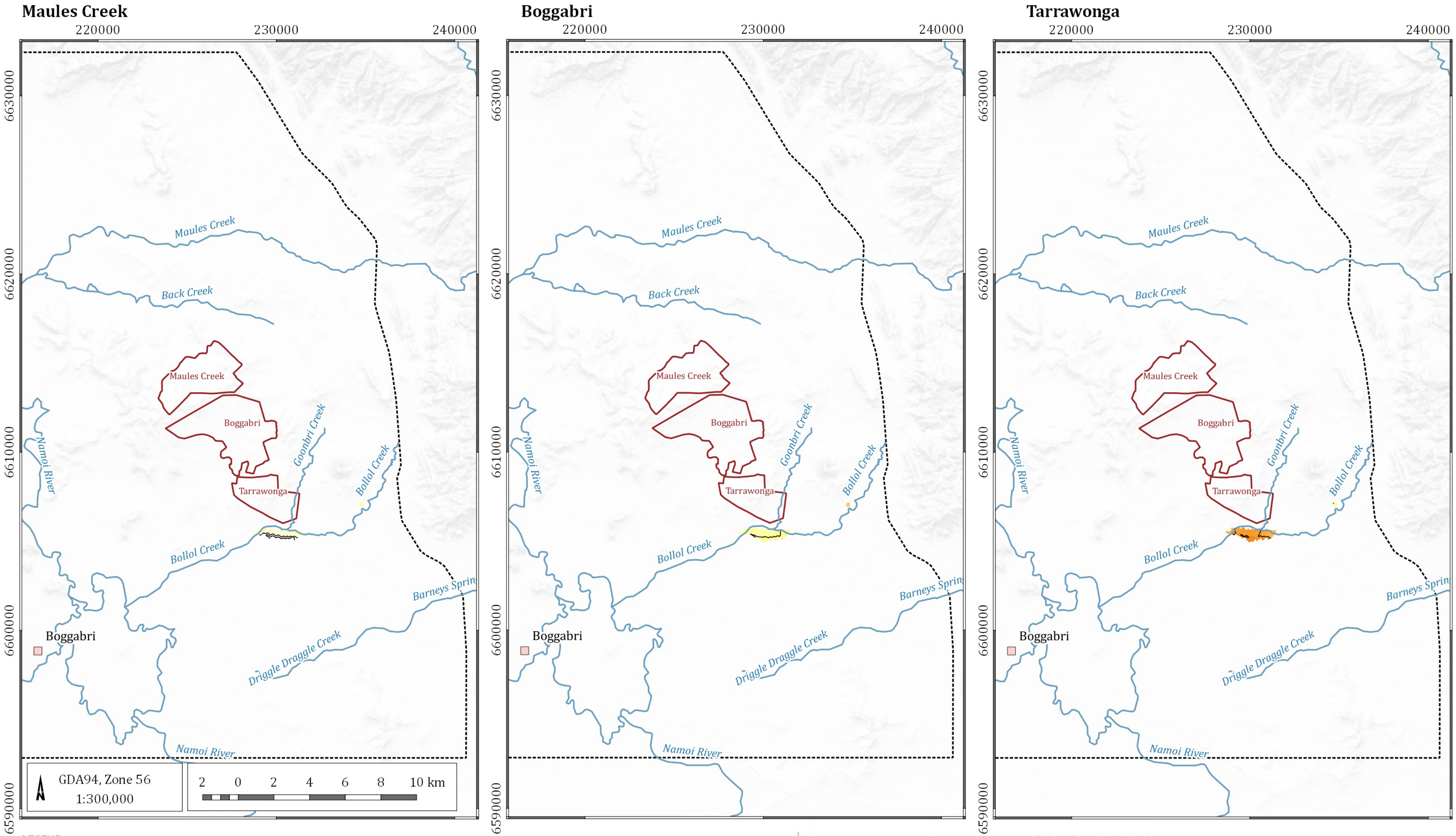
AGE

Percentage of simulated drawdown attributed to each mine at end 2019 - Layer 8 - Merriown seam

DATE 29/03/2017

FIGURE No: **D.3**

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:/Projects/G1850A.BTM_Model/3_GIS/Workspaces/001_Deliverable1/D.01-06_G1850A_Percentage of simulated drawdown attributed to each mine.qgs



LEGEND

- Populated place
- Major drainage
- Mine maximum open cut outlines
- Model extent

Drawdown contribution percentage

0, 10, 20, 30, 40, 50, 60, 70, 80, 90, 100

Drawdown contribution percentage contour

AGE

BTM model update (G1850A)

Percentage of simulated drawdown attributed to each mine at end 2029 - Layer 1 - Narrabri alluvium

DATE
29/03/2017

FIGURE No:
D.4

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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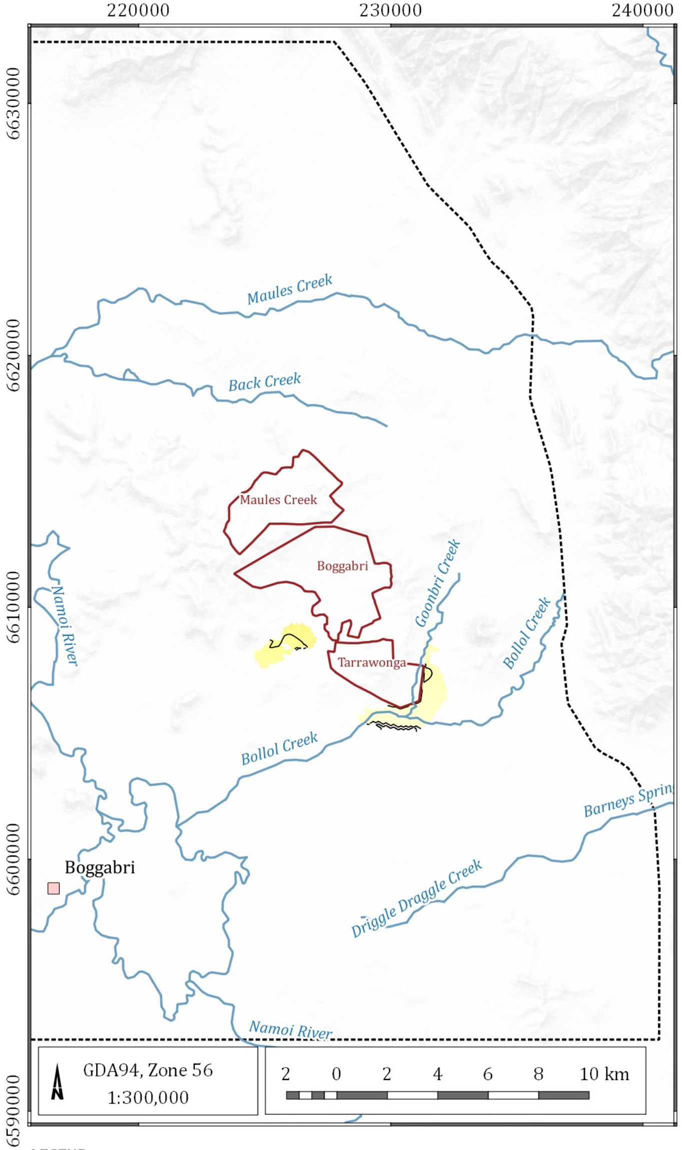
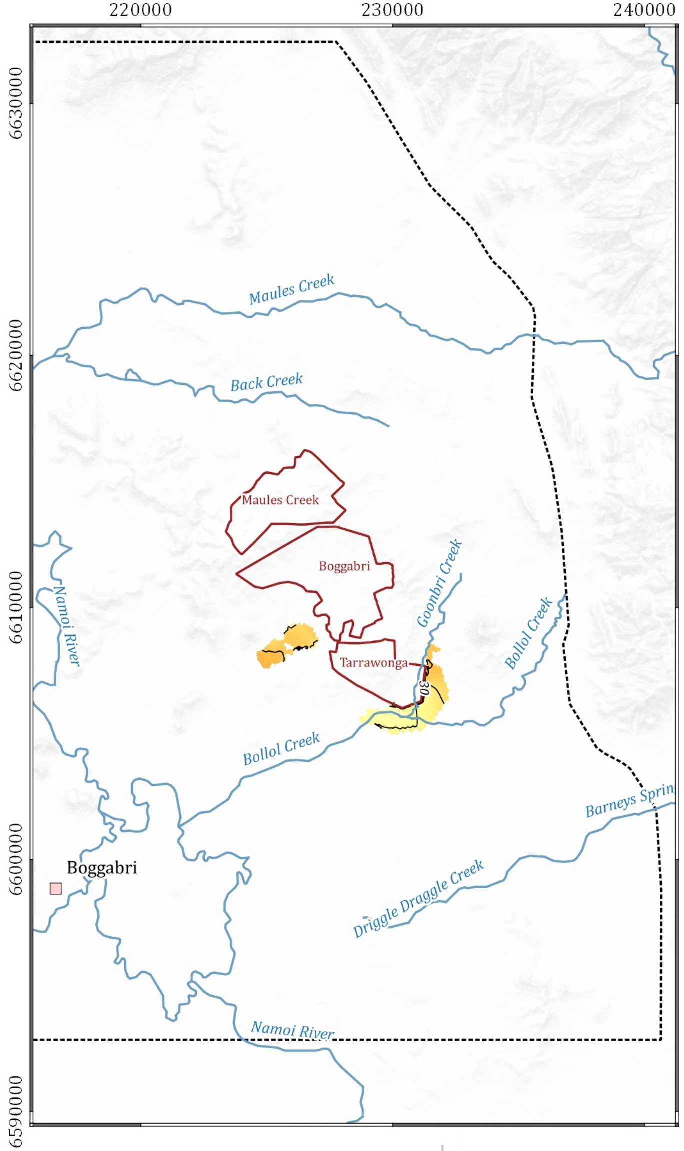
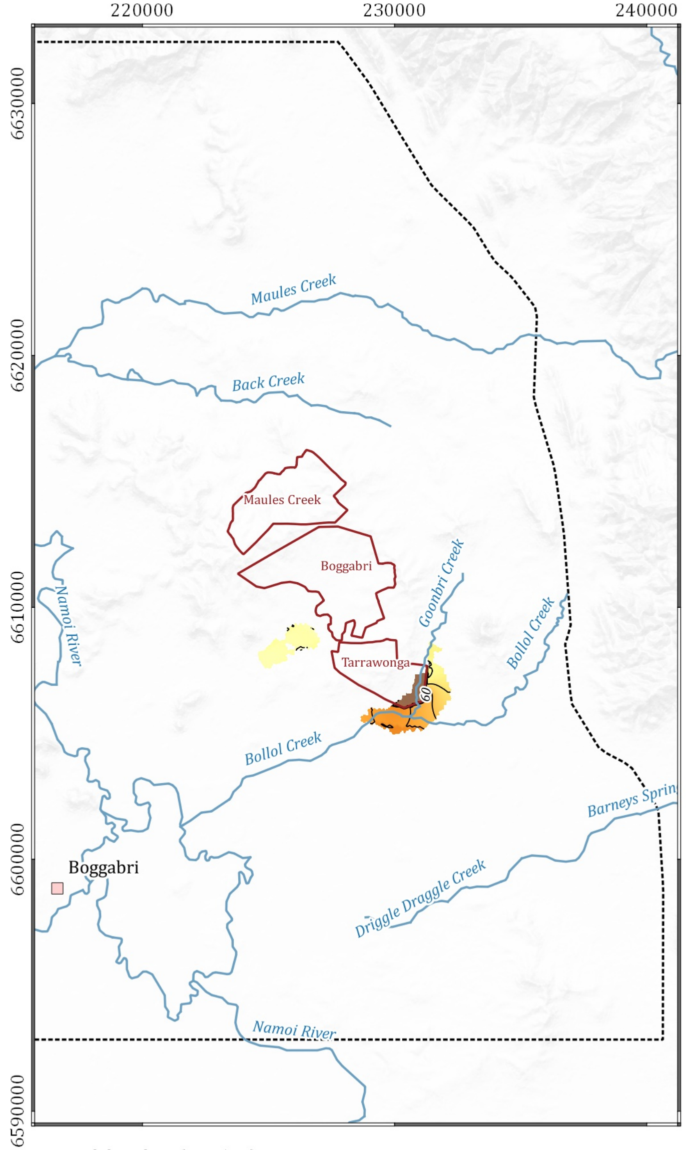
Maules Creek



Boggabri



Tarrawonga



LEGEND

- Populated place
- Major drainage
- Mine maximum open cut outlines
- Model extent

Drawdown contribution percentage

0	60
10	70
20	80
30	90
40	100
50	Drawdown contribution percentage contour

BTM model update (G1850A)

AGE

Percentage of simulated drawdown attributed to each mine at end 2029 - Layer 2 - Gunnedah alluvium

DATE
29/03/2017

FIGURE No:
D.5

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
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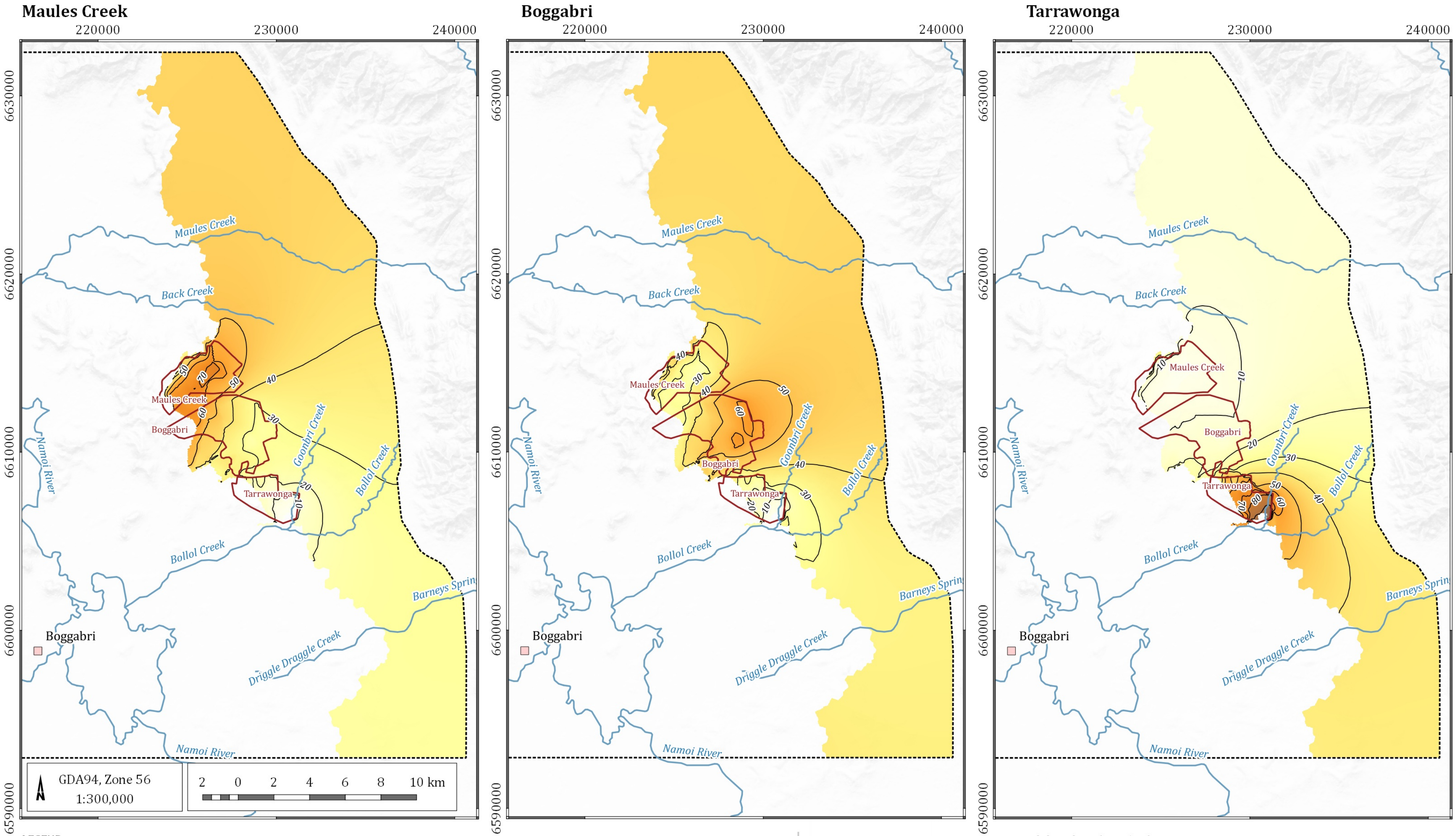

LEGEND

- Populated place
- Major drainage
- Mine maximum open cut outlines
- Model extent

Drawdown contribution percentage

0	60
10	70
20	80
30	90
40	100
50	Drawdown contribution percentage contour

BTM model update (G1850A)

AGE

Percentage of simulated drawdown attributed to each mine at end 2029 - Layer 8 - Merriown seam

DATE
29/03/2017

FIGURE No:
D.6

Source: 1 second SRTM Derived DEM-S - © Commonwealth of Australia (Geoscience Australia) 2011.; GEODATA TOPO 250K Series 3 - © Commonwealth of Australia (Geoscience Australia) 2006.;
G:/Projects/G1850A.BTM_Model/3_GIS/Workspaces/001_Deliverable1/D.01-06_G1850A_Percentage of simulated drawdown attributed to each mine.qgs