Appendix E

Surface Water Quality Assessment

HUME COAL

Surface Water Quality Assessment

DECEMBER 2016

Surface Water Quality Assessment

Hume Coal

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GLOSSARY

Baseline water quality	Existing water quality determined from available monitoring data.
Catchment	Land area draining through the main stream, as well as tributary streams, to a particular site. It always relates to an area above a specific location.
Discharge	Rate of flow of water measured in terms of volume per unit time — for example, cubic metres per second (m^3/s). Discharge is different from the speed or velocity of flow, which is a measure of how fast the water is moving — for example, metres per second (m/s).
Erosion	The action of surface processes such as water flow that remove soil, rock, or dissolved material from one location on the Earth's crust, then transport it away to another location.
Environmental Values (EV)	Values that the community considers important for water use.
First flush	Initial surface runoff from a rainstorm. Usually the stormwater that initially runs off an area will be more polluted than the stormwater that runs off later.
Flow	Water moving steadily and continuously in a current or stream.
Model	Mathematical representation of the physical processes involved in runoff generation and streamflow. Models are often run on computers, due to the complexity of the mathematical relationships between runoff, streamflow and the distribution of flows across the floodplain.
Overland flow	The movement of water over the land, downslope toward a surface water body.
Runoff	Amount of rainfall that actually ends up as streamflow; also known as rainfall excess.
Yield	The total outflow from a drainage basin through surface channels within a given period of time.
Water Quality Objectives	Agreed environmental values and long term goals for NSW's surface water. They include a range of water quality indicators to help assess whether the current condition of our waterways supports those values and users.

ABBREVIATIONS

ADWG	Australian Drinking Water Guidelines
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resources Management Council of Australia and New Zealand
CPP	Coal preparation plant
DECC	Department of Environment and Climate Change
DP&E	NSW Department of Planning and Environment
DPI	NSW Department of Primary Industries
EIS	Environmental impact statement
EPA	NSW Environment Protection Authority
EV	Environmental value
ha	Hectares
HRC	Healthy Rivers Commission
Hume Coal	Hume Coal Pty Limited
km	Kilometres
LGA	Local government area
LPI	NSW Land and Property Information
MHRDC	Maximum harvestable right dam capacity
ML	Megalitres
mm/day	Millimetres per day
Mt	Million tonnes
Mtpa	Million tonnes per annum
MUSIC	Model for Urban Stormwater Improvement Conceptualisation
MWD	Mine water dam
NorBE	Neutral or Beneficial Effect
NOW	NSW Office of Water
NSW	New South Wales
NWQMS	National Water Quality Management Strategy
PWD	Primary water dam
ROM	Run of mine
SB	Stormwater basin
SCA	Sydney Catchment Authority

SEARs	Secretary’s environmental assessment requirements
SEPP	State Environmental Planning Policy
SWQ	Surface Water Quality monitoring site
TDS	Total dissolved solids
TN	Total nitrogen
TP	Total phosphorus
TSS	Total suspended solids
WAL	Water access licence
WQO	Water quality objectives
WTP	Water treatment plant
WM Act	NSW Water Management Act 2000
WSC	Wingecarribee Shire Council

EXECUTIVE SUMMARY

A surface water quality assessment was undertaken for the Hume Coal Project (or ‘the project’), a proposed underground coal mine in the Southern Coalfield, New South Wales.

The Hume Coal Project has been designed to avoid or minimise potential impacts on surface water quality in receiving watercourses. Key aspects of the design that achieve these outcomes are as follows:

- the project does not involve the take of water directly from streams;
- the project does not involve any stream diversions;
- the project will use low impact underground mining methods, which have negligible subsidence impacts;
- only minor instream works across Medway Rivulet and Oldbury Creek are proposed for the project;
- all water in direct contact with coal on the site will be contained and reused within the mine water management system; and
- water that has a low risk of contact with coal, i.e. runoff from areas that do not contain coal stockpiles or processing plant but that could contain small amounts of coal due to mine vehicle traffic, will be managed by containing and reusing the first flush of runoff, after which the water will be released to Oldbury Creek provided water quality criteria are met.

Construction and rehabilitation phase impacts of the project on surface water quality are expected to be neutral by implementing best practice erosion and sediment control management measures in accordance with relevant legislation and guidelines.

The project activities that have the potential to impact on surface water quality during operation are as follows:

- Releases from stormwater basins SB03 and SB04 (the runoff from which has a low risk of coal contact) to Oldbury Creek following pumping of the first flush to the Primary Water Dam for reuse.
- Runoff from mine access roads that drain into the Medway Rivulet catchment.
- The interception of natural baseflow due to underground mining which may change the loading and concentration of some water quality parameters in the surface waters.

The assessment has used water quality modelling to demonstrate that the release of water from SB03 and SB04 to Oldbury Creek will meet criteria for total suspended solids (TSS) and nutrients set by the relevant legislation and guidelines. For other contaminants that may be present in the runoff to these basins, this assessment has established preliminary water quality targets to be used for ongoing water quality monitoring in these basins.

For SB03 and SB04, the water quality discharge limits will be developed to protect the environmental values in the Hawkesbury-Nepean Basin and to achieve a Neutral or Beneficial Effect (NorBE) on water quality. The preliminary limits established in this report will be refined in consultation with the NSW Environment Protection Authority.

Water quality modelling has demonstrated that swales can be used to provide an effective treatment system for runoff from the access roads to meet the NorBE criteria for TSS and nutrients.

Assessment of the impact of intercepted baseflow concluded that, while a small number of contaminants have lower concentrations in the groundwater, any change in water quality due to loss of baseflow from groundwater is likely to be negligible.

The assessment has established preliminary water quality objectives to set targets for monitoring the performance of the project impact on Medway Rivulet and Oldbury Creek. Final water quality objectives should be developed using the additional surface water quality data collected prior to commencement of construction of the project. Surface water quality monitoring should be undertaken throughout construction, operation and rehabilitation at upstream and downstream sites on Medway Rivulet and Oldbury Creek to monitor changes in surface water quality in the receiving environment associated with the project and trigger the implementation of mitigation and remediation measures if required.

1 INTRODUCTION

WSP | Parsons Brinckerhoff was engaged by Hume Coal Pty Limited (Hume Coal) to undertake a surface water quality assessment for the Hume Coal Project (the project), a proposed underground coal mine in the Southern Coalfield, New South Wales (NSW).

This report provides an assessment of the impacts of the project on surface water quality in local catchments and mitigation measures proposed to minimise potential impacts.

1.1 Project location

The project area is approximately 100 km south-west of Sydney and 4.5 km west of Moss Vale town centre in the Wingecarribee LGA (refer to Figure 1.1 and Figure 1.2). The nearest area of surface disturbance will be associated with the surface infrastructure area, which will be 7.2 km north-west of Moss Vale town centre. It is in the Southern Highlands region of NSW and the Sydney Basin Biogeographic Region.

The project area is in a semi-rural setting, with the wider region characterised by grazing properties, small-scale farm businesses, natural areas, forestry, scattered rural residences, villages and towns, industrial activities such as the Berrima Cement work and Berrima Feed Mill, and some extractive industry and major transport infrastructure such as the Hume Highway.

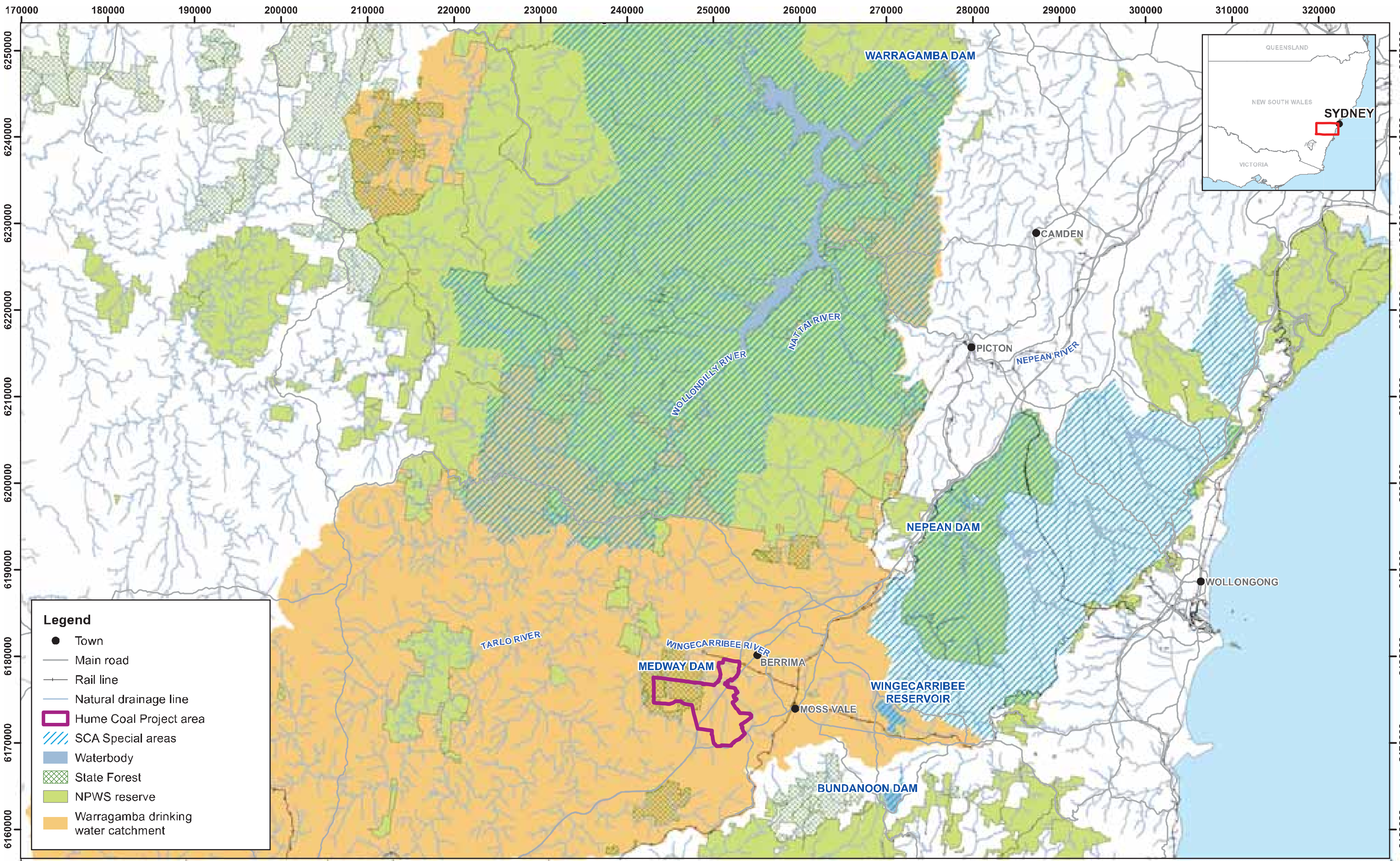
Surface infrastructure is proposed to be developed on predominately cleared land owned by Hume Coal or affiliated entities, or for which there are appropriate access agreements in place with the landowner. Over half of the remainder of the project area (principally land above the underground mining area) comprises cleared land that is, and will continue to be, used for livestock grazing and small-scale farm businesses. Belanglo State Forest covers the north-western portion of the project area and contains introduced pine forest plantations, areas of native vegetation and several creeks that flow through deep sandstone gorges. Native vegetation within the project area is largely restricted to parts of Belanglo State Forest and riparian corridors along some watercourses.

The project area is traversed by several drainage lines including Oldbury Creek, Medway Rivulet, Wells Creek, Wells Creek Tributary, Belanglo Creek and Longacre Creek, all of which ultimately discharge to the Wingecarribee River, at least 5 km downstream of the project area (Figure 1.2). The Wingecarribee River's catchment forms part of the broader Warragamba Dam and Hawkesbury-Nepean catchments. Medway Dam is also adjacent to the northern portion of the project area (Figure 1.2).

Most of the central and eastern parts of the project area have very low rolling hills with occasional elevated ridge lines. However, there are steeper slopes and deep gorges in the west in Belanglo State Forest.

Existing built features across the project area include scattered rural residences and farm improvements such as outbuildings, dams, access tracks, fences, yards and gardens, as well as infrastructure and utilities including roads, electricity lines, communications cables and water and gas pipelines. Key roads that traverse the project area are the Hume Highway and Golden Vale Road. The Illawarra Highway borders the south-east section of the project area.

Industrial and manufacturing facilities adjacent to the project area include the Berrima Cement Works and Berrima Feed Mill on the fringe of New Berrima. Berrima Colliery's mining lease (CCL 748) also adjoins the project area's northern boundary. Berrima colliery is currently not operating with production having ceased in 2013 after almost 100 years of operation. The mine is currently undergoing closure.



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Hume Coal Surface Water Quality Assessment
Figure 1.1
Project location

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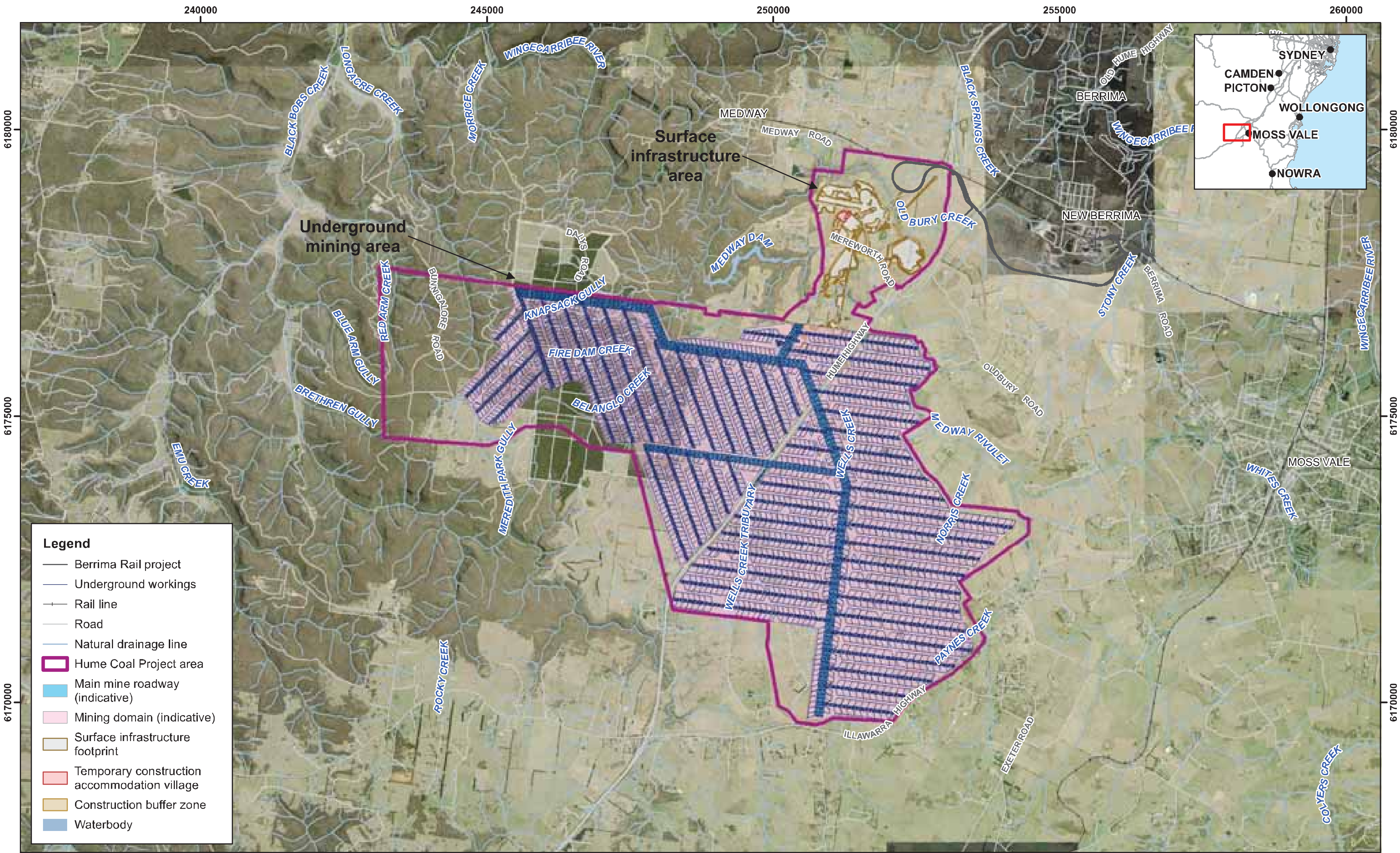

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Hume Coal Surface Water Quality Assessment
Figure 1.2
Project area

1.2 Project description

The project involves developing and operating an underground coal mine and associated infrastructure over a total estimated project life of 23 years. Indicative mine and surface infrastructure plans are provided in Figure 1.2 and Figure 1.3. A full description of the project, as assessed in this report, is provided in Chapter 2 of the main EIS (EMM 2016a).

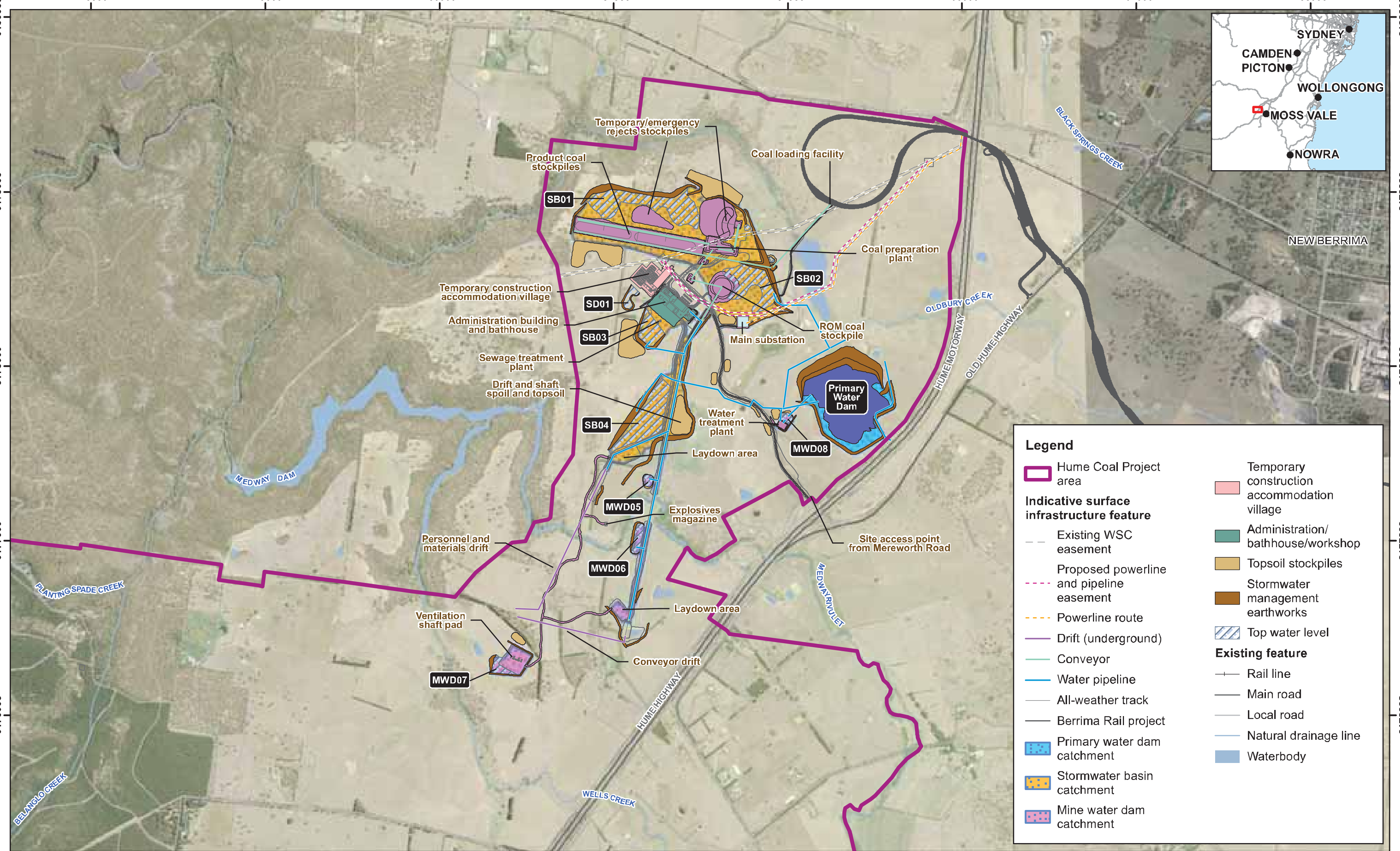
In summary it involves:

- Ongoing resource definition activities, along with geotechnical and engineering testing, and other low impact fieldwork to facilitate detailed design.
- Establishment of a temporary construction accommodation village.
- Development and operation of an underground coal mine, comprising of approximately two years of construction and 19 years of mining, followed by a closure and rehabilitation phase of up to two years, leading to a total project life of 23 years. Some coal extraction will commence during the second year of construction during installation of the drifts, and hence there will be some overlap between the construction and operational phases.
- Extraction of approximately 50 million tonnes (Mt) of run-of-mine (ROM) coal from the Wongawilli Seam, at a rate of up to 3.5 million tonnes per annum (Mtpa). Low impact mining methods will be used, which will have negligible subsidence impacts.
- Following processing of ROM coal in the coal preparation plant (CPP), production of up to 3 Mtpa of metallurgical and thermal coal for sale to international and domestic markets.
- Construction and operation of associated mine infrastructure, mostly on cleared land, including:
  - one personnel and materials drift access and one conveyor drift access from the surface to the coal seam;
  - ventilation shafts, comprising one upcast ventilation shaft and fans, and up to two downcast shafts installed over the life of the mine, depending on ventilation requirements as the mine progresses;
  - a surface infrastructure area, including administration, bathhouse, washdown and workshop facilities, fuel and lubrication storage, warehouses, laydown areas, and other facilities. The surface infrastructure area will also comprise the CPP and ROM coal, product coal and emergency reject stockpiles;
  - surface and groundwater management and treatment facilities, including storages, pipelines, pumps and associated infrastructure;
  - overland conveyors;
  - rail load-out facilities;
  - explosives magazine;
  - ancillary facilities, including fences, access roads, car parking areas, helipad and communications infrastructure; and
  - environmental management and monitoring equipment.
- Establishment of site access from Mereworth Road, and minor internal road modifications and relocation of some existing utilities.
- Coal reject emplacement underground, in the mined-out voids.
- Peak workforces of approximately 414 full-time equivalent employees during construction and approximately 300 full-time equivalent employees during operations.
- Decommissioning of mine infrastructure and rehabilitating the area once mining is complete, so that it can support land uses similar to current land uses.

The project area, shown in Figure 1.2, is approximately 5,051 hectares (ha). Surface disturbance will mainly be restricted to the surface infrastructure areas shown indicatively on Figure 1.3, though will include some other areas above the underground mine, such as drill pads and access tracks. The project area generally comprises direct surface disturbance areas of up to approximately 117 ha, and an underground mining area of approximately 3,472 ha, where negligible subsidence impacts are anticipated.

A construction buffer zone will be provided around the direct disturbance areas. The buffer zone will provide an area for construction vehicle and equipment movements, minor stockpiling and equipment laydown, as well as allowing for minor realignments of surface infrastructure. Ground disturbance will generally be minor and associated with temporary vehicle tracks and sediment controls as well as minor works such as backfilled trenches associated with realignment of existing services. Notwithstanding, environmental features identified in the relevant technical assessments will be marked as avoidance zones so that activities in this area do not have an environmental impact.

Product coal will be transported by rail, primarily to Port Kembla terminal for the international market, and possibly to the domestic market depending on market demand. Rail works and use are the subject of a separate EIS and State significant development application for the Berrima Rail Project.



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Hume Coal Surface Water Quality Assessment

Figure 1.3

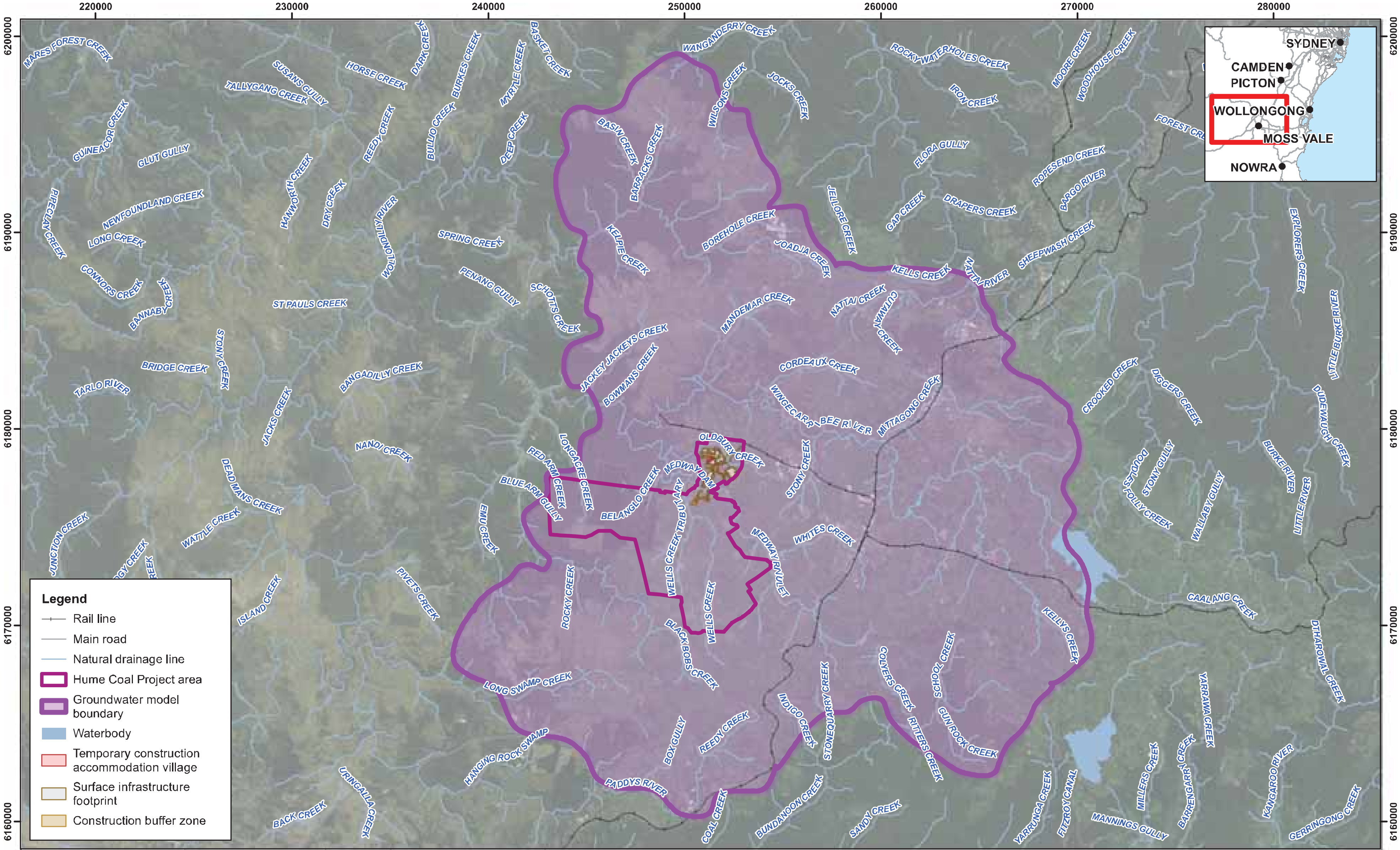
Surface infrastructure layout

1.3 Study area

The study area for surface water quality assessment comprises the streams with potential to be impacted by the project. The project has the potential to impact on the water quality of local streams through:

- Controlled release of water from stormwater basins (SBs) SB03 and SB04 to Oldbury Creek following pumping of the first flush to the primary water dam (PWD) for reuse on site;
- Interception of natural baseflow to streams associated with depressurisation of groundwater systems during underground mining. Numerical groundwater modelling has found that a reduction in baseflow to streams will occur within the groundwater model boundary in the following streams:
  - Medway Rivulet and its tributaries, including Oldbury Creek, Wells Creek, Wells Creek Tributary and Belanglo Creek;
  - Wingecarribee River and its tributaries;
  - Wollondilly River and its tributaries; and
  - Bundanoon Creek and its tributaries.

The study area for the surface water quality assessment is shown on Figure 1.4. The study area comprises the streams with potential to be impacted by the project within the groundwater model boundary.



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Hume Coal Surface Water Quality Assessment
Figure 1.4
Study area

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1.4 Environmental assessment requirements

This assessment has been prepared in accordance with the relevant governmental assessment requirements, guidelines and policies, and in consultation with the relevant government agencies. Guidelines and policies considered are as follows:

- State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011;
- Neutral or Beneficial Effect on Water Quality Assessment Guideline 2015;
- Using MUSIC in Sydney's Drinking Water Catchment 2012;
- National Water Quality Management Strategy 2016;
- NSW Government Water Quality and River Flow Objectives 1999;
- Healthy Rivers Commission Inquiry into the Hawkesbury-Nepean River 1998;
- Australian and New Zealand Guidelines for Fresh and Marine Water Quality 2000;
- Australian Drinking Water Guidelines 2011;
- WaterNSW Principles for Managing Mining and Coal Seam Gas Impacts in Declared Catchment Areas 2014;
- Greater Metropolitan Region Unregulated Water Sources Water Sharing Plan 2011; and
- NSW State Rivers and Estuary Policy 1993

Further details of these guidelines and policies, and how they apply to this assessment, are provided in Section 2 of this report.

The Secretary's Environmental Assessment Requirements (SEARs) related to surface water quality, and the section of this report where the requirement is addressed, are provided in Table 1.1.

Table 1.1 Surface water quality related SEARs

REQUIREMENT	SECTION ADDRESSED
An assessment of the likely impacts of the development on the water quality of the region's surface water resources, having regard for the EPA's, DPI and WaterNSW's requirements and recommendations	Section 5
An assessment of the likely water quality impacts of the development on watercourses, riparian land, water-related infrastructure, and other water uses.	Section 5

To inform preparation of the SEARs, the NSW Department of Planning and Environment (DP&E) invited other government agencies to recommend matters for address in the EIS. These matters were then taken into account by the Secretary for DP&E when preparing the SEARs. Copies of the government agencies' advice to DP&E was attached to the SEARs. The matters are listed in Table 1.2 and have been taken into account in preparing this report, as indicated.

Table 1.2 Agency requirements

REQUIREMENT	SECTION ADDRESSED
DPI, FISHERIES NSW	
Impacts on water quality during all surface and underground construction activities and from ongoing operation of the proposed mine, processing plant, and associated infrastructure of the proposed coal mine.	Section 5
Impacts on water quality and flow from subsidence and groundwater interactions resulting from surface and underground construction and ongoing operation of the coal mine.	Section 5
Analysis of any interactions of the proposed development with water quality and aquatic and riparian environments (including fish and aquatic and riparian vegetation) and predictions of any impacts upon those environments.	Section 5
Safeguards to mitigate any impacts upon water quality, water flow and aquatic riparian environments within and downstream of all waterways within the proposal area during construction and ongoing operation of the proposed coal mine. In particular, provide details on proposal for erosion and sediment control (to be incorporated into a Construction Environmental Management Plan (CEMP) and proposed stormwater and ongoing drainage management measures. Water quality management for the project should be designed to achieve no nett increases in pollutant run-off to receiving waters within the proposal site.	Section 6
Details of ongoing monitoring programs to assess any impacts upon water quality within and downstream of all waterways within the proposal area.	Section 6.4
Fisheries NSW recommend the use of best practice sediment and erosion control, and water quality and stormwater management provisions to safeguard and mitigate impacts on water quality at the site and downstream.	Section 6
DPI WATER	
An assessment of impacts on surface water quality sources related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, and measures proposed to reduce and mitigate these impacts.	Section 5
Proposed surface water monitoring activities and methodologies.	Section 6.4
Assessment of any potential cumulative impacts on water resources, and proposed options to manage the cumulative impacts.	Section 5.2.5
Demonstrate how the proposal is consistent with the relevant rules of the Water Sharing Plan including rules for water quality.	Section 2 and Section 5
Assessment of predicted impacts on the flow of surface water (including floodwater), sediment movement, channel stability, and hydraulic regime, water quality, flood regime, dependent ecosystems, existing surface water users, and planned environmental water and water sharing arrangements prescribed in the relevant water sharing plans.	Section 5

REQUIREMENT	SECTION ADDRESSED
ENVIRONMENT PROTECTION AUTHORITY	
EPA acknowledges the priority to be given to surface and ground water in the EIS. It is noted that on page 63, the proposed water quality assessment includes evaluation against neutral and beneficial effect (NOBE) criteria in accordance with State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011. However, water management should also be assessed using approaches outline in the National Water Quality Management Strategy, ANZECC 2000. These are described in more detail in the standards SEARS but in summary the EIS should: → Identify relevant Water Quality Objectives (WQO) for the surface water, including indicators and associated trigger values or criteria, in accordance with National Water Quality Management Strategy Guidelines. Reference the water quality objectives for the Wingecarribee River catchment in the 'NSW Healthy River Commission of Inquiry into the Hawkesbury Nepean Catchment". Identify any downstream users and uses of the discharged water classified in accordance with relevant ANZECC 2000. → Estimate the chemical composition and load of chemical and physical stressors and toxicants in any discharge of mine water. Compare the level of physical and chemical stressors in any discharge with ANZECC 2000 trigger values for the various environmental values for the waterway. → Investigate options to reduce the levels of pollutants in the discharge of water to protect the environment from harm as a result of that pollution. Identify all practical measures to control or reduce pollutants in the surface water discharges. Identify preferred measures and their justification. → If WQO's cannot be met for the project, demonstrate that all practical options to avoid water discharge have been implemented and outline any measures taken to reduce the pollutant loads where a discharge is necessary. Where a discharge is proposed analyse the expected discharge in terms on the receiving environment, including consideration of all pollutants that pose a risk of non-trivial harm.	Section 5 and Section 6
WATERNSW	
The EIS will need to demonstrate that the proposed measures to capture and treat water impacted by the proposal will have no impact on water quality within the Wingecarribee River.	Section 6
The EIS must describe and justify how the development would have a neutral or beneficial effect on water quality.	Section 5 and Section 6
The full description of the development should include those aspects which have the potential to impact on the quality of surface waters at and adjacent to the site. This includes: → the mining proposal and mine layout → the location, mapping and geomorphology of all creeks and water resources overlying and adjacent to the proposed mining area → the hydrogeological fluxes between surface water including the filling of pine feather voids → the location, management and storage of all hazardous materials → the disposal of wastes from the treatment of the mine waters in the treatment plant → the management of dirty water from the washing and preparation of coal for transport → the location, sizing and description of all water quality management measures → the location and description of all water monitoring points → Onsite domestic (sewage) wastewater management.	Section 3.4, Section 5 and Section 6

REQUIREMENT	SECTION ADDRESSED
The detailed assessment of the development on water resources should also consider the design, construction, operational and decommissioning phases and have regard for operation during periods of wet weather and include: → details of measured and predicted coal mine, preparation area and stockpile area performance with respect to water quality management. → details of measures proposed to adopted to offset impacts associated with construction activities → impacts of overlying and adjacent creeks and water resources within risk Management Zone associated with subsidence → impacts on the proposed onsite domestic (sewage) wastewater management and associated effluent disposal area → pre development and post development run off volumes and pollutant loads from the site → details of measures to manage site water associated with processing coal and coal reject, general stormwater runoff and any human activities like to affect water quality at the site and how NorBE principals will be assessed and applied. → assessment of the impacts of the development on receiving water quality and volume, including from the filling of pine feather voids and associated impacts on the interaction and base flows of surface water → details of the structural stability, integrity, ongoing maintenance and monitoring of all site water management measuring including dams over the life of the project → details of proposed monitoring of surface water flows, and surface water quality along with information on as to how the proposed monitoring will be used to monitor and if necessary mitigate impacts on surface water resources → the principles outlined in the 'Managing Urban Stormwater – Soils and Construction – Mines and Quarries' manual prepared by the Department of Environment and Climate Change (2008).	Section 5 and Section 6
OFFICE OF ENVIRONMENT AND HERITAGE	
The EIS must describe background conditions for any water resource likely to be affected by the development, including: → Existing surface water. → Hydrology, including volume, frequency and quality of discharges at proposed intake and discharge locations. → Water Quality Objectives (as endorsed by the NSW Government http://www.environment.nsw.gov.au/ieo/index.htm) → Indicators and trigger values/criteria for the environmental values identified at (c) in accordance with the ANZECC (2000) Guidelines for Fresh and Marine Water Quality and/or local objectives, criteria or targets endorsed by the NSW Government.	Section 3 and Section 4
The EIS must assess the impacts of the development on water quality, including: → The nature and degree of impact on receiving waters for surface water, demonstrating how the development protects the Water Quality Objectives where they are currently being achieved, and contributes towards achievement of the Water Quality Objectives over time where they are currently not being achieved. This should include an assessment of the mitigating effects of proposed stormwater and wastewater management during and after construction. → Identification of proposed monitoring of water quality.	Section 5 and Section 6

The Hume Coal Project was declared as a controlled action on 1 December 2015 by the then Commonwealth Department of the Environment (now Department of Environment and Energy). The project will be assessed under the Bilateral Agreement between the NSW Government and the Commonwealth Government. Accordingly, the Commonwealth Department of the Environment and Energy has issued supplementary SEARs to address matters of national environmental significance relevant to the project. These matters are provided in Table 1.3, and have been taken into account in preparing this report, as indicated in the table.

Table 1.3 Supplementary SEARs

REQUIREMENT	SECTION ADDRESSED
The EIS should provide a description of the location, extent and ecological characteristics and values of the identified water resources potentially affected by the project. The assessment of impacts should include information on: → substantial and measurable change in the water quality of the water resource for example, a substantial change in the level of salinity, pollutants, or nutrients in the wetland; or water temperature that may adversely impact on biodiversity, ecological integrity, social amenity or human health,	Section 3 and Section 5

2 REGULATORY FRAMEWORK

This section summarises the legislation, policies and guidelines that are relevant to the surface water quality assessment.

2.1 Water Management Act 2000

The *NSW Water Management Act 2000* (WM Act) recognises the need to allocate and provide water for the environmental health of our rivers and groundwater systems, while also providing licence holders with access to water. The main tool the WM Act provides for managing the state's water resources are water sharing plans. These are used to set out the rules for the sharing of water in a particular water source between water users and the environment and rules for the trading of water in a particular water source.

Surface water in the project area is managed under the *Greater Metropolitan Region Unregulated Water Sources Water Sharing Plan 2011*. The project area is located largely within the Upper Nepean and Upstream Warragamba Water Source, mostly within the Medway Rivulet Management Zone with small sections located in the Lower Wingecarribee River Management Zone (Figure 2.1).

Surface water users (other than stock or domestic) must hold a water access licence (WAL) to take water from streams in the study area. The WAL specifies the annual volume that may be taken and the conditions under which water may be taken. Water trading is not permitted between management zones. Water trading within the management zones is allowed subject to assessment.

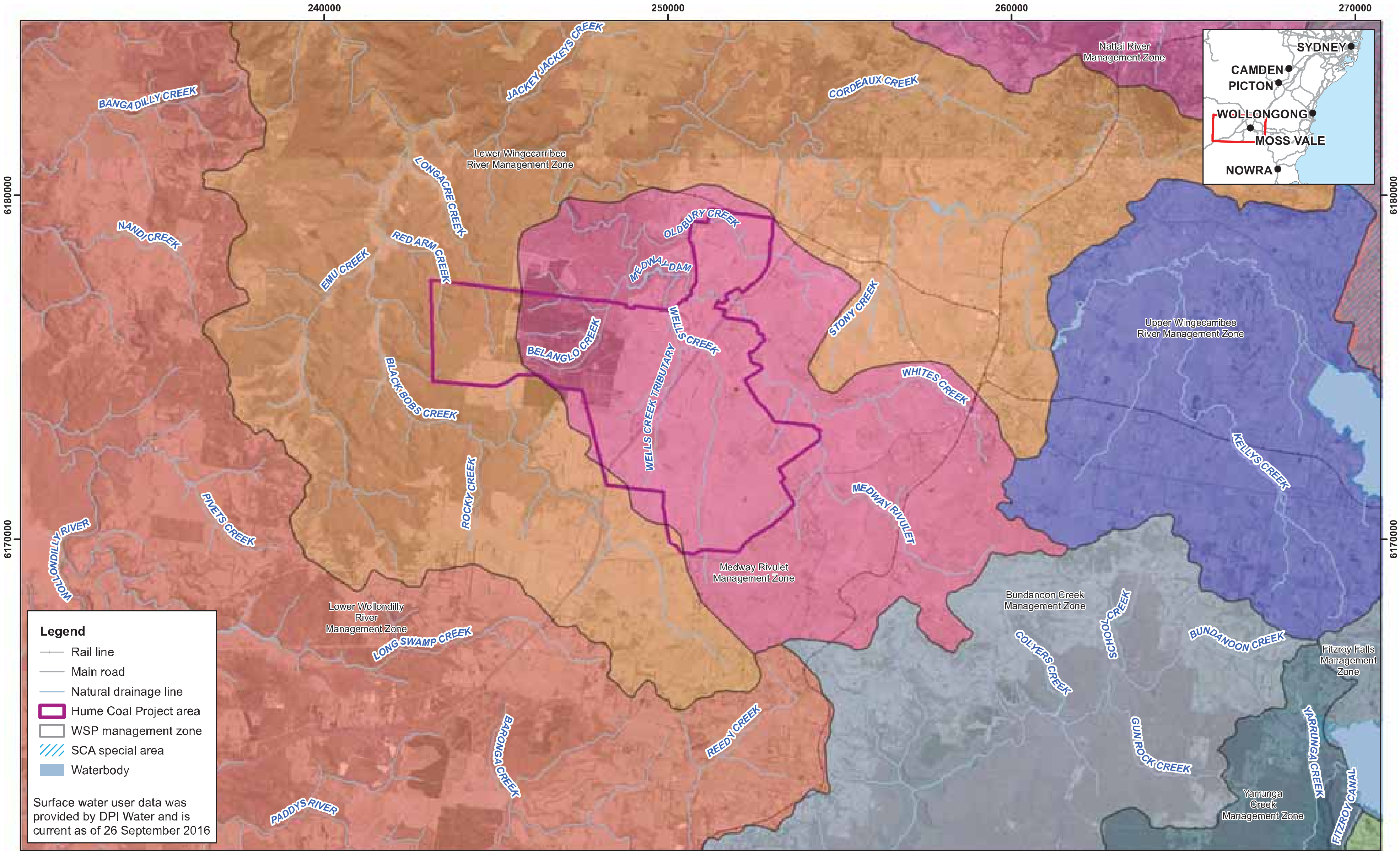
Water may be taken for stock or domestic purposes without a licence under basic water rights. Landholders can take water from streams, or collect a proportion of the rainfall runoff on their property and store it in one or more dams, up to a certain size. The total dam capacity allowed on a property under a harvestable right is determined by calculating the maximum harvestable right dam capacity (MHRDC) for a particular property.

2.2 NSW State Rivers and Estuary Policy 1993

The *NSW State Rivers and Estuary Policy 1993* aims to encourage the sustainable management of the State's rivers, estuaries, wetlands and adjacent riverine plains. The overall objectives are to manage NSW rivers and estuaries in ways which:

- slow, halt or reverse the overall rate of degradation in their systems;
- ensure the long-term sustainability of their essential biophysical function; and
- maintain the beneficial use of these resources.

A set of component policies has been developed, identifying management needs and opportunities and providing clear management principles and guidelines.



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Hume Coal Surface Water Quality Assessment
Figure 2.1
Surface water management zones

2.3 State Environmental Planning Policy (Sydney Drinking Water Catchment) 2011

Under section 34B of the *Environment Protection and Assessment Act 1979*, provision is to be made in a State Environmental Planning Policy (SEPP) requiring consent authorities to refuse consent to development applications relating to any part of the Sydney drinking water catchment, unless the consent authority is satisfied that the proposed development would have a neutral or beneficial effect (NorBE) on water quality.

The resulting SEPP sets out the planning and assessment requirements for all new developments in the Sydney drinking water catchment to prove a NorBE on water quality.

2.4 Neutral or Beneficial Effect on Water Quality Assessment Guideline

Guidelines for the assessment of a NorBE on water quality have been published by WaterNSW (2015). As defined in the guidelines, NorBE on water quality is satisfied if the development:

- has no identifiable potential impact on water quality; or
- will contain any water quality impact on the development site and prevent it from reaching any watercourse, waterbody or drainage depression on the site; or
- will transfer any water quality impact outside the site where it is treated and disposed of to standards approved by the consent authority.

2.5 Using MUSIC in Sydney's Drinking Water Catchment

Within the Sydney drinking water catchment, the Model for Urban Stormwater Improvement Conceptualisation (MUSIC) software must be used to assess the potential impacts of large and complex developments on water quality. MUSIC is a water quality decision support system which estimates stormwater pollutant generation and simulates the performance of stormwater management measures to assess whether water quality targets can be achieved.

WaterNSW released standards in 2012 to assist consultants in preparing MUSIC models to demonstrate a NorBE on water quality for proposed urban and rural land use developments. NorBE is assessed by comparing the quality of runoff from the pre-development site with that from the post-development site including proposed stormwater treatment measures that may be needed to mitigate pollutant loads and concentrations resulting from the proposed land use change.

The standard shows practitioners how to set up a MUSIC model for pre-development and post-development site layouts, considering the existing site characteristics, drainage configuration, the climatic region, and the configuration of post-development site layout and treatment measures in the context of NorBE. The manual also provides conservative NorBE assessment criteria which account for uncertainty in MUSIC predictions.

MUSIC has been used to assess potential impacts of discharges from mine water dams SB03 and SB04 and runoff from mine access roads on surface water quality in accordance with the WaterNSW standard (2012).

2.6 National Water Quality Management Strategy

The National Water Quality Management Strategy (NWQMS)

aims to protect the nation's water resources by improving water quality while supporting the businesses, industry, environment and communities that depend on water for their continued development. The main policy objective of the NWQMS is to achieve sustainable use of water resources, by protecting and enhancing their quality, while maintaining economic and social development.

The NWQMS includes water quality guidelines that define desirable ranges and maximum levels for certain parameters that can be allowed (based on scientific evidence and judgement) for specific uses of waters or for protection of specific values. They are generally set at a low level of contamination to offer long-term protection of environmental values. The NWQMS water quality guidelines include the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZECC 2000) and the Australian Drinking Water Guidelines (NHMRC 2011). The water quality objectives (WQOs) in the NWQMS guidelines have been used along with other data to set preliminary WQOs for the receiving environment of the project (refer Section 6.4).

2.7 NSW Water Quality and River Flow Objectives

The NSW Water Quality and River Flow Objectives are the agreed environmental values and long-term goals for NSW's surface waters. They set out:

- the community's values and uses for our rivers, creeks, estuaries and lakes (i.e. healthy aquatic life, water suitable for recreational activities like swimming and boating, and drinking water); and
- a range of water quality indicators to help us assess whether the current condition of our waterways supports those values and uses.

At the time the water quality and river flow objectives were approved by the NSW government (September 1999) the Healthy Rivers Commission (HRC) had completed public inquiries for the Hawkesbury-Nepean river catchment. The HRC recommended water quality objectives in its final report for the catchment. Government confirmed these objectives in its response to the reports in Statements of Intent.

2.8 Healthy Rivers Commission Inquiry into the Hawkesbury-Nepean River

The HRC was established in 1995 to make recommendations to government on:

- suitable objectives for water quality, flows and other goals central to achieving ecologically sustainable development in a realistic time frame;
- the known or likely views of stakeholder groups on the recommended objectives;
- the economic and environmental consequences of the recommended objectives; and
- strategies, instruments and changes in management practices needed to implement the recommended objectives.

The HRC conducted independent public inquiries for selected rivers, including for the Hawkesbury-Nepean River, to assist the community to consider the options that are available in terms of river health and the use of river resources for commercial and recreational purposes. The findings of the inquiries are provided in the report *Healthy Rivers Commission Inquiry into the Hawkesbury-Nepean River* (HRC 1998).

The report details the environmental values of the catchment, which are the values that the community considers important for water use (HRC 1998). The environmental values adopted by the HRC for the Hawkesbury-Nepean River catchment are the environmental values that have been adopted for the Hume Coal Project. These are discussed in Section 4.

The report recommends that the ANZECC guidelines be adopted as suitable WQOs for the Hawkesbury-Nepean River catchment, with the exception of nutrients and chlorophyll-a. Catchment specific WQOs are provided for total nitrogen (TN), total phosphorous (TP) and chlorophyll-a because these parameters promote algal growth. Management of blue-green algae is one of the most important issues in the Sydney drinking water catchment as blue-green algae can release toxins into the water.

The Hawkesbury-Nepean catchment specific WQOs for nutrients and chlorophyll-a are provided in Table 2.1. These WQOs, together with the WQOs for other parameters in the ANZECC guidelines and other data, have been used to set preliminary WQOs for the receiving environment of the project (refer Section 6).

Table 2.1 HRC recommended WQOs for nutrients (µg/L)

WATER QUALITY INDICATOR	FORESTED AREAS AND DRINKING WATER CATCHMENT	MIXED USE RURAL AREAS AND SANDSTONE PLATEAU	URBAN AREAS – MAIN STREAM	URBAN AREAS – TRIBUTARY STREAM	ESTUARINE AREAS
Total nitrogen	700	700	500	~1000	400
Total phosphorous	50	35	30	~50	30
Chlorophyll-a	7	7	10 - 15	~20	7

Source: Adopted from HRC (1998)

2.9 Australian and New Zealand Guidelines for Fresh and Marine Water Quality

The *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC 2000) have been prepared as part of the NWQMS. The guidelines provide a process for developing WQOs required to sustain current or likely future environmental values for natural and semi-natural water resources. The process involves the following:

1. Identify the environmental values that are to be protected in a particular water body. Environmental values (sometimes referred to as beneficial uses) are particular values or uses of the environment that are important for a healthy ecosystem or for public benefit, welfare, safety or health and which require protection from the effects of pollution, waste discharges and deposits. The following environmental values are recognised in the ANZECC guidelines:
   - aquatic ecosystems
   - primary industries (irrigation and general water uses, stock drinking water, aquaculture and human consumption of aquatic foods)
   - recreation and aesthetics
   - drinking water
   - industrial water
   - cultural and spiritual values
2. Identify management goals and then select the relevant water quality guidelines for measuring performance. A water quality guideline is a numerical concentration limit or narrative statement recommended to support and maintain a designated water use. Based on these guidelines, set water quality objectives that must be met to maintain the environmental values. Water quality objectives are the specific water quality targets agreed between stakeholders, or set by local jurisdictions, that become the indicators of management performance.
3. Develop statistical performance criteria to evaluate the results of the monitoring programs (e.g. statistical decision criteria for determining whether the water quality objectives have been exceeded or not).
4. Develop tactical monitoring programs focusing on the water quality objectives.
5. Initiate appropriate management responses to attain (or maintain if already achieved) the water quality objectives.

The environmental values adopted for the project are provided in Section 4. The water quality guidelines for the environmental values are provided in Table 2.2. Bold values are the most conservative guideline value for the parameter. The guidelines for physical and chemical stressors are those for south-east Australian upland rivers and streams for slightly disturbed ecosystems. The guidelines for other parameters are those for freshwater with a 95% level of protection. The water quality guidelines in Table 2.2 have been used to establish the WQOs for the project (refer to Section 6).

2.10 Australian Drinking Water Guidelines

The Australian Drinking Water Guidelines (ADWG) (NHMRC 2011) provide a framework for good management of drinking water supplies that, if implemented, will assure safety at point of use. The ADWG have been developed after consideration of the best available scientific evidence and are designed to provide an authoritative reference on what defines safe, good quality water, how it can be achieved and how it can be assured.

Drinking water is defined as water intended primarily for human consumption, either directly, as supplied from the tap, or indirectly, in beverages, ice or foods prepared with water. Drinking water is also used for other domestic purposes such as bathing and showering.

The safety of drinking water in public health terms is determined by its microbial, physical, chemical and radiological quality; of these, microbial quality is usually the most important. As conventional water treatment methods are not designed to remove some of these compounds from raw water, it is preferable to avoid them in the raw water supply through catchment and storage management practices.

The ADWG include two different types of guideline value:

- a health-related guideline value, which is the concentration or measure of a water quality characteristic that, based on present knowledge, does not result in any significant risk to the health of the consumer over a lifetime of consumption
- an aesthetic guideline value, which is the concentration or measure of a water quality characteristic that is associated with acceptability of water to the consumer; for example, appearance, taste and odour.

The ADWG guideline values are provided in Table 2.2. The water quality guidelines in Table 2.2 have been used to establish the WQOs for the project (refer to Section 6).

Table 2.2 ANZECC and ADWG water quality guidelines

PARAMETER	UNIT	ADWG (2011) HEALTH	ADWG (2011) AESTHETIC	ANZECC IRRIGATION	ANZECC LIVESTOCK DRINKING	ANZECC AQUATIC ECOSYSTEM	ANZECC RECREATION
PHYSICAL PARAMETERS							
Conductivity	µS/cm	-	-	-	-	**30 - 350**	-
Temperature	°C	-	-	-	-	**-**	-
Turbidity	NTU	-	5	-	-	**2 - 25**	-
pH	pH units	-	6.5 – 8.5	6.0 - 9.0	-	**6.5 - 8.0**	6.5 - 8.5
Total dissolved solids (TDS)	mg/L	-	**600**		2,000	**-**	-
Total suspended solids (TSS)	mg/L	-	-	-	-	**-**	-
NUTRIENTS							
Ammonia as N	mg/L	-	**0.5**	-	-	0.9	-
Nitrate (as N)	mg/L	-	-	-	400	**0.7**	10
Nitrite (as N)	mg/L	-	-	-	30	-	**1**

PARAMETER	UNIT	ADWG (2011) HEALTH	ADWG (2011) AESTHETIC	ANZECC IRRIGATION	ANZECC LIVESTOCK DRINKING	ANZECC AQUATIC ECOSYSTEM	ANZECC RECREATION
Total nitrogen as N	mg/L	-	-	5	-	**0.25**	-
Phosphorus	mg/L	-	-	0.05	-	**0.02**	-
MAJOR IONS							
Calcium	mg/L	-	-	-	**1,000**	-	-
Chloride	mg/L	-	250	**175**	-	-	400
Magnesium	mg/L	-	-	-	**2,000**	-	-
Sodium	mg/L	-	180	**115**	-	-	300
Sulfate as SO_4	mg/L	-	**250**	-	1,000	-	400
TOTAL METALS							
Aluminium	mg/L	-	0.2	5	5	**0.055**	-
Antimony	mg/L	**0.003**	-	-	-	-	-
Arsenic	mg/L	**0.01**	-	0.1	0.5	0.013	0.05
Barium	mg/L	2	-	-	-	-	**1**
Beryllium	mg/L	**0.06**	-	0.1	-	-	-
Boron	mg/L	4	-	0.5	5	**0.37**	-
Cadmium	mg/L	0.002	-	0.01	0.01	**0.0002**	0.005
Chromium	mg/L	0.05	-	0.1	1	**0.001**	0.05
Cobalt	mg/L	-	-	**0.05**	1	-	-
Copper	mg/L	2	1	0.2	0.4	**0.0014**	1
Iron	mg/L	-	0.3	**0.2**	-	-	0.3
Lead	mg/L	0.01	-	2	0.1	**0.0034**	0.05
Manganese	mg/L	0.5	0.1	0.2	-	1.9	**0.1**
Mercury	mg/L	0.001	-	0.002	0.002	**0.0006**	0.001
Molybdenum	mg/L	0.05	-	**0.01**	0.15	-	-
Nickel	mg/L	0.02	-	0.2	1	**0.011**	0.1
Selenium	mg/L	**0.01**	-	0.02	0.02	-	-
Silver	mg/L	0.1	-	-	-	**0.00005**	-
Zinc	mg/L	-	3	2	20	**0.008**	5
HYDROCARBONS							
Benzene	µg/L	**1**	-	-	-	950	-

PARAMETER	UNIT	ADWG (2011) HEALTH	ADWG (2011) AESTHETIC	ANZECC IRRIGATION	ANZECC LIVESTOCK DRINKING	ANZECC AQUATIC ECOSYSTEM	ANZECC RECREATION
Toluene	µg/L	800	**25**	-	-	-	-
Ethylbenzene	µg/L	300	**3**	-	-	-	-
Xylene	µg/L	600	**20**	-	-	-	-
Naphthalene	µg/L	-	-	-	-	**16**	-

Source:ANZECC (2000) and ADWG (2011)
Guidelines for physical and chemical stressors are those for south-east Australian upland rivers and for slightly disturbed ecosystems.
Bold guideline values denote the most stringent guideline value

2.11 WaterNSW Principles for Managing Mining and Coal Seam Gas Impacts in Declared Catchment Areas

WaterNSW has an obligation to protect water quality, quantity and its infrastructure within its land and Sydney drinking water catchments. WaterNSW has established a comprehensive governance framework to protect water supply infrastructure and access conditions for mining activities via development of the report *WaterNSW Principles for Managing Mining and Coal Seam Gas Impacts in Declared Catchment Areas 2014* (ie the WaterNSW Principles). The project is located within the Wingecarribee River, which is a Declared Catchment Area.

In applying the WaterNSW Principles, the Hume Coal Project must provide for the protection of water quality. WaterNSW considers that all mining activities should have a NorBE on water quality in Declared Catchment Areas during construction, operation and rehabilitation stages. The surface facilities associated with mining activities must be managed to either contain any pollutants on the site or transfer them offsite for appropriate treatment and disposal. Mining activities must not result in a reduction in the quality of surface water inflows to storages. Predicted impacts to surface water quality are presented in Section 5 of this report and safeguards to prevent or minimise impacts are discussed in Section 6.

3 EXISTING ENVIRONMENT

3.1 Catchment overview

The project is located in the Hawkesbury-Nepean Basin and lies within the Warragamba drinking water catchment (Figure 1.1).

The main rivers and tributaries of the Hawkesbury-Nepean Basin include the Avon, Cataract, Colo, Cordeaux, Coxs, Grose, McDonald, Wollondilly, Warragamba and Wingecarribee rivers, the latter of which receives drainage from the project area.

The Warragamba drinking water catchment covers 9,051 km^2 and drains to Lake Burragorang, the reservoir behind Warragamba Dam (Figure 1.1). Lake Burragorang is WaterNSW's largest reservoir for the supply of water to Sydney and has a capacity of more than two million megalitres (Sydney Catchment Authority (SCA), 2013). One quarter of the catchment is a declared special area, where the land is mostly pristine bushland and public access is restricted to protect water quality. The remainder of the catchment is divided between eight local council areas, including the Wingecarribee Shire Council (WSC) domain where the project is located (Figure 1.1).

The streams in the project area generally drain in a north-west direction and flow into the Wingecarribee River. The Wingecarribee River joins the Wollondilly River downstream of the project area.

Medway Rivulet and its tributary Oldbury Creek are the primary waterways that flow through the project area. The combined catchment area of both creek systems is 118 km^2 to their confluence. The major tributaries of Medway Rivulet are Wells Creek, Whites Creek, Paynes Creek, Oldbury Creek and Belanglo Creek (refer to Figure 1.4).

Medway Rivulet has its headwaters near Moss Vale, and flows in predominantly west to north-west direction towards the Wingecarribee River. Land use in the upper reaches of the catchment is highly disturbed and cleared for agriculture. River behaviour east of the Hume Highway is characterised by several instream storages that impede the natural flow within the upper catchment and ponded water connected by run/riffle sequences. Medway Rivulet and its major tributaries receive runoff from adjacent farm land. Whites Creek receives urban stormwater from the suburb of Moss Vale.

West of the Hume Highway, Medway Rivulet is confined by steep gullies formed by Hawkesbury Sandstone. Downstream of the project area, Medway Rivulet has been dammed to create a 1,350 ML reservoir. The reservoir is commonly referred to as 'Medway Dam' and is ordinarily part of WSC's water supply system (although Medway Water Treatment Plant, which treats water from the reservoir, is not currently operational). Approximately 5.5 km downstream from the reservoir, Medway Rivulet joins the Wingecarribee River.

Oldbury Creek joins Medway Rivulet approximately 1.5 km downstream from the reservoir. The upper reaches of Oldbury Creek commence near the Boral Cement works in New Berrima. East of the Old Hume Highway, in the upper reaches, the creek is characterised by disconnected instream storages used for agricultural water supply. A large instream farm dam is located adjacent to the proposed CPP precinct. To the north of the proposed CPP the creek becomes confined in gullies formed by the Hawkesbury Sandstone. From the proposed CPP downstream, the creek is characterised by pools connected with run and riffle sequences.

Belanglo Creek joins the Medway Rivulet approximately 300 m downstream of Medway Dam and receives runoff from the Belanglo State Forest (refer to Figure 1.4). The upper reaches of Belanglo Creek are predominately ephemeral with isolated disconnected pools during low flow conditions.

3.2 Climate data

The water quality assessment used outputs from the modelling undertaken for the water balance assessment (Parsons Brinckerhoff 2016b) and flow and geomorphology assessment (Parsons Brinckerhoff 2016a) to assess the potential impacts of the project on water quality. The climate data used for the water balance and flow modelling analyses was based on historical daily data sourced from the Data Drill database (DSITIA 2015).

Data Drill is a daily time series of data at a point location consisting entirely of interpolated estimates. The data are taken from the gridded datasets and are available at any grid point over the land area of Australia. Data Drill is considered superior to individual Bureau of Meteorology (BOM) station records and site observations for water balance modelling purposes because it draws on a greater dataset, both spatially and in time, and does not contain gaps.

The Data Drill for the water balance assessment was obtained for latitude -34.50 and longitude 150.30 (in decimal degrees), which is 0.5 km north of SB01 and SB02. Figure 3.1 shows the Data Drill location and BOM rain gauges located around the Medway Rivulet and Oldbury Creek catchments. The available data for the Data Drill location is for a 127 year period from 1889 to 2015.

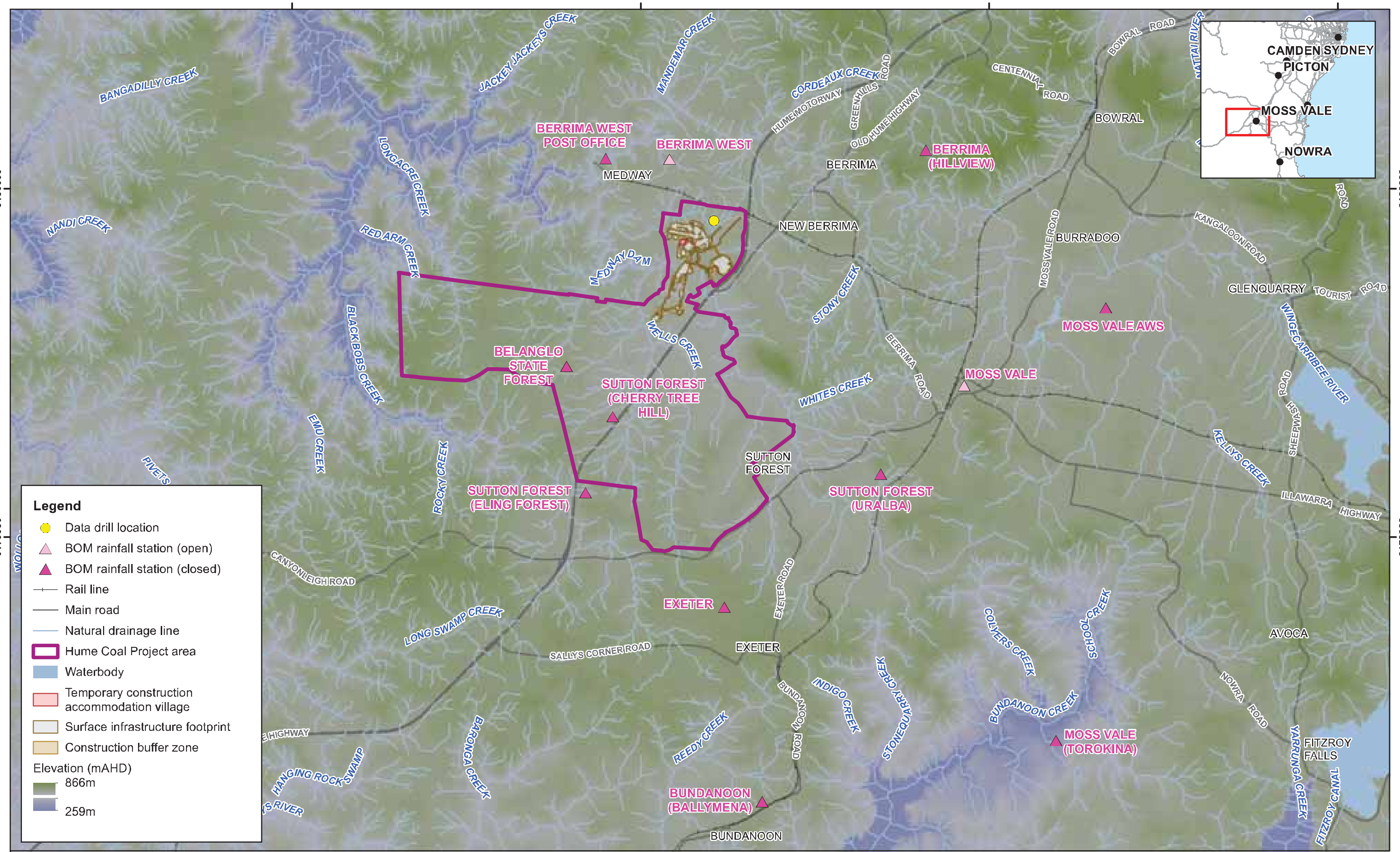
A plot of the Data Drill annual rainfall is provided in Figure 3.2. This plot also contains a 10-year moving average time series, which identifies the period from 1949 to1969 as the wettest period. Similarly the period from 1999 to 2015 appears to be one of the sustained dry periods.

A plot of monthly distribution of average daily evaporation from the Data Drill for the site is provided in Figure 3.3. Lake evaporation data was used in the water balance assessment to estimate evaporation from storages and evapotranspiration data was used for other areas. In the project area, lake evaporation and evapotranspiration is lowest in winter months and highest in summer months.

Summary statistics for rainfall and evaporation are provided in Table 3.1. Further details of the climate data used for the water balance assessment are provided in the water balance assessment report (Parsons Brinckerhoff 2016b).

Table 3.1 Summary climate statistics for Hume Coal Project site — Data Drill (1889 to 2015)

STATISTIC	ANNUAL RAINFALL (MM)	ANNUAL POTENTIAL EVAPOTRANSPIRATION[1] (MM)	ANNUAL LAKE EVAPORATION[2] (MM)
Minimum	393	878	1,034
5th percentile (dry)	525	930	1,095
10th percentile	564	946	1,114
50th percentile (median)	800	1,016	1,190
90th percentile	1,120	1,109	1,264
95th percentile (wet)	1,256	1,122	1,275
Maximum	1,550	1,180	1,306
Average	824	1,021	1,187
Standard deviation	220	60	57



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Date: 21/10/2016	Approved by: LR

Data source: , Hume Coal, Google Earth

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Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A3

Hume Coal Surface Water Quality Assessment
Figure 3.1
Climate data

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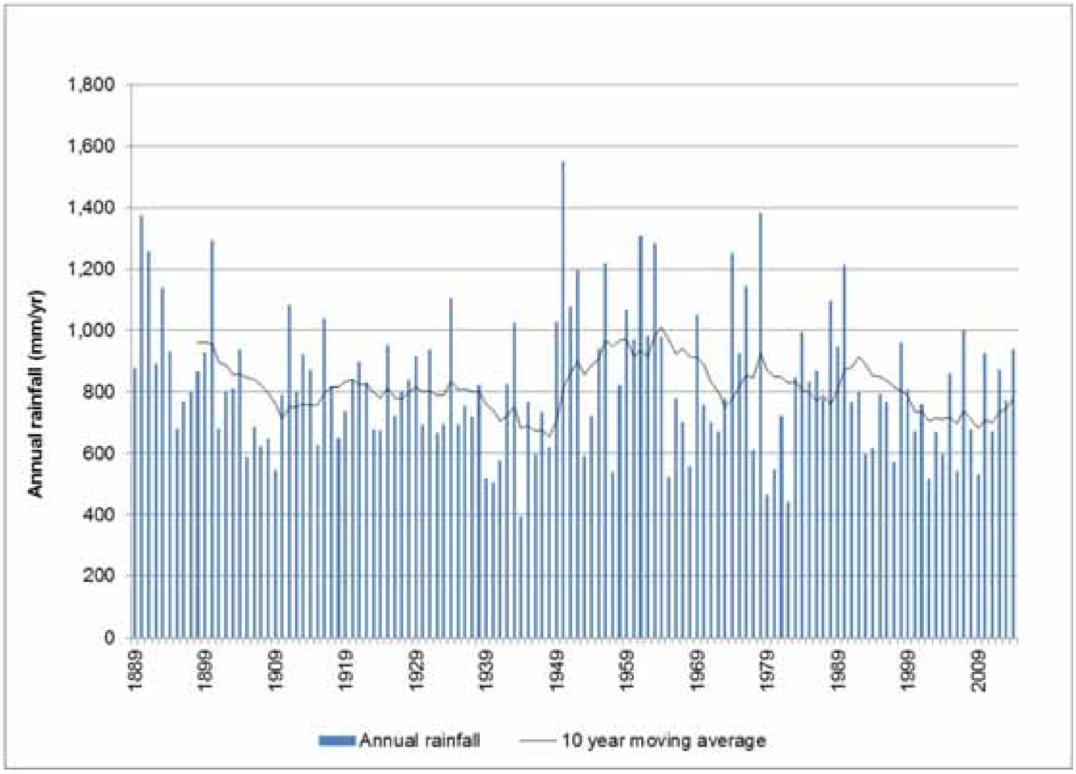


Figure 3.2 Annual rainfall for Hume Coal Project site — Data Drill (1889 to 2015)

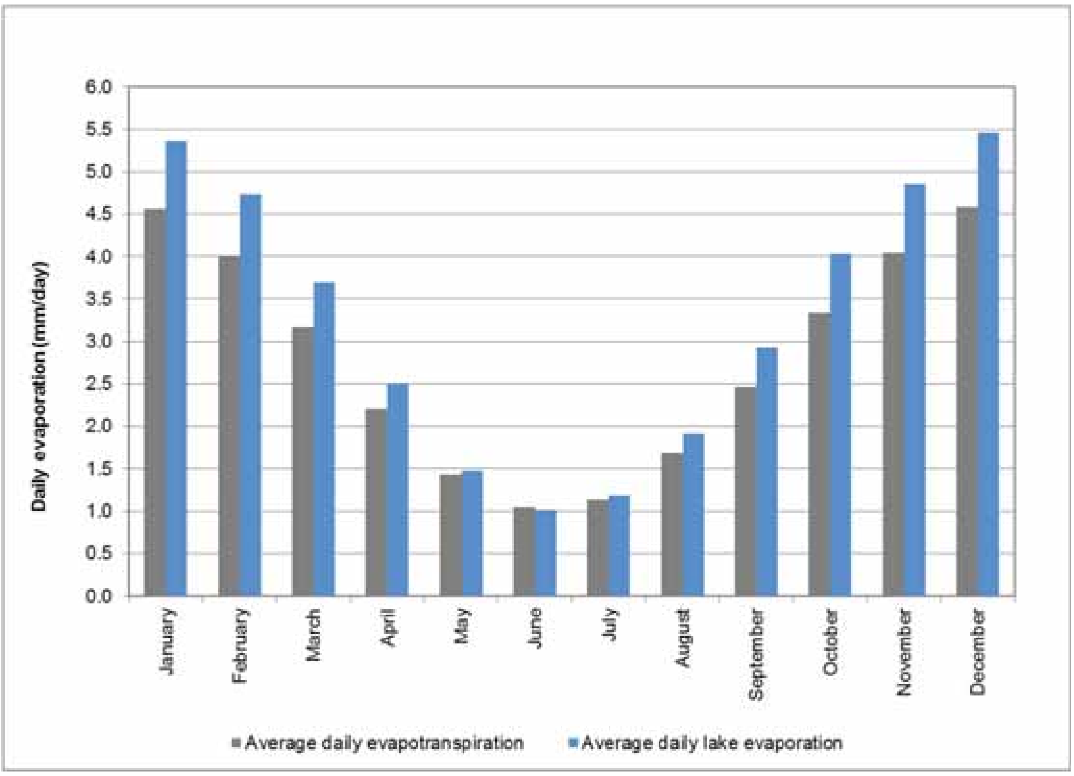


Figure 3.3 Average daily evaporation data – Data Drill (1889 to 2015)

3.3 Streamflow

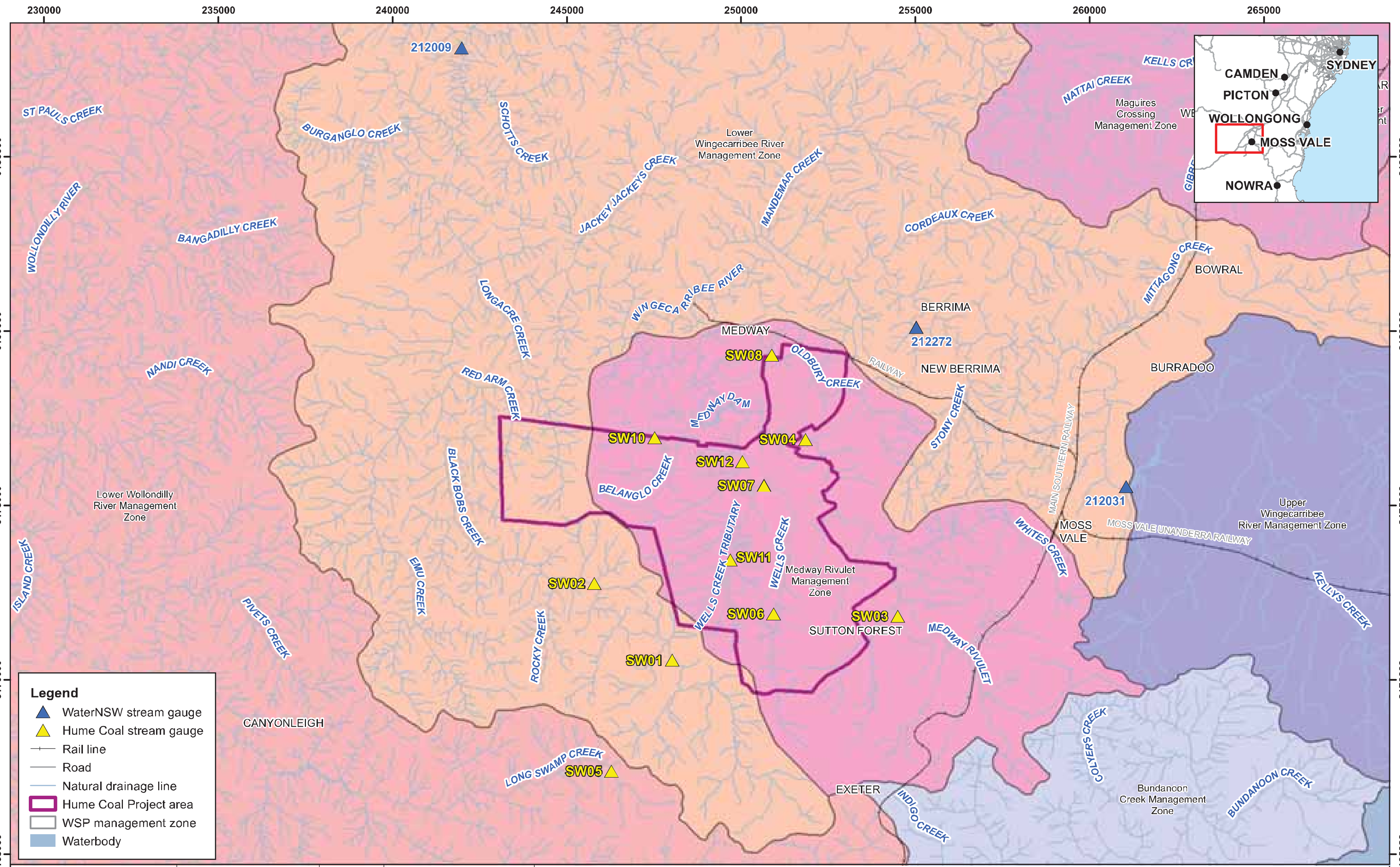
Medway Rivulet and its tributary Oldbury Creek are the primary waterways that flow through the project area. Stream gauging stations in the vicinity of the project area are operated by WaterNSW and Hume Coal. The locations of the stream gauges are shown on Figure 3.4 and listed in Table 3.2.

Table 3.2 Stream gauge locations

MANAGEMENT ZONE	STREAM	HUME COAL MONITORING LOCATIONS	WATERNSW MONITORING LOCATIONS
Medway Rivulet	Medway Rivulet	SW03, SW04	
	Oldbury Creek	SW08	
	Wells Creek and Wells Creek Tributary	SW06, SW07, SW11, SW12	
	Planting Spade Creek	SW10	
Lower Wingecarribee River	Wingecarribee River		212031, 212272, 212009
	Black Bobs Creek	SW01, SW02	
Lower Wollondilly River	Long Swamp Creek	SW05	

The natural flow regimes of streams in the project area are highly disturbed as the catchments have been extensively cleared for agriculture and multiple instream storages, which impede the natural flow, have been constructed along the length of the streams. The flow characteristics are discussed in detail in the *Water Balance Assessment Report* (Parsons Brinckerhoff 2016a).

The groundwater level in the project area is typically higher than the beds of streams, hence the streams in the area receive baseflow from groundwater. During dry conditions this manifests as persistent unconnected or connected pools.



Map: 2200540A_GIS_065_A2 | Author: RP
Date: 21/10/2016 | Approved by: LR

Data source: NSW Land and Property Information 2015, Hume Coal

Coordinate system: GDA 1994 MGA Zone 56
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Hume Coal Surface Water Quality Assessment
Figure 3.4
Stream gauge locations

3.4 Baseline surface water quality

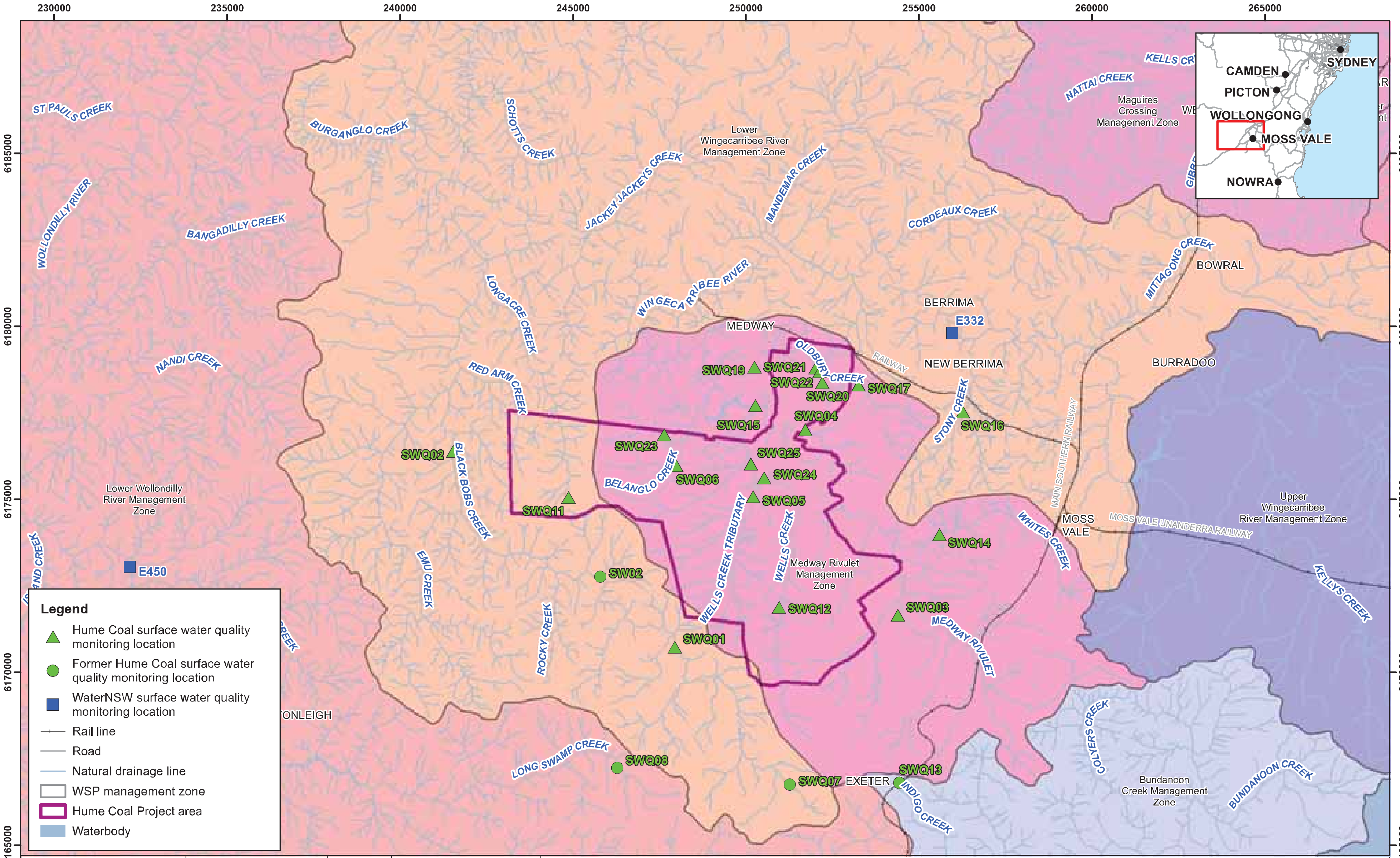
Hume Coal has been undertaking surface water quality monitoring in the project area since April 2012. The monitoring program is ongoing to establish baseline surface water quality conditions prior to mining. Monitoring is undertaken monthly at the locations shown on Figure 3.5 and listed in Table 3.3. Details of the monitoring program and locations are provided in the *Water Fieldwork and Monitoring Report* (Parsons Brinckerhoff 2016c).

WaterNSW also undertakes surface water quality monitoring in the project area. Monitoring has been undertaken at locations on the Wingecarribee River and Wollondilly River since April 2002. The locations are shown on Figure 3.5 and listed in Table 3.3.

Table 3.3 Surface water quality monitoring locations

MANAGEMENT ZONE	STREAM	HUME COAL MONITORING LOCATIONS	WATERNSW MONITORING LOCATIONS
Medway Rivulet	Medway Rivulet	SWQ03, SWQ04, SWQ15*	
	Oldbury Creek	SWQ17, SWQ19, SWQ20^, SWQ21^, SWQ22^	
	Wells Creek and Wells Creek Tributary	SWQ05, SWQ12, SWQ24, SWQ25	
	Whites Creek	SWQ14	
	Belanglo Creek and Planting Spade Creek	SWQ06, SWQ23	
Lower Wingecarribee River	Wingecarribee River		E332
	Black Bobs Creek	SWQ01, SWQ02, SWQ02, SWQ07	
	Longacre Creek	SWQ11	
	Stony Creek	SWQ16	
Lower Wollondilly River	Wollondilly River		E450
	Long Swamp Creek and Hanging Rock Swamp Creek	SWQ08, SWQ10	
Bundanoon Creek	Indigo Creek	SWQ13	

* Monitoring location at Medway Dam
^ Monitoring locations on farm dams on Oldbury Creek



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Date: 14/11/2016	Approved by: LR

Data source: NSW Land and Property Information 2015, Hume Coal

0 1,500 3,000 m

1:100,000

Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A3

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Hume Coal Surface Water Quality Assessment
Figure 3.5
Surface water quality monitoring locations

A summary of baseline surface water quality conditions in Medway Rivulet and Oldbury Creek for the period April 2012 to September 2015 is provided in Table 3.4. Results have been presented as summary statistics for monitoring locations SWQ03, SWQ04 and SWQ15 on Medway Rivulet, and SWQ17, SWQ19, SWQ20, SWQ21 and SWQ22 on Oldbury Creek.

Summary statistics of baseline surface water quality conditions for the monitoring locations in Table 3.3 are provided in Appendix A. Results presented for metals are dissolved concentrations.

The Medway Rivulet and Oldbury Creek results have been compared to the most conservative water quality guideline values for the environmental values in the project area (Section 4.1), with the exception of nutrients which have been compared to the recommended WQOs in the report *Healthy Rivers Commission Inquiry into the Hawkesbury-Nepean River* (HRC 1998). Median and 80th percentile concentrations that exceed guideline values are shaded in grey in Table 3.4. Where more than half or more than 80% of samples returned lower than the laboratory detection limit, then the below laboratory detection limit has been noted for the median or 80th percentile values.

Baseline concentrations of key water quality parameters in Medway Rivulet and Oldbury Creek comply with guideline values with the exception of the following:

- Median and 80th percentile electrical conductivity values for Medway Rivulet and Oldbury Creek exceed the ANZECC (2000) guideline for aquatic ecosystems
- Median and 80th percentile concentrations of nitrogen and phosphorous in Medway Rivulet and Oldbury Creek exceed the WQOs recommended by the Healthy Rivers Commission (HRC 1998)
- 80th percentile concentrations of aluminium in Medway Rivulet and Oldbury Creek exceed the ANZECC (2000) guideline for aquatic ecosystems
- 80th percentile concentrations of copper in Medway Rivulet exceed the ANZECC (2000) guideline for aquatic ecosystems
- Median and 80th percentile concentrations of iron in Medway Rivulet and Oldbury Creek exceed the ANZECC (2000) guideline for irrigation
- 80th percentile concentrations of manganese in Medway Rivulet and Oldbury Creek exceed the ANZECC (2000) guideline for recreation
- Median and 80th percentile concentrations of silver in Oldbury Creek exceed the ANZECC (2000) guideline for aquatic ecosystems.

Site specific WQOs will be developed for these parameters. This is discussed in Section 6.4.4.

Table 3.4 Baseline surface water quality conditions in the project area

PARAMETER	UNIT	GUIDELINE	MEDWAY RIVULET					OLDBURY CREEK				
			NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX	NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX
Physical parameters												
Conductivity	µS/cm	35 – 350	90	116	434	613	910	39	178	456	571	1060
Temperature	°C	-	87	7.1	15	20	27	37	8.8	12	19	26
Turbidity	NTU	2 - 25	87	1.4	5.4	9.6	37	39	1.7	6.5	12	57
pH	pH units	6.5 - 8.0	90	5.7	7.2	6.8 (20th%ile) 7.6 (80th %ile)	8.0	39	5.0	7.4	7.0 (20th%ile) 7.8 (80th %ile)	9.2
TDS	mg/L	600	88	75	292	396	502	39	116	287	366	480
TSS	mg/L	-	91	<5	5.0	9.0	51	39	2.0	5.0	9.0	34
Nutrients												
Ammonia as N	mg/L	0.5	91	<0.01	0.02	0.04	0.11	39	<0.01	0.04	0.12	0.42
Nitrate (as N)	mg/L	0.7	91	<0.01	0.03	0.11	0.89	39	<0.01	0.09	0.66	2.6
Nitrite (as N)	mg/L	1.0	91	<0.01	0.01	0.01	0.05	39	<0.01	<0.01	0.03	0.11
Total nitrogen as N	mg/L	0.5*	91	0.40	0.80	1.1	1.9	39	0.6	1.2	2.1	4.4
Phosphorus	mg/L	0.03*	91	<0.01	0.04	0.08	0.26	39	<0.01	0.07	0.12	0.18
Major ions												
Calcium	mg/L	1,000	91	5	23	32	42	39	14	23	40	48
Chloride	mg/L	175	91	22	62	96	137	39	35	55	66	112
Magnesium	mg/L	2,000	91	4	14	23	38	39	7.0	9.0	13	21

PARAMETER	UNIT	GUIDELINE	MEDWAY RIVULET					OLDBURY CREEK				
			NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX	NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX
Sodium	mg/L	115	91	8	36	54	87	39	20	37	50	75
Sulfate as SO_4	mg/L	250	91	<1	10	27	86	39	5.0	27	73	138
Dissolved metals												
Aluminium	mg/L	0.055	91	<0.01	0.02	0.12	0.66	39	<0.01	0.04	0.12	0.32
Antimony	mg/L	0.003	45	<0.001	<0.001	<0.001	<0.001	39	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.01	91	<0.001	<0.001	0.001	0.002	39	<0.001	<0.001	<0.001	0.001
Barium	mg/L	1.0	91	0.02	0.05	0.07	0.10	39	0.01	0.04	0.04	0.07
Beryllium	mg/L	0.06	88	<0.001	<0.001	<0.001	<0.001	39	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.37	45	<0.05	<0.05	<0.05	<0.05	39	<0.05	<0.05	<0.05	0.05
Cadmium	mg/L	0.0002	91	<0.0001	<0.0001	<0.0001	0.0001	39	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	91	<0.001	<0.001	<0.001	0.001	39	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.05	91	<0.001	<0.001	<0.001	0.003	39	<0.001	<0.001	<0.001	0.003
Copper	mg/L	0.0014	91	<0.001	<0.001	0.002	0.005	39	<0.001	0.001	0.001	0.002
Iron	mg/L	0.2	91	<0.05	0.26	0.51	1.2	39	0.06	0.22	0.35	0.57
Lead	mg/L	0.0034	91	<0.001	<0.001	<0.001	<0.001	39	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.1	91	<0.001	0.04	0.14	2.5	39	0.007	0.06	0.13	2.2
Mercury	mg/L	0.0006	50	<0.0001	<0.0001	<0.0001	<0.0001	1	<0.0001	N/A	N/A	<0.0001
Molybdenum	mg/L	0.01	45	<0.001	<0.001	<0.001	<0.01	39	<0.001	<0.001	<0.001	0.001
Nickel	mg/L	0.011	91	<0.001	0.002	0.003	0.005	39	<0.001	<0.001	0.002	0.002

PARAMETER	UNIT	GUIDELINE	MEDWAY RIVULET					OLDBURY CREEK				
			NO. OF SAMPLES	MIN	MEDIAN	80^{TH} %ILE	MAX	NO. OF SAMPLES	MIN	MEDIAN	80^{TH} %ILE	MAX
Selenium	mg/L	0.01	45	<0.01	<0.01	<0.01	<0.01	39	<0.01	<0.01	<0.01	0.01
Silver^	mg/L	0.00005	54	<0.001	<0.001	<0.01	0.02	7	<0.001	0.02	N/A	0.02
Zinc	mg/L	0.008	91	<0.005	<0.005	<0.005	0.009	39	<0.005	0.005	0.01	0.03
Hydrocarbons												
Benzene	µg/L	1	91	<1	<1	<1	<20	39	<1	<1	<1	<1
Toluene	µg/L	25	91	<2	<2	<2	<50	39	<2	<2	<2	<2
Ethylbenzene	µg/L	3	91	<2	<2	<2	<100	39	<2	<2	<2	<2
Total xylene	µg/L	20	91	<2	<2	<2	<20	39	<2	<2	<2	<2
Naphthalene	µg/L	16	91	<5	<5	<5	<100	39	<5	<5	<5	<5

*WQO recommended by *Healthy Rivers Commission Inquiry into the Hawkesbury-Nepean River* (HRC 1998).
^ Standard and trace laboratory limits of reporting exceed the ANZECC guideline for aquatic ecosystems.
Grey shaded cells indicate median and 80th percentile concentrations that exceed guideline values.
Where results are less than laboratory limit of reporting (<LOR), the statistics have been calculated using the LOR value.

This section presents ‘box-and-whisker’ plots for key contaminants. Box-and-whisker plots are helpful in interpreting the distribution of data. The first and third quartiles are at the ends of the box, the median is indicated with a vertical line in the interior of the box, and the maximum and minimum are at the ends of the whiskers. The number in the middle of the box represents the number of data points used.

Box and whisker plots of TDS concentrations in streams in the project area are presented in Figure 3.6. The results show that all streams in the project area are fresh, with TDS less than 500 mg/L. Belanglo Creek, Planting Spade Creek, Longacre Creek, Long Swamp Creek and Hanging Rock Swamp Creek were fresher than other streams in the project area with TDS generally less than 100 mg/L.

Box and whisker plots of TSS concentrations in streams in the project area are presented in Figure 3.7. TSS concentrations were generally less than 20 mg/L. TSS was highest in Indigo Creek and lowest in Belanglo Creek, Planting Spade Creek, Long Swamp Creek and Hanging Rock Swamp Creek.

Box and whisker plots of pH in streams in the project area are presented in Figure 3.8. pH was generally within the range 5.5 to 8.0. pH was higher in streams draining agricultural land (eg Medway Rivulet, Oldbury Creek and Stony Creek) and lower in streams draining natural or forested catchments (eg Belanglo Creek, Planting Spade Creek, Longacre Creek, Long Swamp Creek and Hanging Rock Swamp Creek). pH was below the lower guideline value for pH of 6.0 in some of the streams draining natural or forested catchments.

Box and whisker plots of TN concentrations in streams in the project area are presented in Figure 3.9. Total nitrogen concentrations were generally higher in streams draining agricultural land (eg Whites Creek, Oldbury Creek and Stony Creek) and lower in streams draining natural or forested catchments (eg Belanglo Creek, Planting Spade Creek, Long Swamp Creek and Hanging Rock Swamp Creek). TN concentrations generally exceeded the HRC guideline value of 0.5 mg/L except in the streams draining natural or forested catchments (Belanglo Creek, Planting Spade Creek, Long Swamp Creek and Hanging Rock Swamp Creek).

Box and whisker plots of TP concentrations in streams in the project area are presented in Figure 3.10. TP concentrations in Stony Creek and Indigo Creek were higher than in other streams in the project area. TP concentrations were lowest in Belanglo Creek, Planting Spade Creek, Long Swamp Creek and Hanging Rock Swamp Creek. Total phosphorous concentrations generally exceeded the HRC guideline value of 0.035 mg/L.

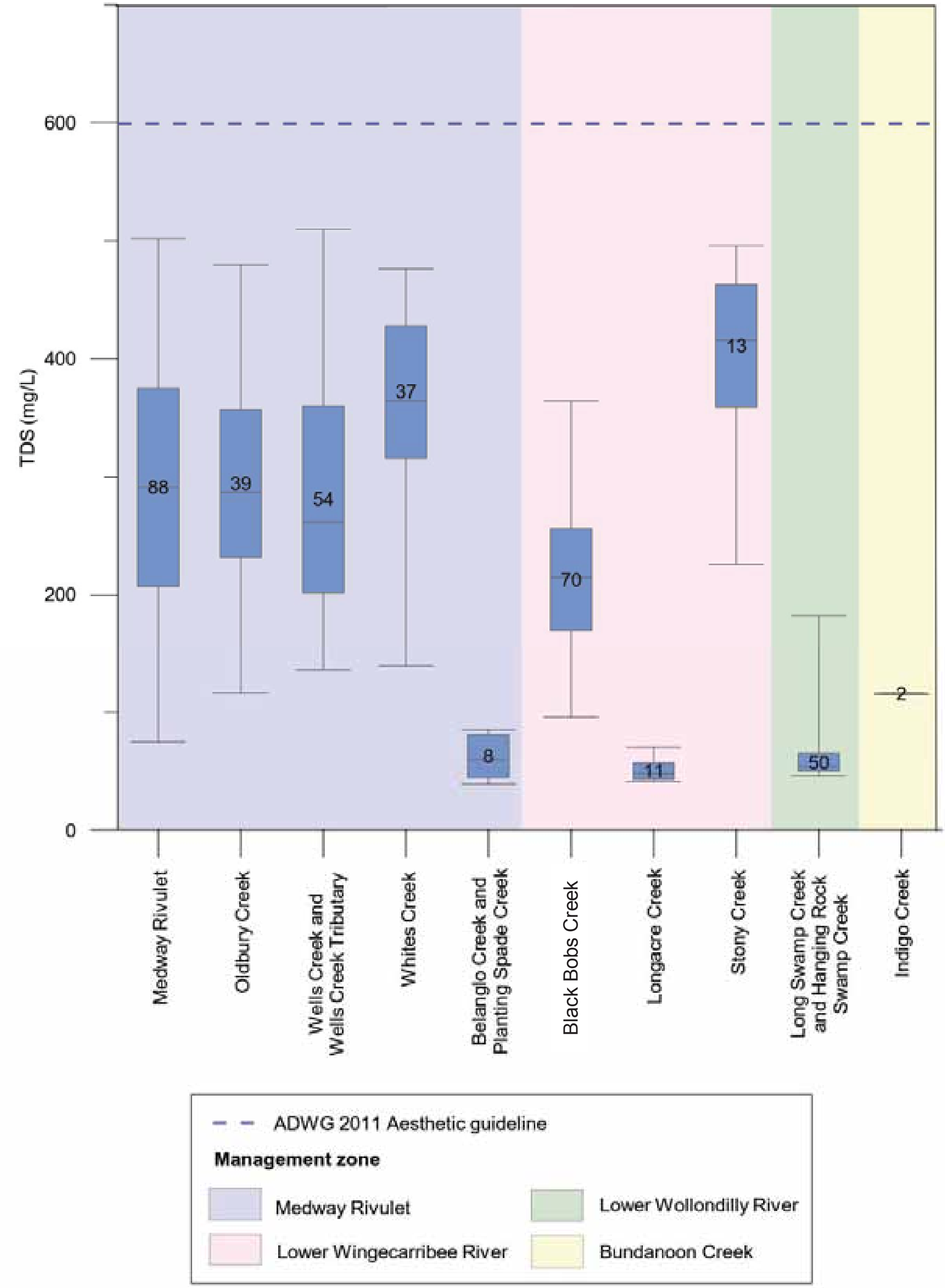


Figure 3.6 Baseline concentrations of total dissolved solids

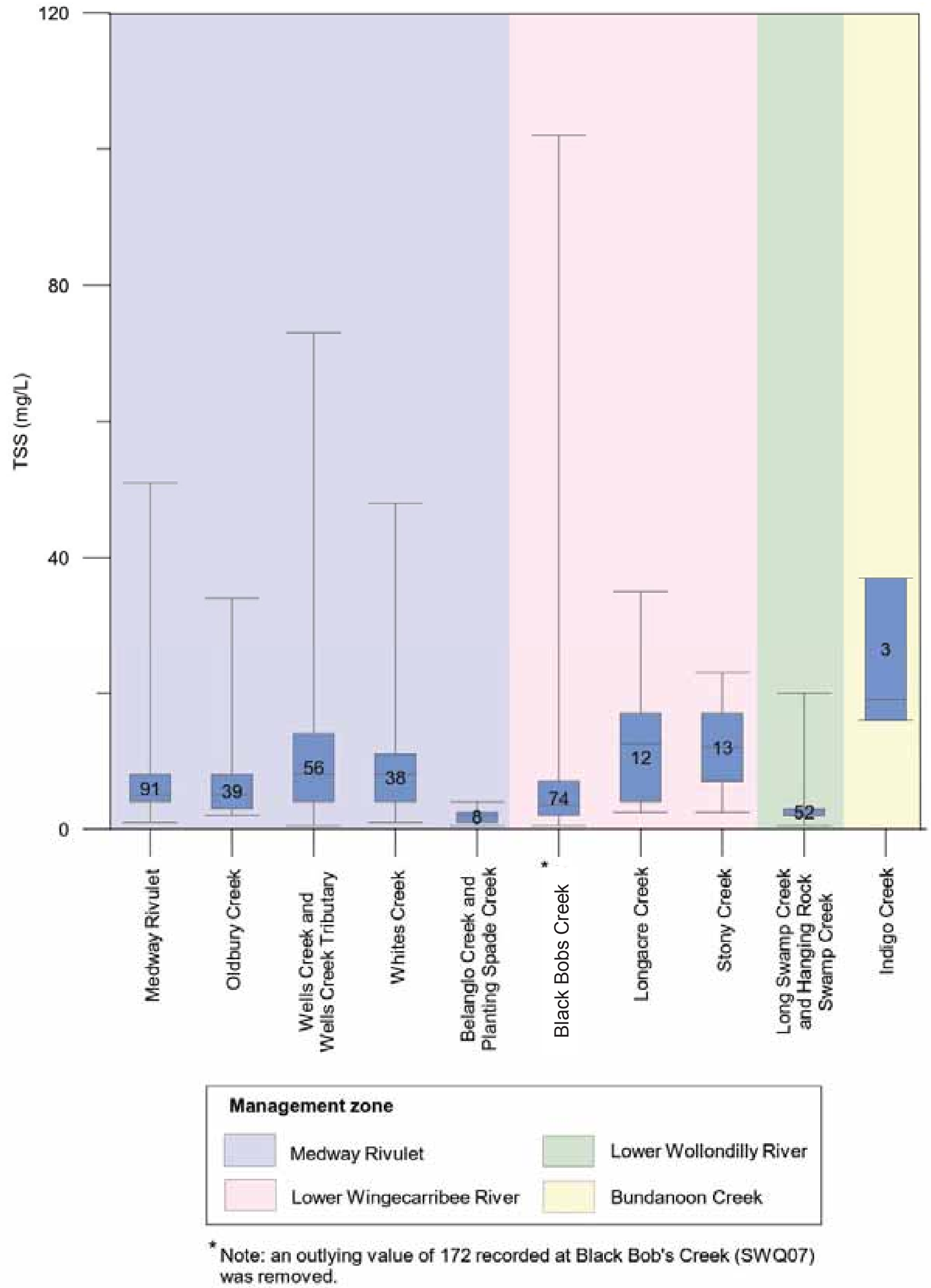


Figure 3.7 Baseline concentrations of total suspended solids

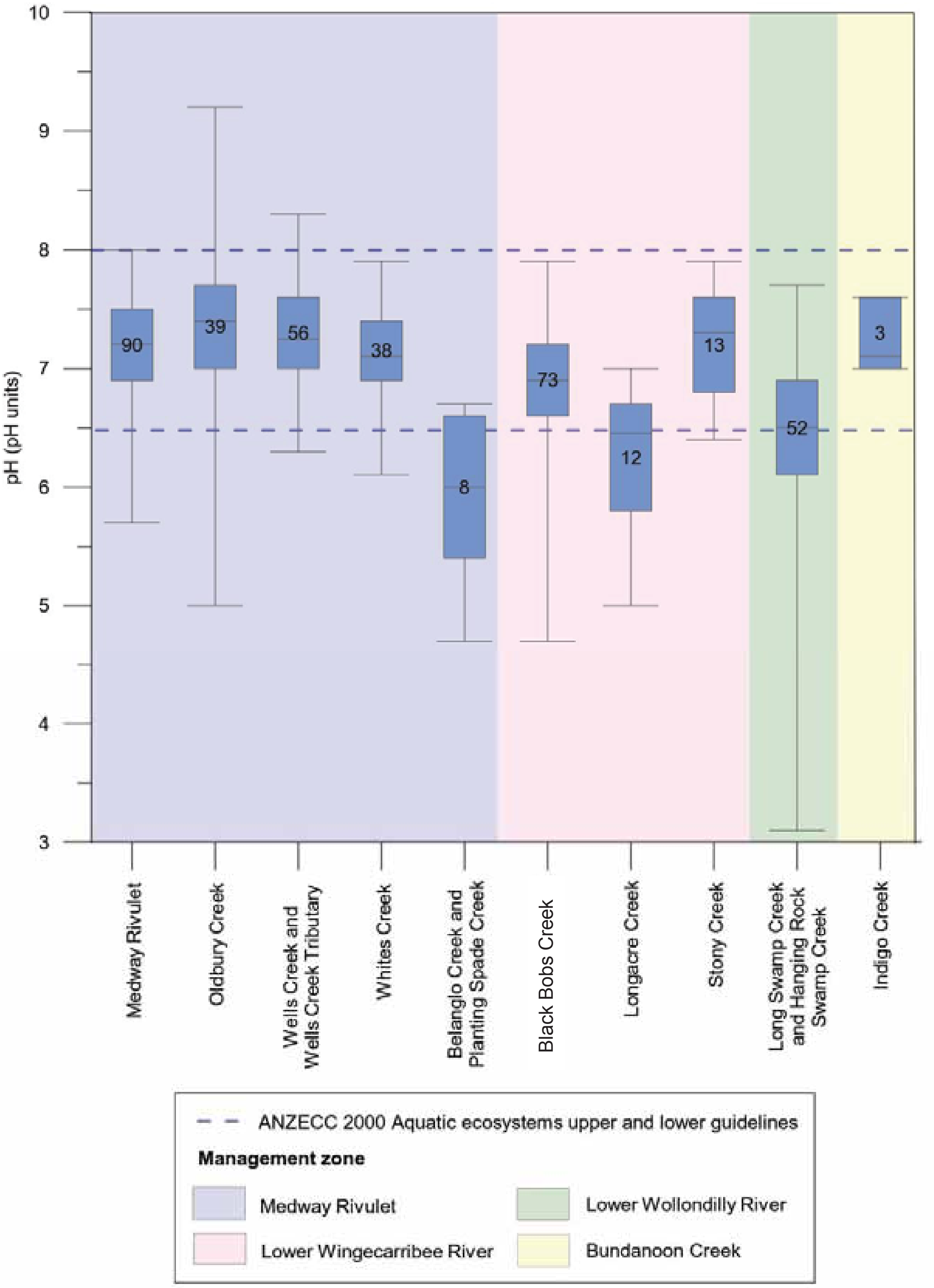


Figure 3.8 Baseline concentrations of pH

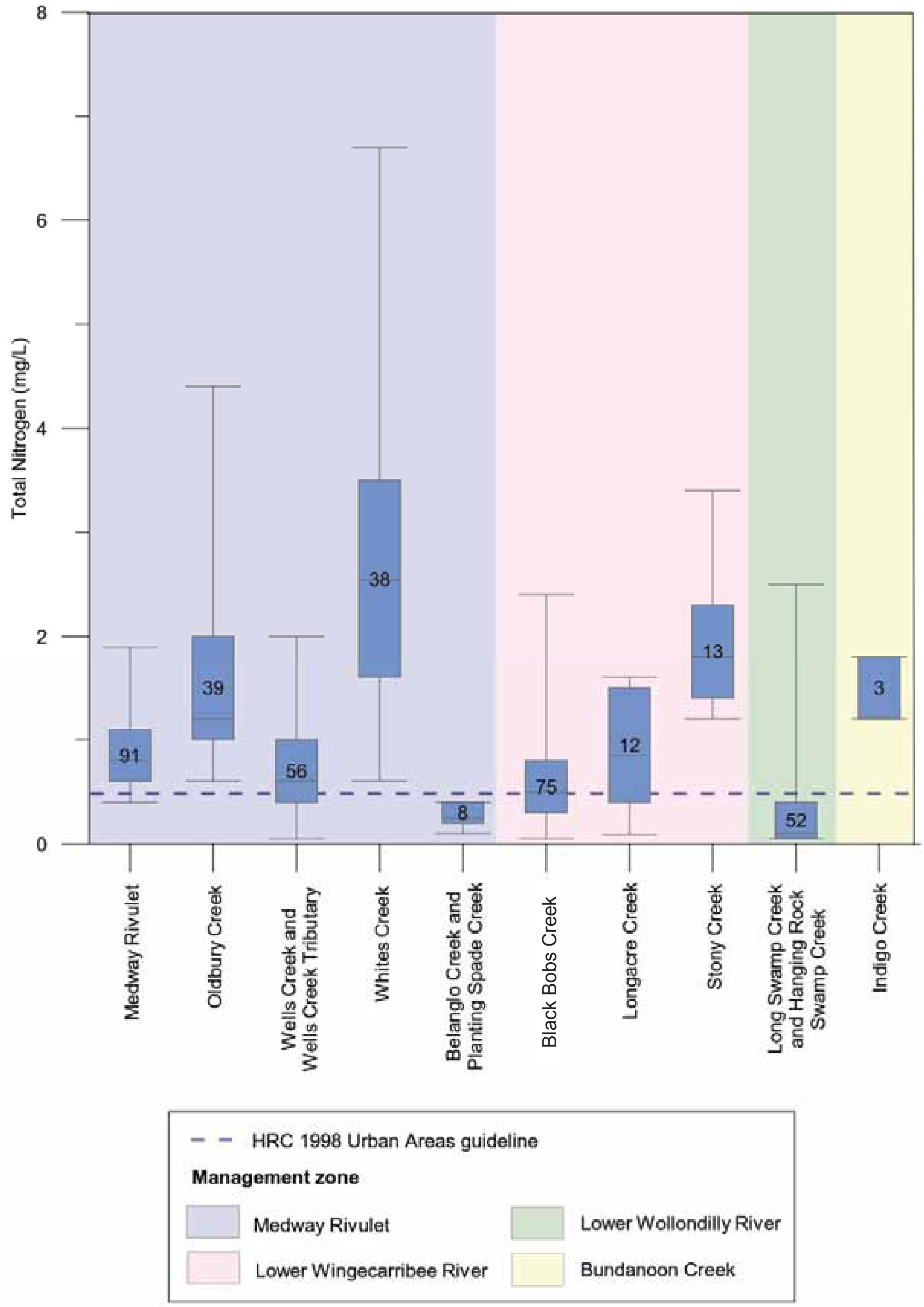


Figure 3.9 Baseline concentrations of Total Nitrogen

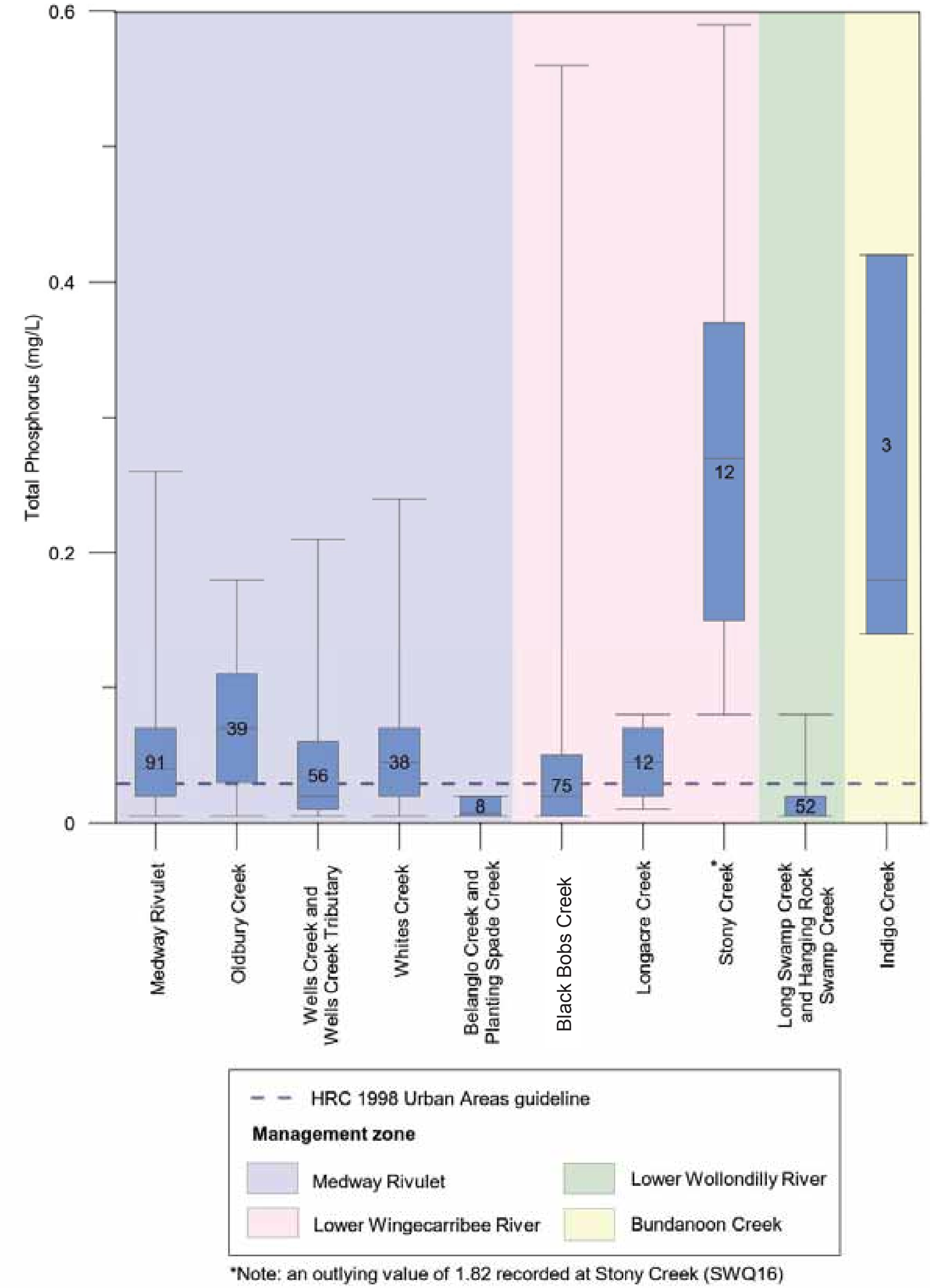


Figure 3.10 Baseline concentrations of Total Phosphorous

4 WATER-RELATED VALUES AND ASSETS

4.1 Environmental values

Environmental values (EVs) are values that the community considers important for water use (HRC 1998). EVs for the Hawkesbury River Catchment are set out in the *Healthy Rivers Commission Inquiry into the Hawkesbury-Nepean River System* (HRC 1998).

Regional EVs are assigned based on land use regions within the Hawkesbury-Nepean catchment. The land use regions within the study area and applicable EVs are provided in Table 4.1.

Table 4.1 Environmental values for surface water in the study area

LAND USE REGIONS	REGIONAL ENVIRONMENTAL VALUES
Predominately forested	Aquatic ecosystems Primary contact recreation Secondary contact recreation Visual amenity Homestead water supply Livestock water supply
Mixed-use Rural and Drinking Water with Clarification and Disinfection	Aquatic ecosystems Primary contact recreation Secondary contact recreation Visual amenity Drinking water – clarification and disinfection Irrigation water supply Homestead water supply Aquatic foods (cooked)

Source: *Healthy Rivers Commission Inquiry into the Hawkesbury-Nepean River System (HRC 1998)*

Downstream of the confluence of the Wollondilly and Wingecarribee Rivers, the land use region is predominantly drinking water catchment where EVs include; aquatic ecosystems, visual amenity, drinking water – disinfection only, and drinking water - groundwater.

4.2 Surface water assets

The surface water-related assets in the study area with potential to be impacted by the project are located in the Medway Rivulet, Lower Wingecarribee River, Lower Wollondilly River and Bundanoon Creek management zones and include::

- Storages used for town water supply, including Medway Reservoir (Medway Dam), Lake Burragorang (Warragamba Dam) and Bundanoon Creek Reservoir;
- Diversion works (pumps) and instream storages used by local water users to extract surface water for water supply;
- Landholders with basic water rights; and
- Ecosystems with potential to be impacted by changes in surface water quality including:

- Instream ecosystems; and
- Riparian ecosystems exposed to overbank flows and flooding.

Further details of surface water-related assets in the study area are provided in Sections 4.2.1, 4.2.2 and 4.2.3. Potential impacts to surface water-related assets associated with the project are assessed in Section 5.

4.2.1 Storages used for town water supply

4.2.1.1 MEDWAY RESERVOIR (MEDWAY DAM)

Medway Dam is located on Medway Rivulet and has a storage capacity of 1,350 ML. The dam was constructed in 1964 and is operated by WSC. Water from the reservoir is ordinarily treated at Medway Water Treatment Plant which has a capacity of 8 ML/day, and supplies the village of Berrima and western parts of Bowral and Mittagong.

WSC hold a 900 ML WAL to take water for town water supply from Medway Dam. Available information from WSC indicates that in the year 2012-2013, Medway Water Treatment Plant treated 414 ML of water from the dam; however the plant was shut down in June 2013. The shutdown, which lasted nearly two years, was used to change the filter media and install a temporary Poly Aluminium Chloride plant to help reduce taste and odour effects from released algal toxins (Beca 2010). Medway Dam is prone to algal blooms in summer due to catchment runoff and nutrient loading, including from Moss Vale Sewage Treatment Plant (STP) upstream. Toxic cyanobacteria (blue-green algae) species have been demonstrated to be present and have been prevalent in historic blooms, resulting in the Medway discharge having to be shut down for prolonged periods (Beca 2010). It is understood that WSC has plans to upgrade the plant over the next 3 years.

Medway Dam is located downstream of the administration and workshop area and receives runoff from pasture lands in the upper and lower reaches of the Medway Rivulet catchment, as well as from the Moss Vale urban area via the Whites Creek tributary.

The location of Medway Dam is shown on Figure 4.1.

4.2.1.2 LAKE BURRAGORANG (WARRAGAMBA DAM)

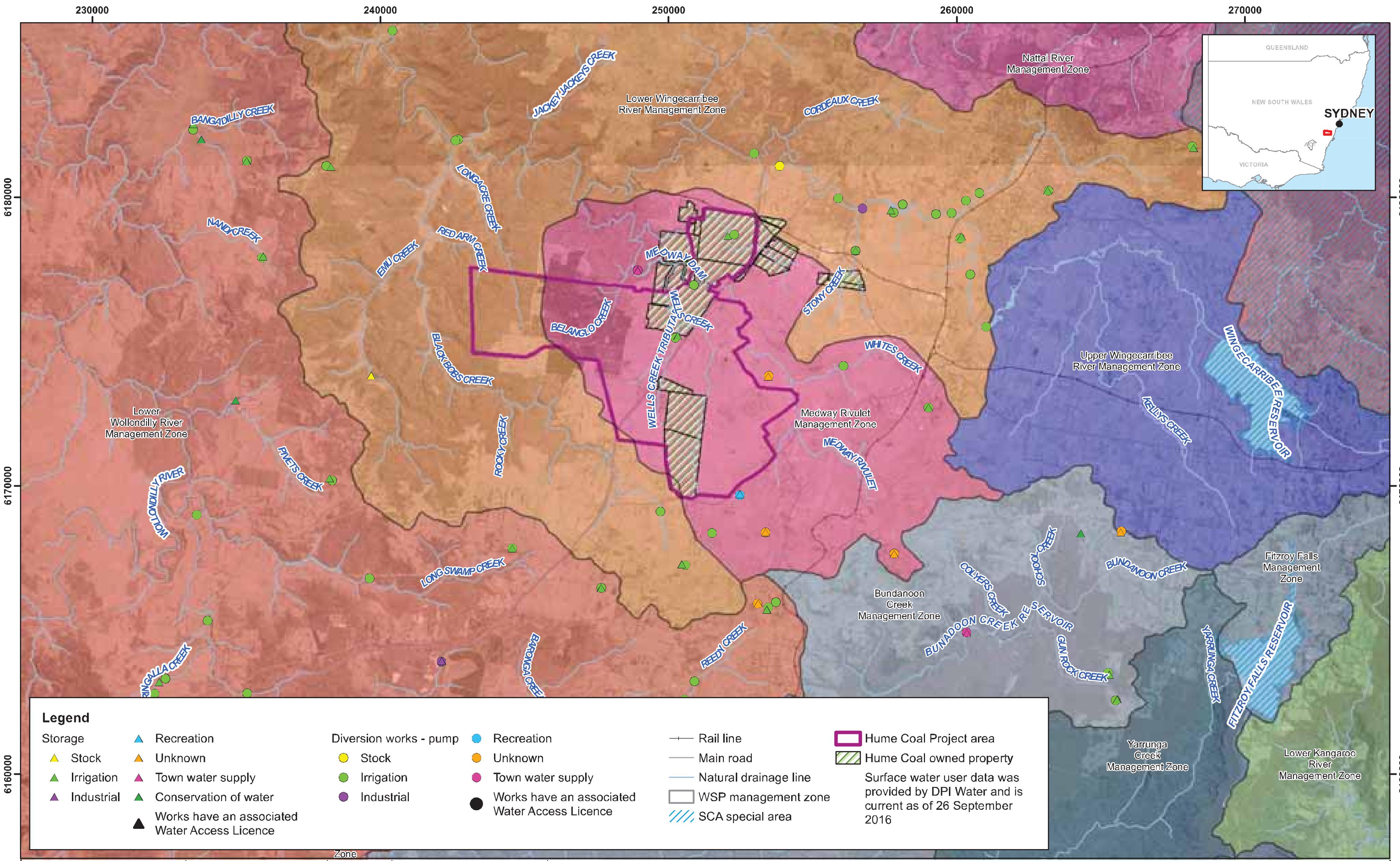
Lake Burragorang is located on the Wollondilly River downstream of the project. The lake is WaterNSW's largest reservoir with a total capacity of more than two million megalitres (SCA 2013). It sits behind Warragamba Dam and has a catchment area of 9,051 km^2 (Figure 1.1).

Lake Burragorang has the capacity to supply up to 80% of Sydney's water. One quarter of the catchment is a declared Special Area, where public access is restricted to protect water quality.

Since the 1970s, during times of drought, water from the Shoalhaven catchment to the south has been pumped to Wingecarribee Reservoir and the Wingecarribee River channel has been used to transport bulk water to Warragamba Dam.

4.2.1.3 BUNDANOON CREEK RESERVOIR (BUNDANOON CREEK DAM)

Bundanoon Creek Dam is located on Bundanoon Creek and has a storage capacity of approximately 2,000 ML. The dam was constructed in the mid 1960s and is operated by WSC. Water from the reservoir is treated at Bundanoon Creek Water Treatment Plant which has a capacity of 10 ML/day, and provides supply to Bundanoon, Moss Vale, Bowral and Mittagong.



Map: 2200540A_GIS_067_A2	Author: RP
Date: 18/11/2016	Approved by: LR

Data source: © Land and Property Information 2015, Hume Coal, NSW Office of Water

1:120,000

Coordinate system: GDA 1994 MGA Zone 56

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Hume Coal Surface Water Quality Assessment
Figure 4.1
Surface water users

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WSC hold a 1,000 ML WAL to take water for town water supply from Bundanoon Creek Reservoir. The location of Bundanoon Creek Reservoir is shown on Figure 4.1.

4.2.2 Local water users

Surface water users in the study area were identified using data obtained directly from the Land and Property Information WAL Register and current as of 5 September 2016.

4.2.2.1 DIVERSION WORKS AND STORAGES

Figure 4.1 shows the location of surface water diversion works (pumps) and storages (dams) in the Medway Rivulet, Lower Wingecarribee River, Lower Wollondilly River and Bundanoon Creek Management Zones current as at 26 September 2016.

There are 6 dams and 11 pumps in the Medway Rivulet management zone. Of these, only Medway Dam and its associated pumps are located downstream of the project area. An additional dam and 2 pumps are located on properties owned by Hume Coal or subsidiaries of Hume Coal.

There are numerous stock and domestic and harvestable rights dams in the study area. A large instream storage is located on Wells Creek Tributary near Belanglo Road (refer to Figure 4.1). Two instream storages are located on Oldbury Creek on Hume Coal owned land to the west of the surface infrastructure area. Numerous other in stream storages are also located within the study area.

Figure 4.2 shows the number of pumps and dams in the study area by purpose. Most pumps and dams in the study area are used for irrigation purposes or a combination of irrigation, stock and domestic purposes.

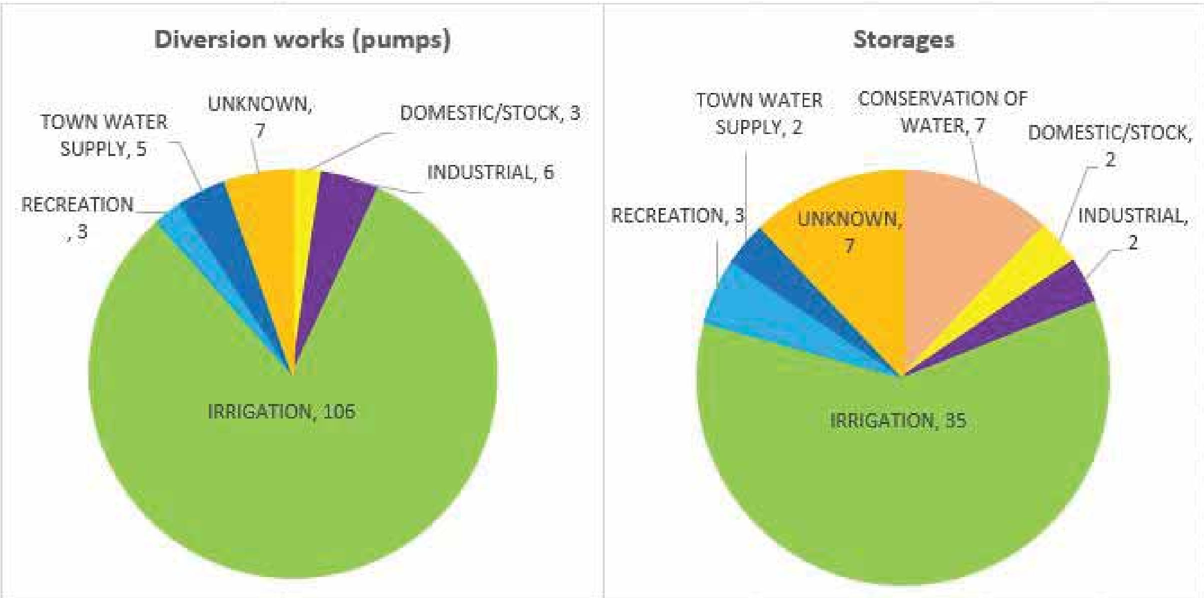


Figure 4.2 Surface water diversion works and storages in the study area by purpose (LPI 2016

4.2.2.2 WATER ACCESS LICENCES

Figure 4.1 shows the location of pumps and dams with associated WALs in the Medway Rivulet, Lower Wingecarribee River, Lower Wollondilly and Bundanoon Creek Management Zones. A breakdown of the WAL volumes by water source and management zone is presented in Table 4.2.

Table 4.2 Numbers of diversion works and storages in the water management zones

WATER SOURCE AND MANAGEMENT ZONE	NUMBER OF DIVERSION WORKS (PUMPS)	NUMBER OF STORAGES	TOTAL VOLUME ML/A
SHOALHAVEN WATER SOURCE			
Bundanoon Creek Management Zone	5	4	1,007
UPPER NEPEAN AND WARRAGAMBA WATER SOURCE			
Lower Wingecarribee River Management Zone	29	12	1,072
Lower Wollondilly River Management Zone	86	32	4,138
Medway Rivulet Management Zone	13	7	1,027

4.2.2.3 BASIC WATER RIGHTS

Basic water rights for landholders in the study area include:

- Domestic and stock rights - Owners or occupiers of land which has stream frontage can take water without a licence. Water taken under a domestic and stock right may be used for normal household purposes and garden and/or for drinking water for stock.
- Native title rights - Anyone who holds native title with respect to water, as determined under the *Commonwealth Native Title Act 1993*, can take and use water for a range of personal, domestic and non-commercial purposes.
- Harvestable rights – Landholders are allowed to build dams on minor streams that capture 10% of the average regional rainfall-runoff on their property without a licence to take water. The MHRDC is the total dam capacity allowed under the harvestable right for a property and takes into account rainfall and variations in rainfall pattern.

The *Greater Metropolitan Region Unregulated Water Sources Water Sharing Plan 2011*, estimates the water requirements of persons entitled to domestic and stock rights to be:

- 13.6 ML/day in the Shoalhaven River Water Source
- 21 ML/day in the Upper Nepean and Warragamba Water Source.

There are no native title rights with respect to water in the study area.

4.2.3 Instream and riparian ecosystems

Ecosystems in the project area with potential to be impacted by changes in surface water quality include:

- Instream ecosystems; and
- Riparian ecosystems exposed to overbank flows and flooding.

Details of these ecosystems are provided in the *Hume Coal Project Biodiversity Assessment Report* (EMM 2016b).

5 IMPACT ASSESSMENT

5.1 Project activities with potential to impact on surface water quality

5.1.1 Construction and rehabilitation

Project activities with the potential to impact on water quality during construction and rehabilitation are listed in Table 5.1. The table provides the catchment where the activity will be located, the potential contaminants, the potential pathway for contamination of local streams and the likelihood of impact.

The construction and rehabilitation phases of the project will involve:

- earthworks activities, which have the potential to cause erosion and sedimentation of local waterways;
- use of vehicles and heavy machinery, storage of fuels, oils and lubricants and equipment maintenance, which have the potential to cause hydrocarbon contamination of local waterways; and
- a construction camp, which has the potential to contaminate local waterways with general waste and sewage.

The construction and rehabilitation phases of the project will be short term in duration and the potential impacts to surface water quality can be suitably managed through the preparation and implementation of site environmental management plans. Details of the environmental management plans to be prepared and implemented for the project are provided in Section 6.1.

Table 5.1 Construction and rehabilitation activities with potential to impact on water quality

PROJECT ACTIVITY WITH POTENTIAL TO IMPACT ON WATER QUALITY	CATCHMENT	POTENTIAL CONTAMINANTS	POTENTIAL CONTAMINATION PATHWAY	LIKELIHOOD OF IMPACT
Construction				
Earthworks/grading Construction of infrastructure Excavation of drifts and stockpiling of materials	Medway Rivulet and Oldbury Creek	TSS, hydrocarbons	Runoff from working areas and areas where spills have occurred to local waterways	Unlikely - short term potential impact that can be suitably managed
Construction camp	Medway Rivulet	TN, TP, Pathogens, BOD	Runoff and discharge of sewage from camp.	Unlikely - general waste will be managed to prevent contamination of waterways; grey water (eg from sinks and showers) will be subject to primary treatment and reused for drip irrigation of landscaped areas and black water (raw sewage will be subject to tertiary treatment and reused in site operations
Rehabilitation				
Decommissioning of mine infrastructure Earthworks/grading and revegetation	Medway Rivulet and Oldbury Creek	TSS, TN, TP, hydrocarbons	Runoff from working areas and areas where spills have occurred to local waterways	Unlikely - short term potential impact that can be suitably managed

5.1.2 Operation

Project activities with the potential to impact on water quality during operation are described in the following sections. Section 5.1.2.1 discusses potential impacts associated with project activities located within the mine water management system, which will be implemented during operation of the project to prevent contamination of local waterways. Section 5.1.2.2 discusses potential impacts associated with project activities located outside the mine water management system.

5.1.2.1 PROJECT ACTIVITIES WITHIN THE MINE WATER MANAGEMENT SYSTEM

Surface water runoff from areas of the site in direct contact with coal will be fully contained within the mine water management system to prevent discharge of this water to local waterways.

The water management system for the project is detailed in the *Water Balance Assessment Report* (Parsons Brinckerhoff 2016b). The water management philosophy adopted for the project can be summarised as follows:

- → Runoff from undisturbed areas will be diverted around or away from the infrastructure into natural watercourses via clean water diversion drains as much as practical.
- → Runoff from disturbed areas within the mine infrastructure footprint will be directed to the SBs, MWDs and the PWD for storage and reuse.
  - Runoff from areas where there is a low risk of coal contact (i.e. runoff from areas that do not contain coal stockpiles or processing plant but that could contain small amounts of coal due to mine vehicle traffic) may be discharged to local creeks after the first flush provided water quality is acceptable. Details of the adopted first flush criteria are provided in Section 5.2.2.
  - Runoff from areas where there is a low risk of coal contact that does not meet the adopted first flush criteria will be transferred to the PWD for storage.
- → Sewage from the administration and workshop area will be treated and reused on site. Grey water will be subject to primary treatment and used for drip irrigation of landscaped areas. Black water will be subject to tertiary treatment and harvested for reuse in the CPP.

Table 5.2 summarises the dams that comprise the mine water management system and the site infrastructure within the dam catchments. The table indicates that SB03 and SB04 capture runoff with a low risk of coal contact. Runoff from these dams may be discharged to Oldbury Creek after the first flush provided water quality is acceptable (to be confirmed by in-line testing of TDS and pH – refer to Section 6.4 for further discussion). MUSIC modelling has been undertaken to assess the potential impacts of discharge from SB03 and SB04 on surface water quality in Oldbury Creek and assess compliance with the NorBE criteria. The methodology and results are presented in Section 5.2.1.

The table also indicates that water from the PWD may be treated in a WTP before a controlled release of water is made to Oldbury Creek. The WTP is a provision included in the project infrastructure to account for the unlikely event of surplus water in the PWD requiring treatment and release to Oldbury Creek. The PWD has been sized to meet the project demand requirements with the capacity to store all surplus water generated by surface and underground activities without the need to release excess water to the local creeks. Runoff after the first flush from SB03 and SB04 will be released to Oldbury Creek provided water quality targets are met. In the unlikely event that this runoff cannot be released from SB03 and SB04, the PWD has the capacity to store the total runoff volume from SB03 and SB04 also, if required. The mine water balance model (refer to the *Water Balance Assessment Report,* Parsons Brinckerhoff 2016b) demonstrates that the PWD has adequate capacity to contain all surplus water and treatment and release of water from the PWD is not required for all climate sequences. The scenario of treating and releasing water from the PWD is therefore not assessed in this report.

Table 5.2 Project activities within the mine water management system

DAM / STORAGE	SITE INFRASTRUCTURE	CATCHMENT	WATER IN DIRECT CONTACT WITH COAL	POTENTIAL DISCHARGE TO LOCAL STREAMS
SB01	Product stockpiles	Oldbury Creek	Yes	No
SB02	CPP, ROM and TLO	Oldbury Creek	Yes	No
Train Load Out (TLO) sump	TLO facility	Oldbury Creek	Yes	No (pumped to SB02)
SB03	Administration and workshop area*	Medway Rivulet	No (low risk of coal contact due to mine vehicle traffic)	Yes, following pumping of first flush to PWD
SB04	Mine road and conveyor embankment	Medway Rivulet	No (low risk of coal contact due to mine vehicle traffic)	Yes, following pumping of first flush to PWD
MWD05	Overland conveyor	Medway Rivulet	Yes	No
MWD06	Conveyor portal	Medway Rivulet	Yes	No
MWD07	Ventilation shaft	Medway Rivulet	Yes	No
MWD08	Stores water to be treated and released to Oldbury Creek, if required**	Oldbury Creek	Yes	No, as demonstrated by mine water balance model**
PWD	Dam storing water pumped from MWDs and underground mine sump dewatering	Oldbury Creek	Yes	No, as demonstrated by mine water balance model**

* Administration and workshop area includes administration, bathhouse, washdown and workshop facilities, fuel and lubrication storage, warehouses, laydown areas, and other facilities.

** The mine water balance model has demonstrated that the PWD has adequate capacity to store all water surpluses generated throughout the mining operation for all climate sequences without requiring releases to local streams.

5.1.2.2 PROJECT ACTIVITIES OUTSIDE THE MINE WATER MANAGEMENT SYSTEM

Project activities outside the water management system with the potential to impact on water quality during operation are listed in Table 5.3. The table provides the catchment where the activity will be located, the potential contaminants, the potential pathway for contamination of local streams and the likelihood of impact.

Project activities outside the mine water management system include:

- vehicle and heavy machinery movements on access roads;
- operation of the WTP, if required (see previous section);
- ongoing resource definition activities, along with geotechnical and engineering testing and fieldwork to facilitate detailed design; and
- depressurisation of groundwater systems during underground mining resulting in a reduction in baseflow to streams.

Potential impacts to surface water quality associated with the first three activities above can be suitably managed through the preparation and implementation of site-specific environmental management plans.

Details of the environmental management plans to be prepared and implemented for the project are provided in Section 6.1.

Road vehicles exiting working areas of the site via the main mine access road will use the drive through wheel wash which will be located at the administration and workshop area. This will prevent coal dust from contaminating surfaces outside the mine water management system. MUSIC modelling has also been undertaken to assess the potential impacts of the access roads on surface water quality in the receiving environment and assess compliance with the NorBE criteria. The methodology and results are presented in Section 5.2.3.

A reduction in groundwater baseflow to streams will result in reduced loadings for all parameters. However, this may also result in an increase in concentrations of some contaminants in streams due to reduced streamflow. A qualitative assessment of potential water quality impacts associated with intercepted baseflow is presented in Section 5.2.4.

Table 5.3 Project activities outside mine water management system

PROJECT ACTIVITY WITH POTENTIAL TO IMPACT ON WATER QUALITY	CATCHMENT	POTENTIAL CONTAMINANTS	POTENTIAL CONTAMINATION PATHWAY	LIKELIHOOD OF IMPACT
Main access road	On ridge line between Medway Rivulet and Oldbury Creek catchments	TSS, hydrocarbons	Runoff to local waterways	Possible – assessed in Section 5.2.3
Access roads over Medway Rivulet and personnel and materials drift access	Medway Rivulet	TSS, hydrocarbons	Runoff to local waterways	Possible – assessed in Section 5.2.
Coal conveyors over Medway Rivulet and Oldbury Creek and conveyor drift access	Medway Rivulet and Oldbury Creek	Salinity, TSS, acidity, metals	Runoff to local waterways	None - the conveyor will be fully contained to prevent loss of coal from the system
Topsoil stockpiles	Medway Rivulet	TSS, TN, TP	Runoff to local waterways	None - the topsoil stockpiles will comprise clean fill. The stockpiles will be stabilised with vegetation to avoid impacts to waterways and their construction will be subject to an erosion and sediment control plan
Water treatment plant including storages, pipelines, pumps and associated infrastructure	Oldbury Creek	Chemicals used for treatment By-products of treatment Hydrocarbons	Spills / runoff to local waterways	None - chemicals for water treatment and by-products of water treatment will be managed and contained to prevent contamination of waterways. Note also that the mine water balance model has demonstrated that the WTP is not required to treat and release surplus water for all climate sequences
Intercepted baseflow due to depressurisation for underground mining	Medway Rivulet, Oldbury Creek, Black Bobs Creek, Lower Wollondilly River, Lower Wingecarribee River	Metals	A reduction in water discharged from groundwater systems to surface water systems in the project area has the potential to alter the quality of water in surface water systems	Possible – assessed in Section 5.2.4

PROJECT ACTIVITY WITH POTENTIAL TO IMPACT ON WATER QUALITY	CATCHMENT	POTENTIAL CONTAMINANTS	POTENTIAL CONTAMINATION PATHWAY	LIKELIHOOD OF IMPACT
Ongoing resource definition activities, along with geotechnical and engineering testing and fieldwork to facilitate detailed design	Medway Rivulet, Oldbury Creek, Black Bobs Creek, Lower Wollondilly River	TSS, hydrocarbons	Runoff from working areas to local waterways	Unlikely - short term potential impact that can be suitably managed

Note: The access road over Oldbury Creek is existing and has not been assessed

5.2 Impact assessment

5.2.1 Assessment criteria

To assess whether the project and its associated treatment measures will have a NorBE on water quality, existing conditions (pre-development) and operational phase (post-development) pollutant loads and concentrations predicted by the MUSIC model have been assessed against the following criteria outlined in the SCA standards (2012):

- The mean annual pollutant loads for the post-development case (including mitigation measures) must be 10% less than the pre-development case for TSS, TP and TN. For gross pollutants, the post-development load only needs to be equal to or less than pre-development load.
- Pollutant concentrations for TP and TN for the post-development case (including mitigation measures) must be equal to or better compared to the pre-development case for between the 50th and 98th percentiles over the five-year modelling period when runoff occurs. Periods of zero flow are not accounted for in the statistical analysis as there is no downstream water quality impact. To demonstrate this, comparative cumulative frequency graphs, which use the Flow-Based Sub-Sample Threshold for both the pre- and post-development cases, must be provided. As meeting the pollutant percentile concentrations for TP generally also meets the requirements for TSS, cumulative frequency analysis is not required for TSS. Cumulative frequency is also not applied to gross pollutants.

A third criterion is provided in the WaterNSW standards (2012); however, only applies to developments where the catchment is more than 70% impervious, which is not the case for the sub-catchments assessed for this project. The criteria above are conservative to account for uncertainty in MUSIC predictions.

5.2.2 Releases from stormwater basins to Oldbury Creek

SB03 and SB04 drain relatively clean catchments, ie no proposed coal stockpiling areas or direct contact between runoff and coal will occur within their catchments. However, there is a low risk of some minor coal contact to occur in these catchments from mine vehicle traffic. For this reason, water will only be discharged from SB03 and SB04 to Oldbury Creek after the first flush to these dams is pumped to the PWD and water quality discharge limit criteria are satisfied.

The first flush refers to the initial surface runoff of a rainstorm. Usually the stormwater that initially runs off an area will be more polluted than the stormwater that runs off later. This is because pollutants deposited onto exposed areas during dry periods are dislodged and entrained by the initial stages of the rainfall-runoff process.

The existence of this first flush of pollutants provides an opportunity for controlling stormwater pollution (EPA 2016). The first flush collected in SB03 and SB04 will be pumped to the PWD and contained within the mine water management system to prevent pollution of local streams. Only once the first flush collected in SB03 and SB04 has been pumped to the PWD will water be released to Oldbury Creek. The following first flush criteria were developed for the project based on the NSW EPA guideline provided at http://www.epa.nsw.gov.au/mao/stormwater.htm:

- The first flush is assumed to have occurred once the daily rainfall exceeds 20 mm. On such days, runoff could be released from SB03 and SB04 to Oldbury Creek. This criterion assumes that the water quality is acceptable for release.
- From the day of occurrence of the first flush, subsequent daily rainfall amounts less than 20 mm for the next four days are assumed to produce clean runoff and releases are allowed to continue to Oldbury Creek.
- If daily rainfall depth remains less than 10 mm after the fifth day, no runoff is released to Oldbury Creek until the next first flush event.

MUSIC modelling has been undertaken to assess the potential impacts of discharge from SB03 and SB04 on TSS and nutrient loads and concentrations in Oldbury Creek and assess compliance with the NorBE criteria. MUSIC modelling has also been undertaken to calculate the maximum concentrations of other contaminants in SB03 and SB04 to achieve the NorBE criteria for mean annual pollutant loads. The methodology and results for these assessments are presented below.

5.2.2.1 ASSESSMENT OF TSS AND NUTRIENTS

This section describes the MUSIC modelling undertaken to assess the releases from SB03 and SB04 against the NorBE criteria. The MUSIC modelling was undertaken in accordance with the WaterNSW standards (2012).

MUSIC MODEL SET UP

MUSIC model nodes were set up for SB03 and SB04 which will discharge to Oldbury Creek and SB01, SB02, PWD and MWD08 which are sub-catchments of Oldbury Creek that will be removed from its catchment during mining operation (refer to Figure 5.1 for the catchment areas). Each model node was set up to represent the following:

- The existing conditions within the catchments: the catchments were assumed to be fully pervious with the land use assumed to be ‘agricultural’.
- The proposed conditions within the catchments of SB03 and SB04 under operation: in this case the catchments are a mix of pervious and impervious areas identified below in Table 5.4 (refer to the *Water Balance Assessment Report*, Parsons Brinckerhoff 2016b). For these conditions the land use was assumed to be ‘industrial’. For the operational phase, the sub-catchments of SB01, SB02, PWD and MWD08 will not contribute any runoff to Oldbury Creek, and therefore these nodes are not included in the proposed conditions model.

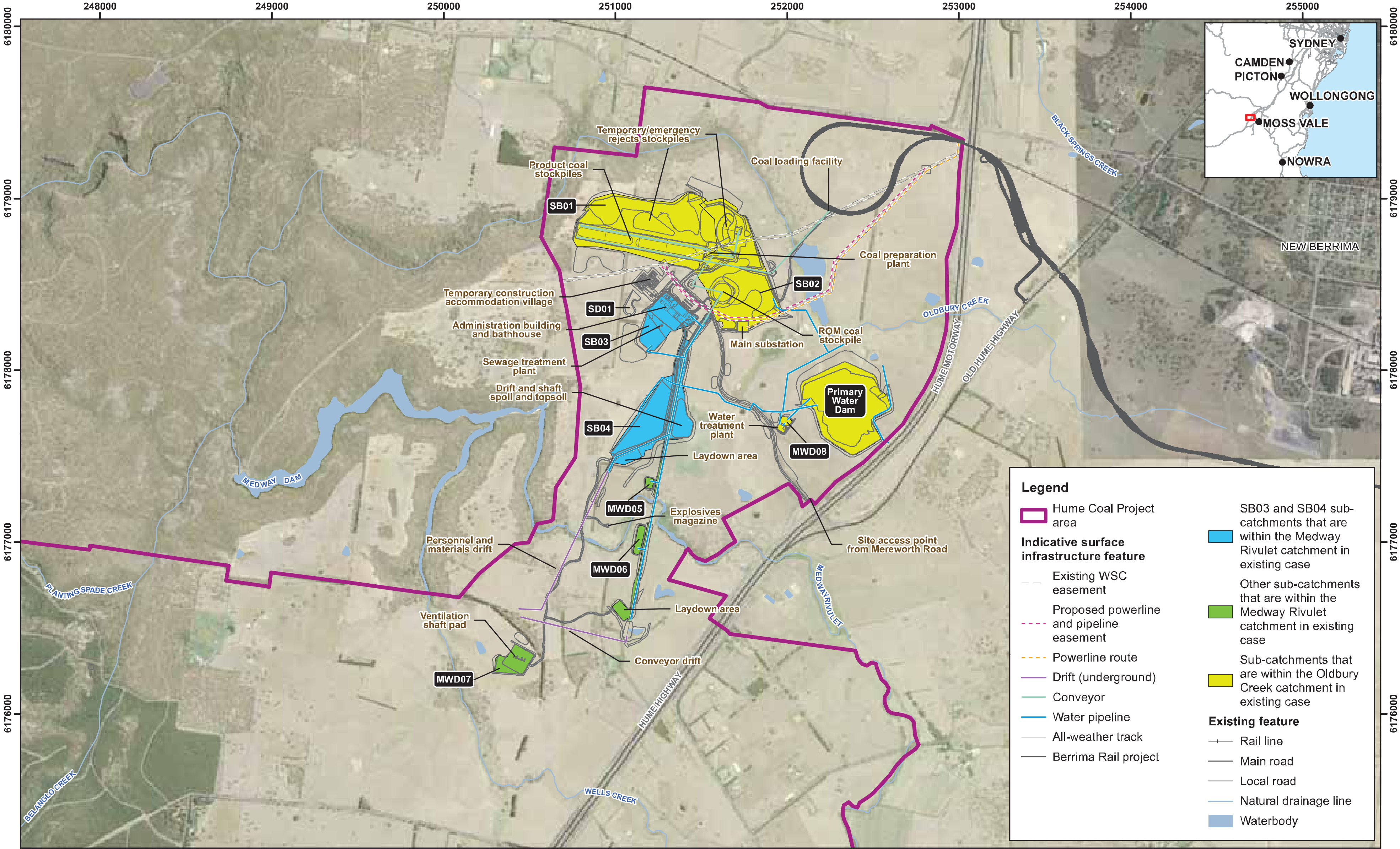
Table 5.4 Operational land use within SB03 and SB04 catchments

LAND USE	SB03 AREA (ha)	SB04 AREA (ha)
Impervious	0.71	0.00
Undisturbed	2.56	8.29
Active spoil area*	0.00	1.89
Hardstand or unsealed road	2.64	4.55
Total area	5.91	14.73
Total impervious	**57%**	**44%**
Total pervious	**43%**	**56%**
**Note: The Geochemistry Report (RGS 2016) identifies a low risk of acid mine drainage from the active spoil areas*		

Climate data

The WaterNSW standard (2012) provides meteorological templates that include the rainfall and potential evapotranspiration data for various catchment areas and which form the basis for the hydrologic calculations in MUSIC.

The appropriate climate zone for the meteorological template file was identified as zone 3 using the WaterNSW website (http://www.waternsw.com.au/water-quality/catchment/development/) (Figure 5.2). The template files were downloaded from the WaterNSW website. The rainfall files were at a 6 minute time step over a period of 5 years from 1997 to 2001. This period includes a range of wet and dry years to ensure conditions simulated are realistic and representative of a range of rainfall patterns. A plot of the zone 3 monthly rainfall is provided in Figure 5.3.



Map: 2200540A_GIS_068_A4 | Author: RP

Date: 14/11/2016 | Approved by: LR

Data source: © Land and Property Information 2015, Hume Coal

Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A3

Hume Coal Surface Water Quality Assessment

Figure 5.1

Catchment areas used for MUSIC modelling of SB03 and SB04 discharges

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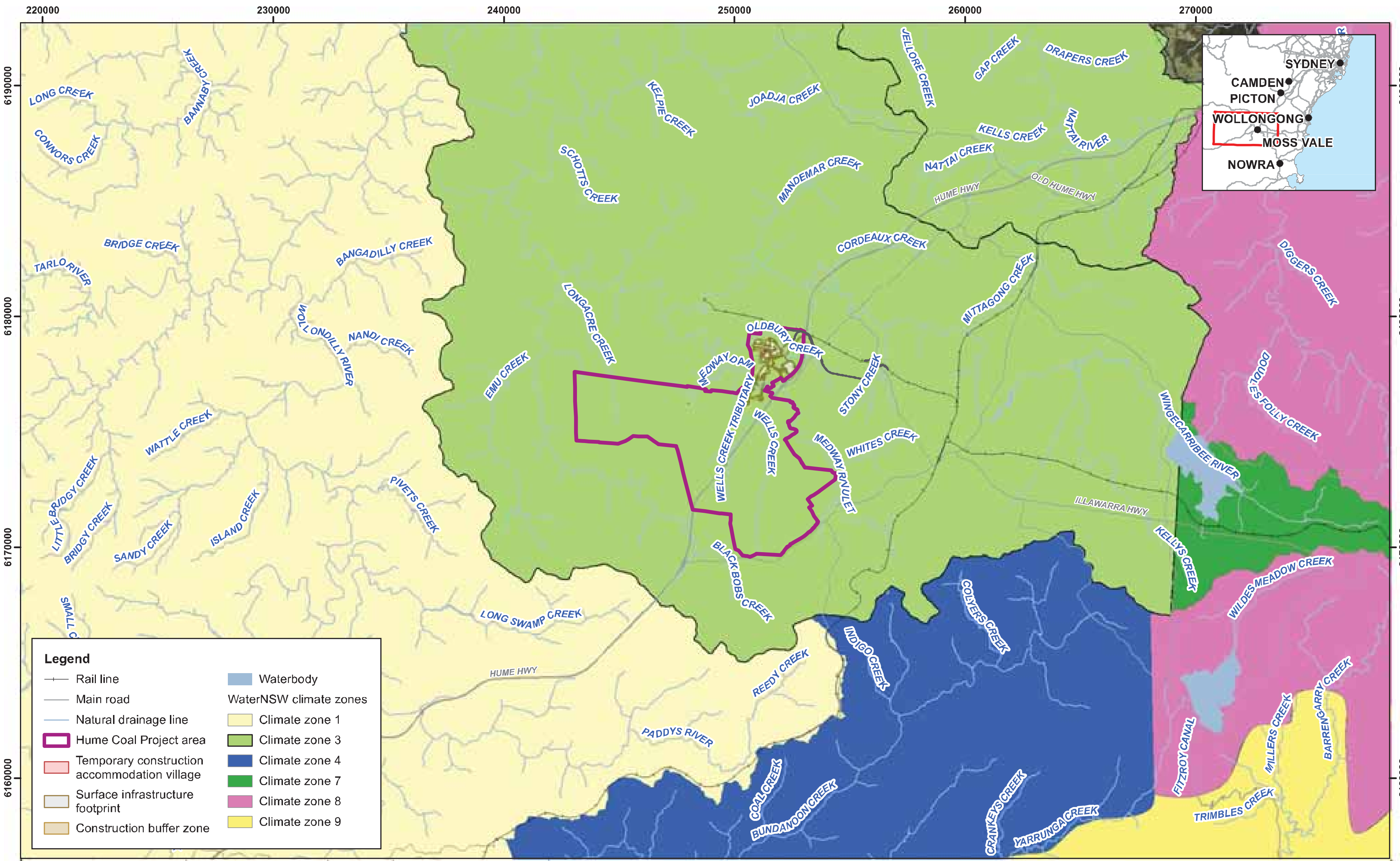

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Date: 21/10/2016 | Approved by: LR

Data source: NSW Property and Information 2015, Hume Coal

0 2,500 5,000 m
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Hume Coal Surface Water Quality Assessment
Figure 5.2
WaterNSW climate zones

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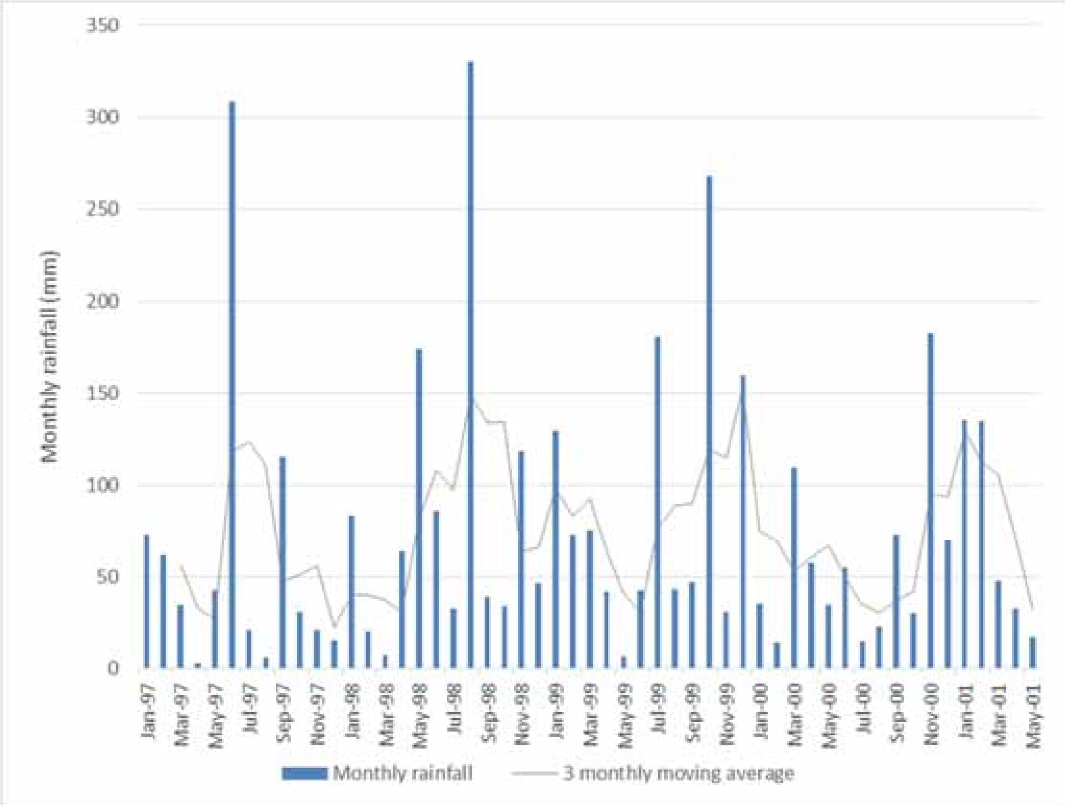


Figure 5.3 Daily rainfall for zone 3 (1997 to 2001) used in MUSIC modelling

Discharge volumes

The meteorological data for the 5 year period was converted from a 6 minute time step to a daily time step and input to the mine water balance model developed in the GoldSim software (refer to the *Water Balance Assessment Report*, Parsons Brinckerhoff 2016b). The GoldSim model was used to generate outflow time series for the SB01, SB02, PWD and MWD08 catchments in their existing states, and for SB03 and SB04 in their operational states. For the operational phase, the model simulated pumping of the first flush to the PWD as per the design criteria for these dams so that the outflow time series generated for the operational phase represented the volumes that would be released to Oldbury Creek after the first flush has been captured and pumped to the PWD.

Inflow data

MUSIC inflows are required to be separated into baseflow, pervious flow and impervious flow. The GoldSim natural catchment output was input into MUSIC as pervious flow. No baseflow or impervious flow was assumed for existing.

For operation the inflow was a mix of impervious and pervious flow as identified for the catchment areas given in Table 5.4, with no baseflow assumed.

MODELLED SCENARIOS

The existing conditions scenario was set up for the SB01, SB02, PWD, MWD08, SB03 and SB04 catchments using the ‘agricultural’ MUSIC source node. The stormwater pollutant parameters used for agricultural land use are given in Table 5.5 and are in accordance with the WaterNSW standards (2012). The operational phase scenario was set up for the SB03 and SB04 catchments using the ‘industrial’ MUSIC source node. The stormwater pollutant parameters used for industrial land use are given in Table 5.5 and are in accordance with the WaterNSW standards (2012).

Table 5.5 Source node mean pollutant inputs into MUSIC for SB03 and SB04 assessment

LAND USE	TSS		TP		TN	
	Mean log (mg/L)	SD log (mg/L)	Mean log (mg/L)	SD log (mg/L)	Mean log (mg/L)	SD log (mg/L)
Storm flow						
Agricultural	2.15	0.31	-0.22	0.3	0.48	0.26
Industrial	2.15	0.32	-0.60	0.25	0.3	0.19

SD Standard deviation

RESULTS

Comparison of mean annual pollutant loads

Table 5.6 provides a summary of existing and operational scenario mean annual pollutant loads for TSS, TP and TN. The results show that mean annual pollutant loads for these parameters are reduced by significantly more than 10%, and therefore meet this NorBE criterion. This is achieved due to the significant reduction in agricultural catchment draining to Oldbury Creek during operation.

Table 5.6 Mean annual pollutant loads in Oldbury Creek due to runoff from SB01, SB02, PWD, MWD08, SB03 and SB04 catchments

PARAMETER	MEAN ANNUAL LOAD		
	EXISTING (FROM SB01, SB02, MWD08 AND PWD)	OPERATION (FROM SB03 AND SB04)	% REDUCTION
TSS (kg/yr)	25,500	4,130	-84%
TP (kg/yr)	125	8	-93%
TN (kg/yr)	483	61	-87%
Flow (ML/yr)	149	20	-86%

Comparison of pollutant concentrations between the 50th and 98th percentiles

Cumulative frequency graphs of TN and TP concentrations in runoff to Oldbury Creek from SB01, SB02, PWD, MWD08, SB03 and SB04 for the existing and operational scenarios are provided in Figures 5.4 and 5.5. The figures demonstrate that pollutant concentrations for the operational scenario are equal to or lower than the existing scenario between the 50^{th} and 98^{th} percentiles, and therefore compliance with this NorBE criterion is achieved.

CONCLUSION

Operational phase releases from SB03 and SB04 to Oldbury Creek were simulated in GoldSim and MUSIC and found to meet the NorBE criteria for TSS, TP and TN. These form the limited parameter set for assessment as stipulated by the WaterNSW standards (2012). However, the analysis does not assess the impacts of other contaminants that may be present in the releases from SB03 and SB04, which is considered in the next section.

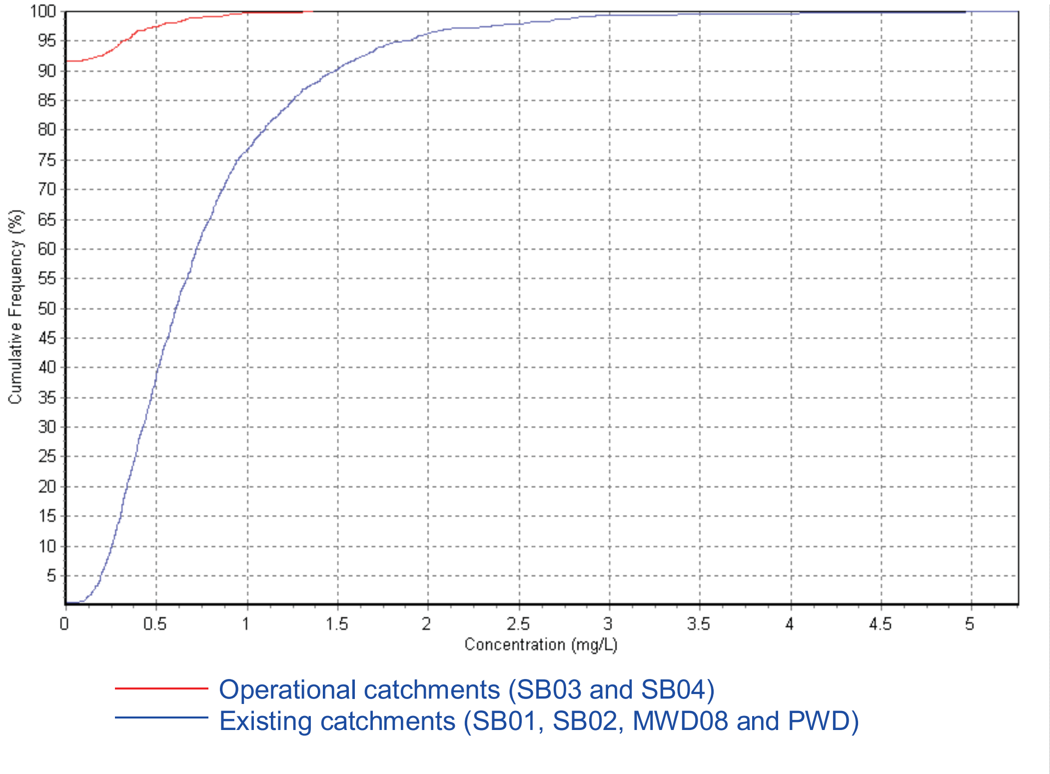


Figure 5.4 Total Phosphorus cumulative frequency graph for SB03 and SB04 discharge assessment

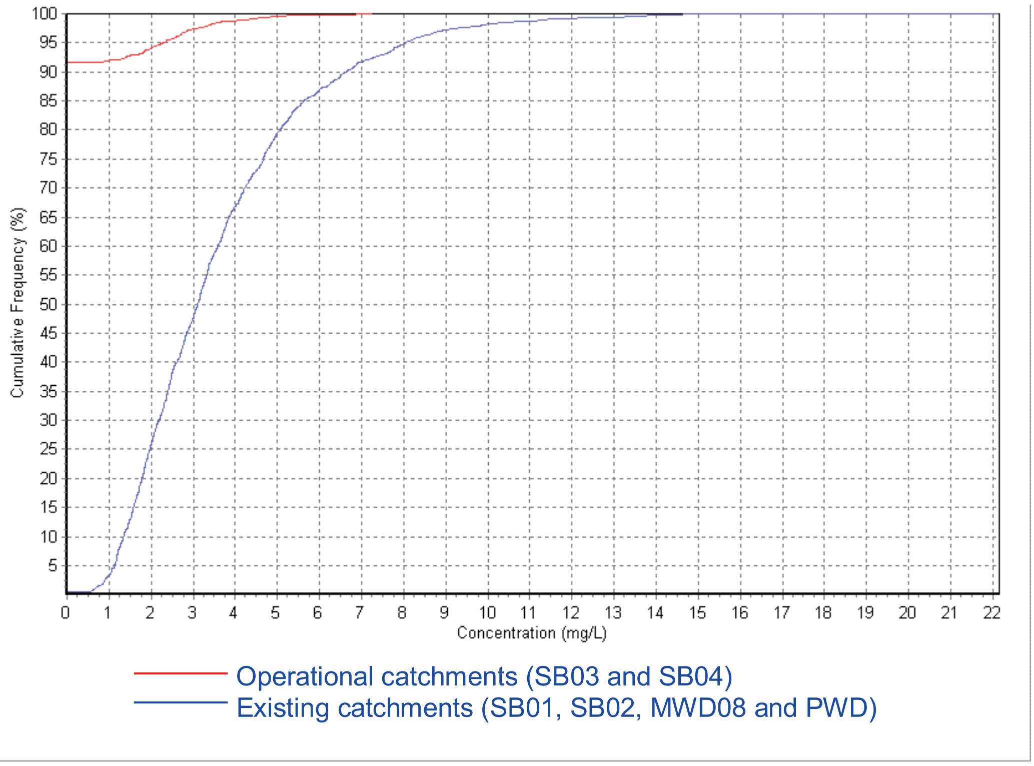


Figure 5.5 Total Nitrogen cumulative frequency graph for SB03 and SB04 discharge assessment

5.2.2.2 OTHER CONTAMINANTS

IDENTIFICATION OF POTENTIAL CONTAMINANTS

Pumping of the first flush from SB03 and SB04 to the PWD is proposed to remove any material containing coal dust or fragments that may be transported into the SB03 and SB04 catchments from mine vehicle traffic. Nevertheless, a conservative approach has been taken for this assessment and potential contaminants in coal dust (in addition to TSS and nutrients) have been considered.

The geochemical assessment of coal and mining waste materials undertaken by RGS (2016) involved leachate testing of coal and coal reject materials. Average leachate concentrations from these tests are presented in Table 5.7.

Comparison of average leachate concentrations with average baseline concentration in Oldbury Creek (at the SW08 monitoring location) indicates that concentrations of some parameters are higher in the coal leachate than in the receiving environment. These parameters have been selected for further assessment and are shown in bold in Table 5.7.

Table 5.7 Comparison of surface water and leachate concentrations

CONTAMINANTS	UNITS	MEAN BASELINE CONCENTRATION (MEDWAY RIVULET)	MEAN LEACHATE CONCENTRATION
Major ions			
Calcium	mg/L	**27**	**31**
Chloride	mg/L	56	43
Magnesium	mg/L	**10**	**11**
Sodium	mg/L	38	3.7
Sulfate as SO4	mg/L	**45**	**126**
Dissolved metals			
Aluminium	mg/L	**0.08**	**0.99**
Antimony	mg/L	<0.001	no value reported
Arsenic	mg/L	**<0.001**	**0.006**
Barium	mg/L	0.04	no value reported
Beryllium	mg/L	<0.001	no value reported
Boron	mg/L	<0.05	<0.05
Cadmium	mg/L	**<0.0001**	**0.005**
Chromium	mg/L	**<0.001**	**0.001**
Cobalt	mg/L	**<0.001**	**0.55**
Copper	mg/L	**0.001**	**0.26**
Iron	mg/L	**0.25**	**5.9**
Lead	mg/L	**<0.001**	**0.11**
Manganese	mg/L	**0.17**	**2.2**
Mercury	mg/L	<0.0001	no value reported

CONTAMINANTS	UNITS	MEAN BASELINE CONCENTRATION (MEDWAY RIVULET)	MEAN LEACHATE CONCENTRATION
Molybdenum	mg/L	**<0.001**	**0.002**
Nickel	mg/L	**<0.001**	**1.2**
Selenium	mg/L	**<0.01**	**0.04**
Silver	mg/L	0.01	no value reported
Zinc	mg/L	**0.01**	**2.8**
Physical parameters			
Electrical Conductivity	µS/cm	476	402
pH	pH units	**7.4**	**3.7**
Total Dissolved Solids	mg/L	291	241

MUSIC MODELLING TO DETERMINE DISCHARGE CONCENTRATION TARGETS

MUSIC modelling was undertaken to assess the mean annual pollutant loads for the 17 contaminants highlighted in bold in Table 5.7 from the SB03 and SB04 catchments under existing conditions. The loads were calculated using the MUSIC model described in the previous section as a mass balance model with the mean concentration for each contaminant specified as the mean baseline concentration measured at SW08.

The MUSIC model was then used to identify the mean concentration of each contaminant that would need to be achieved in the releases under the operational scenario to meet the NorBE criterion of a 10% reduction in the mean annual pollutant load.

The results are provided in Table 5.8, which identifies the target mean concentration in the releases from SB03 and SB04 for each of the 17 contaminants. Contaminants that were below the laboratory limit of detection during the baseline monitoring would also need to remain at or below the laboratory limit of detection in the releases from SB03 and SB04.

Table 5.8 Target mean concentrations for other contaminants in releases from SB03 and SB04

CONTAMINANT	OLDBURY CREEK BASELINE MEAN CONCENTRATION (mg/L)	TARGET MEAN CONCENTRATION IN COMBINED SB03 & SB04 RELEASES (mg/L)	% LOAD REDUCTION FROM EXISTING TO OPERATION
Calcium	27	175	-11%
Magnesium	10	65	-11%
Sulfate as SO4	45	290	-11%
Aluminium	0.08	0.48	-10%
Arsenic	<0.001	0.001	*N/A*
Cadmium	<0.0001	0.0001	*N/A*
Cobalt	<0.001	0.001	*N/A*

CONTAMINANT	OLDBURY CREEK BASELINE MEAN CONCENTRATION (mg/L)	TARGET MEAN CONCENTRATION IN COMBINED SB03 & SB04 RELEASES (mg/L)	% LOAD REDUCTION FROM EXISTING TO OPERATION
Copper	0.001	0.0065	-11%
Iron	0.25	1.6	-13%
Lead	<0.001	0.001	*N/A*
Manganese	0.17	1.1	-11%
Molybdenum	<0.001	0.001	*N/A*
Nickel	<0.001	0.001	*N/A*
Selenium	<0.01	0.01	*N/A*
Zinc	0.01	0.065	-11%

Concentrations of a number of key indicator parameters representing other contaminants will be monitored in the basins as part of the routine monitoring program, to establish that the targets are met in releases. This is discussed in more detail in Section 6.4.

5.2.3 Mine access roads

There are two mine access roads located outside the water management system (see Figure 1.3):

- the main mine access road from Mereworth Road to the administration and workshop area, which follows existing sealed and unsealed roads for most of its length; and
- the access road between the personnel and materials portal, the conveyor portal and the ventilation shaft, which follows existing unsealed tracks.

Vehicles using the roads will not be transporting coal and vehicles exiting the site via the main mine access road will use the drive through wheel wash at the administration and workshop area to prevent coal dust from contaminating surfaces outside the water management system.

MUSIC modelling has been undertaken to assess the potential impacts of the runoff from these roads on surface water quality in the receiving environment and assess compliance with the NorBE criteria.

5.2.3.1 MUSIC MODELLING METHODOLOGY

Existing and operational scenarios were modelled using MUSIC by representing the sub-catchments of the road corridors in their existing conditions as a mix of existing sealed and unsealed roads and agricultural land and proposed conditions as sealed / unsealed roads. The operational phase scenarios included simulation of stormwater quality treatment measures to achieve the NorBE criteria. Modelling has been undertaken in accordance with the WaterNSW standards (2012).

MUSIC MODEL SET UP

Model nodes were established for the two access roads. The main mine access road follows a ridge line between Medway Rivulet and Oldbury Creek, and is a sealed road with a total road corridor area (including embankments) of 5.02ha. The other access road is located within the Medway Rivulet catchment and is an unsealed road with a total area (not including embankments) of 1.32ha. The assessment of the sealed road included the road embankments as it warranted a more detailed assessment and sub-catchment breakdown due to the relatively higher impact of a sealed road on the local catchments. The unsealed road was assessed more simplistically by modelling the impact of the area of the trafficked surface only.

The main mine access road was split into three sub catchments (northern, middle and southern) and represented in the MUSIC model as follows:

- The catchment taken up by the proposed road corridor including cut/fill embankments. Within this catchment there is an existing sealed road and unsealed road. Under existing conditions these areas were represented as 'sealed/unsealed roads'. The remaining land use under existing conditions within the footprint of the proposed road corridor is assumed to be 'agricultural'.
- The catchment taken up by the proposed road corridor in the operational conditions is a mix of 'sealed roads' for the road surface and 'revegetated land' for the cut/fill embankments.

The other access road represented in the MUSIC model as follows:

- The part of the catchment taken up by the proposed road corridor (excluding cut/fill embankments which are assumed to be vegetated) under existing conditions. The land use under existing conditions is assumed to be 'agricultural'.
- The part of the catchment taken up by the proposed road corridor (excluding cut/fill embankments as noted above) in the operational condition. The land use under the operational scenario is 'unsealed roads'.

CLIMATE DATA

The climate data used in the MUSIC model was the zone 3 meteorological template file obtained from the WaterNSW website, as described in Section 5.2.2.

MODELLED SCENARIOS

The existing conditions scenario was set up for each of the sub-catchments using a combination of the 'agricultural' and existing 'sealed/unsealed roads' MUSIC source nodes and assumed to be 100% pervious for agricultural land, 100% impervious for sealed roads, and 50% pervious and 50% impervious for unsealed roads. The operational scenario was set up for each of the sub-catchments using the 'sealed / unsealed roads' and 'revegetated land' MUSIC source nodes and assumed to be 100% impervious for sealed roads, and 50% pervious and 50% impervious for unsealed roads. The stormwater pollutant parameters used for the source nodes are given in Table 5.9 and are in accordance with the WaterNSW standards (2012).

Table 5.9 Source node mean pollutant inputs into MUSIC for mine access roads assessment

LAND USE	TSS		TP		TN	
	MEAN LOG (MG/L)	SD LOG (MG/L)	MEAN LOG (MG/L)	SD LOG (MG/L)	MEAN LOG (MG/L)	SD LOG (MG/L)
Baseflow						
Agricultural	1.3	0.13	-1.05	0.13	0.04	0.13
Unsealed roads	1.2	0.17	-0.85	0.19	0.11	0.12
Sealed roads	1.2	0.17	-0.85	0.19	0.11	0.12
Revegetated Land	1.15	0.17	-1.22	0.19	-0.05	0.12
Storm flow						
Agricultural	2.15	0.31	-0.22	0.3	0.48	0.26
Unsealed roads	3	0.32	-0.3	0.25	0.34	0.19
Sealed roads	2.43	0.32	-0.3	0.25	0.34	0.19
Revegetated Land	1.95	0.32	-0.66	0.25	0.3	0.19

SD Standard deviation

For the operational scenario vegetated swales were included in the MUSIC model to treat the runoff from the sealed and unsealed roads. Vegetated swales are typically trapezoidal open channels that convey and filter stormwater runoff through vegetation to remove coarse sediment (i.e. reduce TSS). The performance of swales is largely dependent on the vegetation height and the gradient and length of the swale. MUSIC has default parameters for these, however, the following parameters were adjusted from the default settings:

→ The exfiltration rate was changed from 0 mm/hr to 2 mm/hr, which is the mid-range value for 'medium clay' recommended by MUSIC. This is a conservatively low value as the soils in the area have sandy clay characteristics which would justify a higher exfiltration rate.

→ The background concentration (C* and C**) for a swale is defaulted to be relatively high. These values were adjusted in accordance with the approach detailed in Fletcher et al (2004) so that a more realistic reduction of pollutant load would be determined – refer to Appendix B for further details.

The adopted parameters for the swales are given below in Table 5.10.

Table 5.10 Adopted swale parameters

SWALE PROPERTIES	ADOPTED VALUES
Length (m)	Varied to meet NorBE criteria
Bed Slope (%)	3
Base width (m)	1
Top Width (m)	5
Depth (m)	0.6
Vegetation Height (m)	0.3
Exfiltration rate (mm/hr)	2
C* C** TN	0.89
C* C** TP	0.096

ASSESSMENT CRITERIA

The assessment criteria for the access roads were as set out in Section 5.2.1, ie:

→ The mean annual pollutant loads for the operational scenario (including mitigation measures) must be 10% less than the existing scenario for TSS, TP and TN.

→ Pollutant concentrations for TP and TN for the operational scenario (including mitigation measures) must be equal to or better compared to the existing scenario for between the 50th and 98th percentiles over the five-year modelling period when runoff occurs.

RESULTS

Comparison of mean annual pollutant loads

Table 5.11 provides a summary of existing and operational scenario mean annual pollutant loads for TSS, TP and TN. The results show that mean annual pollutant loads for these parameters are reduced by more than 10%, and therefore meet this NorBE criterion (note that achieving 10% reduction for TN, the most onerous parameter, results in significantly greater than 10% reductions for TSS and TP when 10%). This is achieved through provision of swales to treat the road runoff. Table 5.12 provides the road corridor lengths and swale lengths required to meet the NorBE criterion for mean annual pollutant load.

Table 5.11 Mean annual pollutant loads from access road catchments

PARAMETER	EXISTING (KG/YR)	OPERATION (KG/YR)	DIFFERENCE TO EXISTING	OPERATION WITH SWALE TREATMENT (KG/YR)	DIFFERENCE TO EXISTING
SEALED ROAD NORTHERN CATCHMENT (3.07 HA)					
TSS	1,250	3,940	215%	410	-67%
TP	3.77	6.79	80%	1.55	-59%
TN	19.7	31.6	60%	17.5	-11%
SEALED ROAD CATCHMENT MIDDLE CATCHMENT (0.99 HA)					
TSS	413	580	40%	176	-57%
TP	1.18	1.06	-10%	0.484	-59%
TN	5.9	31.6	2%	5.2	-10%
SEALED ROAD SOUTHERN CATCHMENT (0.56 HA)					
TSS	357	413	16%	189	-47%
TP	0.846	0.735	-13%	0.442	-48%
TN	4.02	3.73	-7%	3.53	-12%
UNSEALED ROAD CATCHMENT (1.32 HA)					
TSS	276	7,240	2,523%	79.1	-71%
TP	1.19	3.32	179%	0.454	-62%
TN	6.66	14	110%	5.79	-13%

Table 5.12 Required swale lengths for mine access roads to meet NorBE criteria

SUB-CATCHMENT	ROAD CORRIDOR LENGTH (M)	SWALE LENGTH (M)
Sealed road catchment (5.02 ha)	2,540	730
Unsealed road catchment (1.32 ha)	2,000	500

Comparison of pollutant concentrations between the 50th and 98th percentiles

Cumulative frequency graphs of TN and TP concentrations for the access roads for the existing and operational scenarios are provided in Figures 5.6 to 5.13. The figures demonstrate that pollutant concentrations for the operational scenario are equal to or better than the existing scenario between the 50th and 98th percentiles, and therefore compliance with this NorBE criterion is achieved.

CONCLUSION

Runoff from the mine access roads will achieve NorBE assuming treatment swales are provided along the road corridors to receive and treat the road runoff before discharging into the Medway Rivulet catchment at the low points in each road sub-catchment.

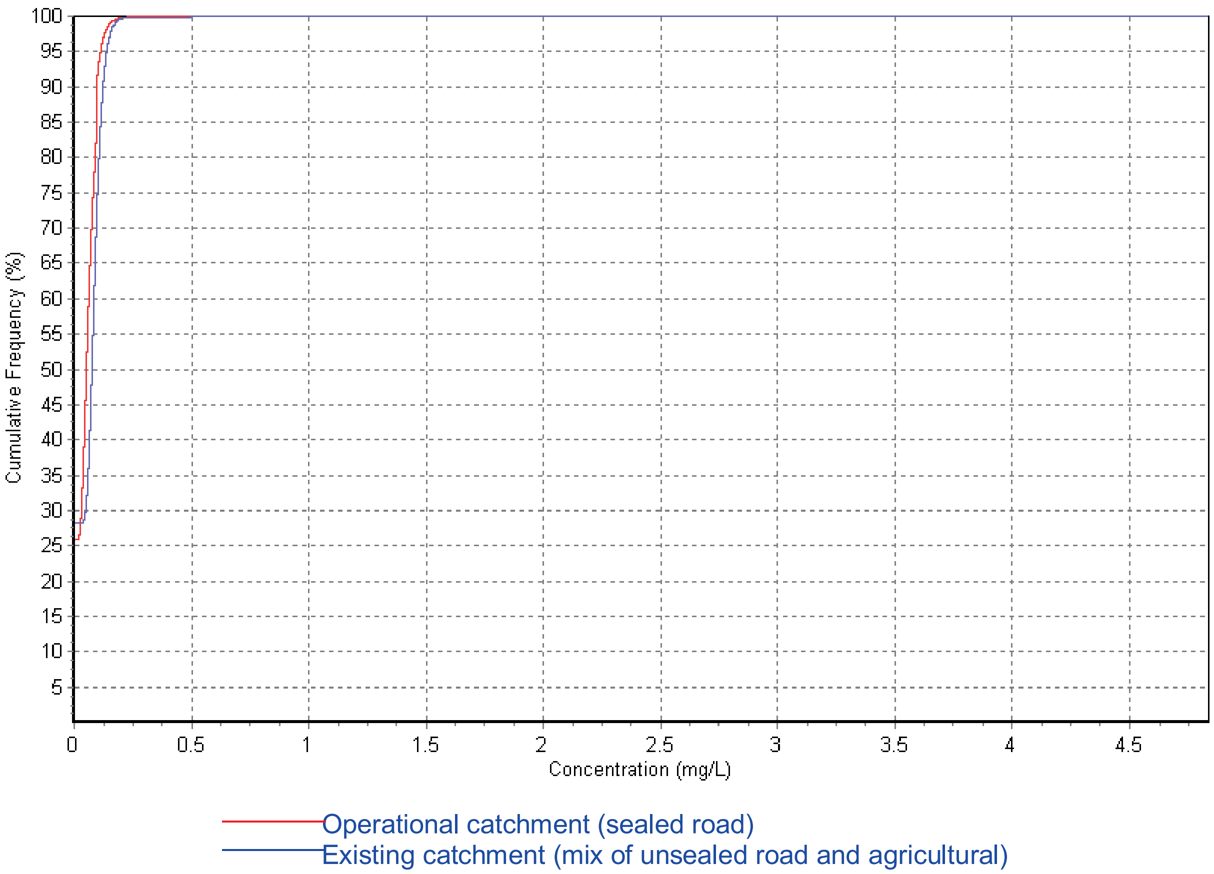


Figure 5.6 Total Phosphorus cumulative frequency graph for sealed road northern catchment

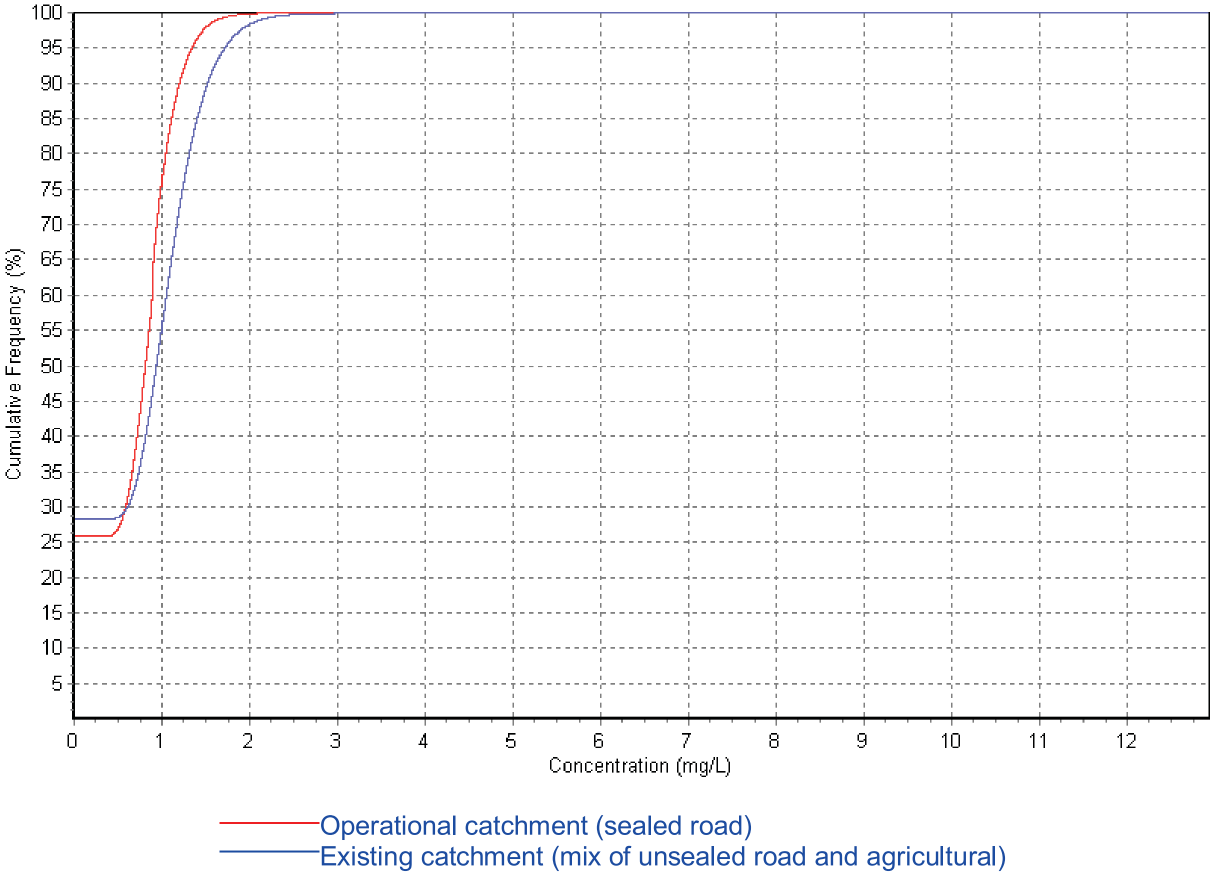


Figure 5.7 Total Nitrogen cumulative frequency graph for sealed road northern catchment

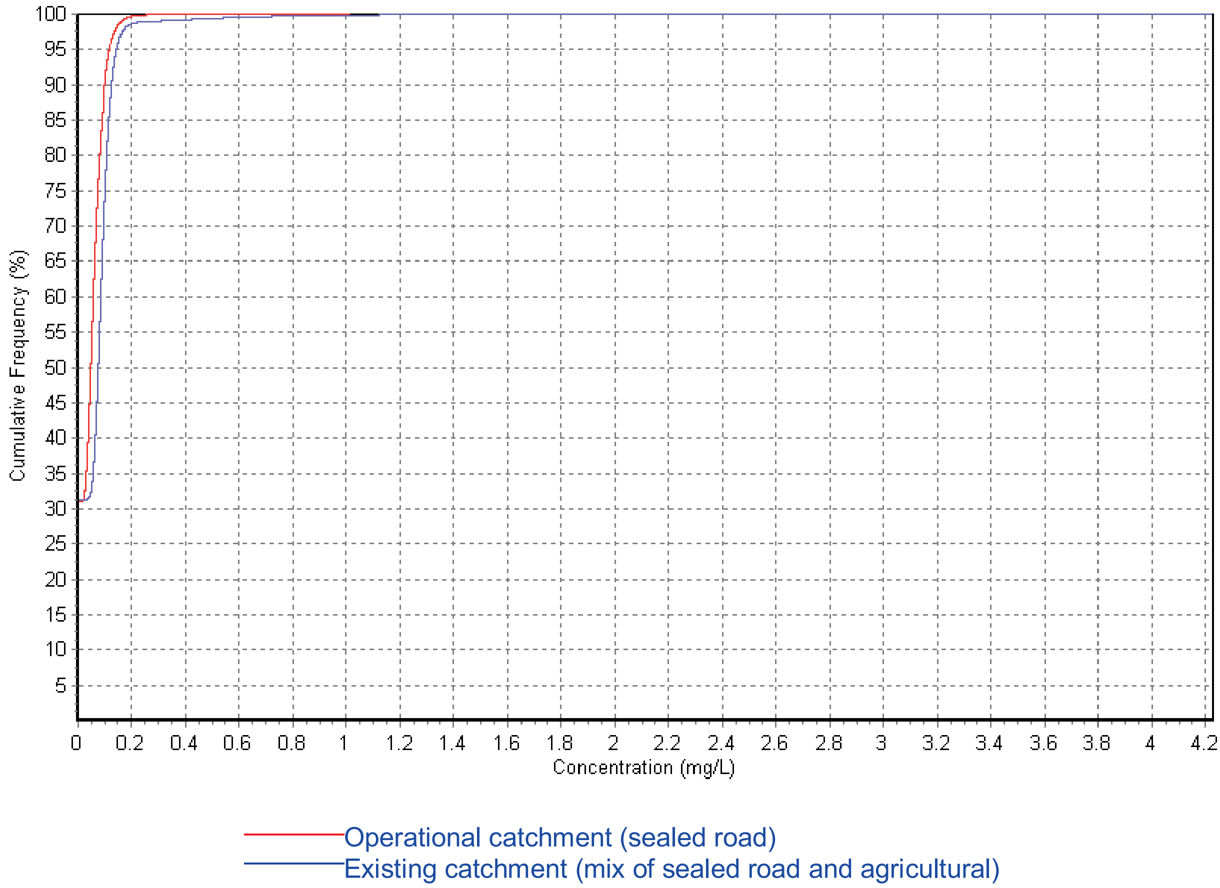


Figure 5.8 Total Phosphorus cumulative frequency graph for sealed road middle catchment

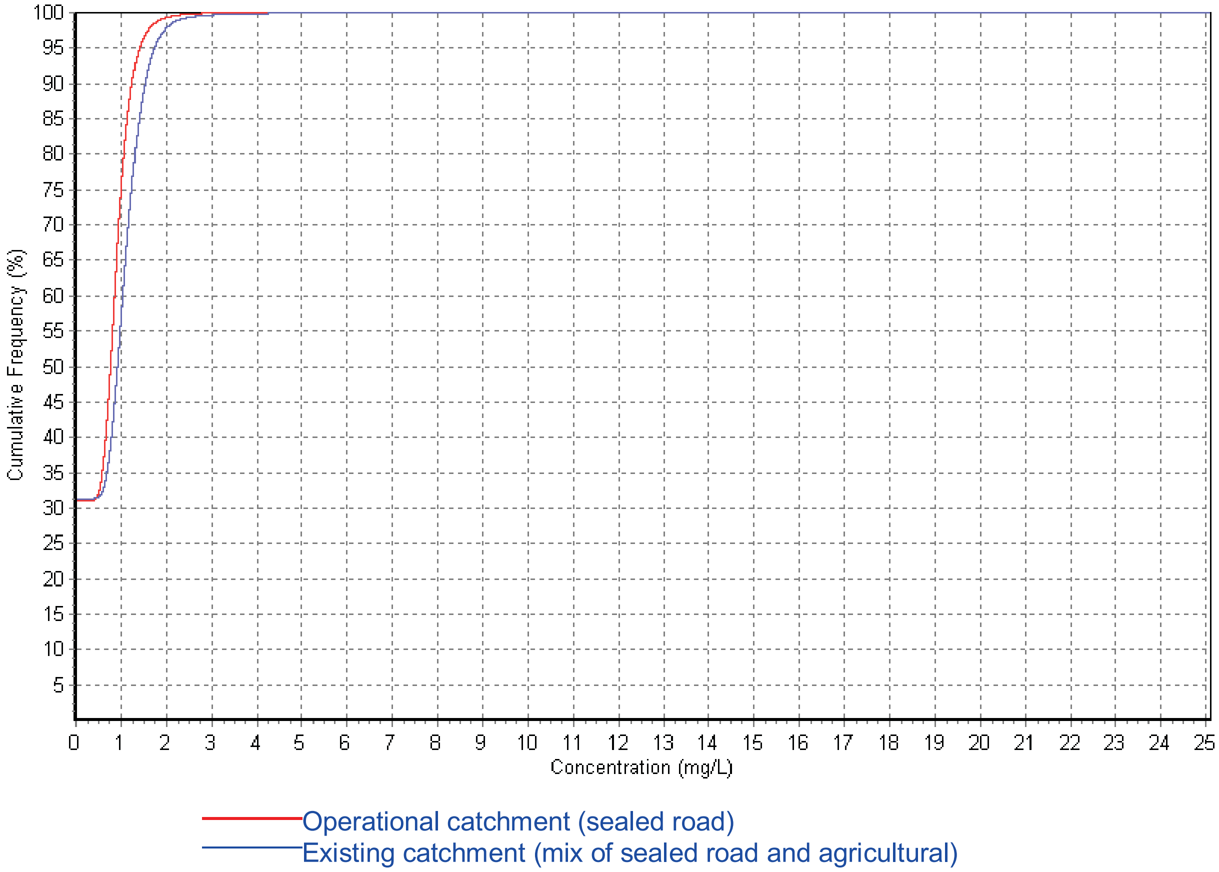


Figure 5.9 Total Nitrogen cumulative frequency graph for sealed road middle catchment

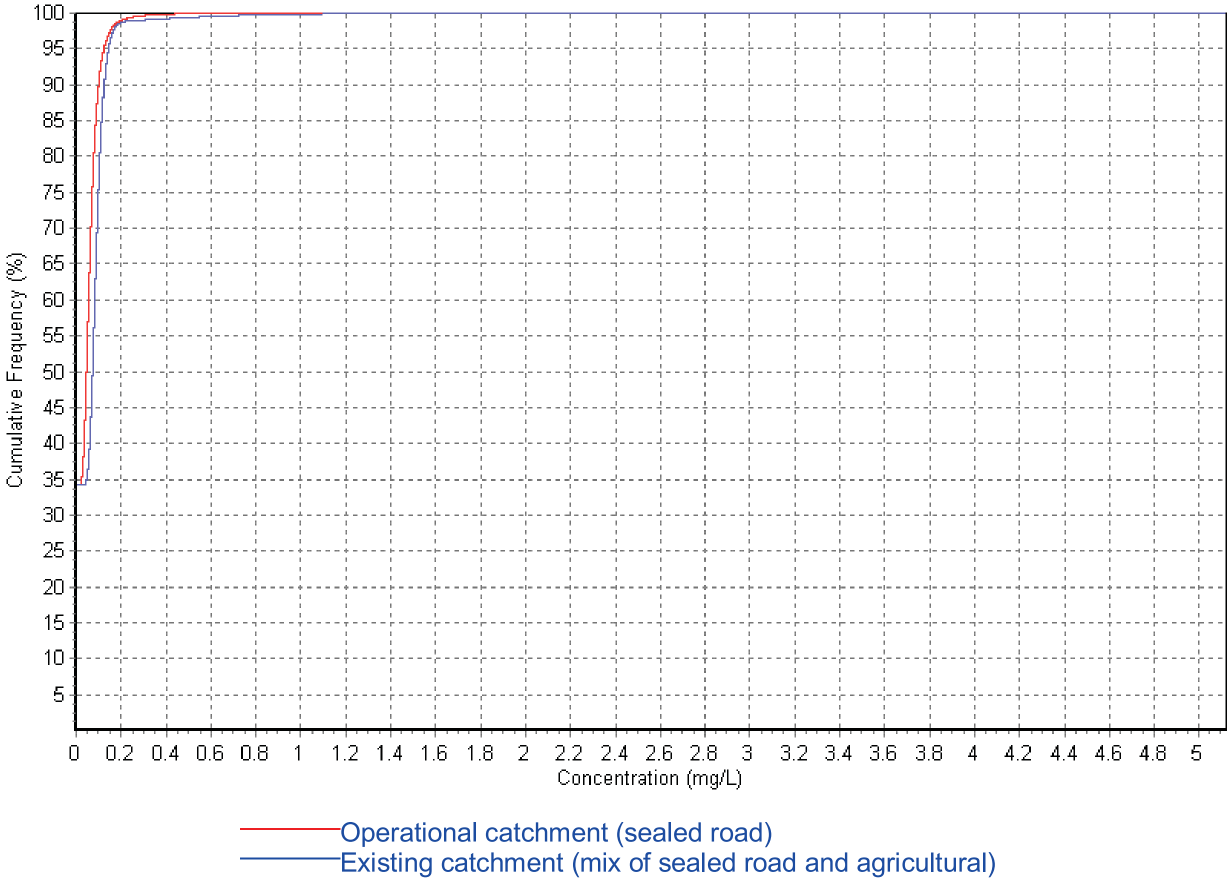


Figure 5.10 Total Phosphorus cumulative frequency graph for sealed road southern catchment

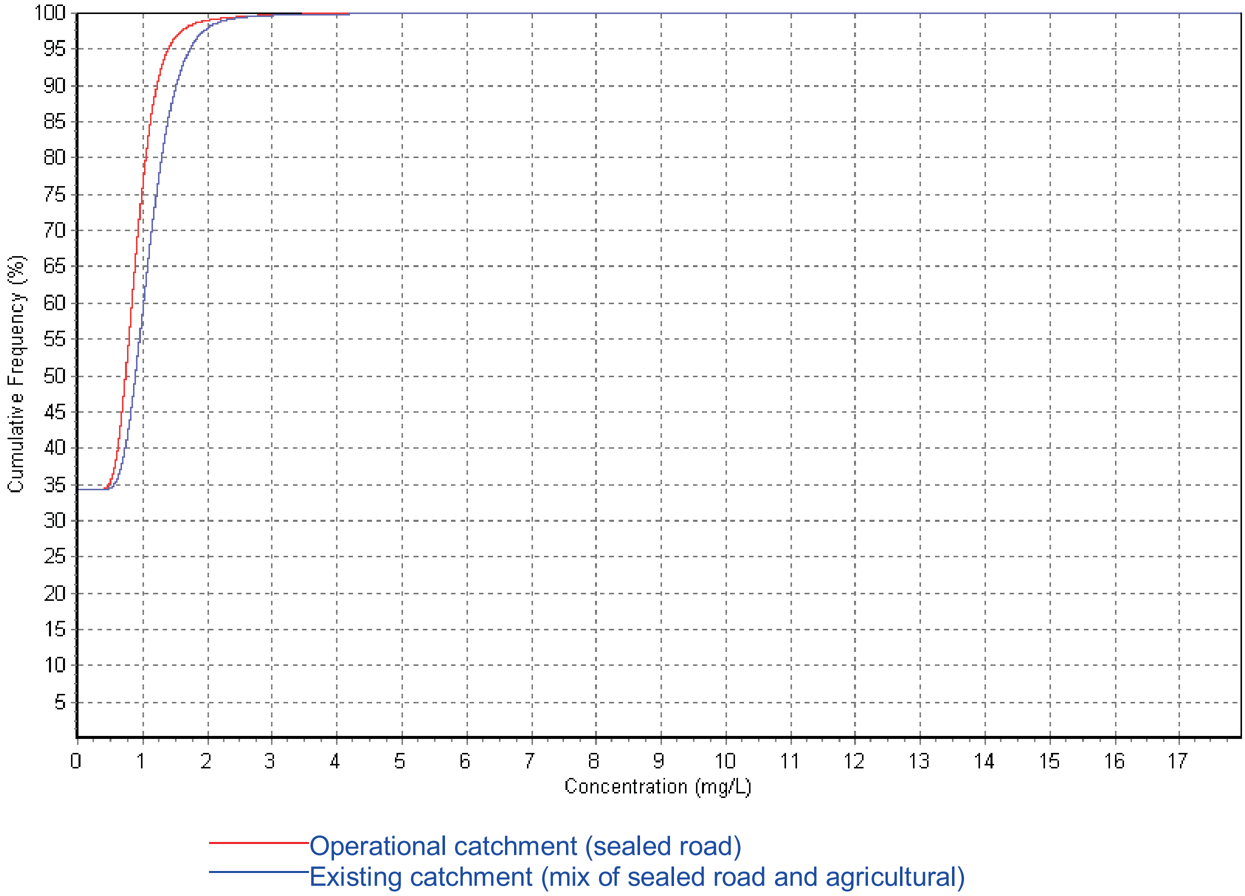


Figure 5.11 Total Nitrogen cumulative frequency graph for sealed road southern catchment

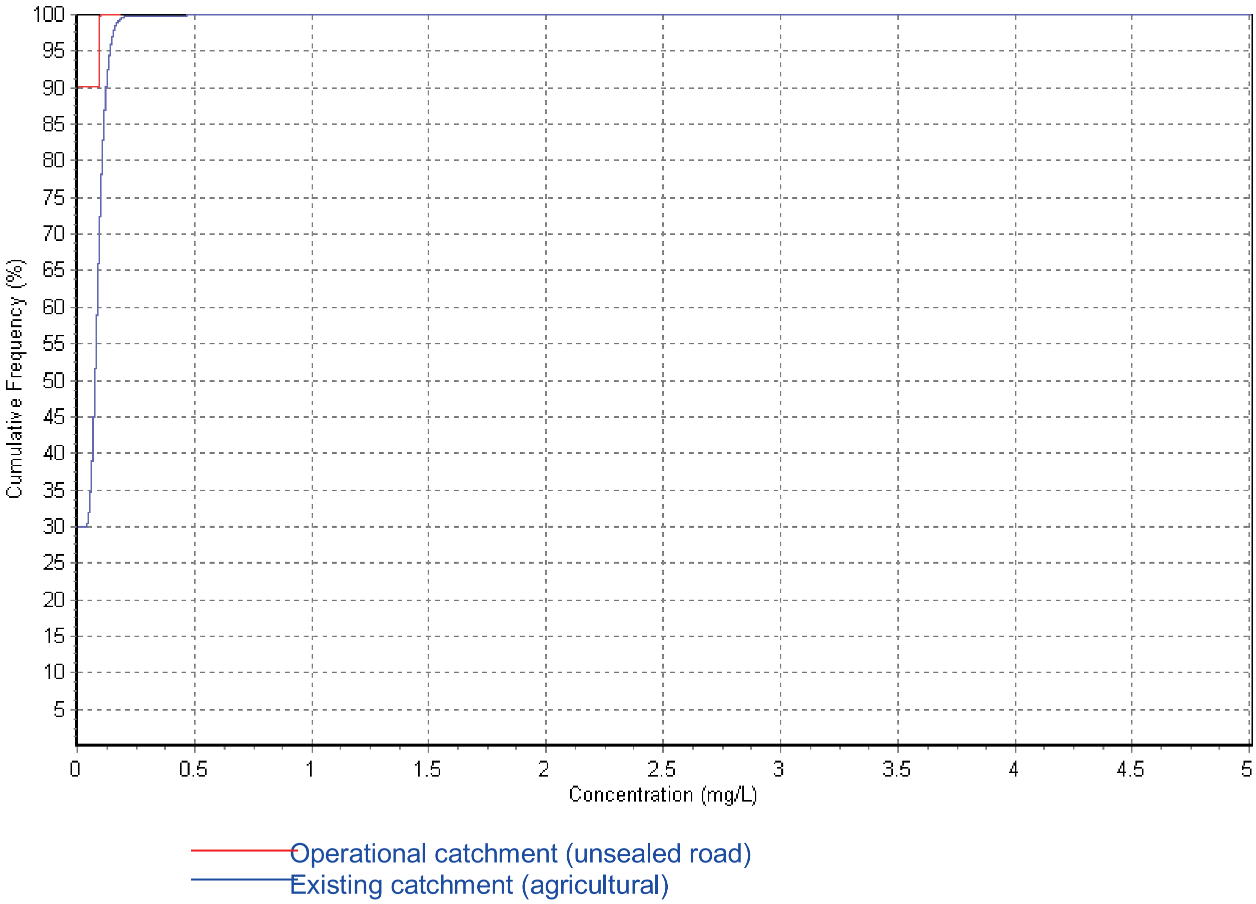


Figure 5.12 Total Phosphorus cumulative frequency graph for unsealed road catchment

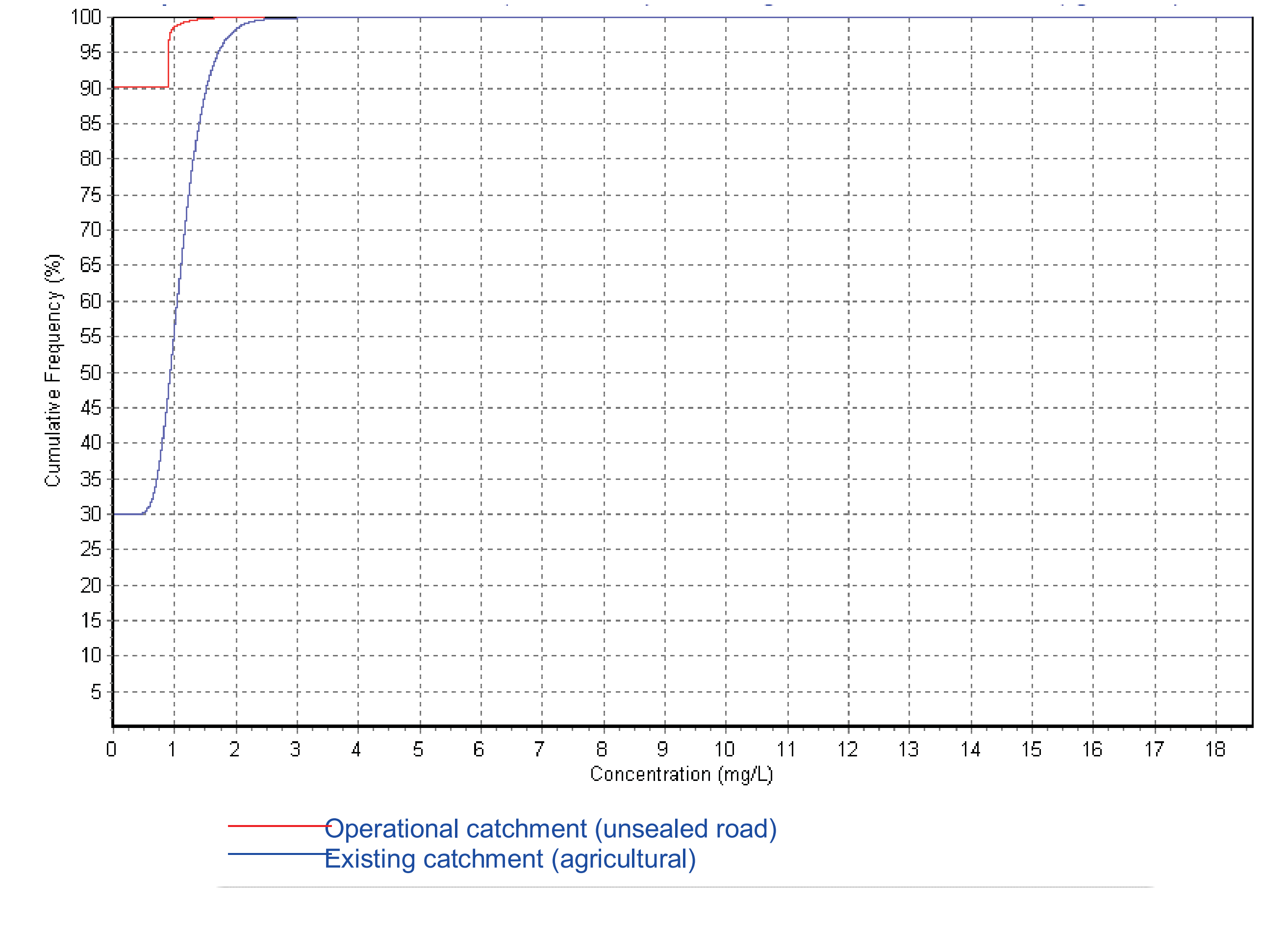


Figure 5.13 Total Nitrogen cumulative frequency graph for unsealed road catchment

5.2.4 Intercepted baseflow

Partial depressurisation of some parts of the groundwater system will occur during underground mining. Dewatering of an unconfined or semi confined groundwater system will result in water level drawdown of the water table (ie lowering of piezometric pressures). In areas where there are overlying streams receiving groundwater contributions to baseflow, this will mean some level of interception of natural baseflow resulting in reduced streamflow, particularly during low flows.

The interception of natural baseflow due to underground mining has been calculated for stream reaches in the project area using the numerical groundwater flow model for the project (Coffey 2016). Numerical groundwater modelling has found that a reduction in baseflow will occur in the following streams:

- Medway Rivulet and its tributaries, including Oldbury Creek, Wells Creek, Wells Creek Tributary and Belanglo Creek;
- Lower Wingecarribee River and its tributaries;
- Lower Wollondilly River and its tributaries; and
- Bundanoon Creek and its tributaries.

A reduction in baseflow will result in reduced loadings for all parameters. However, concentrations may increase due to reduced baseflow where groundwater concentrations are lower than surface water concentrations.

To identify parameters where the concentration may increase due to reduced baseflow, the water quality of the streams in the project area has been compared to groundwater quality in the project area. Where groundwater concentrations are higher than surface water concentrations, a reduction in baseflow is likely to improve the quality of surface water. However, where groundwater concentrations are lower than surface water concentrations, a reduction in baseflow may reduce the dilution of contaminants and result in an increase in contaminant concentrations in the surface water.

Table 5.13 presents a comparison of surface water and groundwater quality in the project area. The groundwater quality data is from groundwater monitoring bores in the project area that target the Hawkesbury Sandstone. Bores targeting the Hawkesbury Sandstone were selected as this is the major water bearing unit in the project area and is understood to be providing baseflow to streams. The locations of the groundwater monitoring bores are shown on Figure 5.14.

The 80th percentile of baseline surface water and groundwater quality data was compared. The results show that concentrations of contaminants were generally higher in groundwater than surface water, with the exception of the following parameters which were consistently higher in surface water:

- Nitrate;
- Calcium, sodium and sulfate; and
- Aluminium.

Comparison to the ANZECC and ADWG guidelines indicates:

- Nitrate – 80th percentile of groundwater and surface water results are within guideline values;
- Phosphorous – 80th percentile of surface water results exceed HRC guideline value;
- Calcium, sodium and sulfate – 80th percentile of groundwater and surface water results are well below guideline values; and
- Aluminium - 80th percentile of surface water results exceed guideline values for aquatic ecosystems and in some cases the ADWG, but not guidelines for irrigation or livestock.

The results indicate that there is potential for an increase in aluminium concentrations in surface water due to a reduction in groundwater baseflow to streams. Comparison to guideline values for aquatic ecosystems, drinking water, irrigation or livestock suggest changes in surface water aluminium concentrations are unlikely to affect the beneficial use of surface water in the project area for irrigation or livestock.

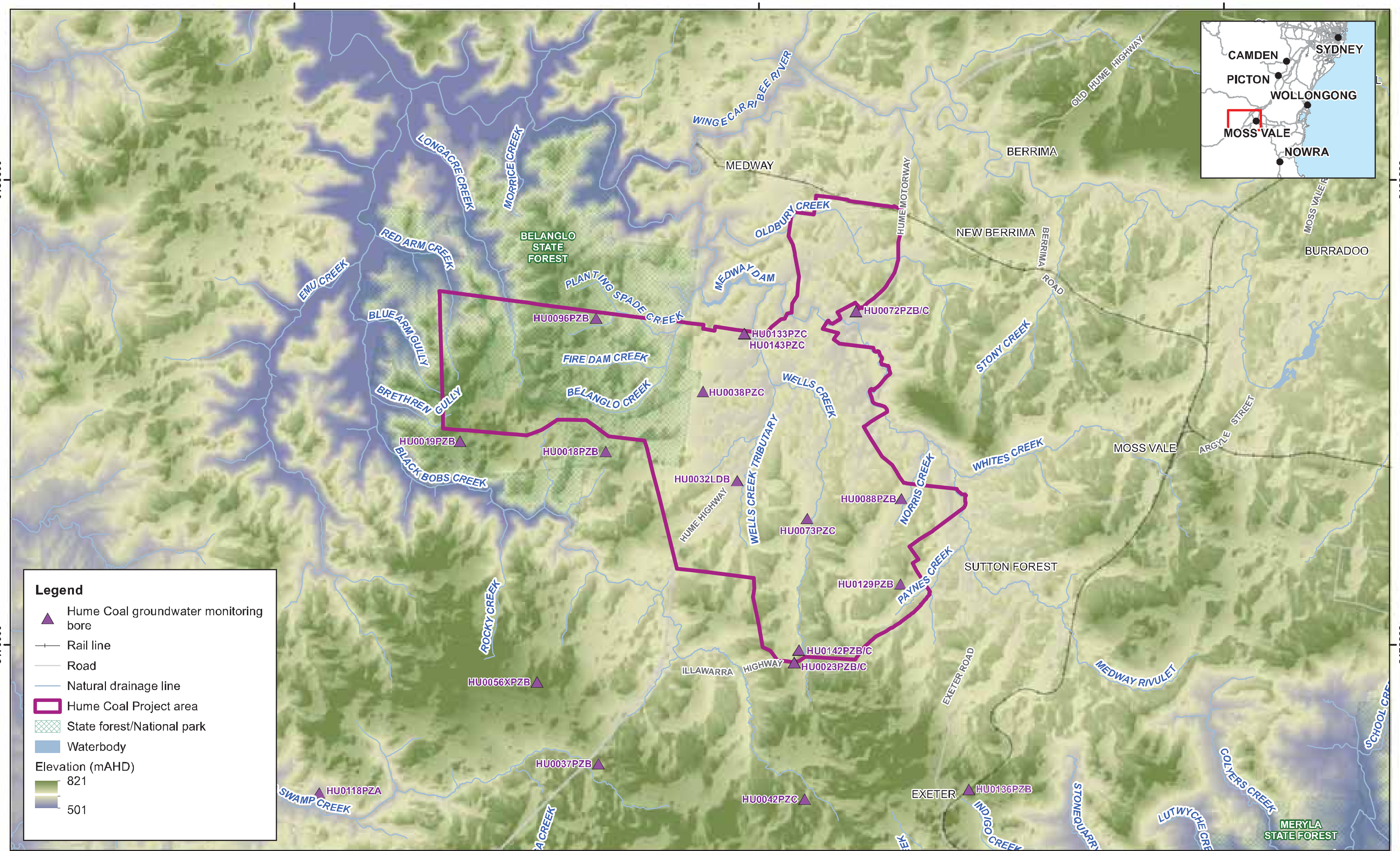
Phosphorous concentrations were generally higher in surface water than groundwater, however the difference between the 80^{h} percentile of surface water and groundwater concentrations is considered minimal and unlikely to be of concern for surface water quality in the project area.

Table 5.13 Comparison of groundwater and surface water quality

PARAMETER	UNIT	GUIDELINE	GROUNDWATER (HAWKESBURY SANDSTONE)					MEDWAY RIVULET MZ					LOWER WINGECARRIBEE RIVER MZ				LOWER WOLLONDILLY MZ	
			NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX	MEDWAY RIVULET	OLDBURY CREEK	WELLS CREEK AND WELLS CREEK TRIBUTARY	WHITES CREEK	BELANGLO CREEK AND PLANTING SPADE CREEK	WINGECARRIBEE RIVER	BLACK BOBS CREEK	LONGACRE CREEK	STONY CREEK	WOLLONDILLY RIVER	LONG SWAMP CREEK AND HANGING ROCK SWAMP CREEK
Physical parameters																		
Conductivity	µS/cm	35 – 350	131	41	241	609	4882	**613**	571	599	**668**	118	239	408	112	**732**	587	183
Temperature	°C	-	131	10	18	20	33	20	19	18	19	13	22	19	19	20	22	17
Turbidity	NTU	2 - 25	2	3.5	8.4	ID	13	9.6	12	22	11	14	54	12	42	23	27	4.6
pH	pH units	6.5 - 8.0	131	4.1	6.1	5.2 (20th %ile) 6.4 (80th %ile)	8.0	6.8 (20th%ile) 7.6 (80th%ile)	7.0 (20th%ile) 7.8 (80th%ile)	6.9 (20th%ile) 7.7 (80th%ile)	6.8 (20th%ile) 7.4 (80th%ile)	5.1 (20th%ile) 6.5 (80th%ile)	7.0 (20th%ile) 8.4 (80th%ile)	6.5 (20th%ile) 7.4 (80th%ile)	5.8 (20th%ile) 6.7 (80th%ile)	6.7 (20th%ile) 7.6 (80th%ile)	7.3 (20th%ile) 8.2 (80th%ile)	5.7 (20th%ile) 6.9 (80th%ile)
TDS	mg/L	600	131	27	159	403	3172	396	366	381	432	79	ND	264	64	465	ND	116
TSS	mg/L	-	18	<5	<5	15	25	9.0	9.0	17	12	2.8	22	10	21	17	20	5.0
Nutrients																		
Ammonia as N	mg/L	0.5	22	<0.01	0.04	0.13	0.78	0.12	0.12	0.06	0.06	0.02	ND	0.08	0.01	0.04	ND	0.02
Nitrate (as N)	mg/L	0.7	30	<0.01	0.02	0.08	0.77	0.66	0.66	0.08	**2.6**	0.08	0.24	0.09	0.02	0.04	ND	0.04
Nitrite (as N)	mg/L	1.0	30	<0.01	<0.01	<0.01	<0.1	0.03	0.03	<0.01	0.02	<0.01	ND	<0.01	<0.01	<0.01	ND	<0.01
Total nitrogen as N	mg/L	0.5*	ND	ND	ND	ND	ND	2.1	2.1	1.0	3.8	0.40	1.21	0.90	1.5	2.4	0.97	0.50
Phosphorus	mg/L	0.03*	18	<0.01	0.03	0.09	0.19	**0.12**	**0.12**	0.07	**0.10**	0.02	**0.10**	0.07	0.07	**0.47**	0.06	0.02
Major ions																		
Calcium	mg/L	1,000	132	<1	5	29	198	32	40	22	43	1.4	ND	16	3.4	48	ND	3.4
Chloride	mg/L	175	132	5.0	37	123	1300	96	66	114	76	27	32	80	20	133	121	42
Magnesium	mg/L	2,000	132	<1	5.0	28	236	23	13	29	13	3.4	ND	17	3.0	20	ND	3.0
Sodium	mg/L	115	132	2.0	21	43	406	54	50	48	66	17	ND	32	11	63	ND	22
Sulfate as SO_4	mg/L	250	132	<1	5.0	8.0	159	27	73	6	96	2.4	28	51	<1	10	19	1.0
Dissolved metals																		
Aluminium	mg/L	0.055	89	<0.01	<0.01	0.02	0.41**	**0.12**	**0.12**	**0.19**	**0.07**	**0.66**	ND	**0.23**	**0.84**	**0.16**	ND	**0.09**
Antimony	mg/L	0.003	89	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.01	89	<0.001	<0.001	0.002	0.04	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Barium	mg/L	1.0	39	0.003	0.05	0.26	0.83	0.07	0.04	0.06	0.04	0.01	0.04	0.04	0.02	0.06	0.05	0.01
Beryllium	mg/L	0.06	30	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.37	89	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.08	<0.05	0.02	<0.05	<0.05	<0.05	0.02	<0.05

PARAMETER	UNIT	GUIDELINE	GROUNDWATER (HAWKESBURY SANDSTONE)					MEDWAY RIVULET MZ					LOWER WINGECARRIBEE RIVER MZ				LOWER WOLLONDILLY MZ	
			NO. OF SAMPLES	MIN	MEDIAN	80^{TH} %ILE	MAX	MEDWAY RIVULET	OLDBURY CREEK	WELLS CREEK AND WELLS CREEK TRIBUTARY	WHITES CREEK	BELANGLO CREEK AND PLANTING SPADE CREEK	WINGECARRIBEE RIVER	BLACK BOBS CREEK	LONGACRE CREEK	STONY CREEK	WOLLONDILLY RIVER	LONG SWAMP CREEK AND HANGING ROCK SWAMP CREEK
Cadmium	mg/L	0.0002	89	<0.0001	<0.0001	<0.0001	0.0008	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	89	<0.001	<0.001	<0.001	0.008	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.05	89	<0.001	0.003	0.009	0.27	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.01	<0.001	0.002	<0.001	<0.001
Copper	mg/L	0.0014	89	<0.001	<0.001	0.006	0.26	0.002	0.001	0.002	0.002	<0.001	0.003	0.002	0.002	0.003	0.005	<0.001
Iron	mg/L	0.2	132	<0.05	4.9	11	22	0.51	0.35	0.55	0.14	0.33	ND	1.3	1.1	0.54	ND	0.42
Lead	mg/L	0.0034	89	<0.001	<0.001	<0.001	0.006	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.1	132	0.001	0.42	0.79	1.7	0.14	0.13	0.22	0.12	0.02	ND	0.26	0.06	**0.84**	ND	0.02
Mercury	mg/L	0.0006	18	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	ND	<0.0001	<0.0001	<0.0001	ND	<0.0001
Molybdenum	mg/L	0.01	89	<0.001	<0.001	0.001	0.011	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Nickel	mg/L	0.011	89	<0.001	0.008	0.02	0.63	0.003	0.002	0.002	0.002	<0.001	0.002	0.02	0.002	0.003	0.002	<0.001
Selenium	mg/L	0.01	89	<0.01	<0.01	<0.01	0.16	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01
Silver^	mg/L	0.00005	ND	ND	ND	ND	ND	<0.01	0.02	<0.001	<0.01	<0.001	<0.001	<0.001	<0.001	0.01	ND	<0.001
Zinc	mg/L	0.008	89	<0.005	0.02	0.07	0.32	<0.005	0.005	<0.005	0.02	<0.005	0.007	0.05	0.01	<0.005	0.008	<0.005
Hydrocarbons																		
Benzene	µg/L	1	20	<1	<1	<1	<1	<1	<1	<1	<1	<1	ND	<1	<1	<1	ND	<1
Toluene	µg/L	25	20	<2	7.0	18	20	<2	<2	<2	<2	<2	ND	<2	<2	<2	ND	<2
Ethylbenzene	µg/L	3	20	<2	<2	<2	<2	<2	<2	<2	<2	<2	ND	<2	<2	<2	ND	<2
Total xylene	µg/L	20	20	<2	<2	<2	<2	<2	<2	<2	<2	<2	ND	<2	<2	<2	ND	<2
Naphthalene	µg/L	16	20	<5	<5	<5	<5	<5	<5	<5	<5	<5	ND	<5	<5	<5	ND	<5

ND No data
ID Insufficient data to calculate
MZ Management zone
*WQO recommended by *Healthy Rivers Commission Inquiry into the Hawkesbury-Nepean River* (HRC 1998).
^ Standard and trace laboratory limits of reporting exceed the ANZECC guideline for aquatic ecosystems.
** Concentrations of most dissolved metals are low, as is characteristic for groundwater with circumneutral pH. Most aluminium measurements are below the detection limit (0.01 mg/L), although a maximum of 0.41 mg/L was recorded in one instance. Aluminium concentrations above 0.01 mg/L are not representative of dissolved species and are believed to be outliers (Geosyntec 2016).
Cells shaded grey indicate 80^{th} percentile surface water concentrations exceed 80^{th} percentile groundwater concentrations
Values in bold indicate lowest guideline value exceeded and 80^{th} percentile surface water concentrations exceed 80^{th} percentile groundwater concentrations



Map: 2200540A_GIS_069_A2 | Author: RP
Date: 14/11/2016 | Approved by: LR
Data source: NSW Land and Property Information 2015, Hume Coal

1:75,000
Coordinate system: GDA 1994 MGA Zone 56
Scale ratio correct when printed at A3

Hume Coal Surface Water Quality Assessment

Figure 5.14
Groundwater quality monitoring locations

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5.2.5 Cumulative impacts

The proposed Berrima Rail Project is located upstream of the Hume Coal Project in the Oldbury Creek catchment (Figure 1.2).

The surface water quality assessment undertaken for the Berrima Rail Project indicates that with the implementation of appropriate management plans and treatment measures in place (ie swales), the water quality in Oldbury Creek will not be impacted by construction, operation or rehabilitation of the Berrima Rail Project.

Cumulative impacts to surface water quality associated with the Hume Coal and Berrima Rail projects will therefore be negligible. Refer to the Berrima Rail Project EIS (EMM 2016c) for details of the surface water assessment.

6 MITIGATION MEASURES AND MONITORING PROGRAM

This section presents recommended mitigation and management measures for the Hume Coal Project to avoid impacts on surface water quality. Mitigation and management measures should be implemented during construction and rehabilitation as well as during operation of the mine.

6.1 Environmental management plans

Most of the potential impacts to surface water quality during construction, operation and rehabilitation can be prevented through the implementation of project-specific environmental management plans. Consistent mitigation and management measures should be applied during construction, operation and rehabilitation of the project to provide personnel with a common understanding of the measures to be applied. The following environmental management plans should be developed and applied for the project:

- An erosion and sediment control plan, which details the measures to control erosion and sedimentation with the project area and of local waterways during construction, operation and rehabilitation phases. Details of the plan are provided in Section 6.2.
- A hazardous materials plan, which details the approach to managing and storing hazardous materials, including fuels, oils, lubricants and chemicals for the WTP.
- A contingency plan for environmental incidents, which details the response actions during an environmental incident such as an oil spill.
- A waste management plan, which details the approach to the management of general waste, sewage and by-products of water treatment on site.

6.2 Construction and rehabilitation

The construction and rehabilitation phases of the project will involve earthworks activities which have the potential to cause erosion and sedimentation of local waterways and water quality impacts in the waterways due to increased TSS loads (and associated adsorbed phase contaminants) if not appropriately managed.

An erosion and sediment control plan should be prepared (as noted in Section 6.1). The erosion and sediment control plan should be part of a Water Cycle Management Plan for the project, which may be required by *Developments in Sydney's Drinking Water Catchment – Water Quality Information Requirements* (WaterNSW 2015). The erosion and sediment control plan should be developed to achieve the surface water management objective below, and should incorporate the soil and water management principles below.

6.2.1 Surface water management objective

According to Vol. 2 of Managing Urban Stormwater: Soils and Construction the goal for surface water management is:

> *'…to ensure that there is no pollution of surface or ground waters. Current best-practice erosion and sediment control techniques are, however, unlikely to achieve this goal, due to the limited effectiveness of most of these techniques. An appropriate management objective is therefore to take all reasonable measures (i.e. implement best-practice) to minimise water-quality impacts from erosion and sedimentation.*
>
> *Given the limited effectiveness of techniques for retaining eroded sediment, a strong emphasis should be placed on pollution prevention through erosion control, rather than relying on treatment techniques to capture these sediments.'*

Therefore, with the paramount objective of not polluting surface waters in the first place, the strategy should be to minimise the discharge of sediment-laden waters from the sites to the adjacent waterways and drainage lines.

6.2.2 Soil and water management principles

The primary principle for surface water management at the site is to minimise erosion and sediment generation at the source, and where this is not possible, to capture and treat any sediment generated before discharge into receiving waterways. The following general principles provide a framework for the development of site-specific options to achieve this:

- Minimise the volume of clean surface water running onto the site from off site.
- Minimise the extent of disturbed areas.
- Minimise surface water from running onto disturbed areas of the site by staging operations and, where necessary, utilising surface water diversion drains and bunds for disposal and processing areas.
- Implement erosion control strategies to minimise generation of sediment in the surface water.
- Implement sediment control strategies to reduce the release of sediment in surface water from the site.
- Minimising the amount of surface water runoff discharged from the site and maximising reuse onsite.
- Maintain all erosion and sediment controls properly by implementing an inspection schedule.
- Vegetate disturbed areas progressively.
- Adopt strategies for early identification of potential surface water issues.

6.3 Operation

The operational phase of the project will involve coal stockpiling and handling activities which have the potential to cause contamination of local waterways if not appropriately managed. The following sections detail the mitigation and management measures that should be implemented to avoid and mitigate potential impacts on surface water quality.

6.3.1 Mine water management system

A mine water management system will be implemented during operation of the project to prevent contamination of local waterways. Surface water runoff from disturbed areas of the site will be fully contained within the mine water management system to prevent uncontrolled discharge of coal contact water to local waterways. The water management system for the project is detailed in the *Water Balance Assessment Report* (Parsons Brinckerhoff, 2016b).

6.3.2 SB03 and SB04 releases

Water will only be released from SB03 and SB04 to Oldbury Creek after the first flush to these dams is pumped to the PWD and contained within the mine water management system. The first flush criteria adopted for the project were developed based on the NSW EPA guideline provided at the http://www.epa.nsw.gov.au/mao/stormwater.htm (refer Section 5.2.1). Routine monitoring of water quality in SB03 and SB04 will be undertaken and in-line monitoring of TDS and pH will be undertaken prior to release to Oldbury Creek to confirm the water in the dams complies with water quality discharge limits to be developed.

Water quality discharge limits will be developed in consultation with the Environment Protection Authority to protect the environmental values in the Hawkesbury-Nepean Basin and achieve a NorBE effect on water quality. Preliminary discharge limits for SB03 and SB04 are provided in Table 6.1. These preliminary limits are based on discharge limits in Environment Protection Licences for other similar operations in the Illawarra and Southern Highlands.

Table 6.1 Preliminary discharge limits for SB03 and SB04 releases

POLLUTANT	UNIT OF MEASURE	100 PERCENTILE CONCENTRATION LIMIT
pH	pH units	6.5 – 8.5
Total dissolved solids (TDS)	mg/L	1500
Total suspended solids (TSS)	mg/L	50
Oil and grease	mg/L	10

In the event that water quality in SB03 or SB04 does not meet the discharge limits, water will not be discharged to Oldbury Creek and will be contained within the mine water management system. The mine water balance modelling (refer to the *Water Balance Assessment Report,* Parsons Brinckerhoff 2016b) has demonstrated that the PWD has the capacity to store all runoff from SB03 and SB04 for all climate sequences, if required.

The discharge limits will be checked using routine monitoring of the water in SB03 and SB04. Simpler in-line testing for TDS and pH will be undertaken at the day to day operational level to inform decisions on whether to release water. This is discussed further in Section 6.4.

6.3.3 Stormwater management measures

All activities within and outside the water management system should be managed in accordance with a Water Cycle Management Plan. The Water Cycle Management Plan should outline all surface water management works following the relevant guidelines set out in the Blue Book, Volume 1 (Landcom, 2004) and the Blue Book, Volume 2E (DECC, 2008). The following site-specific controls would be finalised in the Water Cycle Management Plan:

- Minimise land disturbance.
- Vegetate disturbed areas progressively.

- Stabilisation and drainage of site access roads.
- Control vehicular access to site.
- Dust control.
- Soil and stockpile management.
- Clean water diversion.
- Sediment basin systems for long-term work areas, if required.
- Vegetation establishment.
- Site induction and staff training and education.
- Inspection and monitoring.
- Maintenance of surface water management measures.
- Minimise surface water runoff discharged from the site and maximise reuse onsite.
- Properly maintain all erosion and sediment controls by implementing an inspection schedule.
- Adopt strategies for early identification of potential surface water issues.

6.4 Surface water quality monitoring program

A surface water quality monitoring program will be implemented for the receiving environment during construction, operation and rehabilitation of the project. The program will involve surface water quality monitoring in Medway Rivulet and Oldbury Creek upstream and downstream of working areas during construction and rehabilitation and upstream and downstream of surface infrastructure for the mine during operation. Results of the surface water quality monitoring will be compared to site specific WQOs developed in accordance with the National Water Quality Management Strategy to assess impacts to surface water quality in the receiving environment associated with the project and trigger the implementation of mitigation and remediation measures if required.

6.4.1 Monitoring locations

Surface water quality monitoring will be undertaken in the receiving environment at existing monitoring locations SWQ04 and SWQ15 on Medway Rivulet and SWQ17 and SWQ19 on Oldbury Creek. Monitoring at locations upstream and downstream of surface infrastructure areas and discharge points will allow the impacts of the project on water quality to be assessed. In addition, routine water quality monitoring will be undertaken at SB03 and SB04 and in-line testing of TDS and pH in the SB03 and SB04 discharges will be undertaken prior to release to Oldbury Creek. The surface water quality monitoring locations for the project are shown on Figure 6.1.

6.4.2 Monitoring frequency

Surface water quality monitoring should be undertaken on a monthly basis at the locations shown on Figure 6.1. Monitoring will be undertaken throughout the construction, operation and rehabilitation phases of the project.

In-line monitoring of TDS and pH should also be undertaken on a daily basis prior to and during the release of water from SB03 and SB04 to check that the concentrations of these key parameters are within discharge limits.

Monthly surface water quality monitoring will continue at the locations shown on Figure 6.1 prior to commencement of the project to continue development of the baseline dataset.

6.4.3 Key parameters

Surface water quality monitoring will be undertaken for the potential contaminants associated with project activities during construction, operation and rehabilitation of the project. Key parameters of concern in the Hawkesbury-Nepean catchment, as identified in the report *Healthy Rivers Commission Inquiry into the Hawkesbury-Nepean River* (HRC 1998), will also be monitored (refer Section 2.6).

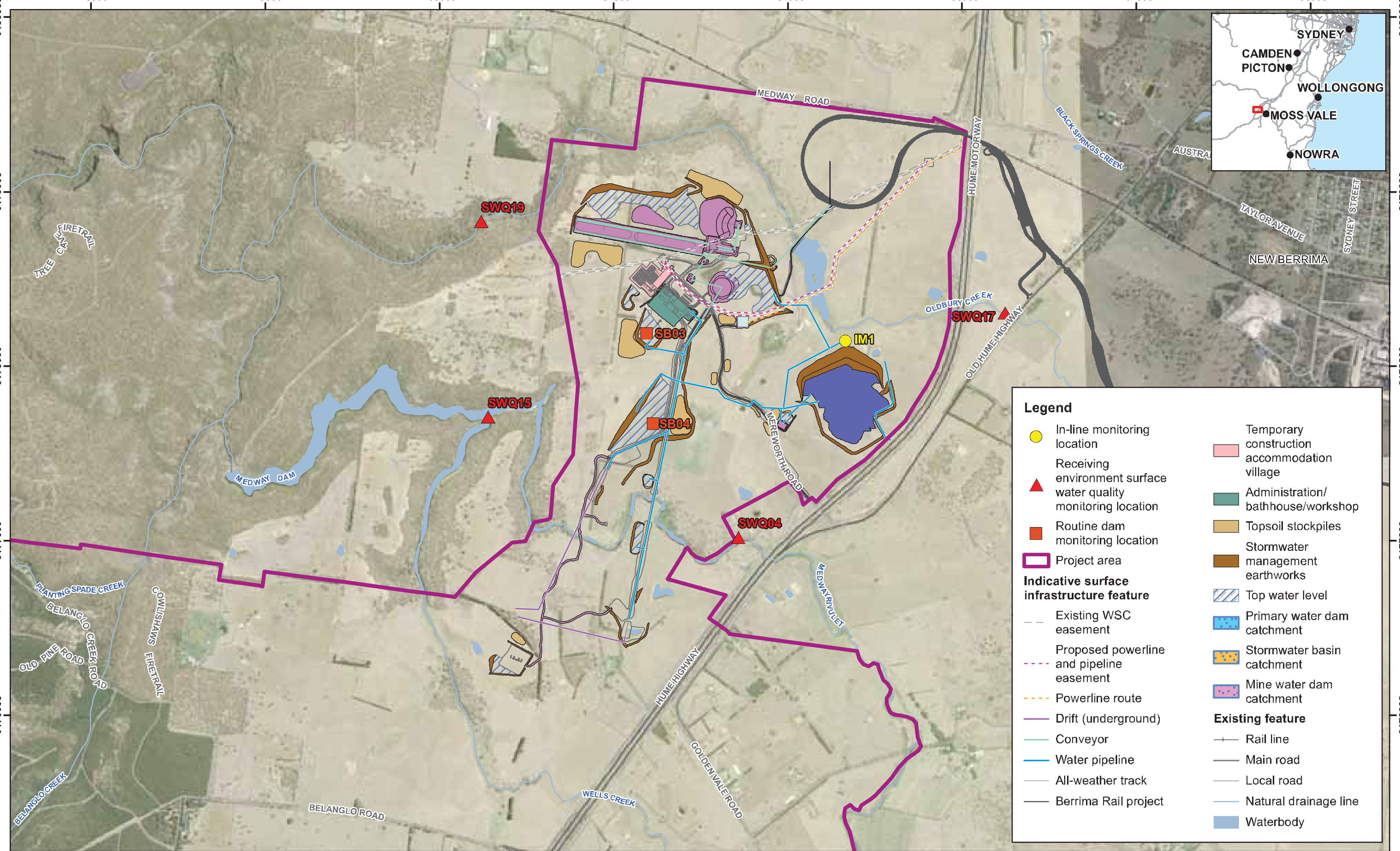
Provision should be made to review the monitoring program annually or every two years so that redundancies and other improvements can be made based on the results of the monitoring program.

The key parameters for the surface water quality monitoring program are summarised in Table 6.2.

Table 6.2 Parameters for surface water quality monitoring program

CATEGORY	SUITE OF ANALYTES
Physical parameters	TDS, TSS, turbidity, pH
Major ions	Calcium, magnesium, sodium, potassium, chloride, sulfate, alkalinity, reactive silica
Metals – dissolved and total	Aluminium, antimony, arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, iron, lead, manganese, mercury, molybdenum, nickel, selenium, silver, zinc.
Nutrients	Ammonia, nitrate, nitrite, TN, TP, phosphorous (reactive)
Hydrocarbons	TRH/TPH, BTEX, naphthalene

TRH/TPH – Total Recoverable Hydrocarbons/Total Petroleum Hydrocarbons
BTEX – Benzene, Toluene, Ethylbenzene, Xylene



Map: 2200540A_GIS_070_A2	Author: RP
Date: 21/10/2016	Approved by: LR

Data source: © Land and Property Information 2015, Hume Coal, Google Earth

0 250 500 m

1:20,000

Coordinate system: GDA 1994 MGA Zone 56

Scale ratio correct when printed at A3

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Hume Coal Surface Water Quality Assessment

Figure 6.1

Receiving environment surface water quality monitoring locations

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6.4.4 Water quality objectives

WQOs are specific water quality targets that can be used as indicators of management performance.

The HRC (1998) report recommends that the ANZECC guidelines be adopted as suitable WQOs for the Hawkesbury-Nepean River catchment, with the exception of nutrients and chlorophyll-a. The environmental values in the project area are provided in Section 4.1 and guideline values for these provided in Table 2.2. For total nitrogen and total phosphorous, the WQOs will be adopted from the report *Healthy Rivers Commission Inquiry into the Hawkesbury-Nepean River* (HRC 1998), which provides catchment specific WQOs for these nutrients.

In circumstances where the median or 80th percentile baseline concentration exceeds the guideline value in the NWQMS guidelines or the WQO in the Healthy Rivers Commission report, site specific WQOs will be developed in accordance with the referential approach in ANZECC (2000). The referential approach involves calculating WQOs on the basis of maximum acceptable departure from reference condition. The acceptable departure suggested is that the WQO be based on the 20th and/or 80th percentile (whichever is most appropriate for the indicator) of values at the reference site.

Ideally site specific WQOs should be based on 24 months of baseline or reference data. The surface water quality results presented in this report are for the period July 2014 to September 2015, however monthly surface water quality monitoring is ongoing and further data will be available in future. Preliminary WQOs and the relevant source basis are provided in Table 6.3. Final WQOs should be developed using the additional surface water quality data collected prior to commencement of construction of the project.

Table 6.3 Preliminary water quality objectives for Hume Coal Project

PARAMETER	UNIT	MEDWAY RIVULET		OLDBURY CREEK	
		PRELIMINARY WQO	SOURCE	PRELIMINARY WQO	SOURCE
Physical parameters					
Conductivity	µS/cm	613	Preliminary WQO (80th percentile of baseline)	571	Preliminary WQO (80th percentile of baseline)
Turbidity	NTU	25*	ANZECC aquatic ecosystems	25*	ANZECC aquatic ecosystems
pH	pH units	6.5 - 8.0	ANZECC aquatic ecosystems	6.5 - 8.0	ANZECC aquatic ecosystems
Total dissolved solids (TDS)	mg/L	600	ADWG aesthetic	600	ADWG aesthetic
Total suspended solids (TSS)	mg/L	9	Preliminary WQO (80th percentile of baseline)	9	Preliminary WQO (80th percentile of baseline)
Nutrients					
Ammonia as N	mg/L	0.5	ADWG aesthetic	0.5	ADWG aesthetic
Nitrate (as N)	mg/L	0.7	ANZECC aquatic ecosystems	0.7	ANZECC aquatic ecosystems
Nitrite (as N)	mg/L	1	ANZECC recreational	1	ANZECC recreational
Total nitrogen as N	mg/L	1.1	Preliminary WQO (80th percentile of baseline)	2.1	Preliminary WQO (80th percentile of baseline)
Phosphorus	mg/L	0.08	Preliminary WQO (80th percentile of baseline)	0.12	Preliminary WQO (80th percentile of baseline)

PARAMETER	UNIT	MEDWAY RIVULET		OLDBURY CREEK	
		PRELIMINARY WQO	SOURCE	PRELIMINARY WQO	SOURCE
Major ions					
Calcium	mg/L	1,000	ANZECC livestock	1,000	ANZECC livestock
Chloride	mg/L	175	ANZECC irrigation	175	ANZECC irrigation
Magnesium	mg/L	2,000	ANZECC livestock	2,000	ANZECC livestock
Sodium	mg/L	115	ANZECC irrigation	115	ANZECC irrigation
Sulfate as SO_4	mg/L	250	ADWG aesthetic	250	ADWG aesthetic
Dissolved metals					
Aluminium	mg/L	0.12	Preliminary WQO (80th percentile of baseline)	0.12	Preliminary WQO (80th percentile of baseline)
Antimony	mg/L	0.003	ADWG health	0.003	ADWG health
Arsenic	mg/L	0.01	ADWG health	0.01	ADWG health
Barium	mg/L	1	ANZECC recreational	1	ANZECC recreational
Beryllium	mg/L	0.06	ADWG health	0.06	ADWG health
Boron	mg/L	0.37	ANZECC aquatic ecosystems	0.37	ANZECC aquatic ecosystems
Cadmium	mg/L	0.0002	ANZECC aquatic ecosystems	0.0002	ANZECC aquatic ecosystems
Chromium	mg/L	0.001	ANZECC aquatic ecosystems	0.001	ANZECC aquatic ecosystems
Cobalt	mg/L	0.05	ANZECC irrigation	0.05	ANZECC irrigation
Copper	mg/L	0.002	Preliminary WQO (80th percentile of baseline)	0.0014	ANZECC aquatic ecosystems
Iron	mg/L	0.51	Preliminary WQO (80th percentile of baseline)	0.35	Preliminary WQO (80th percentile of baseline)
Lead	mg/L	0.0034	ANZECC aquatic ecosystems	0.0034	ANZECC aquatic ecosystems
Manganese	mg/L	0.14	Preliminary WQO (80th percentile of baseline)	0.13	Preliminary WQO (80th percentile of baseline)
Mercury	mg/L	0.0006	ANZECC aquatic ecosystems	0.0006	ANZECC aquatic ecosystems
Molybdenum	mg/L	0.01	ANZECC irrigation	0.01	ANZECC irrigation
Nickel	mg/L	0.011	ANZECC aquatic ecosystems	0.011	ANZECC aquatic ecosystems
Selenium	mg/L	0.01	ADWG health	0.01	ADWG health
Silver	mg/L	0.001	Laboratory limit of reporting (higher than lowest guideline)	0.02	Preliminary WQO (80th percentile of baseline)
Zinc	mg/L	0.008	ANZECC aquatic ecosystems	0.01	Preliminary WQO (80th percentile of baseline)
Hydrocarbons					
Benzene	µg/L	1	ADWG health	1	ADWG health
Toluene	µg/L	25	ADWG aesthetic	25	ADWG aesthetic

PARAMETER	UNIT	MEDWAY RIVULET		OLDBURY CREEK	
		PRELIMINARY WQO	SOURCE	PRELIMINARY WQO	SOURCE
Ethylbenzene	µg/L	3	ADWG aesthetic	3	ADWG aesthetic
Xylene	µg/L	20	ADWG aesthetic	20	ADWG aesthetic
Naphthalene	µg/L	16	ANZECC aquatic ecosystems	16	ANZECC aquatic ecosystems

Notes:
**Upper limit used*

6.4.5 WQO exceedance response

Exceedances of the WQOs at downstream monitoring locations SWQ15 on Medway Rivulet and SWQ19 on Oldbury Creek should be investigated as follows:

→ The concentration at the downstream monitoring location would be compared to the concentration at the upstream monitoring location and:
  - if the concentration at the upstream location exceeds or is equal to the concentration at the downstream location, no further action is required; or
  - if the concentration at the upstream location is lower than the concentration at the downstream location, then the next routine monitoring results are checked. If the monitoring data shows a reoccurrence of the exceedance of the WQO at the downstream location and the lower concentrations at the upstream location, an investigation into the source of contamination and risks to environmental values would be undertaken.

→ If the investigation confirms that the exceedance is a result of Hume Coal activities and indicates potential for risks to environmental values, an action plan to mitigate potential harm would be developed.

7 CONCLUSIONS

Construction and rehabilitation phase impacts of the project on surface water quality are expected to be neutral by implementing best practice erosion and sediment control management measures in accordance with relevant legislation and guidelines.

The mine water management system has been designed to ensure that no coal contact water is released to the receiving environment. The Water Balance Assessment (Parsons Brinckerhoff, 2016b) has demonstrated that all coal contact water will be contained and reused during operation.

The project activities that have the potential to impact on surface water quality during operation are as follows:

- Releases from non-coal contact mine water dams SB03 and SB04 to Oldbury Creek following pumping of the first flush to the PWD for reuse.
- Runoff from mine access roads that drain into the Medway Rivulet catchment.
- The interception of natural baseflow due to underground mining which may change the loading and concentration of some water quality parameters in the surface waters.

MUSIC modelling has demonstrated that the release of water from SB03 and SB04 to Oldbury Creek will meet the NorBE criteria for TSS, TP and TN due to the reduction in flow and associated reduction in loading and concentration compared to the existing agricultural catchment for these contaminants. For other contaminants that may be present in the runoff to these dams, water quality discharge limits will be set and routine and in-line monitoring of water quality in releases from SB03 and SB04 will be undertaken to check that the water in the basins complies with the discharge limits.

For SB03 and SB04, the water quality discharge limits will be developed to protect the environmental values in the Hawkesbury-Nepean Basin and to achieve a NorBE on water quality. Preliminary limits have been established in this report which will be refined in consultation with the NSW Environment Protection Authority.

MUSIC modelling has also demonstrated that swales can be used to provide an effective treatment system for the runoff from the access roads to meet the NorBE criteria.

Assessment of the impact of intercepted baseflow was based on a comparison of contaminant concentrations in groundwater and surface water from the monitoring results. The results indicate that there is potential for an increase in aluminium concentrations in surface water due to a reduction in groundwater baseflow to streams; however, comparison to guideline values for aquatic ecosystems, drinking water, irrigation or livestock suggest changes in surface water aluminium concentrations are unlikely to affect the beneficial use of surface water in the project area for irrigation or livestock.

The Hume Coal Project and the Berrima Rail Project will not have cumulative impacts on surface water quality as the rail project has been assessed to meet the NorBE criteria in its discharge to the Oldbury Creek catchment upstream of the Hume Coal Project.

Preliminary WQOs for the receiving environment have been established in this report based on relevant legislation and guidelines to set targets for monitoring the performance of the project impact on Medway Rivulet and Oldbury Creek. Final WQOs should be developed using the additional surface water quality data collected prior to commencement of construction of the project. Surface water quality monitoring should be undertaken throughout construction, operation and rehabilitation at upstream and downstream sites on Medway Rivulet and Oldbury Creek to monitor changes in surface water quality in the receiving environment associated with the project and trigger the implementation of mitigation and remediation measures if required.

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Appendix A

BASELINE SURFACE WATER QUALITY DATA

PARAMETER	UNIT	GUIDELINE	WELLS CREEK AND WELLS CREEK TRIBUTARY					WHITES CREEK				
			NO. OF SAMPLES	MIN	MEDIAN	80^{TH} %ILE	MAX	NO. OF SAMPLES	MIN	MEDIAN	80^{TH} %ILE	MAX
Physical parameters												
Conductivity	µS/cm	35 – 350	56	209	409.5	599.2	865	38	214	556	668.4	732
Temperature	°C	-	54	7.1	11.6	18.4	25.6	37	7.4	15.1	19.3	21.3
Turbidity	NTU	2 - 25	54	2	9.05	22	149	37	1.4	6.4	11.12	55.5
pH	pH units	6.5 - 8.0	56	6.3	7.25	6.9 (20^{th} %ile) 7.7 (80^{th} %ile)	8.3	38	6.1	7.1	6.8 (20^{th} %ile) 7.4 (80^{th} %ile)	7.9
TDS	mg/L	600	54	136	261.5	381	510	37	139	364	431.8	476
TSS	mg/L	-	56	<1	8	16.6	73	38	<5	8	12	48
Nutrients												
Ammonia as N	mg/L	0.5	56	<0.01	0.02	0.062	0.19	38	0.01	0.04	0.064	2.3
Nitrate (as N)	mg/L	0.7	56	<0.01	0.02	0.08	0.21	38	0.02	1.44	2.556	5.66
Nitrite (as N)	mg/L	1.0	56	<0.01	<0.01	<0.01	0.06	38	<0.01	0.01	0.02	0.1
Total nitrogen as N	mg/L	0.5*	56	<0.1	0.6	1	2	38	0.6	2.55	3.76	6.7
Phosphorus	mg/L	0.03*	56	<0.01	0.02	0.066	0.21	38	<0.01	0.045	0.102	0.24
Major ions												
Calcium	mg/L	1,000	56	6	15.5	22	28	38	13	34.5	43.4	53

PARAMETER	UNIT	GUIDELINE	WELLS CREEK AND WELLS CREEK TRIBUTARY					WHITES CREEK				
			NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX	NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX
Chloride	mg/L	175	56	42	74.5	113.6	147	38	23	63.5	76	112
Magnesium	mg/L	2,000	56	5	19	29	39	38	5	9	13.2	16
Sodium	mg/L	115	56	17	37.5	48	62	38	15	56	66.2	77
Sulfate as SO_4	mg/L	250	56	<1	<1	6	9	38	13	63	96	134
Dissolved metals												
Aluminium	mg/L	0.055	56	<0.01	0.04	0.186	0.89	38	<0.01	0.02	0.066	0.42
Antimony	mg/L	0.003	32	<0.001	<0.001	<0.001	<0.001	15	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.01	56	<0.001	<0.001	<0.001	<0.001	38	<0.001	<0.001	<0.001	0.002
Barium	mg/L	1.0	56	0.022	0.046	0.059	0.092	38	0.017	0.0365	0.042	0.051
Beryllium	mg/L	0.06	55	<0.001	<0.001	<0.001	<0.001	37	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.37	32	<0.05	<0.05	<0.05	<0.05	15	<0.05	0.055	0.08	0.09
Cadmium	mg/L	0.0002	56	<0.0001	<0.0001	<0.0001	0.0001	38	<0.0001	<0.0001	<0.0001	0.0002
Chromium	mg/L	0.001	56	<0.001	<0.001	<0.001	<0.001	38	<0.001	<0.001	<0.001	0.001
Cobalt	mg/L	0.05	56	<0.001	<0.001	<0.001	0.006	38	<0.001	<0.001	<0.001	0.003
Copper	mg/L	0.0014	56	<0.001	<0.001	0.002	0.004	38	<0.001	0.001	0.002	0.008
Iron	mg/L	0.2	56	<0.05	0.15	0.55	2.08	38	<0.05	0.07	0.142	0.39
Lead	mg/L	0.0034	56	<0.001	<0.001	<0.001	<0.001	38	<0.001	<0.001	<0.001	0.001
Manganese	mg/L	0.1	56	0.01	0.0585	0.2168	3.12	38	0.014	0.0505	0.117	0.369
Mercury	mg/L	0.0006	26	<0.0001	<0.0001	<0.0001	<0.0001	24	<0.0001	<0.0001	<0.0001	<0.0001

PARAMETER	UNIT	GUIDELINE	WELLS CREEK AND WELLS CREEK TRIBUTARY					WHITES CREEK				
			NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX	NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX
Molybdenum	mg/L	0.01	32	<0.001	<0.001	<0.001	<0.001	15	<0.001	<0.001	<0.001	<0.001
Nickel	mg/L	0.011	56	<0.001	0.002	0.002	0.004	38	<0.001	0.0015	0.002	0.005
Selenium	mg/L	0.01	32	<0.01	<0.01	<0.01	<0.01	15	<0.01	<0.01	<0.01	<0.01
Silver^	mg/L	0.00005	26	<0.001	<0.001	<0.001	0.02	26	<0.01	<0.01	<0.01	0.06
Zinc	mg/L	0.008	56	<0.005	<0.005	<0.005	0.009	38	<0.005	0.013	0.02	0.029
Hydrocarbons												
Benzene	µg/L	1	56	<1	<1	<1	<1	38	<1	<1	<1	<1
Toluene	µg/L	25	56	<2	<2	<2	<2	38	<2	<2	<2	<2
Ethylbenzene	µg/L	3	56	<2	<2	<2	<2	38	<2	<2	<2	<2
Total xylene	µg/L	20	56	<2	<2	<2	<2	38	<2	<2	<2	<2
Naphthalene	µg/L	16	56	<5	<5	<5	<5	38	<5	<5	<5	<5

*WQO recommended by *Healthy Rivers Commission Inquiry into the Hawkesbury-Nepean River* (HRC 1998).
^ Standard and trace laboratory limits of reporting exceed the ANZECC guideline for aquatic ecosystems.

PARAMETER	UNIT	GUIDELINE	BELANGLO CREEK AND PLANTING SPADE CREEK				
			NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX
Physical parameters							
Conductivity	µS/cm	35 – 350	7	12	77	117.8	125
Temperature	°C	-	7	7	9.8	12.96	17.4
Turbidity	NTU	2 - 25	7	1.5	7.7	14.44	15.7
pH	pH units	6.5 - 8.0	7	4.7	6	5.1 (20th %ile) 6.5 (80th %ile)	6.7
TDS	mg/L	600	7	39	52	78.6	81
TSS	mg/L	-	7	<1	2	2.8	4
Nutrients							
Ammonia as N	mg/L	0.5	7	<0.01	<0.01	0.024	0.03
Nitrate (as N)	mg/L	0.7	7	<0.01	0.02	0.084	0.15
Nitrite (as N)	mg/L	1.0	7	<0.01	<0.01	<0.01	0.05
Total nitrogen as N	mg/L	0.5*	7	0.1	0.2	0.4	0.4
Phosphorus	mg/L	0.03*	7	<0.01	0.01	0.02	0.02
Major ions							
Calcium	mg/L	1,000	7	<1	1	1.4	2
Chloride	mg/L	175	7	10	21	27.2	29
Magnesium	mg/L	2,000	7	1	2	3.4	4
Sodium	mg/L	115	7	8	11	17	17

PARAMETER	UNIT	GUIDELINE	BELANGLO CREEK AND PLANTING SPADE CREEK				
			NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX
Sulfate as SO_4	mg/L	250	7	1	2	2.4	3
Dissolved metals							
Aluminium	mg/L	0.055	7	0.06	0.21	0.656	1.22
Antimony	mg/L	0.003	6	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.01	7	<0.001	<0.001	<0.001	<0.001
Barium	mg/L	1.0	7	0.007	0.01	0.011	0.011
Beryllium	mg/L	0.06	7	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.37	6	<0.05	<0.05	<0.05	<0.05
Cadmium	mg/L	0.0002	7	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	7	<0.001	<0.001	<0.001	0.001
Cobalt	mg/L	0.05	7	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.0014	7	<0.001	<0.001	<0.001	0.001
Iron	mg/L	0.2	7	0.09	0.25	0.33	0.42
Lead	mg/L	0.0034	7	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.1	7	0.006	0.011	0.0208	0.034
Mercury	mg/L	0.0006	1	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.01	6	<0.001	<0.001	<0.001	<0.001
Nickel	mg/L	0.011	7	<0.001	<0.001	<0.001	<0.001
Selenium	mg/L	0.01	6	<0.01	<0.01	<0.01	<0.01

PARAMETER	UNIT	GUIDELINE	BELANGLO CREEK AND PLANTING SPADE CREEK				
			NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX
Silver^	mg/L	0.00005	1	<0.001	<0.001	<0.001	<0.001
Zinc	mg/L	0.008	7	<0.005	<0.005	<0.005	0.016
Hydrocarbons							
Benzene	µg/L	1	7	<1	<1	<1	<1
Toluene	µg/L	25	7	<2	<2	<2	<2
Ethylbenzene	µg/L	3	7	<2	<2	<2	<2
Total xylene	µg/L	20	7	<2	<2	<2	<2
Naphthalene	µg/L	16	7	<5	<5	<5	<5

*WQO recommended by *Healthy Rivers Commission Inquiry into the Hawkesbury-Nepean River* (HRC 1998).
^ Standard and trace laboratory limits of reporting exceed the ANZECC guideline for aquatic ecosystems

PARAMETER	UNIT	GUIDELINE	WINGECARRIBEE RIVER					BLACK BOBS CREEK				
			NO. OF SAMPLES	MIN	MEDIAN	80^{TH} %ILE	MAX	NO. OF SAMPLES	MIN	MEDIAN	80^{TH} %ILE	MAX
Physical parameters												
Conductivity	µS/cm	35 – 350	577	50	144	239.4	420	73	148	331	408.4	561
Temperature	°C	-	288	5.9	17	21.72	28	71	5.3	14.5	19.36	25.5
Turbidity	NTU	2 - 25	741	1.2	19.2	53.9	401	65	0.5	5.9	12.1	94.4
pH	pH units	6.5 - 8.0	278	6	7.4	7.0 (20^{th} %ile) 8.4 (80^{th} %ile)	10.03	73	4.7	6.9	6.5 (20^{th} %ile) 7.4 (80^{th} %ile)	7.9
TDS	mg/L	600	n/a	n/a	n/a	n/a	n/a	70	96	215	263.8	364
TSS	mg/L	-	675	<1	13	22	180	75	<1	5	10	172
Nutrients												
Ammonia as N	mg/L	0.5	n/a	n/a	n/a	n/a	n/a	75	<0.01	0.03	0.078	0.55
Nitrate (as N)	mg/L	0.7	4	0.15	0.198	0.235	0.235	75	<0.01	0.04	0.088	0.28
Nitrite (as N)	mg/L	1.0	1	0.038	n/a	n/a	0.038	75	<0.01	<0.01	<0.01	0.06
Total nitrogen as N	mg/L	0.5*	696	0.09	0.835	1.212	3.98	75	<0.1	0.5	0.9	2.4
Phosphorus	mg/L	0.03*	719	<0.005	0.06	0.102	0.872	75	<0.01	0.02	0.068	0.56
Major ions												
Calcium	mg/L	1,000	n/a	n/a	n/a	n/a	n/a	75	5	13	16	130

PARAMETER	UNIT	GUIDELINE	WINGECARRIBEE RIVER					BLACK BOBS CREEK				
			NO. OF SAMPLES	MIN	MEDIAN	80^{TH} %ILE	MAX	NO. OF SAMPLES	MIN	MEDIAN	80^{TH} %ILE	MAX
Chloride	mg/L	175	141	1	20.9	31.836	63	75	19	61	80	95
Magnesium	mg/L	2,000	n/a	n/a	n/a	n/a	n/a	75	2	14	17	26
Sodium	mg/L	115	n/a	n/a	n/a	n/a	n/a	75	12	27	32	48
Sulfate as SO_4	mg/L	250	55	3	12	27.6	45	75	1	10	50.8	350
Dissolved metals												
Aluminium	mg/L	0.055	n/a	n/a	n/a	n/a	n/a	75	<0.01	0.05	0.228	0.89
Antimony	mg/L	0.003	107	<0.001	<0.001	<0.001	<0.001	23	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.01	107	<0.001	<0.001	<0.001	0.001	75	<0.001	<0.001	<0.001	0.002
Barium	mg/L	1.0	107	0.014	0.032	0.037	0.042	75	0.019	0.033	0.0408	0.076
Beryllium	mg/L	0.06	107	<0.001	<0.001	<0.001	<0.001	74	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.37	107	<0.01	0.02	0.02	0.06	23	<0.05	<0.05	<0.05	0.05
Cadmium	mg/L	0.0002	107	<0.0001	<0.0001	<0.0001	0.0008	75	<0.0001	<0.0001	<0.0001	0.0003
Chromium	mg/L	0.001	107	<0.001	<0.001	<0.001	<0.001	75	<0.001	<0.001	<0.001	0.002
Cobalt	mg/L	0.05	107	<0.001	<0.001	<0.001	<0.001	75	<0.001	0.001	0.0138	0.045
Copper	mg/L	0.0014	107	<0.001	0.002	0.003	0.006	75	<0.001	<0.001	0.002	0.008
Iron	mg/L	0.2	n/a	n/a	n/a	n/a	n/a	75	<0.05	0.42	1.342	8.64
Lead	mg/L	0.0034	107	<0.001	<0.001	<0.001	0.003	73	<0.001	<0.001	<0.001	0.008
Manganese	mg/L	0.1	n/a	n/a	n/a	n/a	n/a	75	0.003	0.056	0.2576	0.568
Mercury	mg/L	0.0006	n/a	n/a	n/a	n/a	n/a	55	<0.0001	<0.0001	<0.0001	<0.0001

PARAMETER	UNIT	GUIDELINE	WINGECARRIBEE RIVER					BLACK BOBS CREEK				
			NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX	NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX
Molybdenum	mg/L	0.01	107	<0.001	<0.001	<0.001	0.002	23	<0.001	<0.001	<0.001	<0.001
Nickel	mg/L	0.011	107	<0.001	0.001	0.002	0.002	75	<0.001	0.003	0.0156	0.043
Selenium	mg/L	0.01	107	<0.01	<0.01	<0.01	<0.01	23	<0.01	<0.01	<0.01	<0.01
Silver^	mg/L	0.00005	107	<0.001	<0.001	<0.001	0.001	55	<0.001	<0.001	<0.001	0.05
Zinc	mg/L	0.008	107	<0.005	<0.005	0.007	0.047	75	<0.005	<0.005	0.0536	0.229
Hydrocarbons												
Benzene	µg/L	1	n/a	n/a	n/a	n/a	n/a	75	<1	<1	<1	<1
Toluene	µg/L	25	n/a	n/a	n/a	n/a	n/a	75	<2	<2	<2	<2
Ethylbenzene	µg/L	3	n/a	n/a	n/a	n/a	n/a	75	<2	<2	<2	<2
Total xylene	µg/L	20	n/a	n/a	n/a	n/a	n/a	75	<2	<2	<2	<2
Naphthalene	µg/L	16	n/a	n/a	n/a	n/a	n/a	75	<5	<5	<5	<5

*WQO recommended by *Healthy Rivers Commission Inquiry into the Hawkesbury-Nepean River* (HRC 1998).
^ Standard and trace laboratory limits of reporting exceed the ANZECC guideline for aquatic ecosystems.
n/a not available

PARAMETER	UNIT	GUIDELINE	LONGACRE CREEK					STONY CREEK				
			NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX	NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX
Physical parameters												
Conductivity	µS/cm	35 – 350	12	63	82	112.2	376	13	348	640	732	764
Temperature	°C	-	12	8.3	11.3	18.8	20.3	12	8.5	16	20	23
Turbidity	NTU	2 - 25	11	8.3	19.1	42.34	57.5	13	5.8	13	23	25
pH	pH units	6.5 - 8.0	12	5	6.45	5.8 (20th %ile) 6.7 (80th %ile)	7	13	6.4	7.3	6.7 (20th %ile) 7.6 (80th %ile)	7.9
TDS	mg/L	600	11	41	48	63.6	70	13	226	416	465	496
TSS	mg/L	-	12	<5	12.5	21.4	35	13	<5	12	17	23
Nutrients												
Ammonia as N	mg/L	0.5	12	<0.01	<0.01	0.01	0.04	13	<0.01	0.01	0.04	0.07
Nitrate (as N)	mg/L	0.7	12	<0.01	0.01	0.024	0.07	13	<0.01	<0.01	0.04	0.17
Nitrite (as N)	mg/L	1.0	12	<0.01	<0.01	<0.01	<0.01	13	<0.01	<0.01	<0.01	0.06
Total nitrogen as N	mg/L	0.5*	12	0.09	0.85	1.5	1.6	13	1.2	1.8	2.4	3.4
Phosphorus	mg/L	0.03*	12	0.01	0.045	0.074	0.08	13	0.08	0.30	0.47	1.8
Major ions												
Calcium	mg/L	1,000	12	2	2	3.4	5	13	17	38	48	56
Chloride	mg/L	175	12	9	14	20.4	24	13	62	106	133	147
Magnesium	mg/L	2,000	12	1	1.5	3	3	13	8	18	20	20

PARAMETER	UNIT	GUIDELINE	LONGACRE CREEK					STONY CREEK				
			NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX	NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX
Sodium	mg/L	115	12	5	9	11	12	13	31	53	63	72
Sulfate as SO_4	mg/L	250	12	<1	<1	<1	1	13	<1	5.0	10	29
Dissolved metals												
Aluminium	mg/L	0.055	12	0.14	0.4	0.836	1.06	13	<0.01	0.06	0.16	0.30
Antimony	mg/L	0.003	7	<0.001	<0.001	<0.001	<0.001	13	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.01	12	<0.001	<0.001	<0.001	0.001	13	<0.001	0.002	0.002	0.003
Barium	mg/L	1.0	12	0.014	0.017	0.0228	0.034	13	0.004	0.04	0.06	0.08
Beryllium	mg/L	0.06	12	<0.001	<0.001	<0.001	<0.001	12	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.37	7	<0.05	<0.05	<0.05	<0.05	13	<0.05	<0.05	<0.05	<0.05
Cadmium	mg/L	0.0002	12	<0.0001	<0.0001	<0.0001	<0.0001	13	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	12	<0.001	<0.001	0.001	0.002	13	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.05	12	<0.001	<0.001	<0.001	0.001	13	<0.001	<0.001	0.002	0.006
Copper	mg/L	0.0014	12	<0.001	0.001	0.002	0.005	13	<0.001	0.002	0.003	0.008
Iron	mg/L	0.2	12	0.37	0.57	1.09	1.51	13	0.10	0.35	0.54	2.4
Lead	mg/L	0.0034	12	<0.001	<0.001	<0.001	0.002	13	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.1	12	0.009	0.0215	0.0556	0.087	13	0.006	0.08	0.84	3.4
Mercury	mg/L	0.0006	5	<0.0001	<0.0001	<0.0001	<0.0001	13	<0.0001	<0.0001	<0.0001	<0.0001
Molybdenum	mg/L	0.01	7	<0.001	<0.001	<0.001	<0.001	13	<0.001	<0.001	0.002	0.002
Nickel	mg/L	0.011	12	<0.001	<0.001	0.002	0.004	13	<0.001	0.002	0.003	0.004

PARAMETER	UNIT	GUIDELINE	LONGACRE CREEK					STONY CREEK				
			NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX	NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX
Selenium	mg/L	0.01	7	<0.01	<0.01	<0.01	<0.01	13	<0.01	<0.01	0.01	0.01
Silver^	mg/L	0.00005	6	<0.001	<0.001	<0.001	0.42	3	<0.001^	<0.01	0.01	0.01
Zinc	mg/L	0.008	12	<0.005	0.006	0.012	0.014	13	<0.005	<0.005	<0.005	0.01
Hydrocarbons												
Benzene	µg/L	1	12	<1	<1	<1	<1	13	<1	<1	<1	<1
Toluene	µg/L	25	12	<2	<2	<2	<2	13	<2	<2	<2	<2
Ethylbenzene	µg/L	3	12	<2	<2	<2	<2	13	<2	<2	<2	<2
Total xylene	µg/L	20	12	<2	<2	<2	<2	13	<2	<2	<2	<2
Naphthalene	µg/L	16	12	<5	<5	<5	<5	13	<5	<5	<5	<5

*WQO recommended by *Healthy Rivers Commission Inquiry into the Hawkesbury-Nepean River* (HRC 1998).
^ Standard and trace laboratory limits of reporting exceed the ANZECC guideline for aquatic ecosystems.

PARAMETER	UNIT	GUIDELINE	WOLLONDILLY RIVER					LONG SWAMP CREEK AND HANGING ROCK SWAMP CREEK				
			NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX	NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX
Physical parameters												
Conductivity	µS/cm	35 – 350	1,040	34	410	587	2,060	52	51	82.5	182.8	293
Temperature	°C	-	217	4.3	16.3	21.8	28.2	51	6.4	12.8	16.92	20.6
Turbidity	NTU	2 - 25	1,521	0.7	7.5	26.88	1,648	50	0.5	2.55	4.58	16.7
pH	pH units	6.5 - 8.0	220	6.5	7.78	7.3 (20th %ile) 8.2 (80th %ile)	9	52	3.1	6.5	5.7 (20th %ile) 6.9 (80th %ile)	7.7
TDS	mg/L	600	n/a	n/a	n/a	n/a	n/a	50	46	53.5	116	182
TSS	mg/L	-	856	1	4	20	2,490	52	<1	2	5	20
Nutrients												
Ammonia as N	mg/L	0.5	n/a	n/a	n/a	n/a	n/a	52	<0.01	0.01	0.024	1.16
Nitrate (as N)	mg/L	0.7	n/a	n/a	n/a	n/a	n/a	52	<0.01	0.03	0.044	0.14
Nitrite (as N)	mg/L	1.0	n/a	n/a	n/a	n/a	n/a	52	<0.01	<0.01	<0.01	0.04
Total nitrogen as N	mg/L	0.5*	869	0.01	0.63	0.97	11.57	52	<0.1	0.1	0.5	2.5
Phosphorus	mg/L	0.03*	880	<0.002	0.027	0.06	1.63	52	<0.01	<0.01	0.02	0.08
Major ions												
Calcium	mg/L	1,000	n/a	n/a	n/a	n/a	n/a	52	<1	1	3.4	7

PARAMETER	UNIT	GUIDELINE	WOLLONDILLY RIVER					LONG SWAMP CREEK AND HANGING ROCK SWAMP CREEK				
			NO. OF SAMPLES	MIN	MEDIAN	80^{TH} %ILE	MAX	NO. OF SAMPLES	MIN	MEDIAN	80^{TH} %ILE	MAX
Chloride	mg/L	175	110	1	79.15	120.6	235	52	13	21.5	42	66
Magnesium	mg/L	2,000	n/a	n/a	n/a	n/a	n/a	52	<1	1	3	5
Sodium	mg/L	115	n/a	n/a	n/a	n/a	n/a	52	9	11	22	37
Sulfate as SO_4	mg/L	250	55	2	11	19	33	52	<1	<1	1	10
Dissolved metals												
Aluminium	mg/L	0.055	n/a	n/a	n/a	n/a	n/a	52	0.02	0.06	0.094	0.32
Antimony	mg/L	0.003	72	<0.001	<0.001	<0.001	<0.001	16	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.01	72	<0.001	<0.001	<0.001	0.001	52	<0.001	<0.001	<0.001	0.002
Barium	mg/L	1.0	72	0.022	0.0425	0.05	0.077	52	0.002	0.008	0.0138	0.025
Beryllium	mg/L	0.06	72	<0.001	<0.001	<0.001	<0.001	51	<0.001	<0.001	<0.001	<0.001
Boron	mg/L	0.37	72	<0.01	0.01	0.02	0.03	16	<0.05	<0.05	<0.05	<0.05
Cadmium	mg/L	0.0002	72	<0.0001	<0.0001	<0.0001	0.0014	52	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	72	<0.001	<0.001	<0.001	<0.001	52	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.05	72	<0.001	<0.001	<0.001	<0.001	52	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.0014	72	<0.001	0.0025	0.005	0.007	7	<0.001	<0.001	<0.001	0.004
Iron	mg/L	0.2	n/a	n/a	n/a	n/a	n/a	52	0.18	0.34	0.42	1.58
Lead	mg/L	0.0034	72	<0.001	<0.001	<0.001	0.007	52	<0.001	<0.001	<0.001	<0.001
Manganese	mg/L	0.1	n/a	n/a	n/a	n/a	n/a	52	0.002	0.0105	0.0188	0.227
Mercury	mg/L	0.0006	n/a	n/a	n/a	n/a	n/a	38	<0.0001	<0.0001	<0.0001	<0.0001

PARAMETER	UNIT	GUIDELINE	WOLLONDILLY RIVER					LONG SWAMP CREEK AND HANGING ROCK SWAMP CREEK				
			NO. OF SAMPLES	MIN	MEDIAN	80^{TH} %ILE	MAX	NO. OF SAMPLES	MIN	MEDIAN	80^{TH} %ILE	MAX
Molybdenum	mg/L	0.01	72	<0.001	<0.001	<0.001	0.002	16	<0.001	<0.001	<0.001	<0.001
Nickel	mg/L	0.011	72	<0.001	0.001	0.002	0.003	52	<0.001	<0.001	<0.001	0.002
Selenium	mg/L	0.01	72	<0.01	<0.01	<0.01	0.01	16	<0.01	<0.01	<0.01	<0.01
Silver^	mg/L	0.00005	n/a	n/a	n/a	n/a	n/a	40	<0.001	<0.001	<0.001	0.06
Zinc	mg/L	0.008	72	<0.005	0.005	0.008	0.035	52	<0.005	<0.005	<0.005	0.033
Hydrocarbons												
Benzene	µg/L	1	n/a	n/a	n/a	n/a	n/a	52	<1	<1	<1	<1
Toluene	µg/L	25	n/a	n/a	n/a	n/a	n/a	52	<2	<2	<2	<2
Ethylbenzene	µg/L	3	n/a	n/a	n/a	n/a	n/a	52	<2	<2	<2	<2
Total xylene	µg/L	20	n/a	n/a	n/a	n/a	n/a	52	<2	<2	<2	<2
Naphthalene	µg/L	16	n/a	n/a	n/a	n/a	n/a	52	<5	<5	<5	<5

*WQO recommended by *Healthy Rivers Commission Inquiry into the Hawkesbury-Nepean River* (HRC 1998).
^ Standard and trace laboratory limits of reporting exceed the ANZECC guideline for aquatic ecosystems.
n/a not available

PARAMETER	UNIT	GUIDELINE	INDIGO CREEK				
			NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX
Physical parameters							
Conductivity	µS/cm	35 – 350	3	167	178	n/a	178
Temperature	°C	-	3	8	12.9	n/a	19.4
Turbidity	NTU	2 - 25	3	37.6	38	n/a	72.6
pH	pH units	6.5 - 8.0	3	7	7.1	n/a	7.6
TDS	mg/L	600	2	115	n/a	n/a	116
TSS	mg/L	-	3	16	19	n/a	37
Nutrients							
Ammonia as N	mg/L	0.5	3	<0.01	0.02	n/a	0.02
Nitrate (as N)	mg/L	0.7	3	0.21	0.21	n/a	0.53
Nitrite (as N)	mg/L	1.0	3	<0.01	<0.01	n/a	<0.01
Total nitrogen as N	mg/L	0.5*	3	1.2	1.2	n/a	1.8
Phosphorus	mg/L	0.03*	3	0.14	0.18	n/a	0.42
Major ions							
Calcium	mg/L	1,000	3	5	10	n/a	15
Chloride	mg/L	175	3	4	6	n/a	7
Magnesium	mg/L	2,000	3	3	4	n/a	6

PARAMETER	UNIT	GUIDELINE	INDIGO CREEK				
			NO. OF SAMPLES	MIN	MEDIAN	80^{TH} %ILE	MAX
Sodium	mg/L	115	3	6	7	n/a	7
Sulfate as SO_4	mg/L	250	3	<1	<1	n/a	5
Dissolved metals							
Aluminium	mg/L	0.055	3	0.41	1.2	n/a	1.33
Antimony	mg/L	0.003	1	<0.001	n/a	n/a	<0.001
Arsenic	mg/L	0.01	3	<0.001	<0.001	n/a	<0.001
Barium	mg/L	1.0	3	0.015	0.016	n/a	0.017
Beryllium	mg/L	0.06	3	<0.001	<0.001	n/a	<0.001
Boron	mg/L	0.37	1	<0.05	n/a	n/a	<0.05
Cadmium	mg/L	0.0002	3	<0.0001	<0.0001	n/a	<0.0001
Chromium	mg/L	0.001	3	<0.001	0.002	n/a	0.002
Cobalt	mg/L	0.05	3	<0.001	<0.001	n/a	<0.001
Copper	mg/L	0.0014	3	0.003	0.004	n/a	0.006
Iron	mg/L	0.2	3	0.36	0.77	n/a	1.16
Lead	mg/L	0.0034	3	<0.001	<0.001	n/a	<0.001
Manganese	mg/L	0.1	3	0.005	0.006	n/a	0.016
Mercury	mg/L	0.0006	3	<0.0001	<0.0001	n/a	<0.0001
Molybdenum	mg/L	0.01	1	<0.001	n/a	n/a	<0.001
Nickel	mg/L	0.011	3	0.003	0.006	n/a	0.008
Selenium	mg/L	0.01	1	<0.01	n/a	n/a	<0.01

PARAMETER	UNIT	GUIDELINE	INDIGO CREEK				
			NO. OF SAMPLES	MIN	MEDIAN	80TH %ILE	MAX
Silver^	mg/L	0.00005	3	<0.001	<0.001	n/a	<0.001
Zinc	mg/L	0.008	3	<0.005	<0.005	n/a	0.012
Hydrocarbons							
Benzene	µg/L	1	3	<1	<1	n/a	<1
Toluene	µg/L	25	3	<2	<2	n/a	<2
Ethylbenzene	µg/L	3	3	<2	<2	n/a	<2
Total xylene	µg/L	20	3	<2	<2	n/a	<2
Naphthalene	µg/L	16	3	<5	<5	n/a	<5

*WQO recommended by *Healthy Rivers Commission Inquiry into the Hawkesbury-Nepean River* (HRC 1998).
^ Standard and trace laboratory limits of reporting exceed the ANZECC guideline for aquatic ecosystems.

Appendix B

ADJUSTMENT OF BACKGROUND NUTRIENT CONCENTRATIONS FOR SWALES

Adjustment of C* and C values for swales**

A key input parameter in MUSIC treatment nodes is the background pollutant levels, C*(stormflow background pollutant concentration) and C** (baseflow background pollutant levels) values. The default MUSIC background concentrations for TP and TN in swales are set high and are required to be revised to simulate more realistic values.

The C* estimate for total suspended solids (TSS) is obtained by Fletcher (2004) from the particle size at which only 20% removal is achieved. The method and particle distribution figures are provided in Fletcher (2004).

Applying the Fletcher (2004) methodology for TP results in a C* value of 0.18mg/L and an EMC of 0.26mg/L. This is significantly higher than the TP EMC recorded in the Hume Coal project baseline water quality data at 0.14mg/L. Therefore, it was considered reasonable to adjust the C* and C** values to reflect the lower recorded TP concentrations in the watercourses in the project area.

The C* was adjusted by identifying the ratio between the C* and the EMC identified in Fletcher (2004) and the EMC from the project area in the equation below.

$$C^*_{new} = EMC_{from\ baseline\ data} * \frac{C^*_{fletcher}}{EMC_{fletcher}}$$

MUSIC applies the same value for both C* and C** for swales. Therefore, the C^*_{new} value was applied for both C* and C**.

The same method was applied for TN and the revised C* and C** for swales for both TP and TN are shown in the table below.

Table B1: Revised C* and C** values for swales

	k	C*	C**
TSS	8000	20	14
TP	6000	0.096^	0.096^
TN	500	0.89^	0.89^

^C* and C** values that were revised

By adjusting the C* it is assumed that the background concentration of the swales will not increase because the swales will be properly maintained.